RELATIONAL CONTRACT FARMING: THEORY AND CASE EVIDENCE

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ABSTRACT. Contract farming is a widespread practice in the developing world and is a means by which farmers get access to credit for inputs and a market for their output. The providers of the credit benefit as the use of better inputs ensures better quality produce. These contracts are often informal word of mouth contracts and, as a result, there are numerous hurdles which must be overcome in order for contract farming to function successfully. For example, the farmer may misuse the loans provided for inputs in non-production activities or she may choose to default on the loan entirely. We develop a relational contracting model which demonstrates how contract farming can function successfully despite these issues. We show that under different situations, the nature of the profit maximizing contract varies. Credit is either provided in-kind or as a combination of in-kind and cash. We provide case evidence in support of the model. This evidence is a combination of our fieldwork in Ghana as well as from the literature.

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1. INTRODUCTION

Contract farming is a ubiquitous institution across most developing agrarian economies. Simply put, it is a long term (often informal) credit relationship between a buyer of a crop and its producer, without which the producer would not have a market for her crop or access to credit for the capital inputs required to produce it. Historically, contract farming has been common in horticultural crops, like tea, fresh fruits, fresh vegetables, cut flowers, etc. These crops have a series of specific technical and production characteristics (quite different from other agricultural crops) that can be conducive to the institutional organization of their production and trade brought about by contract farming.[1] In this paper, we focus on informal contracts and provide a theoretical framework that attempts to explain the conditions under which contract farming arises, how it can be sustained in the absence of formal contracts and the nature of the contract which maximizes profits. The theoretical framework is motivated by case evidence from the literature as well as evidence from a survey of pineapple farmers we conducted in Ghana.

As a motivating example, consider the case of an exporter of a fruit, contracting with a farmer who grows it. There is demand for high quality fruit in the export market and as a result the exporter wants the farmer to produce fruit of such quality. In order to do so, the farmer must apply the proper inputs in production but she does not have the disposable income to invest in the inputs. In order to induce the farmer to use the appropriate inputs, the exporter offers a loan to the farmer and commits to buying the crop from the farmer at a prespecified price. If the fruit of the farmer turns out to be of high quality, the exporter sells the fruit in the export market and recoups his loan by subtracting its value from the final payment to the farmer. By contrast, if the fruit turns out to be of low quality, it cannot be sold and the exporter loses the value of the loan. Low quality fruit could be the result of the farmer diverting the loan to non production reasons or due to exogenous factors outside her control. Instances of this motivating example can be found in numerous agricultural markets all over the developing world. Based on this example, we construct a simple theoretical model the insights of which can be applied to a variety of more general settings.

We propose a simple model which highlights the clear economic trade-offs present in the above arrangement. Providing credit to the farmer allows her to use better inputs in production and thereby raises profits. However, due to the limited liability of the farmer, the risk of the loan is borne entirely by the exporter. To elaborate, the exporter faces three concerns when deciding to loan money to the farmer. Firstly, in spite of the application of proper inputs, the exporter may lose his loan amount if the crop fails due to factors outside the farmer's control such as weather, pests etc. The second concern stems from the inability of the exporter to monitor the farmer. It is not feasible for an exporter who typically contracts with a reasonably large number of farmers to ensure that they are indeed using the loan for crop inputs and not diverting it to non-production

[1]For example, Hill (1986) discusses the rise of such credit institutions among cocoa farmers along the Gold Coast in Ghana. Also see Binswanger and Rosenzweig (1986), Goldsmith (1985), Glover (1984), Jaffee (1987), Jaffee (1994), Key and Runsten (1999), Poulton, Dorward and Kydd (1998), Warning and Key (2002), Scott (1984) and Singh (2002) for case studies on why certain crops may be conducive to organization of this sort.

uses. If the farmer diverts the loan, the crop is more likely to be of poor quality, in which case the exporter does not get paid in the export market and cannot recoup the value of his loan. Thirdly, due to the absence of legal recourse, the exporter cannot stop a farmer who has accepted a loan from him from defaulting on the loan entirely by selling the crop to a different exporter or in the local market.

Our model shows that in spite of the above mentioned hurdles, contract farming can emerge in response to a demand for quality. Put differently, it is possible for the exporter to provide credit, induce a higher quality of fruit and increase profits without fearing default. The above issues are overcome in the following ways. In order to solve the issue of diversion, the exporter can provide loans in the form of inputs (in-kind) and can offer a higher price for quality. It is typically more difficult to divert inputs as they are harder to convert into cash for consumption and the returns of applying them towards non-cash crops are typically lower. By contrast, default can only be discouraged through dynamic incentives. In other words, this informal agreement can only be sustained by the value of the relationship in the future. The farmer will hesitate to default on the loan if that means that the exporter will not contract with her in the future thus denying her the subsequent access to credit for consumption and inputs and a market for her output. Such a contract is called a relational contract (Baker et al. 2002, Levin 2003). There are important differences between these classical models and our relational contract farming model which we elaborate upon when we situate our model within the relational contracting literature in Section 4.4.

To be more specific, we examine a repeated interaction between the exporter and the farmer and focus on stationary equilibria of this repeated game. We show that due to the inability of the exporter to monitor the farmer, there are potentially large losses in social surplus. There are situations when, in equilibrium, credit is not provided even though efficiency would demand offering a level of credit high enough to allow the farmer to purchase the optimal amount of the input for production. By contrast, there are situations where the exporter offers the efficient level of fertilizer as in-kind credit in equilibrium and the farmer neither diverts the credit nor defaults. We provide and interpret the conditions on the parameters of the model for both these cases. The latter result shows that relational contracting is powerful enough to overcome the difficulties posed by the lack of formal credit markets.

The more interesting case is when the farmer is impatient and hence the exporter cannot incentivize her to use the efficient level of fertilizer by only providing in-kind credit. We show that, under certain conditions, higher quality and higher profits can be sustained in equilibrium, by the provision of cash credit for consumption in addition to the in-kind loan. This is a seemingly counterintuitive result and is perhaps the most striking result from our model. The exporter allows the farmer to use the cash loan for consumption and thus it seems that the exporter is needlessly bearing additional risk from the loan without any benefits. However, this additional credit raises the value of the relationship for the farmer and makes her more reluctant to default. This in turn allows the exporter to provide higher in-kind credit thereby increasing profits without fearing default! In fact, it is not uncommon for exporters to provide cash advances for school fees, health

issues etc and we observe such credit in our survey. Our model shows that this seemingly altruistic act can actually result from a profit motive.

We provide case evidence that supports this theoretical framework. Section 2 begins by presenting evidence from fieldwork we conducted in Ghana. This case is particularly interesting as we observe the emergence of contract farming as an institution, due to a change in the shipping technology which increased the demand for higher quality pineapple by the exporter at the time of shipping. Using this particular instance as a point of departure, we set up the model in Section 3. In Section 4, we analyze the model and present the theoretical results. Section 5 discusses the broader literature on contract farming. In this section, we present a number of other cases on contract farming based on work in other fields to illustrate the relevance and importance of our model. Section 6 concludes.

2. Case Evidence: Pineapple in Ghana

In this section, we present specific case evidence from the pineapple industry in Ghana in order to motivate our theoretical analysis. We collected some of this information via interviews with exporters in the field. This particular case is interesting, as we observe the emergence of contract farming in response to a change in the market which led to a higher demand for quality. Specifically, there were no contracting arrangements before 1996, after which contract farming emerged and was booming by 2001.

The survey of Goldstein and Udry (1999) shows that in 1996, there was little evidence of any contract farming between exporters and farmers. They surveyed farmers in four villages from November 1996 to August 1998, a sample that had 63 pineapple farmers in 1996 (108 farmers by 1998), who produced approximately 800,000 kg of pineapple, worth 158 million cedis (the total quantity exported in 2000 was 28.5 million kg), on 334 acres of land. To quote from their work: "Surprisingly, this type of contract is rare. Over the first year and a half of the survey, only four loans (of 1100 recorded) were made by exporters to cultivators in our sample." Moreover, only about 49% of the pineapple farmers used any fertilizers and the mean amount used was about 40kg per hectare, compared to the recommended amount of 400kg per hectare. So to summarize, in 1996, there were no credit contracts between exporters and farmers, and farmers used very small amounts of fertilizer indeed.

Prior to 1996, pineapple exporters in Ghana shipped their produce to European markets by air. In 1996, refrigerated sea freight became available as an option. The cost savings to the exporters of using sea freight as compared to air shipping was substantial: a reduction from $688 per pallet to $173 per pallet, and by 2000, about 65% of pineapple was shipped by sea. However, this technological innovation created a new issue for the exporters. The shift to sea freight involved a much longer transit time (now ten to twelve days via sea vs. a few hours by air). This meant that exporters had to care about aspects of quality that were previously unimportant. For the case of air freight, the quality of the pineapple at the time of shipping was essentially the quality at the time it was offered to the end customer and so for all intents and purposes quality was observable

by the exporter. This allowed him to examine the quality of the fruit and select only export quality pineapple for shipping.

By contrast, the long transit time associated with sea freight meant that the exporter could not assess the quality of the fruit at the time of shipping. In particular, this implied that the exporter could not select only the high quality fruit from each farmer to ship. Only the careful application of the right kind of fertilizer by the farmer could produce a high enough quality of fruit which would not spoil or be damaged by the time it reached the European market. This, in turn, implied that the actions of the pineapple farmers during the growing season became of primary concern to the exporter. Failure by the farmer to invest in the proper inputs could have led to the exporter's fruit being rejected, or worse, to the cancellation of future contracts with his European buyers.[2] In addition, it was not feasible for the exporter to monitor the farmer to ensure proper production. This change in demand for quality led to the emergence of credit arrangements between the exporters and pineapple farmers in the form of in-kind transfers by which the exporters provided farmers with high-quality fertilizers in exchange for a contract on the fruit.

In 2001, we visited Ghana and conducted interviews and farm visits with a number of the exporters. The exporters we interviewed accounted for 42% of total exports in 2000 (the largest firm exported only from its own farms and accounted for an additional 22% of exports). These exporters accounted for about 600 outgrowers and every exporter mentioned working with only a specific group of outgrowers from whom they regularly purchased fruit and with whom they had contracting relationships. These contracts were not formal or written contracts, they included a fixed price and the exporter usually contracted to buy the entire pineapple crop of his outgrowers. The price they paid varied by season, and they didn't pay the outgrowers until they received payment for the fruit from their buyers, which usually took about four to six weeks. In most cases, the exporters distinguished between their "regular" outgrowers, anywhere between ten and sixty in number, with whom they have exclusive contracts and from whom they commit to purchase all their fruit, and other farmers, whom they can approach should they need more fruit for export, but with whom they do not contract with on a regular basis. In particular, we found that most of the exporters we spoke to gave credit to farmers in the form of inputs as well as cash advances for emergencies/shocks, like school fees, health problems, etc. The value of the credit was deducted from the price paid to the outgrower for the fruit. Two exporters had, in fact, underwritten loans to their outgrowers from commercial banks and they ensured that these loans were repaid when they paid the farmer.

From the interviews we conducted, we found that exporters considered critical not just the quantities but also the types of fertilizers used by the farmers. There are several fertilizers available to farmers, of different qualities and prices. Outgrowers have the incentives to use the cheapest fertilizers, like ammonia and urea and to avoid the more expensive potassium nitrates and sulfates. The cheaper fertilizers affect fruit quality negatively as they cause the fruit to absorb

[2]The cost of shipping was paid by the European buyers and moreover, they determined the quantity of the shipment. This prevented exporters from pursuing strategies such as shipping a larger quantity than that demanded so that the order could be filled in the event that some of the fruit was rejected.

excess water. This not only increases the size of the fruit, which is an added benefit to the outgrowers, but also reduces the shelf life of the fruit by making it more susceptible to browning and bruising during harvest and transport. Therefore the exporters offered high quality fertilizer as in-kind credit in order to control the quality of the final product.

In the next section, we use this case as a point of departure to build the model. We also provide a brief summary of the changes in the Ghanaian pineapple industry since 2001 in Appendix A.

3. THE MODEL

We consider the interaction between an exporter of a crop and a farmer who grows it.[3] The farmer produces a fixed quantity of a crop which can either be of high or low quality. It is assumed that the farmer does not have the resources to purchase the inputs to production. We assume that the application of fertilizer only affects the probability that the crop is of high quality but does not the affect the total quantity. Since the farmer has no resources, the exporter can provide the farmer with credit which the farmer could then use on fertilizer. This credit could be either in the form of a cash loan, an in-kind loan (the loan is in the form of fertilizer) or both. After receiving the loan, the farmer makes a decision on how to utilize the loan. She could choose to apply the loan towards production or could divert the loan towards consumption. The exporter cannot monitor the amount of fertilizer the farmer chooses to apply.

After harvesting, the farmer can sell her crop to the exporter as per the contract or choose to default. If she sells it to the exporter, she gets the contracted price of the crop less the value of the loan. Default involves selling the crop to a different exporter which allows the farmer to renege on her repayment obligation. Since the contract isn't enforceable, the only thing preventing the farmer from defaulting is the lack of access to credit in the future as the exporter will not contract with her in the future.

We focus on the best stationary equilibrium for the exporter or, in other words, the stationary equilibrium which yields him the most profit. Stationarity implies that both the exporter and the farmer behave identically at each time period on the equilibrium path. Before formally defining the model, the following is a summary of the main predictions.

(1) If the export price is low, the exporter will not offer any credit even though it is socially optimal for him to do so.
(2) If the export price is not very low and provided the farmer is sufficiently patient, the exporter will offer the efficient amount of fertilizer in the form of an in-kind loan.
(3) If the farmer is sufficiently impatient, under certain circumstances, the exporter offers cash for consumption along with inputs in the form of an in-kind loan.

We will discuss each prediction in the coming sections.

[3]We refer to the exporter with masculine pronouns and to the farmer with feminine pronouns to avoid confusion.

3.1. *Notation and the Stage Game*

We start off by describing the primitives of the model. We normalize the quantity of fruit produced by the farmer to 1. The quantity of fertilizer used by the farmer in production is denoted by k. The amount of fertilizer application determines the probability that the crop will turn to be of high quality. The probability that the crop is of high quality after the application of k units of the fertilizer is

$$\phi k = \text{ Probability of high quality crop by application of } k \text{ units of fertilizer.}$$

The optimal level of fertilizer for the crop is k^* and an application of more fertilizer than k^* is harmful to the crop. It is assumed that even an application of the optimal level of fertilizer does not lead to a sure success or

(A1) $$\phi k^* < 1.$$

Agriculture by its very nature has inherent risks which cannot be controlled. The above assumption reflects the fact that there are exogenous factors such as weather, pests etc. which are outside the farmer's control and which could lead to low quality output in spite of her best efforts. Finally, the price of fertilizer is normalized to 1.

The farmer chooses between spending resources for consumption and applying fertilizer. We model this by endowing the farmer's utility function with two components- utility from consumption and benefits from production. The farmer's needs for consumption vary. With probability $\gamma_l \in (0,1)$, the farmer does not have pressing needs for consumption and her utility function is given by

$$c + p\phi k.$$

With probability $\gamma_h = 1 - \gamma_l$, the farmer has pressing needs for consumption and her utility function is given by

$$\mu c + p\phi k,$$

where $\mu > 1$. This models situations where the farmer needs resources to deal with pressing concerns such as health care, schooling for children etc. We term these states as the "low state" and "high state" respectively. Where convenient, we use $\mu_l = 1$ and $\mu_h = \mu$ to denote marginal utility of consumption in the low and high state respectively. The average marginal utility of consumption is denoted by

$$\overline{\mu} = \gamma_h \mu_h + \gamma_l \mu_l = \gamma_h \mu + \gamma_l.$$

The farmer is assumed to have no resources to invest in inputs and therefore can only apply fertilizer if the exporter provides credit. The exporter can offer credit either in cash or in kind (by loaning the farmer fertilizer) or by offering a combination of the two. We denote the dollar amount of cash credit by L^c and the dollar amount of in-kind credit by L^k. Since we have normalized the price of fertilizer to 1, L^k is also the quantity of fertilizer loaned to the farmer. Upon receiving the loan, the farmer decides whether to use it for consumption or whether to invest in production. We use the term *diversion* to refer to credit utilized by the farmer for consumption.

If the exporter offers the farmer only credit in cash, her budget set is

$$k + c \leq L^c.$$

By contrast, the farmer cannot efficiently divert in-kind credit to consumption. Formally, we model this by assuming that 1 dollar worth of fertilizer can only be converted to $\alpha < 1$ units of consumption. This assumption can be interpreted in two ways. Firstly, due to lack of efficient markets for inputs, it is unlikely that the farmer would be able to sell the fertilizer at market price. Secondly, even if there were other farmers willing to pay market price for the fertilizer, in all likelihood, it would not be easy to locate them and this would impose a search cost on the farmer. Finally, she could divert the fertilizer by applying it to some other non-cash crops she grows. In this case, our assumption implies that the returns from using the fertilizer on such crops is lower. To summarize, when the loan is in-kind, the farmer's budget set becomes

$$k + \frac{c}{\alpha} \leq L^k.$$

Finally, when credit is offered in a combination of cash and in-kind, the farmer's budget set becomes

$$k + \min\{L^c, c\} + \frac{1}{\alpha}\max\{c - L^c, 0\} \leq L^k + L^c.$$

We now describe the contracting process between the exporter and the farmer. This description makes the timing of events in the stage game explicit.

The Stage Game

(1) The state of consumption needs of the farmer is realized and observed by both the farmer and the exporter.
(2) The exporter decides whether to contract with the farmer. If the exporter chooses not to contract with the farmer, the game ends.
(3) The exporter offers the farmer a price p for her output, a cash loan L^c and/or an in-kind loan L^k.
(4) The farmer decides whether or not to accept the contract. If the farmer rejects the contract, the game ends.
(5) The farmer selects the amount of the loan k to spend towards production and the amount c to divert towards consumption.
(6) At the time of harvest, the farmer chooses whether to default and sell her fruit to a different exporter at the price p.
(7) If the farmer chooses not to default, the exporter ships her fruit and the quality of the fruit is revealed.
(8) If the quality of the fruit is revealed to be high, the exporter is paid a price q in the export market. He, in turn, pays the farmer the contracted price p less the loan amount $L^c + L^k$.

The expected utility of the farmer at the time she makes the decision to invest in production[4] is

(Farmer's Utility) $$\phi k[p - (L^k + L^c)] + \mu_i c,$$

which depends on the state $i \in \{h, l\}$. We would like to point out two aspects of the above expressions. Firstly, the equation makes the limited liability of the farmer explicit. In the event that the fruit turns out to be of low quality, she is not obliged to repay the loan. Secondly, the larger the loan amount, the lower the marginal benefit the farmer receives from investing in fertilizer. Higher quality can only result from providing a higher loan amount to the farmer. But this in turn would require the exporter to offer a higher price to keep the marginal returns to the farmer from investing in production the same.

The expected utility of the exporter at the time he offers the contract is[5]

(Exporter's Utility) $$\phi k \left[q - p\right] - \left[1 - \phi k\right] \left[L^c + L^k\right].$$

Notice that, when the fruit is of high quality (the probability of which depends on the level k of fertilizer used by the farmer), the exporter recovers his loan amount as he subtracts it from the final payment to the farmer. By contrast, when the fruit turns out to be of low quality, the exporter does not get paid in the export market and ends up losing the amount of the loan. Clearly the exporter's utility does not depend on the level of consumption c chosen by the farmer.

We make the following assumption relating the export price q and the marginal utility from consumption in the high state μ:

(A3) $$q\phi > \mu.$$

This assumption states that there are social benefits to increasing the quality of the fruit even in the high state. Put differently, the expected social surplus generated by spending one dollar on production is $q\phi$ which is greater than the utility which the farmer gains by using the dollar for consumption. Of course, this implies that there are also efficiency gains from applying fertilizer in the low state.

Table 1 summarizes the notation for easy reference.

TABLE 1. Summary of Notation

q = Price paid to the exporter in the export market	p = Price the exporter pays to the farmer
c = Consumption of the farmer	k = Amount of fertilizer applied
L^c = Cash loan amount	L^k = In-kind loan amount
ϕ = Marginal increase in probability of high quality fruit by application of fertilizer	k^* = Optimal quantity of fertilizer
μ = Marginal utility of consumption	α = Return from diversion of fertilizer

[4]Technically, the profit to the farmer in the event that the fruit is revealed to be of high quality is $\max\{p - (L^c + L^k), 0\}$. In principle, the exporter could offer the farmer a price lower than the amount of the loan. However, in equilibrium, the utilities to both parties are identical when the price $p < (L^c + L^k)$ and $p = (L^c + L^k)$ as in neither case is the exporter going to pay the farmer.

[5]In order to calculate his expected revenue, the exporter must be able to correctly forecast the amount of k of fertilizer that the farmer will apply. Of course, the exporter will be able to do this in equilibrium.

3.2. *The Repeated Game*

We examine the repeated interaction between the exporter and the farmer. Specifically, we analyze perfect public equilibria[6] of the infinitely repeated game where the stage game is the extensive form game we defined in the previous subsection. The discount rate of the farmer is denoted by $\delta < 1$. We focus on *stationary equilibria* of this infinitely repeated game. In these equilibria, the exporter and the farmer behave identically on the equilibrium path, each time the stage game is played. On the equilibrium path, every time a high state is observed, the exporter offers the same high state contract, the farmer always accepts the contract and behaves the same way. Similarly, the exporter and farmer behave identically over time when the low state is observed. Of course, the high state and low state strategies could be different. We now formally describe the equilibrium strategies of the exporter and the farmer.

Since the exporter never observes the farmer's past choices of k and c, he cannot condition his strategy on this information. He only observes the contract he offered (if any), whether the farmer defaults (if she accepted the contract) and if she doesn't default whether the fruit turned out to be of high or low quality. Stationary strategies require the exporter to offer the same high state contract $(p_h^*, L_h^{k*}, L_h^{c*})$ every time a high state is observed and the same low state contract $(p_l^*, L_l^{k*}, L_l^{c*})$ every time a low state is observed on the equilibrium path. We now describe the exporter's complete strategy. The exporter offers a contract $(p_h^*, L_h^{k*}, L_h^{c*})$ at the first period if the state is high and $(p_l^*, L_l^{k*}, L_l^{c*})$ if the state is low. At histories where he has offered this contract at all times in the past and the farmer has never defaulted, the exporter will continue to offer this contract. At any other history, the exporter will choose to not contract with the farmer. Notice that, as long as the farmer does not default, the exporter will continue to offer the same contract irrespective of the number of times the fruit turned out to be of high or low quality.

By contrast, the farmer's histories consist of the contracts offered by the exporter (if any), her choices of fertilizer and consumption (when she accepted the contract), whether she chose to default or not and the realized qualities of the fruit. The farmer plays the following strategy. At histories where the exporter has offered $(p_h^*, L_h^{k*}, L_h^{c*})$ in the high state and $(p_l^*, L_l^{k*}, L_l^{c*})$ in the low state at each point of time in the past, the farmer has chosen k_h^* and c_h^* in the high state and k_l^* and c_l^* in the low state at each point of time in the past and she has never defaulted, she will continue to choose k_h^* and c_h^* in the high state and k_l^* and c_l^* in the low state and not default. At any other history, if the exporter were to offer the farmer a contract, she would accept the contract, choose consumption and inputs optimally and default on the loan.

We should point out that it is without loss of generality to assume that deviations off the equilibrium path are punished in the most severe way (Abreu 1988) as the above strategies prescribe. Stationary strategies $\{(p_h^*, L_h^{k*}, L_h^{c*}), (p_l^*, L_l^{k*}, L_l^{c*})\}$ by the exporter and $\{(k_h^*, c_h^*), (k_l^*, c_l^*)\}$ by the

[6]In this equilibrium refinement, Nash equilibrium play follows each history. In essence, it is the equivalent of subgame perfection in an incomplete information repeated game (Fudenberg et al. 1994).

farmer constitute an equilibrium if they satisfy the following conditions for $i \in \{L, H\}$

(Positive Exporter Profit)

$$\phi k_i^* \left[q - p_i^*\right] - \left[1 - \phi k_i^*\right] \left[L_i^{c*} + L_i^{k*}\right] > 0$$

(Optimal Choice of Input)

$$k_i^*, c_i^* \in \underset{k,c}{\operatorname{argmax}} \left\{\phi k[p_i^* - (L_i^{k*} + L_i^{c*})] + \mu_i c\right\}$$

subject to

$$k + \min\{L_i^{c^*}, c\} + \frac{1}{\alpha}\max\{c - L_i^{c*}, 0\} \leq L_i^{k*} + L_i^{c*}$$

(No Default)

$$\phi k_i^* \left[p_i^* - (L_i^{c*} + L_i^{k*})\right] + \mu_i c_i^* + \frac{\delta}{1-\delta} \sum_{j \in \{h,l\}} \gamma_j \left\{\phi k_j^* \left[p_j^* - (L_j^{c*} + L_j^{k*})\right] + \mu_j c_j^*\right\} \geq \phi k_i^* p_i^* + \mu_i c_i^*$$

The first condition just says that the exporter has positive expected benefits at the beginning of each stage game and therefore gains from offering the contract. If he chooses to offer any other contract, the farmer would respond by accepting and defaulting following which the exporter would not contract with her in the future. This would yield the exporter a non-positive payoff and hence he has no incentive to deviate.[7] The second condition states that the farmer chooses inputs and consumption optimally. Since the exporter does not condition his strategy on the revealed quality of the fruit, the equilibrium choices of the fertilizer and consumption must maximize the farmer's utility in any given period. The third condition ensures that the farmer does not find it optimal to default. On the left side of the inequality is the lifetime value of the relationship. On the right side is the utility that the farmer gets from selling her fruit to a different exporter thereby forgoing her repayment obligations. However, once she defaults, the exporter will punish her by not contracting with her in the future which gives her a continuation value of 0.

It is important to point out that there could potentially be a continuum of stationary equilibria.[8] We focus attention on the stationary equilibrium which yields the maximum expected profit to the exporter and we term this equilibrium the *exporter best stationary equilibrium*. In light of our survey evidence, this seems to be an appropriate choice. We should also point out that there could be nonstationary equilibria that yield higher profits for the exporter. Focusing on stationary equilibria substantially simplifies the analysis and can highlight the tradeoffs in contract farming in a transparent way. Moreover, the discount factor of the exporter plays no part in the analysis of stationary equilibria whereas it would be critical if we looked at nonstationary equilibria. Usually a common discount factor is assumed, however, we feel such an assumption is not appropriate in our setting as we would expect the farmer to be more myopic than the exporter.

[7]Notice, that it is possible for an equilibrium to exist where the exporter makes a loss in one of the two states but still has positive expected profit. Of course, this would require the exporter to be sufficiently patient which would make him willing to bear the loss in order to gain positive expected profits in the future. The definition we present describes equilibria which do not depend on the exporter's discount factor.

[8]This is because the stage game is an extensive form game. Therefore any deviations by the exporter can be punished by the farmer immediately and, as a result, these deviations can never benefit the exporter. This allows for a large number of different contracts to occur in equilibrium.

4. Analyzing the Model

We start off by making the following intuitive observation, the proof of which is in Appendix B.

Lemma 1. *In the exporter best stationary equilibrium, it must be the case* $L_i^{k*} = k_i^*$ *and* $L_i^{c*} = c_i^*$ *for* $i \in \{h, l\}$.

This lemma states that there is no benefit for the exporter to loan cash to the farmer to purchase inputs or alternatively loan fertilizer knowing that the consumer is diverting some or all of it to consumption in equilibrium. This lemma allows us to simplify notation and henceforth we refer the loan amounts L_i^{k*}, L_i^{c*} as simply k^*, c^*. Therefore the strategies of both the farmer and the exporter for the exporter best stationary equilibrium can now be summarized by the tuple $\{(p_i^*, k_i^*, c_i^*)\}_{i\in\{h,l\}}$.

The exporter best stationary equilibrium is a solution to the following optimization problem

$$\{(p_i^*, k_i^*, c_i^*)\}_{i\in\{h,l\}} \in \underset{\{(p_i,k_i,c_i)\}_{i\in\{h,l\}}}{\operatorname{argmax}} \left\{ \sum_{i\in\{L,H\}} \gamma^i \left(\phi k^i \left[q - p^i \right] - \left[1 - \phi k^i \right] \left[k^i + c^i \right] \right) \right\}$$

subject to

$$(\text{Div}_h) \qquad \phi[p_h - (k_h + c_h)] \geq \alpha\mu$$

$$(\text{Div}_l) \qquad \phi[p_l - (k_l + c_l)] \geq \alpha$$

$$(\text{Def}_h) \qquad \phi k_h[k_h + c_h] \leq \frac{\delta\gamma_h}{1-\delta}\left[\phi k_h(p_h - k_h - c_h) + \mu c_h\right] + \frac{\delta\gamma_l}{1-\delta}\left[\phi k_l(p_l - k_l - c_l) + c_l\right]$$

$$(\text{Def}_l) \qquad \phi k_l[k_l + c_l] \leq \frac{\delta\gamma_h}{1-\delta}\left[\phi k_h(p_h - k_h - c_h) + \mu c_h\right] + \frac{\delta\gamma_l}{1-\delta}\left[\phi k_l(p_l - k_l - c_l) + c_l\right]$$

The objective function represents the expected payoff of the exporter and the constraints ensure that the solution to the problem corresponds to a stationary equilibrium. The first two constraints (Div_h), (Div_l) in the above maximization problem ensures that the in-kind loan k_i provided by the exporter is used by the farmer in production and is not diverted. The marginal benefit from using a unit of in-kind loan in production is given by the left side of these inequalities and the right side denotes the marginal benefit from diverting a unit of fertilizer towards consumption. If this inequality did not hold, the farmer would use both the cash and the in-kind for consumption and would not use any inputs in production which would violate Lemma 1. We term these the *diversion constraints*. Notice that the diversion constraint is more restrictive in the high state (Div_h) as the right hand side is larger than that of (Div_l). When the farmer has more urgent needs for consumption, the exporter must provide her with a higher price to ensure that she does not divert the loan.

The third and fourth constraints (Def_h), (Def_l) in the above maximization problem ensure that the farmer does not default on the loan. It is simply a rearrangement of the (No Default) condition we used in Section 3.2 to define a stationary equilibrium. We term these the *default constraints*. Notice that the right hand side of both of these inequalities is the same. This reflects the fact that

in a stationary equilibrium, the farmer's continuation value is the same in both the high and low state.

The theoretical analysis in this paper involves deriving the properties of the solution to the above maximization problem. The technical difficulty is in isolating which of the constraints bind at various parameter values. Before, analyzing the above maximization problem, we start off by first describing the socially efficient amount of credit.

4.1. *Socially Efficient Level of Fertilizer Application*

Recall that we have assumed $\phi q > \mu > 1$. From a social perspective, this implies that irrespective of the realized state there is greater benefit in investing a dollar's worth of fertilizer up to the level k^* in production than allowing the farmer to use that dollar for consumption. Therefore from the perspective of a social planner, the socially efficient amount of fertilizer usage is k^* is both states. This can only be achieved if the exporter provides the farmer with a loan worth k^* in both states.

4.2. *The Nature of In-kind Credit*

We start off by examining the nature of in-kind loans offered to the farmer in the exporter best stationary equilibrium. The aim of this subsection is to show two things. The first is that the inability of the exporter to monitor the farmer can lead to inefficient outcomes. Secondly, we show that in spite of the inability to monitor and prevent default, there are values of q where the exporter offers the efficient amount of credit as long as the farmer is sufficiently patient.

To make the above arguments, we examine the maximum profit that the exporter can make in a stationary equilibrium when he offers only in-kind loans. When the exporter offers only in-kind credit, the maximum expected profit attainable in stationary equilibrium is the solution to the following problem:

$$\max_{p_h,k_h,p_l,k_l} \sum_{i\in\{h,l\}} \gamma_i \left\{ \left\{ \phi k_i \left[q - p_i \right] - \left[1 - \phi k_i \right] k_i \right\} \right\}$$

subject to

$$\phi[p_i - k_i] \geq \alpha\mu_i,$$

$$\phi k_i^2 \leq \frac{\delta}{1-\delta} \left[\gamma_h \phi k_h (p_h - k_h) + \gamma_l \phi k_l (p_l - k_l) \right] \qquad \text{for } i \in \{h, l\}.$$

The first constraint is the diversion constraint and the second constraint is the default constraint where both are simplified by setting $c = 0$. The diversion constraint implies that $p_i - k_i \geq \alpha\mu_i/\phi$ which in turn implies that for sufficiently patient farmers, the default constraints will not bind even at the highest (efficient) level of in-kind credit k^*. This is intuitive as when farmers are patient, they care more about the future and as a result are less likely to default. The exporter then only needs to provide the farmer with a high enough price for quality so that she has the correct static incentives to apply the equilibrium level of fertilizer in the absence of monitoring. Notice

also that when the default constraints are not binding at the optimum, there is no benefit from offering cash credit.

Since the profit of the exporter is decreasing in price, one of the diversion or default constraints must bind. By the above argument, for sufficiently patient farmers, the exporter will offer price and credit such that they satisfy the diversion constraint with equality or $p_i = k_i + \alpha\mu_i/\phi$. We can then plug this into the objective function and rewrite the exporter's problem as

$$\max_{k_h,k_l} \left\{\gamma_h k_h \left[\phi q - (\alpha\mu + 1)\right] + \gamma_l k_l \left[\phi q - (\alpha + 1)\right]\right\}. \tag{1}$$

This immediately shows that if $\phi q < 1 + \alpha$, the exporter will not provide any credit in either state in the exporter best stationary equilibrium or, in other words, not contract with the (sufficiently patient) farmer. But this in turn implies that the exporter will not contract with the farmer in *any* stationary equilibrium even when the farmer is very patient. If the farmer were to be impatient, then in addition to the diversion, the exporter would also have to worry about default. This intuition can be summarized in the following proposition.

Proposition 1. *If $\mu < \phi q < 1 + \alpha$, the exporter does not contract with the farmer in any stationary equilibrium irrespective of the farmer's discount factor.*

It should be pointed out that with nonstationary strategies, in principle, the exporter could generate positive social surplus in a repeated interaction. For example, the exporter could have a strategy which denies credit to the farmer in future periods should the fruit turn out to be of low quality. This would discourage the farmer from diverting the credit. This result is in contrast to what Levin (2003) finds for standard relational contracts. He shows that the maximum surplus that can be generated in equilibrium can be generated by a stationary equilibrium.[9] By contrast, in our setting, no surplus can be generated using stationary contracts when $\mu < \phi q < 1 + \alpha$ whereas nonstationary contracts could potentially lead to positive surplus. That said, it is possible to show that for the above parameter values, no nonstationary equilibrium can generate the efficient outcome. This is because, in order to incentivize the farmer, some surplus has to be destroyed on the equilibrium path.

From a further examination of (1) and by repeating the previous argument, we can conclude that when $1 + \alpha < q < 1 + \alpha\mu$, the exporter will not offer in-kind credit in the high state of the exporter best stationary equilibrium irrespective of the farmer's discount factor. In this case, however, the export price is high enough to make it profitable for the exporter to always offer in-kind credit in the low state. This can be seen as follows. Suppose the exporter offers the farmer an in-kind loan k_l along with a price $p_l = k_l + \alpha/\phi$. At this price, the farmer will not divert the loan to consumption. Since the exporter offers no credit in the high state, we can plug $k_h = 0$ in the low state default constraint and get

$$\frac{1 - \delta + \delta\gamma_l}{\delta\gamma_l} k_l \leq p_l.$$

[9]To be precise, Theorem 2 in Levin (2003) states "If an optimal contract exists, there are stationary contracts that are optimal."

Since $p_l \geq \alpha/\phi$, the right side of the above inequality is positive. Therefore, for any $0 < \delta < 1$, there is a low enough value of k_l such that the above default constraint is slack. This implies that there is a small enough amount of in-kind loan that the exporter can provide in the low state such that the farmer would neither divert nor default. This would yield higher profits than providing no credit at all. Of course, if the farmer is impatient or δ is close to 0, the amount of this credit while positive is very small, as the exporter fears default. This result is summarized in the following proposition.

Proposition 2. *If $1 + \alpha < q < 1 + \alpha\mu$, the following are true for the exporter best stationary equilibrium:*

(1) *The exporter does not provide in-kind credit to the farmer in the high state.*
(2) *The exporter always provides a positive amount of in-kind credit in the low state or $k_l > 0$.*
(3) *For sufficiently patient farmers (there exists a $\underline{\delta} < 1$ such that whenever $1 > \delta > \underline{\delta}$), the exporter offers the efficient level k^* of in-kind credit in the low state.*

Lastly, when $q > 1 + \alpha\mu$, the exporter always benefits from offering an in-kind loan in both states. A similar argument to the previous proposition can be used to argue that even if δ is close to 0, the exporter can attain higher profits by offering a small amount of in-kind credit in both states. Of course, when the farmer is very patient, the exporter offers the efficient level of in-kind credit in both states. Lastly, the proposition also shows that the exporter always offers weakly more credit in the low state. This is intuitive as it is easier to prevent diversion in the low state. The proof of the following result is in the appendix.

Proposition 3. *If $q > 1 + \alpha\mu$, the following are true for the exporter best stationary equilibrium:*

(1) *The exporter always provides a positive amount of in-kind credit in both states or $k_h, k_l > 0$.*
(2) *The exporter always offers weakly more in-kind credit in the low state. In other words $k_l \geq k_h$.*
(3) *For sufficiently patient farmers (there exists a $\underline{\delta} < 1$ such that whenever $1 > \delta > \underline{\delta}$), the exporter offers the efficient level k^* of in-kind credit in both states.*

Henceforth, we assume that the price in the export is high enough so that the exporter would like to provide in-kind credit to the farmer in both states or

(A4) $$q\phi > 1 + \alpha\mu.$$

4.3. *The Nature of Cash Credit*

Proposition 3 shows that despite concerns about diversion and default, the efficient amount of fertilizer can be provided in equilibrium for sufficiently patient farmers. In practice, however, farmers in developing countries may be quite myopic.[10] Proposition 3 also states, that in spite of being impatient, the farmer is offered in-kind credit in both states although the amount of this credit is potentially small. However, Proposition 3 does not state whether or not the farmer is

[10]An example of such behavior is reflected in the fact that farmers borrow repeatedly at extremely high interest rates (see for example Aleem 1990, Dreze, Lanjouw and Sharma 1997 and more recently Karlan and Mullainathan 2009).

offered cash credit in the exporter best stationary equilibrium. In this subsection, we show that under certain conditions, providing cash for consumption along with in-kind credit can result in higher equilibrium profits for the exporter. In our opinion, this is the most interesting theoretical insight in the paper.

As we have stressed, contract farming provides an important source of credit for farmers in the absence of formal credit institutions. Farmers are often provided with cash for emergency expenditures along with in-kind credit. Of course, like the in-kind loan, the value of the cash loan is subtracted from the final payment to the farmer. That said, the risk of the loan is borne entirely by the exporter as if the fruit turns out to be of low quality, the exporter will not get paid and the amount of the loan is lost. Moreover, since the cash is being used by the farmer for consumption, this loan does not in any way directly aid in the production of higher quality fruit. Hence, on the surface it seems that such behavior is altruistic on the part of the exporter.

However, there is an indirect benefit from providing cash credit. If the farmer knows that she can count on the exporter to loan her cash for future emergencies, this increases the value of the relationship. Defaulting on the loan today not only implies that she will no longer have access to the export market, it also means that she will lose access to cash credit for potentially important expenditures such as on health, schooling of children etc. Therefore the exporter realizes that provision of such credit discourages default. But this in turn allows the exporter to provide a higher level of in-kind credit than he would been able to in the absence of the additional cash credit. Providing a higher level of in-kind credit ensures higher quality which benefits the exporter directly in the export market but also indirectly as it means that it is less likely that he will lose the total amount loaned to the farmer.

The exporter faces the following tradeoffs. As long as the exporter provides a high enough price for the output, he does not have to fear either diversion or default. This is because a higher price slackens both the diversion constraint and the default constraint. By contrast, additional cash credit slackens the default constraint but tightens the diversion constraint. The latter happens because additional credit in any form increases the repayment obligation of the farmer which decreases the marginal benefit of investment in production. Therefore, the exporter considers providing cash credit only when default is a bigger concern than diversion. Of course, this is not always the case and it occurs only at specific values of the parameters.

The above intuition is summarized in the following proposition which we feel is the most striking theoretical result in the paper. The proof is uninstructive and can be found in Appendix B.

Proposition 4. *The following are true for the exporter best stationary equilibrium:*

(1) *The exporter never offers cash credit in the low state or* $c_l^* = 0$.
(2) *When* $2\overline{\mu} - 1 > \phi q > 2\alpha\overline{\mu} + 1$, *for sufficiently impatient farmers (there exists a* $\overline{\delta} < 1$ *such that whenever* $0 < \delta < \overline{\delta}$*), the exporter will offer both cash credit in the high-state along with in-kind credit in the exporter best stationary equilibrium.*

We now provide some intuition for the range of parameters in the above proposition. When the farmer is impatient, default is the predominant issue. The first inequality $2\overline{\mu} - 1 > \phi q$ implies that the export price is not very high in relation to the marginal utility of consumption for the farmer. Supposing this were not the case, the exporter would choose to reduce default incentives by providing the farmer with a higher price instead of providing cash credit. A high enough export price would ensure that it would not be very costly for the exporter to pay the farmer more for her output to avoid default and diversion. The second inequality $\phi q > 2\alpha\overline{\mu} + 1$ implies that diversion is sufficiency inefficient. This is important, as while cash credit lowers incentives to default, it increases the benefits from diversion. By contrast, if α were close to 1, then the benefits that cash credit provides in reducing default incentives would be overcome by the encouragement it provides to the farmer to divert.

Note that the conditions in Proposition 4 are merely sufficient and are not necessary. It is possible to construct examples of cases where the provision of cash credit can lead to higher revenues even when the farmer is relatively patient. Our aim was to show in the simplest possible way the existence of such scenarios and provide intuitive interpretations of the conditions. A complete characterization of parameter values which lead to cash credit is possible, however, it is a cumbersome case by case analysis and provides no additional interesting insights.

4.4. *Related Relational Contracting Literature*

We would be remiss were we not to mention a few papers from the large and insightful literature on relational contracts. Here we provide a brief description of some related theoretical work. An important early contribution in the literature on relational contracting is Macleod and Malcolmson (1989). They examine a repeated moral hazard framework with one worker and a deterministic output. Levin (2003)'s extension of their model allows for either moral hazard over the worker's effort or adverse selection over the worker's type. A key difference between his model and ours is that in our setup the farmer's possible set of actions is limited by the payment provided by the principle. Moreover, in our setup there is a tradeoff between increasing the set of actions for the farmer by providing a higher loan and the additional burden imposed by the provision of this loan on the functioning of the contract. This is manifested in the fact that while Levin shows that the stationary contracts can generate the maximum level of surplus, this is not necessarily the case in our model.

There is also a dynamic contracting literature in macroeconomics that includes some models with self enforcing contracts. A few early examples that focus on insurance and consumption-smoothing aspects of long-term relationships are Thomas and Worrall (1988) and Atkeson (1991). The agent in our model is risk neutral so these issues are absent in our setting. Perhaps more closely related are the works of Thomas and Worrall (1994) and Albuquerque and Hopenhayn (2004). In their models, an agent (firm or entrepreneur) requires a loan to make a profitable investment and repayment is not enforceable. Our works differ along two main dimensions. Firstly, in their work, lenders are not seeking to maximize profits. This difference is critical as lenders in our setting have to worry about profits and not just about the avoidance of default. Secondly, in

our setting credit can be provided in multiple ways. Our main contribution is to examine how the different ways of providing credit affect the relationship and thereby the exporter's profit.

5. General Case Evidence

In this section, we provide some case evidence on a variety of developing country experiences with contract farming over the past few decades. Note that contract farming is not a new institution, though it has certainly surfaced in some parts of the developing world more recently. There is an extensive literature on contract farming, with a large part of it about the US and other developed countries. And, in practice, there are a wide variety of agricultural contracts between sellers and buyers - Eaton and Shephard (2001) and Bijman (2008) provide good reviews.

In this paper, we tackle a particular type of contract: one where a buyer (exporter in this case) provides the farmer with inputs on credit to encourage a high quality of output and subtracts the loan from the final amount paid for the output. Our aim in this paper has been to analyze this one main aspect of contract farming and our theory serves to explain why credit is provided despite the numerous hurdles presented by the lack of formal contracts and the inability to monitor. By no means do we claim that this paper can explain all the nuances of contract farming and to this end, in the conclusion, we highlight a few avenues for future research.

Bijman (2008) calls the type of contract we study a resource providing contract and claims that such contracts are particularly important when quality management is an issue. He distinguishes these contracts from pure marketing contracts which specify the timing of the sale and the quality of the output and production management contracts where the farmer agrees to follow precise production methods and input regimes specified by the buyer (but there is no credit). In reality, contract farming combines elements of all of these types of contracts (see, for example, Hueth et al. (2007)). As Singh (2002) points out, every contract specifies at least price, quantity, quality and time but often a lot more.

The literature on contract farming is extensive and spans many fields, including sociology, anthropology, politics and economics.[11] Since our theoretical framework examines credit contracts, our case review also focuses on contracts that provide in-kind credit: when they arise, what their

[11]There is a large literature on the impacts of contract farming that we do not discuss in detail here, though the particular scenarios each of the papers is studying may be included in Table 3, depending on whether there was enough information available on the details of the contracts. In general, most empirical studies find large income and welfare gains for farmers to contracting. For example, Bellemare (2010) finds a 12-18% increase in income, 16% decrease in income volatility, 30% increase in probability of receiving a formal loan in Madagascar. Warning and Key (2002) find 55% higher revenues for peanut farmers in Senegal. Similar results are found by Simmons, Winters and Patrick (2005), Miyata, Mino and Hu (2009), Rao and Qaim (2010), Minten, Randrianarison and Swinnen (2009), Maertens and Swinnen (2009), Birthal, Joshi and Gulati (2005) and Ramaswami et al (2006). Little (1994) also finds increases in incomes for most participants.

specific form may be, when they have failed and why. We emphasize the role of interlinked markets[12], not just purchase contracts, but contracts where the buyer or exporter provides credit in return for the crop. In addition, our case review also focuses on what the literature describes as "quality specificity." This is well described by Jaffee (1994) as "...wide variations in quality from unit to unit and from one supply period to another, requiring the transmission of quality-related information and providing incentives for commodity buyers to intervene in the production process through the provision of inputs, technical advice, and so on."

We first document (drawing heavily on Little and Watts (1994) and, in particular, on Watts (1994)) the importance of this type of credit contract in the developing world. In addition, we update this evidence by synthesizing all the more recent case studies as much as possible to not just document the importance of such interlinked contracts, but also documenting the contractual form and the reasons provided in these studies as to why the schemes have worked, illustrating the importance of the following two core components of our model: the demand for quality that is linked to specific inputs and the use of reputation to enforce the credit relationship. We then discuss some cases in more detail where there is evidence that the exporter provides cash or additional support over and above the standard in kind credit contract. Finally, we describe contracting schemes that have failed and what drove these failures, drawing on a few representative examples from the literature.[13]

In addition to specific case studies, there is a vast literature that describes more generally when and where contract farming will be successful (see, for example, Minot (2007), Little (1994), Watts (1994), Grosh (1994) and Dorward, Kydd and Poulton (1998)). Overall these studies generally point to the following being important (which are all confirmed in the case evidence below):[14]

(1) It works where there are large buyers (exporters, large scale processors and supermarkets), but with competition amongst the buyers.[15]
(2) It does not work for commodities that are homogeneous, non-perishable and where quality is easily observable - the transaction costs here are low and spot markets (outside options) are therefore efficient; it only works for cases where spot markets are not efficient, i.e.

[12]There is a broader literature on interlinked markets, see Bell (1988) for a review - he identifies the emergence of interlinked markets when transaction costs are high, and there is asymmetric information and moral hazard. In general, the theoretical literature on interlinked markets has focused on sharecropping (see, for example, Binswanger and Deninger (1997)) and the link between output and land markets and not on the link between output and input markets.

[13]There is a literature that documents the issues contract farming schemes have had in the past, usually because of political or social frictions. For example, Porter and Phillips-Howard document cases in Nigeria and South Africa where there were staffing issues, water control and labor issues. Watts (1994) documents some of the conflicts between growers and contractors over production conditions, credit, transportation costs, collection of produce and pricing. Some of this arose because the schemes were government run or run by parastatals. We do not discuss this older literature where some of the issue arose because the organizations running the contract farming were parastatals.

[14]Woodruff (1998) also shows how macroeconomic policies can affect contract enforcement more generally - he documents the case of the footwear industry in Mexico where there was a breakdown in contract enforcement after trade liberalization because firms could no longer share information to be able to use reputation to enforce contracts.

[15]Locke (2008) looks in more detail at the emergence of trust in Italy and Brazil and how producer organizations were formed to help uphold quality standards and maintain competitiveness.

where spot markets cannot convey information on aspects of quality that final consumers care about.

(3) Contracting happens where crops have important quality variation and specialized inputs are needed to raise quality (sometimes inputs that are otherwise not easily available to farmers, see Goldsmith (1985) for an example), or for high value crops, or for highly perishable crops with technically difficult production.
(4) Contract farming cannot be sustained if there is leakage (farmers side selling) - strong repayment incentives are needed.
(5) A strong demand for the crop.

We start by reviewing the case evidence in Watts (1994). Watts provides an excellent description of the state of contract farming in the developing world. We replicate Table 1 from Watts here (Table 2 in our paper), where he reviewed 66 different contracting schemes across 16 different countries. It is clear from Table 2 just how important a part of agrarian economies contract farming is. Watts also clearly documents in Table 2 the importance of the need for quality as a driver of contracting and especially for contract arrangements that involve in-kind credit across all these schemes.

Before we update the analysis in Watts, we should note that agriculture in developing countries has changed dramatically in the last fifteen years. A lot of the cases in Watts (1994), as can be seen from Table 2, involve state run (and often funded) schemes with a large role for parastatal organizations. In fact, the range of studies in Little and Watts (1994) make this more evident. This aspect has certainly changed over the last fifteen years as a lot of these developing economies have liberalized. For example, Kenya was historically one of the most important economies to be studied in this literature (see Grosh (1994), Jaffee (1993, 1998)) because about 15-20% of farming households were participating in contract farming, and across a wide variety of crops like tea, coffee, tobacco, oilseeds, sugarcane, vegetables, pineapple, sugar and horticulture. During this time, this was mostly Kenyan parastatals as the contractors, certainly for tea, coffee and sugar. However, the Kenyan experience has changed dramatically with a lot of the contractors now being private, post the liberalization in the late 1990s. For example, Mumias that was a large sugar parastatal contracting with up to about 60,000 farmers in the late 1980s, is now a private company that is in fact publicly traded and that still contracts with about 80,000 farmers.

The more recent case studies therefore cover mostly private arrangements that involve private processors or, more often the case, exporters. We document all the more recent evidence in Table 3. We use a very different structure to Table 2 and focus on providing more details on the contract as well as some evidence on what contributed to success in each of these cases. From Table 3, it is clear that most contract farming schemes now involve at the very least credit in kind for inputs as well as a market for output. In addition, most of these cases describe the need for high quality that is dependent on the careful application of inputs and also identify the role of reputation in contributing to success.

Finally, Table 3 also shows a number of cases where the contractor provides the farmer with more than just an in-kind loan to reinforce the relationship. This happens in the pineapple industry in Ghana as documented in the specific case above. Even in the earlier literature, there is some evidence of contractors providing more than just in kind credit. For example, Jackson and Cheater (1994) document how cotton farmers in Zimbabwe also get rights to housing, water, electrical pumping, and administrative services. This was also true for the case of the Kenya Tea Development Authority that had about 150,000 outgrowers in the mid 1980's and provided cash loans as well access to housing and water systems (Grosh (1994)).

5.1. *Failures of Contract Farming*

Finally, we take some time to document a few of the examples in the literature where contract farming failed. Both Grosh (1994) and Jaffee (1993) document the case of the Kenya Horticultural Exporters (KHE). During the 1984 drought in Kenya, spot prices rose and were 2-3 times the contract price and so the contracting scheme collapsed. Jaffee (1993) in fact goes through seven different cases in Africa in detail. Of these seven, five were at least initially a success, partly because they involved an interlinked input and output market. Of these five, only one survived. Two of the other four terminated for exogenous reasons (mostly political). Of the remaining, two, one terminated because competition lowered prices tremendously and the second was the case of KHE that terminated because a drought caused extremely high spot prices. Looking at the two early failures, he documents one case where no inputs were provided as part of the contract, so it was simply a purchase contract and it failed because the produce suffered from low quality so the industry moved towards vertical integration instead. The second failure he documents was because of a large, permanent slump in the market for the product.

Barrett et al (2010) document how contract non compliance is very sensitive to adverse shocks and how it also is a function of the number of smallholders that a given exporter or buyer is contracting with - the more growers a buyer contracts with, the more likely there is to be some default. In India, they document a lot of exit on both the firm side as well as the farmer side because of highly volatile demand and lots of competition.

Carney (1994) looks at a government run rice scheme in the Gambia. The farmers were provided with water, a mechanical plowing service and a package of high-yielding rice varieties, fertilizers and pesticides and were expected to repay the costs of land preparation, water and inputs with a portion of their harvest. A failure to repay debts would lead to eviction from the scheme. Yields of rice were much lower than expected and many farmers were unable to repay their loans, which caused the scheme to collapse.

Daddieh (1994) looks at palm oil in Ghana and Cote D'Ivoire. Ghana was a success and Cote d'Ivoire was also generally successful in the early years, but later, the prices offered to outgrowers were very low and so the farmers defaulted by diverting produce to the open market.

Poulton, Dorward and Kydd (1998) describe how prior to liberalization, parastatals were the contractors in a lot of Sub-Saharan economies, linking the provision of credit (as in-kind inputs) to

access over farmer output. After liberalization, however, there was competition with many more buyers, so farmers had incentive to default on input loans and sell to alternative buyers. In their Ghana cotton case, even though firms colluded to offer a common seed price, the price ended up being too low and generated strategic default.

6. Conclusion

Informal contracts of various kind are widespread in the developing agrarian economy and are critical for its proper functioning. Contract farming is important not just because it provides farmers with a market for their produce but also serves as a means to provide them with inputs (that determine quality) which they either may not be able to afford or not have access to. In addition, being able to provide her output as collateral, allows farmers to get access to credit for consumption emergencies. The aim of this paper has been to study the economics behind contract farming: why it emerges and, more importantly, why it functions. Our theoretical framework displays the power of relational contracting and how it can be used to overcome the inability to monitor and the hold-up problem facing the creditor.

There are a number of different avenues for future research. One particular direction which might prove fruitful would be to generalize the theory to allow for the exporter to pick a farmer to contract with out of a set of farmers. Such a direction has been taken by Levin (2002) and Board (2010) who develop classical relational contracting models where there are multiple agents. If farmers have unobserved heterogeneities, they would like to develop a reputation with the exporter so that they do not lose out to other farmers in securing future contracts. History dependent contracts could make explicit the incentives for the farmers to build such reputations and the value of loyalty in discouraging default.

Another interesting way to generalize the model, is to allow the demand for the crop in the export market and hence the price q to vary over time. As we have argued, the success and failure of contract farming depends on future profits for both parties and these are driven by potential future demand for the crop. A bleak future encourages farmer default and makes it more attractive for exporters to renege on their payment obligations. In such a model, we could expect to see the changing demand lead to the dissolution and the re-emergence of contract farming over time.

Table 2 (Drawn from Table 1 in Watts (1994))

Commodity	Class	# Countries	# Schemes		Ownership (% schemes)			Avg # farmers	Avg acreage/ farmer (ha)	Export (E) or domestic (D)	Services	Organizational form
			Total	% with Nucleus Estate	Private	State	Joint					
Coffee	Q	4	4	50	50	50	0	500	1.5	D, E	C, E, I	1, 3
Cotton	Pr	4	4	50	33	67	0	9,500	-	D, E	C, E, I, T	3
Dairy	P, T	3	3	25	0	100	0	4,000	-	D	-	1, 4
Gari (cassava)	F, Pr	1	1	0	100	0	0	141	1	D	E, I, T	2
Horticulture	Q, P	9	10	10	80	0	20	1,160	0.2	E	C, E, I, T	2, 4
Oilseeds	Pr	1	1	0	100	0	0	1,500	1.5	D	E, T	3
Palm Oil	Pr	5	8	100	0	80	20	2,000	4.0	D, E	C, E, I, T	1,2
Pineapples	Pr	2	2	50	50	0	50	25	-	E	E, I, T	1, 2
Poultry	T	1	1	100	0	0	100	20	400	D	C, E, I, T	1, 2
Rice	F	2	2	0	0	50	50	2,000	0.2	D	C, E, I, T	2
Rubber	Pr	2	2	100	50	50	0	1,200	5.0	E	C, E, T	1, 2
Spices	Q	1	1	0	-	-	-	100	small	E	E, I, T	3, 4
Sugar	P, Pr	6	12	90	33	33	33	5,000	2.3	D, E	C, E, I, T	1, 2
Tea	P, Pr	5	7	60	33	67	0	26,000	0.5	D, E	C, E, I, T	1, 2
Tobacco	Q	6	6	0	10	45	45	5,500	0.6	D	C, E, I, T	3

Some columns from Watts (1994) have been omitted.

Class: Q=quality control, P=perishability, Pr=large scale processing,, T=throughput, F=food contracts

Services: C=credit, I=inputs, T=technical assistance, E=extension

Organizational form: 1=nucleus estate and processing, 2=centralized outgrowers & processing, 3=decnetralized outgrowers & processing, 4=outgrowers & marketing company

Table 3: Case Study Summary Post Watts (1994)

Study	Commodity	Country	Export (E) or domestic (D) market	What does the contract provide	Descriptions of the contracts and why they succeeded
Barrett et al (2010)	Pineapple Gherkin Cotton Papaya Marigold Vegetables Horticulture	Ghana India India India India Madagascar Nicaragua	E E D, E D, E D, E D, E D	IKC, T	Claim a relation between group participation and contracting. NGO involvement seems to increase profits to firms and expected welfare gains of suppliers. Reputation and social connections play a role in small-holder participation.
Bellemare (2010)	Green vegetables	Madagascar	E	IKC, T	Technical assistance and supervision provided by the buyer (proxy is number of visits by a technical assistant) increased productivity of farmers in contract farming arrangements.
Michelson (2010)	Fresh vegetables	Nicaragua	D	IKC* (provided by NGOs)	Supermarkets want products of a particular quality and volume, produced by specific agricultural practices. Farmers who enter the supermarket supply chain experience less price volatility, and positive effects on income. They also make significant investments in productive assets and irrigation
Harou and Walker (2010)	Pineapples	Ghana	D, E	T	Time of entry and participation in a co-operative appear to be important determinants for farmers' ability to continue to produce pineapples through shocks.
Rao and Qaim (2010)	Vegetables	Kenya	D	T* (provided by NGOs)	Participation in supermarket channels increased income significantly. Smaller, poorer farms benefited disproportionately. Farmers who receive NGO support are more likely to participate
Minten, Randrianarison and Swinnen (2009)	Vegetables	Madagascar	E	IKC, T	Small farmers that participate in contract farming have higher welfare, more income. Also find significant effects on technology adoption, better resource management and spillovers on the productivity of staple rice crop.
Maertens and Swinnen (2009)	Horticulture	Senegal	E	CC, IKC, T	Highly significant and large effects on income and poverty. Shift from small-holder contract farming to estate production shifts mechanism of benefit from product markets to labor markets.
Suzuki, Jarvis,	Pineapples	Ghana	E	CC, IKC	Exporters in Ghana purchase some of their supplies from farmers

and Sexton (2008)					on contract. Suggest that exporters are transferring some risk of demand fluctuations to contract farmers who can diversify their risk over different crops
Miyata, Minot and Hu (2007)	Apples Green Onions	China	D, E E	IKC, T IKC, T	Farmers cited guaranteed and high prices as major reasons for contracting production. Study suggests that contract farmers earn more, and, in some cases, have higher yields. Firms, in turn, can ensure food safety and quality requirements of consumers.
Hernandez, Reardon and Berdegue (2007)	Tomatoes	Guatemala	D	IKC*, T* (from input companies, not buyers)	Famers selling to supermarkets have more capital, are more specialized in horticulture and are larger. They have higher yields, but also higher input use so profits are similar to farmers in the traditional market channel
Saenz- Segura (2006)	Pepper Chayote	Costa Rica Costa Rica	D, E D, E	IKC, T CC, IKC, T	Contracts provide farmers with the insurance, incentives and information that is required for them to initiate new production for international markets. This has positive implications for equity, efficiency and sustainability.
Strohm and Hoeffler (2006)	Green Beans Passion Fruit Potatoes Poultry	Kenya	E E D D	IKC, T T CC, T IKC, T	Advantages of contract farming to producers: guaranteed market, higher prices and regular payments, pre-financed inputs, technical assistance, and transport. Advantages to buyers: Can ensure quantity and quality and meet food standards and traceability requirements for export.
Ramaswami, Birthal and Joshi (2006)	Poultry	India	D	IKC, T	Contract production more efficient than production by independent growers. While most of the efficiency gain goes to the buyers, contract growers do benefit over being independent growers.
Masakure and Henson (2005)	Vegetables	Zimbabwe	E	IKC, T	Top four reasons from farmers are the need for extra income, no transport costs, guaranteed output market and reliable supply of inputs
Guo, Jolly and Zhu (2005)	Agricultural Products	China	D, E		Find that informal contracts have higher compliance than formal contracts (due to social networks and reputation mechanisms). For firms, contracts stabilize supply of raw materials and improve quality. For farmers, price stability and market access are cited as advantages of contract farming.
Birthal, Joshi and Gulati (2005)	Milk, Broilers, Vegetables	India	D	IKC, T	Contract farming reduces transaction costs. No bias against small-holders. Farmers benefit from assured market and higher prices
Winters,	Hybrid Seed	Indonesia	D,E	CC, IKC, T	The contract was welfare-improving for farmers. Attribute

Simmons and Patrick (2005)	Corn				success of contracting to presence of farmers' groups which lowers transaction and enforcement costs for firm
Minot and Ngigi (2004)	Fresh Fruits and Vegetables	Kenya Cote D'Ivoire	E E	IKC, T* (Provided by govt)	Both Kenyan and Ivorian horticultural exports have been a success although in Kenya more smallholders have benefited than in Cote D'Ivoire. Factors contributing to success include geography and climate, transport infrastructure, political stability, and good investment climate.
Singh (2002)	Vegetables (Tomato, Potato, Chili)	India	E	IKC, T	Production requires high degree of quality which depends on specific inputs. For farmers, better and reliable income, better farming skills and better soil management are incentives to continue contract farming; 90% of farmers met contract terms in the past.
Warning and Key (2002)	Peanuts	Senegal	E	IKC, T	Perceived honestly mattered in which farmers picked to participate. The use of local agents by the contracting firm helped address the problem of asymmetric information.
Key and Runsten (1999)	Frozen vegetables	Mexico	E	CC, IKC, T	Reputation; Input markets hard to access for farmers and inputs expensive, especially early on
Woodruff (1998)	Footwear	Mexico	D, E		In the closed economy manufacturer's associations could share information on retailers as a means of contract enforcement. Trade liberalization reduced manufacturers' power since retailers now had an expanded pool of suppliers and it was difficult for trade associations to provide information on foreign buyers.
Poulton, Dorward and Kydd (1998)	Cashew Cotton Cotton	Tanzania Ghana Pakistan	Not specified	IKC	Most small-holders need seasonal credit to purchase inputs: contracts allow for farmers to repay loans at harvest time. Strategic default is minimized by use of intermediaries with local knowledge who can help ensure repayment.
Porter and Phillips-Howard (1997)	Barley Sugar, Tea	Nigeria South Africa	Not specified	IKC, T	Small farmers have greatest bargaining power when they retain ownership of land and water supply, have alternative sources of income and have experience with MNCs.

CC= Cash Credit, IKC= In-Kind Credit (in the form of inputs), T=Technical Assistance

APPENDIX A. CHANGES IN THE PINEAPPLE INDUSTRY AFTER 2001

In 2004, the industry faced a large drop in European demand as they shifted to a different pineapple variety. However, Harou and Walker (2010) and Barrett et al. (2010) also discuss the role of market saturation in contributing to the almost collapse of the industry. Harou and Walker (2010) study entry and exit of farmers into pineapple cultivation and claim that cooperatives and other farmer organizations helped farmers produce and sell pineapple by giving them more bargaining power and market power with exporters. Unfortunately, they do not distinguish contract farming with a pure purchase contract on the part of the exporter here. From their surveys with farmers, they find that of the farmers that exit the industry completely, 35% claimed it was due to a bad market, 26% due to lack of funds and 16% because of default and exporter problems. However, there is little systematic information on what the 2003/2004 demand shock did to farmers that were in successful credit contracting relationships across the industry. The Harou-Walker sample is the same as the Goldstein Udry sample and it is not clear how many were in credit relationships (as opposed to simple buying contracts) with exporters and how those that were fared in response to this supply shock. That said, it would be unsurprising if it led to a collapse in contracting given the volume of pineapple exported fell about 44% between 2005 and 2007.

APPENDIX B. PROOFS

B.1. *Proof of Lemma 1*

Proof. Assume the converse that either $L_i^c \neq c_i$, $L_i^k \neq k_i$ or both for some $i \in \{h, l\}$. We first observe that the farmer will never simultaneously use cash for fertilizer and divert fertilizer towards consumption. This is because she could increase utility by using ε amount of the cash spent on fertilizer for consumption and instead use ε of the in-kind credit towards production instead of diversion. This leaves the two remaining cases which are addressed individually.

Case I: $k_i > L_i^k$ or the farmer is using all of the in-kind loan and part of the cash loan for production.

Consider instead that the farmer is offered an in-kind loan of k_i and a cash loan of $L_i^c + k_i - L_i^k = c$ without changing the price. This serves to shrink the farmer's budget set but she can still choose k_i, c_i and hence this will still remain an optimal choice for her. Since the total value of the loan is unchanged this will not affect her default constraint.

Case II: $k_i < L_i^k$ or the farmer is some of her in-kind loan to consumption.

Consider instead that the farmer is offered an in-kind loan of k_i and a cash loan of $L_i^c + \alpha(L_i^k - k_i) = c_i$ without changing the price. Once again, this serves to shrink the farmer's budget set but she can still choose k_i, c_i and hence this will still remain an optimal choice for her. Since the total value of the loan is reduced, this relaxes the default constraint and hence, this will still constitute an equilibrium. However, the lower total amount of the loan implies higher profits for the exporter. □

B.2. *Proof of Proposition 3*

We start off by making the following observation about the maximization problem which constitutes the exporter best stationary equlibrium.

Lemma 2. *Constraints* (Def_h) *and* (Def_l) *bind.*

Proof. Let us start off by arguing constraint (Def_h) binds. We can use an identical argument for constraint (Def_l). Let us assume to the contrary that (Def_h) does not bind. We first argue that in this case (Div_h) must bind. If it didn't then we could increase k_h^* by a small amount and alter p_h^* in such a way so that $\phi k_h^*(p_h^* - k_h^* - c_h^*)$ remains unchanged. This change would not affect default constraint (Def_l) and since the diversion constraint (Div_h) and default constraint (Def_h) are slack, a small enough change would not violate them. This change, however, would increase revenue in the high state. This can be seen by examining the expression for revenue in the high state

$$\phi k_h^* \left[q - p_h^*\right] - \left[1 - \phi k_h^*\right] \left[k_h^* + c_h^*\right] = \left[\phi k_h^* q - k_h^* - c_h^*\right] - \phi k_h^* \left[p_h^* - k_h^* - c_h^*\right]$$

The second term is unchanged and the first term increases as $\phi q > 1$. Therefore, (Div_h) must bind. Since (Div_h) binds, the price p_h^* must be given by

$$p_h^* = \frac{\alpha\mu}{\phi} + k_h^* + c_h^*.$$

Plugging this into the revenue expression for the high state we get

$$k_h^* \left[\phi q - \alpha\mu - 1\right] - c_h^*.$$

Now, we can increase both p_h^* and k_h^* by ε. This leaves the diversion constraint (Div_h) unchanged and further slackens the right side of low state default constraint (Def_l). For a small enough increase the slack high state default constraint will continue to hold and since $\phi q > \alpha\mu + 1$, this would lead to an increase in revenue. Therefore, we conclude that at the exporter best stationary equilibrium (Def_h) must bind. Since $\phi q > \alpha + 1$ as well, the identical argument can be made to show (Def_l) binds as well. □

Immediately, the previous lemma implies that

$$k_h^*[k_h^* + c_h^*] = k_l^*[k_l^* + c_l^*]$$

Lemma 3. *In the exporter best stationary equilibrium* $k_h^* \leq k_l^*$ *and* $c_h^* \geq c_l^* = 0$.

Proof. We will show that it is never optimal for the exporter to provide a cash loan in the low state. This in turn implies $k_h^* \leq k_l^*$ using the above shown equality $k_h^*[k_h^* + c_h^*] = k_l^*[k_l^* + c_l^*]$. The reason the exporter doesn't provide a cash loan in the low state is simple. Providing a cash loan requires the exporter to raise the price to discourage default and has to face the risk of the cash loan as well. Instead of providing a cash loan in the low state it is better for the exporter to offer a higher price instead. This is shown as follows. The profit the exporter makes in the low state can be rewritten as

$$\phi k_l^* \left[q - p_l^*\right] - \left[1 - \phi k_l^*\right] \left[k_l^* + c_l^*\right] = (\phi q - 1)k_l^* - \left[\phi k_l^*(p_l^* - k_l^* - c_l^*) + c_l^*\right]$$

Consider now that the exporter instead offers no cash loan and instead offers a price p such that

$$\phi k_l^*(p - k_l^*) = \phi k_l^*(p_l^* - k_l^* - c_l^*) + c_l^*.$$

First observe that when $c_l^* > 0$, $p - k_l^* > \frac{\alpha}{\phi}$. This is because the diversion constraint implies $p_l^* - k_l^* - c_l^* \geq \frac{\alpha}{\phi}$ and hence,

$$\phi k_l^*(p - k_l^*) = \phi k_l^*(p_l^* - k_l^* - c_l^*) + c_l^* \geq \alpha k_l^* + c_l^* > \alpha k_l^*.$$

Therefore when the exporter offers a price p and an in-kind loan k_l^*, the diversion constraint in the low state is satisfied. Notice also that the right side of the default constraints are unaffected by our choice of p and hence the high state default constraint is still satisfied. Since ${k_l^*}^2 < k_l^*[k_l^* + c_l^*]$, the low state default constraint is slack. Moreover, examining the rewritten profit expression, we can conclude that the revenue of the exporter is unaffected by this alternate contract.

But now if we were to increase k_l^* by ε and adjust p in a way keeping $\phi k_l^*(p - k_l^*)$ constant we can improve profits. Moreover, since both the diversion and the default constraint in the low state are slack, small enough changes will not violate them. This completes the proof. □

A consequence of these lemmas is that when no cash credit is offered in the high state, then the in-kind credit offered in both states is the same or $k_h = k_l$. This considerably simplifies the maximization problem corresponding to the exporter best stationary equilibrium. The remainder of our argument proceeds as follows. We find the highest level of profit attainable by the exporter by offering an in-kind loan alone and and argue that this can be improved upon by offering some cash credit in the high state. This would then imply that cash credit is offered in the high state in the exporter best stationary equilibrium.

Proof of Proposition 3. The first part follows from the Proposition 2 and Lemma 2. Using the argument to prove Proposition 2, we can conclude that $k_l > 0$. But then Lemma 2 implies that $k_h > 0$. The second part of the proposition is shown in Lemma 3. The proof of part 3 follows from the fact that the default constraints do not bind for sufficiently high δ even when the exporter offers k^* in both states. □

B.3. *Proof of Proposition 4*

Proof of Proposition 4. Let us start off by writing the problem for the exporter without cash credit and imposing $k_l = k_h = k$. The objective function is now

$$\max_{p_h, p_l, k} \left\{ \phi k q - [1 - \phi k]\, k - \phi k[\gamma_h p_h + \gamma_l p_l] \right\}.$$

There is only one default constraint

$$\begin{aligned} \phi k^2 &\leq \frac{\delta}{1-\delta} \left[\phi k(\gamma_h p_h + \gamma_l p_l - k) \right] \\ \equiv \frac{k}{\delta} &\leq \gamma_h p_h + \gamma_l p_l \end{aligned}$$

but two diversion constraints

$$p_h \geq \frac{\alpha\mu}{\phi} + k,$$
$$p_l \geq \frac{\alpha}{\phi} + k.$$

Since the above constraints are linear in k, there will be a value of k above which only the default constraint will bind. When only the default constraint binds, we can just rewrite the maximization problem in terms of a single price $p = \gamma_h p_h + \gamma_l p_l$ as this will be the only price that appears in the constraint and in the objective function. The level of in-kind credit at which the default constraint binds is simply the solution to the above three constraints when they hold with equality or

$$\tilde{k} = \frac{\alpha\delta(\gamma_h\mu + \gamma_l)}{\phi(1-\delta)} = \frac{\alpha\delta\overline{\mu}}{\phi(1-\delta)}.$$

There is a value of the discount factor $\tilde{\delta}$ such that $\tilde{k} < k^*$ whenever $\delta < \tilde{\delta}$. Until otherwise specified, in the argument that follows, we take $\delta < \tilde{\delta}$. In order for more in-kind credit to be optimal it must be the case that the derivative of the profit equation at $\tilde{k}$ along the default constraint be positive. Taking a derivative at values of k above $\tilde{k}$, we get

$$\begin{aligned}\pi'(k) =& \phi\left[q - p\right] - \phi k\frac{dp}{dk} - \left[1 - 2\phi k\right],\\ =& \phi\left[q - \frac{k}{\delta}\right] - \frac{\phi k}{\delta} - \left[1 - 2\phi k\right].\end{aligned} \tag{2}$$

Evaluating the derivative at $\tilde{k}$, we get

$$\begin{aligned}\pi'(\tilde{k}) =& \phi\left[q - \frac{\alpha\overline{\mu}}{\phi(1-\delta)}\right] - \frac{\alpha\overline{\mu}}{1-\delta} - \left[1 - \frac{2\alpha\overline{\mu}\delta}{1-\delta}\right]\\ =& \phi q - 1 - 2\alpha\overline{\mu}\end{aligned}$$

Since $\phi q > 1 + 2\alpha\overline{\mu}$, the exporter's profit can be raised by offering an in-kind loan higher than $\tilde{k}$. Setting (2) equal to zero we can get the profit maximizing level of in-kind credit $\hat{k}$,

$$\begin{aligned}&\phi\left[q - \frac{\hat{k}}{\delta}\right] - \frac{\phi\hat{k}}{\delta} - \left[1 - 2\phi\hat{k}\right] = 0,\\ \implies &\hat{k} = \frac{\delta(\phi q - 1)}{2\phi(1-\delta)}.\end{aligned}$$

Of course, the first order condition only yields the solution when $\hat{k} \leq k^*$. Once again, there will be a value of δ given by $\hat{\delta}$ such that $\hat{k} < k^*$ whenever $\delta < \hat{\delta}$. Until otherwise specified, in the argument that follows we take $\delta < \min\{\tilde{\delta}, \hat{\delta}\}$.

The high state default constraint is

$$\phi k p + \left[\gamma_h\mu - \frac{\phi k}{\delta}\left(1 - (1-\gamma_h)\delta\right)\right]c \geq \frac{\phi k^2}{\delta}.$$

We start off by showing that $\gamma_h\mu > \phi\hat{k}\left(\gamma_h + \frac{1-\delta}{\delta}\right)$. Plugging in the expression for $\hat{k}$, we get

$$\gamma_h\mu > \phi\frac{\delta(\phi q - 1)}{2\phi(1-\delta)}\left(\gamma_h + \frac{1-\delta}{\delta}\right)$$

$$\equiv \phi q < \frac{2\gamma_h \mu(1-\delta)}{1-\delta+\delta\gamma_h} + 1$$
$$\equiv \phi q < \frac{2\gamma_h \mu}{1+\frac{\delta\gamma_h}{1-\delta}} + 1$$

Notice the right side of the above inequality is decreasing in δ and therefore attains a maximum at $\delta = 0$. But at $\delta = 0$ the right side reduces to $2\gamma_h\mu + 1$ and the inequality is satisfied as we have $\phi q < 2\gamma_h\mu + 1 - 2\gamma_h$ by assumption.

We now argue that

$$\frac{\gamma_h(1-\phi\hat{k})}{\gamma_h\mu - \frac{\phi\hat{k}}{\delta}(1-(1-\gamma_h)\delta)} < 1.$$

Recall that we have already shown that the denominator of the above expression is positive. Simplifying, we get

$$\frac{\gamma_h\left[2(1-\delta)-\delta(\phi q-1)\right]}{2\gamma_h\mu(1-\delta)-(\phi q-1)(1-\delta+\delta\gamma_h)} < 1,$$
$$\equiv \gamma_h\left[2(1-\delta)-\delta(\phi q-1)\right] < 2\gamma_h\mu(1-\delta)-(\phi q-1)(1-\delta+\delta\gamma_h),$$
$$\equiv 2\gamma_h(1-\delta) < 2\gamma_h\mu(1-\delta)-(\phi q-1)(1-\delta),$$
$$\equiv 2\gamma_h < 2\gamma_h\mu-(\phi q-1),$$
$$\equiv \phi q < 2\overline{\mu}-1.$$

The last inequality is true by assumption. We finally argue that the exporter can get higher profits than the contract which consists of in-kind loan $\hat{k}$ and the associated price $p = \hat{k}/\delta$. We show this by arguing that profit can be increased by decreasing the price p and instead providing some cash credit c. We reduce the price p by $\frac{\varepsilon}{\phi\hat{k}} > 0$ where ε is small. This would lead to a violation of the default constraint. We can now increase c in order to satisfy the default constraint. A decrease in p by $\frac{\varepsilon}{\phi\hat{k}} > 0$ leads to a decrease of the left side of the default constraint by ε. Therefore we can satisfy the default constraint by increasing c by $\frac{\varepsilon}{\gamma_h\mu-\frac{\phi k}{\delta}(1-(1-\gamma_h)\delta)}$. For small enough ε, the diversion constraint will not be violated as it is slack. This changes profit by

$$\Delta\pi = \varepsilon - \frac{\gamma_h(1-\phi\hat{k})}{\gamma_h\mu-\frac{\phi k}{\delta}(1-(1-\gamma_h)\delta)}\varepsilon = \varepsilon\left(1-\frac{\gamma_h(1-\phi\hat{k})}{\gamma_h\mu-\frac{\phi k}{\delta}(1-(1-\gamma_h)\delta)}\right) > 0$$

Therefore profits can be increased above the maximum attainable profits via in-kind loans alone and this implies that at the exporter best stationary equilibrium cash credit will be offered. This completes the proof. □

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