Adapting Contract Theory to Fit Contract Farming

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Abstract

This article discusses the current state of contract theory and its usefulness for conceptualizing issues related to agricultural contracting. I will discuss the limitations of existing theory for applied work, and what methodological improvements are needed to enhance the usefulness of the theory to agricultural economists. One pervasive problem is that the canonical economic literature on contracts is rather fragmented and the various methodological strands are narrow in their focus. As such, there is a need for agricultural economists to engage in methodological research to develop applied contracting models that can capture higher order features of real world agricultural contracts while delivering generalizable comparative statics predictions. The need for such research is obvious as contracting continues to expand along the entire modern food marketing channel. In the latter part of this article, I develop a simple model to illustrate how classic methodological approaches can be combined with recent developments in contract and game theory to construct applied theory models that are useful for capturing some important features of agricultural contracts.

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This article discusses the usefulness of contract theory for conceptualizing contracting problems in agriculture. I will discuss the current state of the theory and offer my views on what methodological improvements are needed for the theory to be useful for modeling important features of agricultural contracts while being able to deliver comparative statics results that are useful for making generalizable predictions about how policy interventions and other exogenous shocks might affect contracting outcomes. According to MacDonald and Korb (2011), the use of contracts in agriculture has been increasing over the last several decades. In 1969, contract governed only 12% of the total value of U.S. agricultural production, but this has increased to 39% in 2008 and there is no evidence that this trend will slow down as the modern food marketing channel is increasingly dominated by food manufacturers and retailers that emphasize food product innovation and food safety, which require a high degree of coordination between firms in different segments of the channel (Myers et al., 2010).

Despite the widespread use of contracts in agriculture, it is curious that agricultural economists have, for the most part, not leveraged cutting edge contract theoretic tools that have been developed in recent years to study problems in agriculture. While agricultural economists were fairly active in the late 90s and early 2000s in leveraging contract theory to study agricultural problems, this seems to have waned in recent years despite the rising trend in agricultural contracting.[1] Moreover, despite a long tradition of agricultural economists making significant methodological contributions in many areas of economics (e.g. applied econometrics and consumer/producer theory), this does not seem to have carried over to contracts.[2]

[1]For example, in the late 90s and early 2000s, Goodhue (2000); Hueth and Ligon (1999a); Hueth et al. (1999); Hueth and Ligon (1999b, 2001); Hueth and Melkonyan (2004); Knoeber and Thurman (1995); Leegomonchai and Vukina (2005); Tsoulouhas and Vukina (2001) all used contract theory to model specific agricultural contracting or policy issues. Since 2005, the author is only aware of the work of Lee et al. (2008); Wu (2010)

[2]Two exceptions include early papers by Innes (1990); Innes and Sexton (1994). But the author is not aware of any other papers since that time.

The lack of methodological advancement in contract theory within the agricultural economics community has limited agricultural economists to providing only incomplete analyses of recent policy issues. For example, in June 2010, the USDA-GIPSA proposed new rules to amend the Packers and Stockyard Act, which is the major anti-trust statute for agricultural input markets. A key proposal is that growers do not have to prove competitive harm when suing for breach of contract that results only in specific harm to the grower. However, the rules have been controversial leading some U.S. Senators to question GIPSA's "impartiality" (Southern Farm Network, 2011). The position taken by these senators appear to be consistent with the findings of a number of economic studies, which have found little evidence of market power using traditional tools from industrial organization (U.S. GAO, 2009). However, while traditional tools look for evidence of market power by identifying monopsony mark-downs relative to competitive pricing, contract theorists have long known that carefully constructed contractual mechanisms can mitigate welfare losses from market power. A similar point was also made by Sexton (2013) who points out that it is difficult to use traditional oligopoly/oligopsony models to quantify the existence of market power in farm procurement settings involving the use of contracts. Thus, the lack of methodological integration between traditional IO models and contract theory has left agricultural economists with very little to say about the potential contracting outcomes that may occur under the GIPSA rule.

One possible explanation for why applied researchers have had difficulty making methodological contributions is that the general economics literature on contracts has historically been rather fragmented. This has created methodological divides where applied researchers who leverage particular methodological approaches are also implicitly taking sides in ideological debates among contract theorists. This can limit the scope of methodological contributions made by applied researchers as the major strands of contract theory can be rather narrow in their focus in the sense that some methodological strands focus on tight modeling frameworks, logical consistency, and generalizability of results, whereas other strands focus on real world applicability at the expense of generalizability and internal consistency. I will discuss these different strands in more detail in the next section, but for now, it is important to point out that some recent advancements, especially from the relational contracting literature, have great potential to deliver generalizable results that are also consistent with stylized facts from the real world.

Canonical Contract Theory: The Complete and Incomplete Contracts Approaches

Since the early 70s, contract theory has largely evolved into a theoretical field within mainstream economics. Contract theorists typically impose simplifying assumptions to develop tractable stylized models and/or make rather idealized assumptions about what types of contracts are possible and how performance is governed. Many of the assumptions are sufficiently controversial such that there has been a methodological divide between those who advocate the "complete contracts" methodology and those who advocate the "incomplete contracts" approach (Tirole, 1999).

The complete contracts approach has largely dominated the literature and is considered the textbook model on contracts. Classic applications include structuring incentives in order to overcome asymmetric information problems such as moral hazard and adverse selection. The key assumption of complete contract theory is that, in a contractual relationship between two parties, a contract governs all aspects of performance under all contingencies and therefore the key is to design an optimal state-contingent plan. Because the contracting parties are able to foresee all relevant contingencies, there should be no "surprise" contingencies that will arise. Therefore, all performance obligations across all contingencies of both parties can be specified in the initial contract. Moreover, performance obligations under this contract can be third-party verified and enforced and sufficient legal penalties exist to deter each party from deviating from the contract.[3] Taken together, this set of assumptions implies that no party to a complete contract has *ex post* discretion to deviate from the upfront agreement. Indeed, the presence of discretionary latitude to deviate from the upfront agreement is synonymous with incomplete contracting because there are unspecified or unenforceable contingencies in a contract.

Even casual observation of real world contracts suggest that most are not fully state-contingent and that at least one contracting party has some degree of ex post discretionary latitude. This discretionary latitude can be damaging in an efficiency sense because the typical contracting relationship is analogous to a sequential game. If the last mover has discretionary latitude to deviate from the upfront agreement and honoring the agreement is costly, then the last mover will behave opportunistic (e.g. shirk on promised bonuses for instance). If the other party to the contract is forward looking, she will anticipate this and shirk on her obligations as well. The net effect could be that both parties will underinvest in performance or the parties will refuse to contract in the first place. Even when there is no clear last mover and/or important variables are only contractible *ex post* after a state is realized, the parties may still have to engage in ex post bargaining, which can also lead to inefficiencies.

The concern over ex post discretion was one of the driving forces behind the

[3]Although hidden information such as agent effort or type is non-verifiable, it is well-known that if there are variables that are correlated with the hidden information, a complete contract can still be specified around these variables. There will typically be some loss in efficiency as the contract design problem will involve incentive compatibility constraints, but nonetheless, the contract will still be fully state-contingent.

"incomplete contracts" movement which consists of two sub-strands, including *transactions cost theory* (Klein and Alchian, 1978; Williamson, 1979) and *property rights theory* (Grossman and Hart, 1986; Hart and Moore, 1990). Due to space constraints, I will not discuss these sub-strands of the incomplete contracts approach in detail and instead refer the reader to Gibbons (2005) or Wu (2006) for surveys of this literature. However, it is important to point out that the incomplete contracts approach is methodologically quite different from the complete contracts approach in that contractual form does not endogenously emerge from an optimization problem as in the complete contracts approach. Instead, contract structure is typically arbitrarily and exogenously imposed on a problem so that the researcher can focus instead on what types of institutions or patterns of asset ownership can minimize the damage caused by unspecified contingencies and ex post discretion.

Given the methodological differences between the two approaches, it is no surprise that there has been an ideological divide where scholars from each side have been critical of the other approach. One of the most obvious criticisms of the complete contracts approach is that many of the contracts that emerge from the typical constrained optimization problems are overly complex and often do not match what is observed in practice. Moreover, it is rather rare that a complete contract governs every aspect performance. In practice, many formal contracts serve only as default obligations that are triggered if some informal relational agreement breaks down.[4] In turn, critics of the incomplete contracts approach often argue that the literature lacks rigorous foundations, many assumptions are *ad hoc*, and that some of the models are internally inconsistent. As an example of the latter criticism, Tirole (1999) points out that some incomplete contracting models assume that agents are boundedly rational, which prevents them from writing complete contracts, and yet, the models are solved

[4]Dixit (2007) discusses this issue and develops some formal models.

using dynamic programming where agents are assumed to be able to perfectly foresee their future payoffs. Another sharp criticism described by Schmitz (2001) is that the incomplete contracts approach often takes two arbitrarily defined simple contracts, say C_1 and C_2 that are both suboptimal, and compares their efficiency properties. There is no explanation concerning how these simple contracts emerged because they are not derived from first principles. Thus, one cannot know whether there exists a third contract, say C_3, that might implement first best. The problem with these *ad hoc* comparisons is that it is difficult to know whether the analysis of institutions or organization form under *ad hoc* contracts such as C_1 and C_2 hold only for these two contracts or hold more generally. Indeed, many of the analytic models used in the incomplete contracts approach are often motivated by very specific case studies such as the classic Fisher Body/General Motors vertical integration problem. Thus, many of these models appear to resemble structured case studies.

Many of the criticisms of the two major contracting methodologies are also relevant for applied researchers working on agricultural contracts. Specifically, the canonical complete contracts model may not be able to capture higher ordered features of actual agricultural contracts. On the other hand, the more flexible incomplete contracts approach can potentially capture higher ordered features of agricultural contracts but many of the assumptions may be too *ad hoc* to generate comparative statics predictions that hold beyond very specific cases and a very specific set of parameters. In the next section, I will discuss these issues in more detail.

Important Features of Agricultural Contracts

Even casual observation of actual agricultural contracts reveals that many of them combine a curious mixture of very precise state-contingent terms that govern quality/defects and very loose guidelines for many other important obligations. In particular, quantity commitments such as scheduling/delivery timing, volume purchased by the contractor or raised by the grower (in production contracts), and/or changes in quantity from year-to-year/flock-to-flock are only described broadly, if at all. On the surface, this seems puzzling as quantity sold or delivered in a given time frame seems to be as important as quality in determining grower revenue and contractor costs. Thus, most contracts in practice do not appear to be fully state-contingent leaving at least one party with *ex post* discretionary latitude over some obligations. There is of course some heterogeneity across contracts both within and across commodities but it seems fairly clear that most contracts are incomplete and the patterns of heterogeneity seem to be with respect to the *degree* of incompleteness rather than whether contracts are complete or incomplete in an absolute sense.

Even when one contract is apparently more complete than another, another channel through which incompleteness can arise is if it is too costly or difficult to enforce specific terms in a contract (Tirole, 1999). For example, the typical broiler production is far more detailed than say, a processing tomato marketing contract. The former can be more than 10 pages long whereas the latter can be as short as one page. So it appears as if the typical broiler production contract is more "complete" than the typical processing tomato marketing contract. However, the institutions that verify quality are very different across the two sectors. In particular, a third-party entity known as the Processing Tomato Advisory Board (PTAB), which is jointly funded by growers and processors, conducts quality grading of tomatoes whereas performance measurement is often conducted by the integrator in broiler production. Despite more detailed contracts, the lack of third-party verifiability limits the enforceability of the terms in broiler contracts. Without third-party enforcement, there will exist discretionary latitude to deviate from the agreement since it is hard for a third-party such as a court or regulator to verify that a deviation has occurred. Some states, such as Georgia, have passed laws to improve transparency of performance measures in broiler contracts. Wu and Roe (2007) footnote 1 points out that Georgia HB 648 requires integrators to provide "any statistical information and data used to determine compensation paid" at the grower's request.

Another complicating factor in pinning down the exact source of contractual incompleteness is that there appears to be substantial heterogeneity in contractual structure even across contractors for the same commodity. For example, even with a credible third-party that measures quality of processing tomatoes, some processors in some years appear to leave out state-contingent payments for quality factors. This is puzzling because it is relatively low cost to condition payments on quality and yet some processors do not do so. This is consistent with the findings by Scott (2003) who examined a large number of actual business contracts and found that a significant number of them appeared to be endogenously incomplete in that they do not condition on even verifiable performance measures. If contracts are indeed endogenously incomplete, then modifications must be made to both canonical complete and incomplete contract models.

The fact that many agricultural contracts are incomplete implies that at least one party to the contract will have *ex post* discretionary latitude. This latitude to deviate from the upfront agreement means that the contracting parties must learn to manage *counter-party risk*. Counterparty risk refers to the risk that one's counterparty to a contract will not fulfill his/her end of the agreement. While this risk is largely ignored in canonical contract theory, it is a real and pervasive concern in the farming and agribusiness world (Narduzzo, 2010). Indeed, Section 7 of the Producer Protection Act states that "One of the greatest risks for a producer in production contracting is the risk of not getting paid. This section establishes a first priority lien for a producer for amounts due under a production contract involving livestock, raw milk, or crops" (Iowa Attorney General's Office, 2000). While there is always some counterparty risk from exogenous events outside of the control of the contracting parties even under complete contracts, counterparty risk is magnified under incomplete contracts since parties with discretionary latitude can endogenously choose not to honor their obligations when it is not profitable to do so. However, classical contract theory does not typically incorporate counterparty risk into contract design problems; instead, the focus is on the tradeoff between risk vs incentives where "risk" refers to randomness in translating the agent's effort into the performance outcome that the principal cares about. This risk is largely exogenous and can be dealt with through adjusting the power of incentives to achieve second best outcomes. While counterparty risk is largely missing from the contract theory literature, a similar concept exists in the game theory literature where theorists have used the notion of strategic uncertainty and risk dominance to model how players behave in coordination games where players are unsure of the strategic choices made by their counterparties. Thus, theoretical tools have been developed for modeling counterparty risk.

Repeat contracting is another feature that is quite common in agriculture. In footnote 2 of Wu and Roe (2007), the authors state: "In personal communication, senior members of the California Processing Tomato Growers Association suggested to one of the authors that, in any given year, processors will re-sign 90% of growers from the previous year. Thus, repeat trading is quite common." Hamilton (2001) suggests that many broiler contracts tend to continue to trade repeatedly across many flocks until terminated. Leegomonchai and Vukina (2005) make a similar point that broiler contracts are repeat contracts across many flocks. Repeat trading is easy to handle because we know from the game theoretic literature that repeat trading can be useful for mitigating the inefficiencies that arise in one-shot games such as the

Prisoner's Dilemma game. Since contracting relationships are similar to sequential Prisoner's Dilemma games, *ex post* discretionary latitude can be disciplined under repeat trading and can provide us with some insight into why contracts might be endogenously incomplete. I will discuss this in detail in the next section.

Lastly, I want to highlight a feature of the agricultural contracting environment that has generated considerably controversy, which is buyer concentration and buyer power in agricultural procurement markets. This issue was the focus of Richard Sexton's 2012 Presidential Address at the AAEA meetings (Sexton, 2013) and is also discussed in detail in his paper with John Crespi and Tina Saitone (Crespi et al., 2012). Sexton (2013) emphasizes some important trends including (but not limited to) increasing concentration in the processing sector and increasing use of contracts. Sexton asks a key fundamental question (see page 214, second paragraph of Sexton (2013)): *"How do we reconcile food industries that are structural oligopolies/oligopsonies with high barriers to entry, ample opportunities to obtain cooperative outcomes, and anecdotal evidence supporting little competition in farm product procurement with an extensive empirical literature that finds little market power?"* Sexton suggests that the impact of market structure change on market intermediaries holds the key to offering an explanation and provides some examples of how large processors may not wield their market power in the presence of processing capacity constraints or fixed sales contracts. Sexton also points out that it is difficult to use traditional oligopoly/oligopsony models to quantify the existence of market power in farm procurement settings involving the use of contracts. In the next section, I will provide a detailed discussion of how combining buyer power with endogenous contractual form can provide some complementary insights to the points raised by Sexton.

To summarize, contractual incompleteness, repeat trading, counterparty risk, and/or buyer/market power are, in my view, some of the first order features that are important to capture in modeling agricultural contracting. I am sure there are other features that I have missed as contracting relationships can be complex and it is impossible to model everything. But the purpose of modeling is not to mimic the real world, but to add clarity about the real world. This can be best achieved using a parsimonious model that captures a few of the most important, generalizable first order forces underlying contractual relationships. In the next section, I will discuss modeling issues related to agricultural contracts.

Modeling First Order Features of Agricultural Contracts

I will now discuss how one might go about developing contracting models that are useful for capturing the important features outlined in the previous section. It will be important to start with economic primitives using a constrained optimization framework in which we are clear about the constraints, the exogenous variables and the endogenous variables. Specifically, it is important to treat contractual terms as endogenous so that an optimal contractual form can emerge from the optimization problem and is not just imposed in an *ad hoc* manner. Deriving the contractual form from first principles allows us to make more generalizable analytical predictions.

By starting from a constrained optimization problem, we are in a sense taking the classic "complete contracts" approach to contracting problems. However, a key point of departure is that I assume that the third-party enforcement technology is potentially imperfect which reduces the set of feasible contracts available to the principal. Assuming that there are exogenous (to the contracting parties) imperfections in the enforcement technology is quite common in the recent contracting literature (e.g. Bernheim and Whinston (1998); Levin (2003); Dixit (2007); MacLeod (2007)), although it is not the only way to model exogenous imperfections in contracting institutions. For example, Battigalli and Maggi (2002, 2008) assume there are exogenous costs to describing all relevant contingencies which ultimately limits fully state-contingent contracts.[5] The important point is that the modeler has some flexibility in defining the source of exogeneity although an applied researcher must be careful in ensuring that the maintained assumptions are consistent with stylized facts and real world institutions. Moreover, it is crucial that the maintained assumption is truly exogenous and does not create internal inconsistencies within the model.

I will now set up a up a contract design problem to illustrate one approach to modeling agricultural contracts. What I present from this point forward are preliminary results from several of my working papers that are currently in development (citations omitted temporarily during the review process to avoid disclosing author's identity). While the ideas are preliminary and results will be fully developed in forthcoming working papers, organizing them in a coherent way might be useful for illustrating how one can take tools from several papers to build a useful model.

Consider a principal (e.g. a processor or integrator) who contracts with an agent (e.g. farmer) in order to produce some commodity for which quality is important. For now, I will omit quantity considerations so that we can focus on quality incentives.[6] I will also abstract away from exogeous uncertainty and asymmetric information issues such as moral hazard and adverse selection since they often distract readers from the most basic definition of a contract which is that a contract is simply an agreement that

[5]In addition, if one is modeling the design of contracting institutions, then obviously one could not treat the enforcement technology as exogenous. Thus it is important to match assumptions with the problem at hand

[6]It would not be difficult to relax this assumption and consider both quality and quantity considerations. In fact, one could combine the two by using a multitask principal-agent model in the spirit of Holmstrom and Milgrom (1991)

is meant to be enforced.[7] Instead, I will focus on enforcement limits that may leave at least one party with discretionary latitude to deviate from the upfront agreement.[8]

Under a contract, each party has obligations or must take actions consistent with the agreement. We can specify the principal and agent's actions generically as $a_i \in A_i$ where $i = A, P$. A key assumption is that there is an agency conflict so that the two parties have conflicting of objectives.

Assumption 1. *There is an agency conflict in that for* ${a_A}' > {a_A}''$ *and* ${a_P}' > {a_P}''$, *we have:* $\pi_P(a_P, {a_A}') > \pi_P(a_P, {a_A}'')$; $\pi_P({a_P}', a_A) < \pi_P({a_P}'', a_A)$; $\pi_A(a_P, {a_A}') < \pi_A(a_P, {a_A}'')$; *and* $\pi_A({a_P}', a_A) > \pi_A({a_P}'', a_A)$

In other words, all else equal, the principal always prefers that the agent increases his actions while minimizing her own actions. The opposite is true for the agent. For example, the agent's obligation might be to deliver some quality level $q \geq Q$ where capital Q refers to the quality level specified in the contract and q refers to the actual quality delivered. The principal's obligation is $w = p + b \geq W$ where w is total actual payment and W is the promised payment in the contract. The total payment w can also be decomposed into a base price, p and a bonus payment b. I use capitalized P and B for the contractually specified fixed and bonus payments, respectively. The payoff functions for the two parties are $\pi_P = r(q) - p - b$ and $\pi_A = p + b - c(Q)$

[7] In my experience, researchers who don't specialize in contract theory often think of contracts as being synonymous with models of asymmetric information. While contracts can certainly be used to mitigate asymmetric information and are fact introduced this way in most textbooks, moral hazard and adverse selection are simply special cases of a broader class of problems within contract theory. While the tradeoff between risk and incentives (moral hazard problems) and nonlinear pricing (adverse selection) are certainly interesting and well-known, perhaps even more fundamental in practice is the incentive problems associated with getting parties to honor their promises. This is often abstracted away in textbook treatments where there is an implicit assumption that a perfect legal system and omniscient third-party exists to verify and enforce contracts

[8] The three major classes of information problems within the contract theory literature are moral hazard, adverse section and the availability of public information for a third-party to enforce a contract. While the first two types of information problems are well-known, the third type is less well-known outside the incomplete contracts and relational contract literature. Dixit (2007) provides a nice discussion of the importance of public information in driving contractual relations.

where $r' > 0$, $r'' \leq 0$, $c' > 0$ and $c'' \geq 0$. Note that the principal always prefers higher quality all else equal and the agent always prefers a higher payment.

I model exogenous imperfections in the enforcement technology in the sense of Bernheim and Whinston (1998).

Assumption 2. *Assume that enforcement limits can be represented by an ordered partition of A_i, $E_i = \{e_{i1}, ..., e_{iN_i}\}$ where party i prefers smaller actions in E_i and party j prefers higher actions. A third-party cannot distinguish any two actions that belong to the same subset e_{in} but can distinguish two actions that belong to different subsets of the partition, e_{ik} and e_{il}, where $k \neq l$.*

By assumptions 1 and 2, only $\underline{e}_{in} = \inf e_{in}$ for all n are contractible (i.e. 3rd party enforceable). That is, only the smallest action in each subset of the partition can be enforced. Moreover, finer partitions of E_i implies better enforcement technology as it increases the number of enforceable actions.

As a simple illustration, suppose that an agent produces a good that can only take three quality levels $A_A = \{low, medium, high\}$. An example of a perfect enforcement technology is $E_A = \{e_{A1}, e_{A2}, e_{A3}\} = \{\{low\}, \{medium\}, \{high\}\}$. Note that each element of the partition is a singleton so a third-party can perfectly distinguish every quality level. An example of imperfect enforcement is $E_A = \{e_{A1}, e_{A2}\} = \{\{low\}, \{medium, high\}\}$. Here a third-party knows when low quality has occurred but cannot distinguish medium quality from high quality. Thus, the contractible set is $\underline{E_A} = \{\underline{e_{A1}}, \underline{e_{A2}}\} = \{low, medium\}$. Finally, if $E_A = \{e_{A1}\} = \{\{low, medium, high\}\}$ then quality is almost completely unenforceable by a third-party. Only low quality is trivially contractible.

My purpose in using all of this machinery is that it gives us a more precise way of defining an incomplete contract and how enforcement limits constrain the contract choice set. Continuing with our example, under a perfect enforcement technology, $E_A = \{e_{A1}, e_{A2}, e_{A3}\} = \{\{low\}, \{medium\}, \{high\}\}$, it is possible to write a fully complete contract. This complete contract can either specify $Q = high$ in exchange for a price P or it can provide a set of state-contingent prices P_l, P_m and P_h to be paid under each quality realization without demanding a specific quality level. In the former contract, a third-party directly enforces Q and P whereas in the latter, a third-party enforces the contingent payments P_l, P_m and P_h. So long as the contingent payments are chosen to ensure incentive compatibility of producing high quality, the two contracts are theoretically outcome equivalent as they both implement $Q = high$, though the latter contract tends to be much more effective when there is randomness in translating an agent's action into a quality realization so that an agent cannot guarantee a specific quality level. But since I have not introduced randomness into the model, I will henceforth focus on the former type of contract.

Under a regime such as $E_A = \{e_{A1}, e_{A2}\} = \{\{low\}, \{medium, high\}\}$, which is imperfect, it is still possible to write a complete contract by specifying $Q = medium$ in exchange for some fixed payment P. Since *medium* is in the contractible set, a third-party can enforce and sanction deviations from *medium*. Moreover, a fixed payment is always enforceable. Therefore, neither the principal nor agent have discretion to deviate from the upfront agreement. Notice that with imperfect enforcement, it is now impossible to write a complete contract that specifies $Q = high$. Thus, enforcement limits reduce the set of enforceable contracts available. What does an incomplete contract look like here? There are numerous possible ways of specifying incomplete contracts, but I will provide one example to illustrate. Suppose a contract specifies $Q = high$, a fixed payment P and a bonus B if the agent delivers $q = high$. Because $Q = high$ is not contractible, it follows that the agent always has ex post discretion to deviate from $Q = high$. That is, the agent can choose $q < Q$. Additionally, because B

is contingent on $Q = high$, it is also not contractible and is therefore a discretionary bonus. In other words, both parties have *ex post* discretion to deviate from the upfront agreement. One can easily see that an incomplete contract would leave to efficiency losses. To see this, note first that the principal would offer a contract that just satisfies the agent's participation and incentive compatibility constraints; i.e. $\pi_A = P + B - c(high) = \overline{u}$ and $B = c(high) - c(low)$. Thus, $P = \overline{u} + c(high) - B = \overline{u} + c(high) - c(high) + c(low) = \overline{u} + c(low)$. Since this is a sequential game where the principal is the last mover, a rational principal would not pay an unenforceable bonus. Therefore, the agent would only receive $P - c(high) = \overline{u} + c(low) - c(high) < \overline{u}$ by producing high quality. A forward looking agent would anticipate this and choose $q = low$ which would ensure him $\overline{u}$. Backward inducting one more stage, the principal should anticipate that the best she can hope for is $r(low) - P = r(low) - \overline{u} - c(low)$ so only low quality gets traded.[9] This efficiency loss is the crux of classic arguments about the undesirability of incomplete contracts.

Now that we have a formal way of conceptualizing incomplete contracts, we can account for the second major feature of agricultural contracts which is that they often involve repeat trading. One of the most active areas of research in contract theory in recent years has to do with relational contracts (Bernheim and Whinston, 1998; Levin, 2003; Brown et al., 2004; MacLeod, 2007; Kvaløy and Olsen, 2009; Halac, 2012). Thus, there has been significant advancement in the tools available for analyzing trade under incomplete contracts and repeat trading. The basic premise of a relational contracting model is that the performance outcome (in our case quality Q) is not public information and is therefore difficult for a third-party to enforce.[10] Therefore,

[9] Even if the principal were to write a contract based on a *minimum* quality of $Q = medium$, the outcome would still be less than $Q = high$ so efficiency losses would still occur.

[10] Thus, relational contracts are fundamentally dealing with a verifiability problem rather than an asymmetric information problem. While moral hazard and adverse selection are not necessary ingredients of a relational contract, one can still study relational contracting with the addition of

the contracting parties must self-enforce their agreement through repeat trading. If there are relationship specific rents available and the contracting parties value the future, then continuation payoffs can discipline current behavior.

Following (citation of one of author's other working papers), I now combine the imperfect enforcement apparatus with a relational contracting model to show how incomplete contractual form can be endogenized. Let the agent's action set (quality choice) be denoted by $A_A = [\underline{q}, \overline{q}] \subset \mathbb{R}_+$ where E_A is a partition of A_A and represents the enforcement technology. Let u_f and π_f denote the payoffs to the agent and principal, respectively, from the most profitable complete contract given enforcement limits. Then the optimal relational contract is obtained by solving:

$$\max_{Q,P,B} (1-\delta)\left[r(Q) - P - B\right] + \delta V\left[Q, P, B\right] \quad s.t. \tag{1}$$

$$(1-\delta)\left[r(Q) - P - B\right] + \delta V\left[Q, P, B\right] \geq u_f \tag{2}$$

$$(1-\delta)\left[P + B - c(Q)\right] + \delta U\left[Q, P, B\right] \geq \pi_f \tag{3}$$

$$(1-\delta)\left[r(Q) - P - B\right] + \delta V\left[Q, P, B\right] \geq (1-\delta)\left[r(Q) - P\right] + \delta \pi_f \tag{4}$$

$$(1-\delta)\left[P + B - c(Q)\right] + \delta U\left[Q, P, B\right] \geq (1-\delta)\left[P - c(\underline{q})\right] + \delta u_f \tag{5}$$

Note that 2 and 3 are the participation constraints and 4 and 5 are dynamic incentive compatibility constraints or self-enforcement constraints. $V(Q, P, B)$ and $U(Q, P, B)$ are value functions for continuous payoffs.[11]. Furthermore, to simplify the analysis, I will assume that contracts are stationary in that the same incentive scheme is offered every period. Levin (2003) has shown that, under the assumption of risk neutrality,

asymmetric information. See Levin (2003); Halac (2012) for examples.

[11]Note that by multiplying the objective functions by $(1-\delta)$, I have converted payoffs into average payoffs per-period, which is quite standard in in the repeated game literature

if an optimal relational contract exists, then there are stationary contracts that are optimal. Since I have not imposed exogenous risk on my model, I can focus attention on stationary contracts which has the benefit of greatly simplifying the analysis. In particular, because the same compensation plan is offered every period, problem 1 becomes essentially a static optimization problem.

Note that 4 and 5 can be combined to get:

$$\frac{\delta}{1-\delta}\left[V\left[Q,P,B\right]-\pi_f\right] \geq B \geq \left[c(Q)-c(\underline{q})\right]-\frac{\delta}{1-\delta}\left[U\left[Q,P,B\right]-u_f\right] \tag{6}$$

This provides a very intuitive look at the self-enforcement conditions. Essentially, 6 says that the promised unenforceable bonus has to be large enough to prevent the agent from shirking; i.e. it must cover the cost difference between honoring the agreement by producing Q and the most profitable shirk which is to produce minimum quality $\underline{q}$ minus future discounted surplus that the agent gets from the relationship. Conversely, for the promised bonus to be credible, it cannot be so large that it exceeds the discounted rents that the principal receives from the relationship. If the promised bonus is not credible, the agent will either not deliver on quality or reject the contract. We can also use 6 and solve for δ which yields:

$$\delta \geq \underline{\delta}(Q)=\frac{c(Q)-c(\underline{q})}{r(Q)-c(\underline{q})-u_f-\pi_f} \tag{7}$$

The critical value $\delta(Q)$ is the cutoff point for the informal contract to be self-enforcing and depends on Q. When the principal wants to contract for higher Q, this puts pressure on the self-enforcement constraint. Thus, the self-enforcement constraint can limit the level of quality that can be sourced. However, the self-enforcement constraint also depends on δ and the payoffs u_f and π_f, which in turn, depends on the quality of the enforcement technology. Thus, there is an interaction between contractual incompleteness, contract structure and the enforcement technology.

Given space constraints, I will not derive the optimal contract using the full set of Kuhn-Tucker conditions and instead refer the reader to the original paper (author's paper citation without during the review process). Instead, I will state the key result from the paper.

Proposition 1. *Let Q_f be the largest quality level in the enforceable set and $r'(Q_f) > c'(Q_f)$. If there exists Q such that $Q^{f.b.} \geq Q > Q_f$ such that*

- $\delta \geq \underline{\delta}(Q)$
- $(1-\delta)\left[r(Q) - P - B\right] + \delta V\left[Q, P, B\right] \geq \pi_f$
- $(1-\delta)\left[P + B - c(Q)\right] + \delta U\left[Q, P, B\right] \geq u_f$

then the parties prefer an incomplete contract.

In other words, if there is enough imperfection in the enforcement technology so that there exists some Q between first best $Q^{f.b.}$ and Q_f, and Q can be self-enforced, and enough surplus is generated so that both parties can receive average per-period payoffs that are at least as high as their payoffs under the formal contract, then the principal will use an incomplete contract to trade. Note that as the enforcement technology improves, the contractible set $\underline{E_A}$ will converge to A_A. Thus, in the limit, the highest contractible quality level $Q_f \to Q_{f.b.}$ so the parties will increasingly gravitate toward complete contracts. However, if the enforcement technology is poor enough, then Q_f will be relatively low and the contracting parties will rely on a self-enforcing incomplete contract to produce some $Q > Q_f$.

The issue of counterparty risk also has a game-theoretic equivalent in the form of strategic uncertainty, which is a well known textbook concept in game theory.

Strategic uncertainty is particularly important for analyzing coordination games of the following form:

Table 1: A Coordination Game

	S1	S2
S1	A,a	D,d
S2	C,c	B,b

This is a coordination game if the payoffs are such that $A > C$, $B > D$, $a > d$, and $b > c$. There are two pure-strategy Nash equilibria in this game (S1,S1) and (S2,S2). If in addition, $A > B$ and $a > b$, then (S1,S1) is known as the *payoff dominant* equilibrium. Strategic uncertainty exists in this game if each player is uncertain about the strategy chosen by the other player and therefore do not know which equilibrium to coordinate on. Counterparty risk is present because if, for example, the row player tries to coordinate on the payoff dominant strategy, it runs the risk that the column player will actually choose S2, leaving the row player with only a payoff of D, which is far lower than A. If D is small enough, then it becomes very risky to try to coordinate on the good equilibrium. The row player might just decide to play it safe and choose S2 to minimize her potential losses. Thus, Harsanyi and Selten (1988) call (S2,S2) the *risk dominant* equilibrium.[12]

While the typical static principal-agent game is not a coordination game but instead resembles a sequential Prisoner's Dilemma game, a *repeated* PD game does resemble a coordinaton game. It is well known that the only pure strategy Nash equilibrium in the one-shot PD is for both players to defect. But a repeated PD can support a cooperative outcome as a second (payment dominant) equilibrium. Blonski

[12] While the term risk dominant contains the word "risk," risk dominant outcomes are not driven by risk preferences. RD is simply based on a comparison of the size of relative losses from choosing different strategies and failing to coordinate. Specifically, (S2,S2) is risk dominant if $(B-D)(b-c) \geq ((A-C)(a-d)$

et al. (2011); Bo and Fréchette (2011) conduct repeated PD experiments and show that when cooperation is both an equilibrium action and a risk dominant action, then cooperation is observed more frequently than when it is only an equilibrium action. The key anchoring point has to with what they refer to as the "sucker's payoff" which refers to the payoff one receives when trying to cooperate but the other player defects. One is then a "sucker" for trying to cooperate in the first place. Consider the following payoff tables for a symmetric one-shot PD game (on left)and the same game repeated an indefinite number of periods with a discount factor of δ (on right).

	Coop.	Defect
Coop.e	A,A	D,C
Defect	C,D	B,B

	Coop.	Defect
Coop.	$\frac{A}{1-\delta},\frac{A}{1-\delta}$	$D+\frac{\delta B}{1-\delta}, C+\frac{\delta B}{1-\delta}$
Defect	$C+\frac{\delta B}{1-\delta}, D+\frac{\delta B}{1-\delta}$	$\frac{B}{1-\delta},\frac{B}{1-\delta}$

In order for the above games to be PD games, it must be the case that $C > A > B > D$. Thus, the payoff D is the sucker's payoff. In the repeated PD, both (Coop,Coop) and (Defect,Defect) are equilibria so long as $\frac{A}{1-\delta} \geq C + \frac{\delta B}{1-\delta}$. Solving for δ yields the critical value $\underline{\delta} = \frac{C-A}{C-B}$. So long as $\delta \geq \underline{\delta}$, then (Coop,Coop) is a second equilibrium and the repeated prisoner's dilemma has a similar structure as a coordination game. However, Blonski et al. (2011); Bo and Fréchette (2011) find that the sucker payoff $D + \frac{\delta B}{1-\delta}$ plays a prominent role in determining whether experimental subjects will play (Coop,Coop) even when $\delta \geq \underline{\delta}$ holds. Specifically, if D is small enough, there is great counterparty risk and subjects hesitate to cooperate because being the first to initiate cooperation is extremely risky.

The above has relevance for counterparty risk in agricultural contracts because a relational contract has a structure similar to a repeated sequential PD. Recall that a relational contract is self-enforcing when 7 holds. However, even if self-enforcement holds, the one-shot outcome remains a viable equilibrium so we cannot rule out the possibility that the parties will shirk on their contract. The added wrinkle in contracting vs the standard PD game is that, since contract structure is endogenous, the principal can alter and shift the degree of strategic uncertainty by adjusting the guaranteed price P and the discretionary component B. Unfortunately, the principal and agent have conflicting interests; raising P while reducing B increases the agent's guaranteed payment while reducing the agent's strategic uncertainty. The opposite is true for the principal. Note that increasing P while reducing B is analogous to a situation where the principal is providing the agent with more guarantees that are enforceable while reducing her own discretionary latitude. But if P is low and B high, then the principal is leaving herself with a lot of *ex post* discretion while providing the agent with very little explicit guarantees that can be legally enforced.

If the principal has all of the bargaining power and makes a take-it-or-leave-it offer, which is the typical case for many agricultural contracts, it is not difficult to guess what might happen here - the principal will choose the highest B and lowest P she can get away with while satisfying the agent's participation constraint.[13] Also note that $u_f = \overline{u}$ since the agent is always held to her outside option, $\overline{u}$, even under a formal contract. To be more precise, note that 6 can be rearranged as $\frac{\delta}{1-\delta}\left[V\left[Q,P,B\right]+U\left[Q,P,B\right]-\pi_f-\overline{u}\right]\geq B\geq\left[c(Q)-c(\underline{q})\right]$ which reduces to:

$$\frac{\delta}{1-\delta}\left[r(Q)-c(Q)-\pi_f-\overline{u}\right]\geq B\geq\left[c(Q)-c(\underline{q})\right] \tag{8}$$

In words, the discretionary bonus cannot exceed discounted future surplus, but must be high enough to cover the agent's cost of honoring the contract to be incentive compatible. If there is slack in 8 for a given Q, then there is a continuum of B that would satisfy self-enforcement. The principal thus has some flexibility in structuring

[13] The assumption that the principal makes a take-it-or-leave is not necessary; one can also develop a more complex model that explicitly includes a bargaining process.

the incomplete contract; she can choose a B closer to the right-hand bound of 8 (less discretion) or closer to the left-hand bound (more discretion). Consider two extreme cases: (1) the principal sets $B = c(Q) - c(\underline{q})$ so B just binds on the right-hand side; or (2) $B = \frac{\delta}{1-\delta}\left[r(Q) - c(Q) - \pi_f - \overline{u}\right]$ so B binds on the left-hand side.

Case 1: $B = c(Q) - c(\underline{q})$

Given $B = c(Q) - c(\underline{q})$ and stationarity, it is easy to solve for P using the binding one-shot participation constraint $P + B - c(Q) = \overline{u}$ which yields $P = \overline{u} + c(\underline{q})$. Since agent incentive compatibility is just satisfied, the standard assumption is that the agent will deliver contracted quality level, Q. However, with strategic uncertainty (the agent chooses quality before knowing the buyer's choice of b), this is not so clear.

If the agent chooses to honor the contract by choosing $q = Q$, then he receives average per-period payoff of $\overline{u}$ (or total discounted payoff of $\frac{\overline{u}}{1-\delta}$) since he is held at his reservation utility under the contract. If he shirks, he is sure to receive $b = 0$ since the principal chooses the actual bonus after observing quality. Thereafter, one can assume that the agent only receives his reservation utility $\overline{u}$ as this is the worst equilibrium outcome (Levin, 2003). Thus, the agent's per-period payoff is $(1-\delta)(P - c(\underline{q})) + \delta\overline{u} = \overline{u} + c(\underline{q}) - c(\underline{q}) = \overline{u}$. In other words, under this contract, the agent is indifferent between delivering $q = Q$ and $q = \underline{q}$ but the conventional assumption is that when incentive compatibility is just satisfied, the agent delivers $q = Q$. However, with strategic uncertainty, the agent's per-period sucker payoff becomes relevant and it is $(1-\delta)\left[P - c(Q)\right] + \delta\overline{u} = \overline{u} + (1-\delta)\left[c(Q) - c(\underline{q})\right] < \overline{u}$. On the other hand, the agent can shirk against this negative outcome by choosing $\underline{q}$ to begin with and receiving average per-period payoff of $P - c(\underline{q}) = \overline{u}$, which exceeds the sucker's payoff. With no gain from honoring the contract and only potential loss from being the "sucker", it is risk dominant for the agent to choose $q = \underline{q}$ rather than $q = Q$. This in turn implies that the principal should only expect to receive an average per-period payoff of $(1-\delta)\left[r(\underline{q}) - \overline{u} - c(\underline{q})\right] + \delta\pi_f$.

Case 2: $B = \frac{\delta}{1-\delta}\left[r(Q) - c(Q) - \pi_f - \overline{u}\right]$

With a maximum credible discretionary bonus of $B = \frac{\delta}{1-\delta}\left[r(Q) - c(Q) - \pi_f - \overline{u}\right]$, the agent is essentially made to be the residual claimant of discounted future surplus which provides very high-powered incentives. Moreover, the principal retains considerable discretionary latitude to reduce payment in the event that performance is undesirable. Using the participation constraint, one can easily derive $P = \overline{u} + c(Q) - \frac{\delta}{1-\delta}\left[r(Q) - c(Q) - \pi_f - \overline{u}\right] = \overline{u} + c(Q) - \frac{\delta}{1-\delta}S(Q)$. Under this contract, if the agent choose $q = Q$, he receives average per-period payoff that equals his reservation payoff, $\overline{u}$. But if he shirks, he gets only $(1-\delta)(P - c(\underline{q})) + \delta\overline{u} = \overline{u} + (1-\delta)\left[c(Q) - c(\underline{q})\right] - \delta S(Q)$. Note that honoring the contract yields a higher per-period payoff because $\overline{u} - \overline{u} - (1-\delta)\left[c(Q) - c(\underline{q})\right] + \delta S(Q) = -(1-\delta)\left[c(Q) - c(\underline{q})\right] + \delta S(Q)$, which is positive iff $\frac{\delta}{1-\delta}S(Q) \geq C(Q) - c(\underline{q})$. But this is just the condition for self-enforcement.

To determine whether honoring the contract is risk dominant for the agent, note that his average per-period"sucker's payoff" is $(1-\delta)(P - c(Q)) + \delta\overline{u} = \overline{u} - \delta S(Q)$. If the agent decides to hedge against this low payoff by choosing $q = \underline{q}$ to begin with, then he gets a per-period payoff of $(1-\delta)(P - c(\underline{q})) + \delta\overline{u} = \overline{u} + (1-\delta)\left[c(Q) - c(\underline{q})\right] - \delta S(Q)$. It is easy to show that this is greater than the sucker payoff by the amount $(1-\delta)\left[c(Q) - c(\underline{q})\right]$, which is the avoided losses from hedging. Hence, if the gain from choosing $q = Q$ is greater than the avoided losses from choosing $q = \underline{q}$, then the agent's risk dominant strategy is $q = Q$. The required condition is $-(1-\delta)\left[c(Q) - c(\underline{q})\right] + \delta S(Q) \geq (1-\delta)\left[c(Q) - c(\underline{q})\right]$, which is equivalent to:

$$\frac{\delta}{1-\delta}S(Q) \geq 2\left[c(Q) - c(\underline{q})\right] \tag{9}$$

Condition 9 says that if discounted future relationship specific surplus is sufficiently high, then $q = Q$ is risk dominant for the agent. Thus, if the relationship is sufficiently valuable to the contracting parties, then the principal can expect a per-period profit of $r(Q) - P - B = r(Q) - c(Q) - \overline{u}$ which exceeds her profit from Case 1. Consequently, when given a choice, the principal always prefers the Case 2 contract which offers a smaller upfront guarantee (P) to the agent and a larger discretionary component (B).

The downside to a larger discretionary bonus and small base price is that it exposes the agent to more counterparty risk in two ways. First, note that the average per-period sucker's payoff in the Case 1 contract is $\overline{u} - (1 - \delta)\left[c(Q) - c(\underline{q})\right]$ but it is $\overline{u} - \delta S(Q)$ under the Case 2 contract. Hence, the sucker's payoff is clearly better under the Case 1 contract so long as the condition 8 holds. If the agent honors the contract, but the principal does not, the agent suffers higher losses under the Case 2 contract.[14] Even if the principal and agent have established a successful relational contract, any exogenous shock, such as new technology or demand side factors that causes shifts in revenues, costs, or beliefs about the future can alter the critical value 7 and disrupt self-enforcement. The Case 2 contract thus makes the agent more vulnerable to exogenous shocks. Second, it can be shown that increasing the size of B makes it less likely that it will be risk dominant for the principal to actually pay the bonus. Due to space constraints, I will not develop this claim here and refer the reader to (citation of author's paper withheld during review process). However, the intuition is simple. Just as a low B that was close to the the right-hand-side of 8 did not provide high enough powered incentives for the agent to deliver $q = Q$, a high B close to the left-hand side of 8 makes it very tempting for the principal to shirk on the bonus. Indeed, if the principal is uncertain as to whether the relationship might

[14] Despite there being a worse sucker's payoff, the agent still finds it risk dominant to produce high quality under the Case 2 contract because the very high-powered incentive.

continue the next period, she may find it risk dominant not to honor the bonus. In short, a highly discretionary contract minimizes a principal's strategic uncertainty, but shifts a lot of strategic uncertainty onto the agent.

The final issue I will discuss is buyer power. First, note that I am already assuming that the principal has all of the bargaining power and makes a take-it-or-leave it offer to the agent. Hence, the agent's expected per-period profit under the contract just equals his outside option of $\overline{u}$, which is the payoff from the next best contract offered to him. However, the expected size of this outside option depends on the degree of buyer competition in the marketplace. If a farmer can only purchase from one processor and rejects a take-it-to-leave-it offer, then he may have to switch commodities or leave the industry. I denote $\tilde{u}$ as the scrap value of unemployed production assets. However, if there are other contractors, then the agent will receive $\overline{u}$ from the next best contract. Letting k be the number of contractors and f be the number of farmers, I let the probability of finding an alternative contract be represented by $k/f \leq 1$. As the number of contractors reduce relative to the number of agents, it becomes increasingly less likely that an agent finds an alternative contract. Hence, I let $\hat{u} = (k/f)\overline{u} + (1 - k/f)\tilde{u}$ denote the expected reservation utilty which is decreasing in contractor concentration.

When buyer concentration increases, this causes the agent's outside option to drop from $\overline{u}$ to $\hat{u}$. One can see from the self-enforcement constraint 8 that this relaxes the left-hand-side of the self-enforcement constraint. This makes it possible for the principal to increase the size of the discretionary bonus. Note that a bonus of size of $\hat{B} = \frac{\delta}{1-\delta}[r(Q) - c(Q) - \pi_f - \hat{u}]$ under concentration would not be credible under in an environment with more competition because it would breach the self-enforcement constraint. Thus, an agent would reject such a contract under competition but not under concentration. At the same time, since the agent's outside option has eroded, the agent's participation constraint is also relaxed so the principal can reduce the size of P. In short, with concentration, agent's are more willing to accept contracts with lower payments and higher exposure to strategic uncertainty and counterparty risk. These contracts provide higher powered incentives to the agent, reduce the cost of incentives to the principal, and shifts more strategic uncertainty from the principal to the agent. This reduces contracting costs for the principal, which can potentially cause the principal to expand purchases. Thus the favorable impact (to the principal) of market concentration on agency costs can work in the opposite direction of the volume depressing impact of pure monopsony/oligopsony power. The net effect is that the traditional welfare loss triangle from market power might be mitigated.

These predictions can potentially explain why grower complaints about contracts can co-exist with little empirical evidence of efficiency losses due to market power. From a policy perspective, my analytical results suggest that the 2010 GIPSA rule that relaxes the traditional court requirement that growers also have to prove competitive harm when suing for breach of contract that results only in personal harm might make some economic sense.

Conclusion

This paper provides a discussion and overview of methodological issues in canonical contract theory that limit the ability of the theory to adequately model important features of agricultural contracts. I also show how recent developments from contract and game theory can buttress canonical methodological approaches to facilitate the development of a relational contracting model that can capture many important features of the agricultural contracting environment including contractual incompleteness, repeat trading, counterparty risk, and market concentration. The model can shed light on why contracts might be endogenously incomplete, how incomplete contractual form can shift strategic uncertainty and counterparty risk from the principal to the agent, and why market concentration may not lead to efficiency losses but can increase strategic uncertainty faced by growers. These insights can have implications for supply chain management, market channel coordination, and important policy implications.

I would like to caution that the model I developed in this paper is rather preliminary and represents only one approach to modeling agricultural contracts. Moreover, I have not discussed empirical strategies for testing contract theories and predictions. It is my hope that this paper will stimulate more agricultural economists to make contributions to applied contracting methodology, and develop innovative empirical tools for testing contract theory and answering important policy questions.

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