

**Relational Agreements & Rented Farmland:
Implications for Agricultural Contracting and Land Stewardship**

by

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ABSTRACT

RELATIONAL AGREEMENTS & RENTED FARMLAND: IMPLICATIONS FOR AGRICULTURAL CONTRACTING AND LAND STEWARDSHIP

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With a significant portion of farmland in the rental market, it is important to understand what type of impacts landowners and tenants have on the declining farmland soils. We know landlord-tenant relationships are structured through simple, legally enforceable contracts and self-enforcing handshake deals. However, previous literature has either not distinguished the contract structure or has applied the textbook assumption of full contract enforceability. With these assumptions in place, the tenant is not offered an incentive for unverifiable actions, such as displays of land stewardship. This thesis compares different contract structures using agency theory to present the influence on the tenant's choice in effort in farming practices and land stewardship behaviour. This shows literature has been misguided and consequently has modeled the landlord-tenant relationship inaccurately. This thesis concludes with a recommendation for researchers to leverage relational contract theory in future research on the topic of farmland relationships.

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1 Introduction

With a significant portion of farmland rented out in Canada (40%) and Ontario (30%) (Deaton et al., 2018; Bryan et al., 2015; Statistics Canada, 2017), it is important to study the economics of farmlands. However, to conduct such a study a good tool is required. My objective is to present such a tool in economics, which can help us describe and understand the relationships between the key market players. Levin (2003) introduced relational contract theory as a method to model such relationships.

Relational contract theory allows for flexibility with respect to the structure of a contract and adjustments that go beyond the contractual requirements (Levin, 2003). The theory can capture both the formal and informal components of a contract. The formal aspects are represented by the legally verifiable portions of a contract (e.g. a written agreement). Informal aspects, on the other hand, are difficult for a third party to verify (e.g. performance of skills, like leadership, initiative, or stewardship). These types of agreements can also include verbal promises or handshake deals. In addition to capturing the full contract, both formal and informal agreements, relational contract theory also models repeated transactions, renewability, and reputation effects. This is very useful as it reflects the characteristics of farmland contractual agreements.

Farmland rental contracts are a composite of both formal and informal agreements (Levin, 2003; Allen & Lueck, 1992; Michler & Wu, 2020b), include terms for automatic renewal (Allen & Lueck, 1992), and consider reputation effects (Allen & Lueck, 1992; OMAFRA, 2016). Nevertheless, existing literature has not focused on theory, assumed

farmland agreements last only one period (or season), or ignored the informal agreements of the rental contract. As a result, these studies are ignoring the defining characteristics of the farmland rental market and limiting our understanding of it.

To briefly illustrate, a contract containing the details of the agreement is considered formal if verifiable by a third party. This is commonly assumed to be the main contract. However, in practice, it is merely used as proof of agreement and contains minimal details. Most agreements between the landlord and tenant are considered to be informal, handshake deals, or verbal promises. As such we can expect conservation practices and good stewardship practices to be informally governed. Future researchers can leverage relational contract theory to investigate how the contract and environment interact, for example.

This thesis aims to present relational contract theory as a good economic tool for describing farmland rental agreements made between a landlord and tenant. The remainder of the thesis proceeds as follows. Chapter 2 describes the common features of a farmland contract in North America and examines how these contracts have been portrayed in existing studies. After the foundation of the contract structures is introduced, Chapter 3 details the theoretical model and its constraints. The three constraints interact to describe the conditions under which the parties will decide to; 1) form an agreement, 2) provide incentives either formally or informally, and 3) terminate or continue their collaboration over time. Chapter 4 will set up the theoretical model and present two cases: a literature standard contract model and a relational contract. These cases will demonstrate the influence contract structures have on the tenant's choice of

actions. Finally, the thesis concludes with a summary of the results in Chapter 5 and a discussion of their applications in Chapter 6. The final chapter highlights the recommendation made to future researchers to consider relational contract theory when modeling farmland contractual agreements.

2 Background

The focus of this chapter is to describe the typical features found in a North American rental agreement. The goal is to create familiarity with the common features of these agreements, to more easily see why relational contract theory is useful in studying farmland rental markets. A key distinction will be made between the terms *formal* and *informal*, as they will be frequently used to describe the type of agreements making up the contract. When referring to a 'contract', I am discussing the composite of both the formal and informal agreements of the landlord-tenant relationship. This is slightly different from the standard understanding that a contract means legally enforceable documentation depicting the relationship. Once a clear understanding of the contract structure is established, I will provide a short analysis of the literature on landlord-tenant relationships. The main argument of my thesis is that by disregarding the informal aspects of the relationship, current literature that examined the farmland market is incomplete. This will be further illustrated in Chapter 3.

2.1 Contracting Structures

In North America, agricultural contracts are frequently described as handshake deals or verbal agreements (Allen & Lueck, 1992; Wu, 2014; Levin, 2003). However, in practice, the contract tends to involve both formal and informal agreements (Levin, 2003). This suggests that the formal agreement of the relationship is simple and brief (Allen & Lueck, 1992) and used as a backup or proof of agreement, rather than the main contract. For this reason, the landlord-tenant relationship is presumed to be self-sustained through reputation effects. This is possible as both parties have a long-term interest in maintaining the relationship (Allen & Lueck, 1992)¹. As will be demonstrated through this thesis, relational contract theory encompasses all these distinguishing features (e.g. renewability, reputation effects, contract structure).

Agreements that are considered formal, are verifiable by a third party and therefore legally enforceable. By this, I mean that a third party (e.g. a court or adjudicator) can observe and verify that the terms of the agreement are met and can enforce the parties to act as outlined in the contract. The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) outlines the following as *required* items in a written agreement: (1) the names and addresses of the landlord and tenant; (2) the legal description of the rental property, including which land and buildings are excluded from the agreement; (3) the rental rate to be paid (i.e. fixed rental rate or crop sharing) and the scheduling of payments; (4) the terms of the agreement, which outline the start and end dates of the

¹ Allen and Lueck (1992) found that on average the landlord-tenant relationship lasts 11.5 years. A more recent study conducted by Deaton et al (2018) found the average relationship to last approximately 8 years.

agreement. The agreement can be extended to include the procedure for renewing the agreement, as farmland relationships can last longer than one crop cycle (one period). A complete agreement outlines the rights and obligations of the parties with regard to every possible state of the future (Baker & Krawiec, 2006). For example, the landlord and tenant may choose to add the conditions of contract termination, the restrictions and uses of the land (e.g. listing any municipal zoning restrictions), the right to sublease, specified productions and management practices, and compensation due to property damages (OMAFRA, 2016). A complete contract may also include how the tenant will be evaluated for performance and the compensation he will be offered.

FARMLAND LEASE
This agreement is between "Landowner" of [residence] and "Farmer" of [residence], April 1, 1982.
SOUTHEAST 1/4 of SECTION 17-140-63
"Farmer" agrees to pay "landowner" \$30.00 per acre for 156 tillable acres for the crop year of 1982. Total payment of \$4680.00, 10% due April 1, 1982 -- \$468.00. 90% due October 1, 1982 -- \$4212.00 for a total of \$4680.00.
This lease shall be renewed automatically year to year unless either party notifies the other party by September 15. If lease is not renewed, renter will be paid for the summer fallow with price per acre to be established at that time. All government payments go to the renter.
Signed by owner _____ Signed by renter _____

Figure 2.1: Example of a simple formal agreement provided by an anonymous North Dakota farmer from Allen & Lueck (1992)

However, a complete formal agreement is not typically the case. Take for example the written agreement in Figure 2.1. This simple agreement for the rental of farmland in

North Dakota includes the addresses of the landlord and tenant, the description of the rental property, the rental rate charged, and the breakdown of payments. It also includes the conditions for renewal and termination. In addition to these required details, the parties have also specified that government payments are allocated to the renter. Though this agreement may be dated, it represents the type of written agreements made today; simple and brief (Allen & Lueck, 1992). This could be due to the guidelines provided by the government concerning documentation pertaining to land. In Ontario, any documents with an interest in land must be in writing (Government in Ontario, 1990), and follow the OMAFRA guidelines concerning the information included.

It is clear the formal agreement (Figure 2.1) does not capture the full relationship between the landlord and tenant (Allen & Lueck, 1992; Wu, 2014; Levin, 2003). The 'missing' pieces are part of the informal agreements made by the landlord and tenant. These types of agreements are not verifiable by a legal party (e.g. the court). As the main feature of agricultural contracts is renewability, it provides the contracting parties a way to self-enforce the agreements (Wu, 2014). A simple example is performance compensation. In a business, an employer may provide their employees a bonus for displaying various skills (e.g. teamwork, leadership, initiative) which cannot be verified or observed by a third party. The compensation they receive is pecuniary (either monetary or a favour).

On the farmland, however, the landlord does not monitor the day-to-day activities of the tenant. She may request the tenant cares for the land and may specify a conservation production practice, such as cover crops, or water and wildlife protection practices.

Consider the following case of the bobolink in Simcoe County, Ontario. The endangered bird creates its nest in hayfields and its breeding season overlaps with the hay harvest. This resulted in the landlords asking tenants not to plant hay due to the loss of development opportunities (Luo, 2015). Other requests may not be based on the production and management of the farmland. If the landlord lives on the land, she may request that the tenant does not use manure on the crops surrounding the house. Another example is if the landlord is on the way to the city or has local connections to sellers, she may offer to do a favour for the tenant.

As demonstrated, formal agreements are brief in detail but are legally enforceable. Handshake deals or verbal agreements are common aspects of farmland rental agreements. However, the study of farmland rental markets in literature has implicitly assumed that what is contained in the legal documentation (ex. Figure 2.1) is all there is to the landlord-tenant relationship. By adopting this assumption, we are losing a lot of explanatory power.

2.2 Literature

There is a growing interest among agricultural economists in the farmland rental market. Topics² within this area include insurance and policies (Lee, Wu, & Fan, 2008; and Wu, 2010), choice of contract (Huffman & Just, 2004; Bryan, et al., 2015), environmental

² The literature presented in this section will not be described in detail, however the reader is encouraged to reference them for insights on the landlord-tenant relationship and possible ways to adapt the simplified model for future research.

implications of renting farmland (Deaton, et al., 2018), among others. All these explorations have provided valuable insights, but they have been restricted.

I aim to show how the assumptions made about the nature of rental agreements is incomplete. Several observational studies are agnostic about the formal economic mechanisms driving their findings. Topics of study include tenure security (Deaton et al., 2018; Leonhardt, Braito & Penker, 2021), the decision-making process of key agricultural stakeholders (Luo, 2015; Carolan et al., 2004), and agricultural development (Akram et al., 2019). Some studies do leverage some aspects of formal economic theory. However, they implicitly assume that the relationship is short-lived (Lee et al., 2008; Huffman and Just, 2004; Bryan et al., 2015), or the contract is perfectly enforceable (Bryan et al., 2015). By doing so, the distinguishing characteristics of farmland contract relationships are dismissed. As a result, the insights from these studies are incomplete. With agricultural contracts being composed of mostly informal agreements (Levin, 2003; Allen & Lueck, 1992; Michler & Wu, 2020b), the results explain only a small portion of the relationship. This results in landlords making misguided decisions regarding the rental rate to charge or the value of the relationship is misrepresented.

In order to foster solid economic literature on farmland rental markets, it is important to conduct empirical studies that are grounded in economic theory (Wu, 2014). A recent strand of literature on agricultural contracting points out that it is critical to consider the fact that most agreements are constituted by formal and informal aspects, last for a long time (beyond one period or crop cycle), and include reputational, as well as pecuniary

concerns (Levin, 2003; Michler & Wu, 2020b). Relational contract theory has been suggested as a tool for modeling agricultural contracts (Wu, 2014; Michler & Wu, 2020b), however, it has not been fully considered in recent literature. Instead, as mentioned above, the literature omits some features, such as renewability, and keeps the analysis in one period (e.g. crop cycle), or does not consider the informal agreements that occur.

To illustrate how a more complete theory of relational farmland contracts would enrich our understanding of the field, I present a simplified model of a landlord and tenant relationship in the following chapter. Leveraging relational contract theory, the model will include the previously omitted features of farmland contracts (i.e. renewability, formal and informal agreements, and reputation effects).

3 Theoretical Model

Relational contract theory stems from agency theory and repeated transactions (Michler & Wu, 2020b). Agency models involve a principal and an agent. The principal desires some outcome and must rely on an agent to achieve it. Their relationship is governed by an incentive scheme that ties the agent's actions to rewards. It is common for these relationships to last a longer period of time with the contract set to automatic renewal terms. The field of contract theory studies to solve some common problems that occur in these relationships. Relational contracts differ from standard incentive contracts because of an additional constraint, which limits the incentives the principal can offer (Levin, 2003).

To illustrate how relational contract theory can be used to enrich our understanding of the farmland rental market, I present a simplified example of a farmland owner (principal) and a tenant (agent). The sequence of events for this model (Figure 3.1) is that of a typical principal-agent model. It begins with the landlord offering a contract to the tenant. The contract outlines the rental rate to be paid by the tenant and any formal incentives offered by the landlord. The tenant will also consider any informal incentives the landlord may offer during the contractual discussion (or in the future). The overall structure of the contract must encourage the tenant to participate in the contract voluntarily and incentivize the tenant to behave in alignment with the landlord's values. The tenant decides to reject or accept the contract. If the tenant chooses to reject the contract, the two parties will receive their outside options or alternative payoffs. The outside option can reflect the market value of the farmland if it were sold today for the landlord; or it can be the salary of a job in a neighbouring urban area for the tenant. On the other hand, if the tenant were to accept the contract, his next decision will be the level of effort he exerts into two types of activities. At the end of the contract, when the outcomes are observed by both parties, the contractual payoffs are then received.

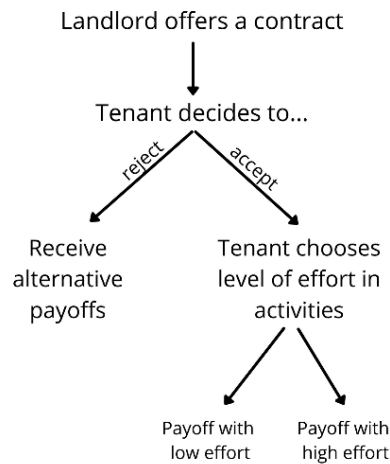


Figure 3.1: Sequence of events for Principal-Agent Model

For this thesis, the tenant can exert effort into two activities: farming efforts and excessive use of nitrogen. Farming activities are composed of the various actions the tenant can take to impact the yield of the land. This includes everything from preparing the land, sowing the seeds, water application, weed and pest maintenance, to harvest at the end of the season. Tenants have been found to apply more nitrogen than required by economists and agronomists (Pannell, 2016). Reasons for this excessive application of nitrogen vary and include the potential of green and healthy-looking crops, thus impressing neighbours and competition (Pannell, 2016); the farmer's perception and knowledge of best practices, or uncertainty (Sheriff, 2005). As a result, the extra nitrogen applied is not absorbed by the crop but left in the land. This leads to concerns such as contamination of ground and surface water, and greenhouse gas emissions (Ahmed et al., 2017). The landlord may be aware of these consequences and wish for her land to be taken care of.

As farmland contracts are known to last a long period, good faith is important in maintaining the contracting relationship (Levin, 2003; OMAFRA, 2016). Since informal agreements are mere promises which the parties may deviate from, it is important to include a way to enforce them. This is done through the threat of termination. If a contract results in termination, the contracting parties receive their outside options and will face damages to their reputation – especially the deviating party. This impacts their future ability to maintain the land investment (landlord) or secure a rental opportunity (tenant). The self-enforcing constraint sets a limit on the promised incentive, so they remain credible to the tenant.

This theoretical model can be used to describe the relationship between a farmland owner and a tenant. The next chapter will take the model as developed by Gil and Zanarone (2018) and adapt it to portray an agricultural contract case.

4 Limit Case Differences³

Using contract theory, this chapter presents two cases; a literature standard case and a relational contract. The literature standard case constraints the landlord to offering a contract that is assumed to be fully formal, meaning a legal party exists that can enforce all aspects of the contract. This assumption constrains the landlord-tenant relationship to one period and implies that it does not repeat beyond this. The second case will

³ The appendix contains a third case which took the opposite assumptions of the literature-standard case. In place was the extreme assumption that the contract is not verifiable and therefore not enforceable by a court (purely informal).

include unverifiable informal incentives along with formal ones. The inclusion of the informal incentives modifies the optimization problem with the addition of one constraint. This chapter will demonstrate the two contract structures and the influences it has on the optimal choice of action of the tenant. The following chapter will compare the results of the two cases.

4.1 Model Set-Up

In each of the following cases, there is a tenant (he/him) and a landlord (she/her), who are both assumed to be risk-neutral and discount the future by a factor of $\delta \in [0,1]$.

Their relationship follows the sequence of events described in Chapter 3. First, the landlord offers a rental contract ($w(y, p)$) to the tenant. This contract outlines the rental rate the tenant would pay for the use of the farmland ($s < 0$). The contract would also include any formal (b) and informal (B) incentives the landlord may offer on the outcomes (p and y). The contract is denoted as the following $w(y, p) = s + bp + By$.

The incentives presented are based on two outcomes: the tenant's performance measure and the landlord's desired outcome. The tenant's performance is evaluated based on the total yield he produces on the rented farmland (p). Yield is an observable outcome, meaning a third party could enforce the incentives offered on it. As the yield is enforceable, the incentive offered is considered formal (b). This type of incentive can be compared to a flexible cash lease arrangement. One common arrangement is to have base rental price (s) and adjust based on yield [amount and/or price] (bp) (OMAFRA, 2014). The second outcome is the landlord's desired outcome of land stewardship. In

this example, she cares about her land and would like the tenant to not expose the land to excessive nitrogen application. The tenant would be evaluated on the landlord's perceived quality of the farmland (y). This outcome cannot be enforced by a third party, which results in this incentive being informal (B). Informal incentives can be offered by either party and are pecuniary in nature. If the landlord is offering more promises the net flow will be to the tenant $B > 0$, and $B < 0$ if the net flow is to the landlord. This follows the description of farmland rental agreements provided in Chapter 2, where the rental rate is included formally, and all other arrangements are considered informal.

Next, the tenant will decide whether to reject or accept the contract. If the tenant chooses to reject the contract, the landlord and tenant will receive their outside options or alternative payoffs, $\bar{\pi}$ and \bar{u} respectively. Alternatively, the tenant can choose to accept the contract, where he will next decide on his level of effort into the two activities: excessive use of nitrogen (a_1) and farming efforts (a_2). These activities come at a cost of $c(a_1, a_2) = \frac{k}{2}(a_1^2 + a_2^2)$, where k is a cost parameter. Once the tenant chooses his actions, the two outcomes are observed by the parties; (1) the landlord's desired outcome of well taken care of land ($y \in \{0,1\}$); and (2) the tenant's performance measured as yield ($p \in \{0,1\}$). The quality of the land is directly impacted by the tenant's excessive use of nitrogen. The chances the landlord perceives the land to be of good quality, $y = 1$, has a probability of $1 - a_1$, which shows the decrease in land quality with use. The landlord perceives the land to be of poor quality, $y = 0$, has a probability of a_1 . The tenant's performance measure of yield is influenced by both his farming efforts and excessive use of nitrogen. The land will produce a high yield, $p = 1$, with probability

$a_1 \cos\theta + a_2 \sin\theta$ and low yield, $p = 0$, with probability $1 - a_1 \cos\theta - a_2 \sin\theta$, where $\theta \in [0^\circ, 90^\circ]$ is a parameter measuring the misalignment between the landlord's values (land stewardship) and the tenant's goals (high yield). Once the outcomes are observed, the contracted payoffs are received. The landlord desires her land to be taken care of so land quality is presented as a quasi-reduction in total profits. Her contracted payoffs are the rental rate less the contracted incentives. This is denoted as $\pi = y - w(y, p)$. The tenant's payoff is the contracted incentives less the rental rate and less the cost of the activities.

Two transaction costs arise in the developed model. These costs are involved in the farmland market exchange; (1) the misalignment between the tenant's measured performance (p) and the landlord's desired output (y); and (2) the legal enforceability of the agricultural contract. The misalignment is measured by the parameter $\theta \in [0^\circ, 90^\circ]$. When $\theta = 0^\circ$, the probability distributions of the two outcomes are derived from the same activity (a_1) and are considered to be aligned. As the tension increases and θ approaches its upper limit (90°), the probability distributions become based off opposite activities. With θ increasing, the probability of good yield ($p = 1$) becomes increasingly more determined by the tenant's farming efforts (a_2) and less by the excessive nitrogen use (a_1). At the upper limit, the outcomes are influenced by one individual action; yield (p) by the excessive use of nitrogen (a_1) and the perceived land quality (y) by the tenant's farming efforts (a_2).

Regarding the legal enforceability of the agricultural contract, two types of enforcements are in place. The contract is composed of formal and informal incentives. The formal incentives offered and the tenant's measured performance (bp) are observable and therefore enforceable by a third party. The informal incentives and the landlord's perceived quality of the land are not verifiable and therefore cannot be enforced by a third party (By). In this case the incentives are self-enforced through threat of contract termination.

4.2 Purely Formal Contracts (Literature-Standard Case)

In the literature standard case, the landlord is constrained to offering a fully formal contract. This follows what is typically done in textbook models (Michler & Wu, 2020a, 2020b), where a legal party exists that can verify the outcomes and enforce the contract. This model also assumes that the relationship between the landlord and tenant only lasts one period. The contract the landlord offers outlines the rental rate (s) for the farmland and the formal incentives (bp). It can be denoted as $w(y, p) = w(p) = s + bp = s + b(a_1 \cos\theta + a_2 \sin\theta)$.

The landlord seeks to maximize her profits with the contract she offers. In order to do so, the offered contract must be structured to meet two constraints: the tenant's participation constraint (PC) and the incentive compatibility constraint (IC). The participation constraint is with regards to the tenant's voluntary participation in the contractual relationship. This means the contract must offer a better or equal payoff to the tenant's alternative payoff (outside option). Typically, the landlord's participation

constraint would also be considered, however as the landlord is offering the contract, it can be assumed that the constraint is met. The incentive compatibility constraint is such that the contractual incentives encourage the tenant to behave in ways that align with the landlord's values, while maximizing the tenant's utility. The landlord's maximization problem can be presented as the following:

$$\max_{s,b} \pi = (1 - a_1) - (s + bp) \quad (1)$$

$$\text{Subject to: } PC: s + b(a_1 \cos \theta + a_2 \sin \theta) - \frac{k}{2}(a_1^2 + a_2^2) \geq \bar{u}$$

$$IC: (a_1, a_2) \in \text{argmax} \{s + b(a_1 \cos \theta + a_2 \sin \theta) - \frac{k}{2}(a_1^2 + a_2^2)\}$$

The participation constraint structures the contract so that the tenant is likely to accept the offer. In order to do so, the landlord needs to offer a rental rate (s) that is persuading to the tenant, but also maximizes her own profits. The minimum persuading rental rate can be identified by rearranging the participation constraint into the following:

$$s \geq \bar{u} - b(a_1 \cos \theta + a_2 \sin \theta) + \frac{k}{2}(a_1^2 + a_2^2) \quad (2)$$

Substituting the rental rate equation (2) into the landlord's profit maximization problem simplifies to:

$$\max_b \pi = 1 - a_1 - \bar{u} - \frac{k}{2}(a_1^2 + a_2^2) \quad (3)$$

$$\text{Subject to: } IC: (a_1, a_2) \in \text{argmax} \{s + b(a_1 \cos \theta + a_2 \sin \theta) - \frac{k}{2}(a_1^2 + a_2^2)\}$$

The incentive compatibility constraint of the tenant allows the landlord to consider the tenant's reaction to a given set of incentives. The landlord is able to identify the tenant's utility maximizing effort into farming actions (a_2) and the excessive application of nitrogen (a_1). If the tenant were to accept the landlord's contract, he would choose his level of effort into the activities to solve:

$$\max_{a_1, a_2} u = s + b(a_1 \cos\theta + a_2 \sin\theta) - \frac{k}{2}(a_1^2 + a_2^2) \quad (4)$$

The solutions representing the optimal actions under a formal contract are $a_1^{*F} = \frac{b \cos\theta}{k}$ and $a_2^{*F} = \frac{b \sin\theta}{k}$. Under this contract structure, the tenant is incentivized to exert effort into both activity types. If the landlord were to increase the value of the formal bonus (b) that she offers on the yield (p), the tenant would increase his level of effort in both activities. Yield is influenced by both activities, so an increase in both can be expected. In the case the cost parameter (k) were to increase, indicating higher expenses for the tenant's activities, the tenant would lower activity efforts. Besides these influencing factors on the action choice, the alignment of the desired outcomes (θ) also influences the tenant's efforts. As the misalignment of the tenant's goals and landlord's values increases (θ approaches 90°), the tenant's excessive nitrogen usage decreases (a_1) while his farming efforts (a_2) increases.

Substituting the optimal actions of the tenant into the landlord's maximization problem (3), would result:

$$\max_b \pi = 1 - \frac{bcos\theta}{k} - \bar{u} - \frac{b^2}{2k} \quad (5)$$

If the farmland rental agreement was fully enforceable and set to last one period, as assumed by this model, the tenant can be expected to put effort into both activities. This model represents what has been done by researchers, given their current tools. The next case will examine a contract that allows for the addition of informal agreements. Doing so will leverage relational contract theory and allow for farmland contract features to be included. This case will represent what is commonly found 'in practice' in an agricultural setting.

4.3 Combination Contracts (Relational Contract Theory Case)

In the second case, there are no constraints on the type of contract that can be offered. This means the landlord may offer a contract that includes both formal and informal incentives. This type of contract is commonly found in practice (Allen & Lueck (1992), Wu (2014), Michler & Wu (2020b)) and can be denoted as $w(y, p) \equiv s + bp + By = s + b(a_1cos\theta + a_2sin\theta) + B(1 - a_1)$. The informal incentives (By) offered are pecuniary promises that either party can offer. For this example, the net flow will be from the landlord to the tenant, where the landlord is offering a bonus for the tenant's reduction in nitrogen application. In order for the informal pecuniary incentives to be enforced, the relationship is assumed to last more than one period, allowing for threat of contract termination. To keep the informal agreements credible, a self-enforcement constraint is added to the landlord's profit maximization. The addition of the informal agreements into

the contract and the restriction of self-enforcement constraint are the two changes made to the contracting scheme presented in Case 1.

The landlord's objective is to maximize her profits. Her objective function is subject to the same constraints as in the previous case; the tenant's participation constraint (PC) and the incentive compatibility constraint (IC). In addition to these constraints, the landlord must ensure that the informal incentives provided are credible to the tenant. This is done through the inclusion of the self-enforcement constraint (SEC). The landlord's profit maximization problem can be presented as the following:

$$\max_{s,b,B} \pi = (1 - a_1) - (s + bp + By) \quad (6)$$

$$\text{Subject to: } PC: s + b(a_1 \cos\theta + a_2 \sin\theta) + B(1 - a_1) - \frac{k}{2}(a_1^2 + a_2^2) + \frac{\delta}{1-\delta} U(c) \geq \frac{\bar{u}}{1-\delta}$$

$$IC: (a_1, a_2) \in \operatorname{argmax} \left\{ s + b(a_1 \cos\theta + a_2 \sin\theta) + B(1 - a_1) - \frac{k}{2}(a_1^2 + a_2^2) + \frac{\delta}{1-\delta} U(c) \right\}$$

$$SEC: (1 - a_1) - s - b(a_1 \cos\theta + a_2 \sin\theta) - B(1 - a_1) + \frac{\delta}{1-\delta} \Pi(c)$$

$$\geq (1 - a_1) - s - b(a_1 \cos\theta + a_2 \sin\theta) + \frac{\delta}{1-\delta} \bar{\pi}$$

The tenant's participation constraint shows that the contractual payoffs from today and the discounted future payoffs of cooperating ($U(c)$), are greater or equal to the payoffs of the tenant choosing his outside option forever ($\frac{\bar{u}}{1-\delta}$). Through the participation constraint, the landlord is able to establish the minimum rental rate to charge the tenant.

Levin (2003) showed that a one period (stationary) contract exists that is optimal in

every period that it is offered, meaning the landlord will offer the same optimal contract every period (Michler & Wu, 2020a). As a result, the landlord establishes the minimum rental rate as $s \geq \bar{u} - b(a_1 \cos\theta + a_2 \sin\theta) - B(1 - a_1) + \frac{k}{2}(a_1^2 + a_2^2)$, to encourage the tenant to accept the contract. Substituting the rental rate into the landlord's problem yields:

$$\max_{b,B} \pi = 1 - a_1 - \bar{u} - \frac{k}{2}(a_1^2 + a_2^2) \quad (7)$$

Subject to:

$$IC: (a_1, a_2) \in \operatorname{argmax} \{s + b(a_1 \cos\theta + a_2 \sin\theta) + B(1 - a_1) - \frac{k}{2}(a_1^2 + a_2^2) + \frac{\delta}{1-\delta}U(c)\}$$

$$\begin{aligned} SEC: (1 - a_1) - s - b(a_1 \cos\theta + a_2 \sin\theta) - B(1 - a_1) + \frac{\delta}{1-\delta}\Pi(c) \\ \geq (1 - a_1) - s - b(a_1 \cos\theta + a_2 \sin\theta) + \frac{\delta}{1-\delta}\bar{\pi} \end{aligned}$$

If the tenant were to accept the contract offered, he would choose his actions to maximize his utility:

$$\max_{a_1, a_2} u = s + b(a_1 \cos\theta + a_2 \sin\theta) + B(1 - a_1) - \frac{k}{2}(a_1^2 + a_2^2) \quad (8)$$

The tenant's utility maximization can also be solved as a one period game, because the tenant will behave in a similar fashion to the landlord, where he will choose the same optimal actions each period (Levin, 2003; Michler & Wu, 2020a). The optimal solutions are given as $a_1^{*C} = \frac{b \cos\theta - B}{k}$ and $a_2^{*C} = \frac{b \sin\theta}{k}$. Under this contract structure the tenant still

has an incentive to put effort into both farming activities (a_2) and excessive nitrogen application (a_1). The formal bonus (b) offered has influence on both activities. If the formal bonus was increased, the effort in both activities would increase. Including the informal agreements (B_y) in the contract, decreases the level of nitrogen applied by the tenant by the strength of the informal bonus (B). Both activities are also influenced by the cost parameter (k), when increasing will decrease the efforts of the tenant. As the measure of misalignment (θ) increases towards its upper bound, the tenant will reduce his excessive nitrogen usage and increase his farming efforts.

Substituting the optimal action choices of the tenant into the landlord's problem (7), simplifies the landlord's problem to the following:

$$\max_{b,B} \pi = 1 - \frac{bcos\theta - B}{k} - \bar{u} - \frac{b^2}{2k} + \frac{bcos\theta B}{k} - \frac{B^2}{2k} \quad (9)$$

Subject to:

$$\begin{aligned} SEC: (1 - a_1) - s - b(a_1 \cos\theta + a_2 \sin\theta) - B(1 - a_1) + \frac{\delta}{1 - \delta} \Pi(c) \\ \geq (1 - a_1) - s - b(a_1 \cos\theta + a_2 \sin\theta) + \frac{\delta}{1 - \delta} \bar{\pi} \end{aligned}$$

The self-enforcement constraint (SEC) of the landlord is applied to profit maximization problem to keep her informal incentives credible. This constraint compares two possible states of the world: (1) if the landlord keeps her promises today and forever; and (2) if the landlord cheats and does not honour her promises today. Under the first state, the landlord fulfills her end of the contract and rewards the tenant (if applicable). Both

parties are happy, and the relationship continues forever. The payoffs from cooperating tomorrow and in the future ($\Pi(c)$) are discounted by a factor of $\delta \in \{0,1\}$, into today's values. If the landlord did not keep her word and the tenant is cheated of his bonus, the relationship will be terminated (second state). In this case the parties will receive their outside options forever. The landlord will suffer from societal damages, as her reputation will receive blowback for cheating. For the self-enforcement constraint to hold, cooperating in the relationship forever needs to offer greater or equal payoffs as to saving the value of the informal promises (B) and terminating the relationship forever. Since the landlord has the option to cheat on the informal incentive payoffs, there are bounds on the incentives that can be credibly promised (Levin, 2003). The constraint can therefore be rearranged into the following:

$$SEC: \frac{\delta}{1-\delta} [\Pi(c) - \bar{\pi}] \geq B(1 - a_1) \quad (10)$$

The rearranged self-enforcement constraint shows what needs to hold for the relationship to continue and the limits to credible promises. On the left-hand side is the discounted value of the landlord-tenant relationship and on the right, is the value of the promised incentives in this case. The relationship value indicates whether the landlord deems this relationship valuable enough to continue to cooperate. This is calculated by taking the difference between the value of cooperating and the outside option. If the net value is positive, cooperation is valued more. The opposite is true if the value is negative. The outside option is an exogenous factor, which the parties do not have control over, yet it is impacting the relationship value. For the informal promises to be

considered credible, the discounted value of the relationship needs to be greater or equal to the value of the promises. If the promises are larger than the discounted relationship, the inequality flips, and the promises are no longer credible.

This second case is more reflective of the current practice that takes place in the farmland rental market. Key features that are typically omitted, such as long-term relationships, renewability, reputation effects, and informal agreements are included within the relational theory contract case.

5 Results

As shown in the previous chapter, the level of effort the tenant puts into the two activities is dependent on the contract structure. The optimal actions of the tenant are presented in Table 5.1, where the difference is clearly seen. In this chapter, I will analyze what this means for future researchers.

Table 5.1: Tenant’s Optimal Actions Under Different Contract Structure

	<i>Case 1 (Purely Formal)</i>	<i>Case 2 (Combination)</i>
<i>Use of nitrogen (a_1)</i>	$a_1^{*F} = \frac{bcos\theta}{k}$	$a_1^{*C} = \frac{bcos\theta - B}{k}$
<i>Farming efforts (a_2)</i>	$a_2^{*F} = \frac{bsin\theta}{k}$	$a_2^{*C} = \frac{bsin\theta}{k}$

As seen in Table 5.1, under both contract structures the tenant is incentivized to put effort into the two activities: farming and excessive nitrogen use. The level of effort the

tenant exerts into farming activities is not impacted by the contract structure, This means regardless of the contract structure the tenant will tend to the farmland with identical effort.

However, when comparing the excessive use of nitrogen, the tenant is shown to use less under a relational contract. By including the previously omitted informal agreements, we can see the tenant is actually incentivized to reduce his nitrogen application. This difference may be due to the inclusion of the relationship value (through the self-enforcement constraint) or the tenant acting in good faith to maintain the farmland contract when it comes to renewal. This finding is supported by Pannell's research (2006, 2016, and 2019) on flat payoff functions. The research demonstrates that at input rates either slightly above or below the optimum rate, the payoff the tenant receives will be slightly less than the optimal payoff, but still capture up to 95% of the optimal (Pannell, 2019). As farmers do not bear the external costs of greenhouse gas emissions or water pollution (Rajsic et al., 2012; Pannell, 2016), the landlord has an opportunity to influence the behaviour of the tenant. The informal incentive the landlord offers may help to offset the loss in payoffs when the tenant reduces nitrogen application. The landlord offering an incentive may bring the nitrogen application level down closer to the recommendations of agronomists, who suggest a lower optimal rate of nitrogen than economists (Pannell, 2016).

6 Discussion

With a significant portion of Canadian farmland being rented out, how the farmland rental market interacts is becoming of greater importance. Though previous literature has provided valuable insights into the farmland rental market, but it has been limited. Literature has assumed agricultural contracts to be fully enforceable by a legal third party and that relationships only last one period. However, we know this to not be the defining characteristics of these types of contracts. Agricultural contracts are not fully formal and may include handshake deals or verbal promises, along with some formal aspects (i.e. government required documentation). These contracts tend to last a longer period of time as they are set to automatic renewal terms, unless terminated. As presented in the thesis, relational contract theory is useful for the study of farmland rental markets because it maintains these defining characteristics (i.e. renewability, contract structure, reputation).

The simplified cases presented in this thesis have shown that by restricting the contract structure, it leads to misrepresentation of the landlord-tenant relationship. By not including informal incentives into our models, we are losing explanatory power and limiting our understanding to a small fraction of the relationship. Leveraging relational contract theory will allow for a more complete understanding of the farmland rental market and more accurate modeling.

Future researchers may expand on the presented model by adapting model extensions from existing literature. This model assumed risk neutrality of both contractual players,

yet uncertainty is a characteristic of farming investments. Huffman and Just (2004) model allowed the landlord and tenant(s) to be characterized with varying degrees of risk aversion. Another potential avenue to explore is cases of multiple agents. Landlords may rent their plots of farmland to multiple agents and have similar contracts established. The presented model displayed a one-to-one relationship between a landlord and tenant. It could be adapted, as done in Huffman and Just (2004), to include multiple agents that the landlord has arrangements with. The goal of this thesis was to present a starting point for future researchers with a developed relational contract model to be applied in future research. It is a call to action to apply the versatile tools available to economists.

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APPENDICES

Appendix A: Variable Descriptions

Table A: Description of Variables

Variable	Description
$w(y, p)$	The contract offered by the landlord to the tenant
s	Rental rate charged for the farmland ($s < 0$)
b	Strength of formal incentive, evaluated on the tenant's measured performance (p)
B	Strength of informal incentive, evaluated on the landlord's desired outcome (y)
$\bar{\pi}/\bar{u}$	The landlord's/tenant's outside option (alternative payoff)
$c(a_1, a_2)$	Cost of activities taken up by the tenant $c(a_1, a_2) = \frac{k}{2}(a_1^2 + a_2^2)$, where k is a cost parameter
a_1	Excessive use of nitrogen; defined as the usage rate above the optimal application rate
a_2	Farming efforts: these include sowing seeds, watering crops, pest and weed maintenance
y	Landlord's desired outcome; measured as the perceived land quality; $y = 1$ (good health) with a probability $1 - a_1$ and $y = 0$ (poor health) with probability a_1
p	Tenant's measured performance; measured as yield; $p = 1$ (high yield) with probability $a_1 \cos \theta + a_2 \sin \theta$ and $p = 0$ (low yield) with probability $1 - a_1 \cos \theta - a_2 \sin \theta$
θ	The measure of alignment between the desired outcomes of the two parties ($\theta \in [0^\circ, 90^\circ]$). At the lower limit the outcomes (p, y) are determined by the same action (a_1). As the misalignment increases, p becomes more influenced by a_2 and less by a_1 .
π/u	The landlord's/tenant's payoff from being in the contractual relationship
δ	Discount factor $\delta \in \{0, 1\}$
$\Pi(c)/U(c)$	The landlord's/tenant's future payoffs from cooperating in the contractual relationship

Appendix B: Purely Informal Contract Case

For the purposes of completeness, the purely informal case has been included in the appendix of this thesis. The results are abnormal and suggest a case that is not realistic.

Under this scenario the landlord is constrained to offering informal incentives (By). In this case a legal third party is unable to observe the desired outcome, good land quality, which the landlord is evaluating the tenant on. Here the rental rate (s) is the bare bones contract that the government requires, but it is merely used as a back-up or proof of agreement rather than as the main agreement. This changes how the relationship is modeled. The offered contract is now denoted as $w(y, p) = w(y) = s + By = s + B(1 - a_1)$.

The landlord's profit maximization problem can be presented as the following:

$$\max_{s, B} \pi = (1 - a_1) - (s + By) \quad (11)$$

$$\text{Subject to: } PC: s + B(1 - a_1) - \frac{k}{2}(a_1^2 + a_2^2) + \frac{\delta}{1-\delta}U(c) \geq \frac{\bar{u}}{1-\delta}$$

$$IC: (a_1, a_2) \in \operatorname{argmax} \{s + B(1 - a_1) - \frac{k}{2}(a_1^2 + a_2^2) + \frac{\delta}{1-\delta}U(c)\}$$

$$SEC: (1 - a_1) - s - B(1 - a_1) + \frac{\delta}{1-\delta}\Pi(c) \geq (1 - a_1) - s + \frac{\delta}{1-\delta}\bar{\pi}$$

The landlord's profit maximization problem is constrained by the participation constraint of the tenant, the incentive compatibility constraint, and her own self-enforcement constraint. Solving this case as the other cases presented in this thesis, the landlord will charge a rental rate of $s^I = \bar{u} - Ba_1 + \frac{k}{2}(a_1^2 + a_2^2)$, and her problem is simplified to the following:

$$\max_B \pi = \left\{ \frac{2B - B^2}{2k} \right\}$$

$$\text{Subject to SEC(L): } a_1 - s - Ba_1 + \frac{\delta}{1-\delta} \Pi(c) \geq a_1 - s + \frac{\delta}{1-\delta} \bar{\pi}$$

$$IC: (a_1, a_2) \in \operatorname{argmax} \left\{ s + B(1 - a_1) - \frac{k}{2} (a_1^2 + a_2^2) + \frac{\delta}{1-\delta} U(c) \right\}$$

If the tenant were to agree to the contract, he would choose his actions to maximize his utility:

$$\max_{a_1, a_2} u = \left\{ s + Ba_1 - \frac{k}{2} (a_1^2 + a_2^2) \right\}$$

The solutions are given as $a_1^{*I} = \frac{B}{k}$ and $a_2^{*I} = 0$. This shows that under a purely informal contract, the tenant is incentivized to reduce his excessive nitrogen application and exert no effort into farming.

Appendix C: Tenant's Optimal Actions

Table C.1 Tenant's Optimal Actions under Three Different Contract Structures

	<i>Case 1 (Purely Formal)</i>	<i>Case 2 (Combination)</i>	<i>Case 3 (Purely Informal)</i>
<i>Use of nitrogen (a_1)</i>	$a_1^{*F} = \frac{bcos\theta}{k}$	$a_1^{*C} = \frac{bcos\theta - B}{k}$	$a_1^{*I} = -\frac{B}{k}$
<i>Farming efforts (a_2)</i>	$a_2^{*F} = \frac{bsin\theta}{k}$	$a_2^{*C} = \frac{bsin\theta}{k}$	$a_2^{*I} = 0$