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Endogenous emergence of credit markets: Contracting in response to a new technology in Ghana ☆

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ABSTRACT

Access to credit is important for the productivity and overall welfare of farmers in developing countries. We present a theoretical framework which shows that a change in the mode of shipping (from air to sea) in the Ghanaian pineapple industry made it profitable for pineapple exporters to provide myopic farmers with both in-kind loans (to improve productivity) and cash loans (for consumption smoothing) despite being unable to monitor farmers or enforce repayment. The innovative theoretical result is that providing farmers with additional cash loans can enforce greater input use without compromising repayment. We provide evidence in the form of a case study documenting the dramatic rise of informal credit (through contract farming) after the switch to sea-freight between 1996 and 2001. Using this anecdote, we argue that credit arrangements can arise spontaneously, absent non-market interventions to meet market needs even in the absence of proper legal protections for creditors.

1. Introduction

There is general agreement among researchers and policymakers that poor agricultural households in developing economies lack adequate access to credit. These poor households do not meet the traditional criteria for borrowing (especially given the long production cycle in agriculture) and hence are often perceived as bad credit risks by private financial institutions. This has a significant impact on these households for whom credit is vital. Loans allow smallholder farmers to invest enough to get productivity gains and it has been shown that alleviating capital constraints can have big effects.[1] In addition, loans may be crucial for poor households to smooth consumption in emergencies and thus can affect nutrition, health and overall household welfare.

In response to this need for credit, policymakers have attempted to intervene in markets. Governments have introduced state-owned development banks and while some have been successful,[2] others have proved to be an inefficient source of credit,[3] have been subject to political capture[4] and have had distortionary effects.[5] Microfinance institutions have been shown to have impacts but the impacts seem to be small on average with bigger benefits for only a small proportion of people.[6] Ultimately, developing economies need a range of financial products and no single type of credit instrument can suffice. For example, microfinance loans are typically paid every week and are hence of limited use for capital investments in the agricultural cycle.

Our contribution in this paper is primarily theoretical. We use anecdotal case study evidence from the pineapple industry in Ghana to document the advent of a new shipping technology and the concurrent

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[1] Conning and Udry (2007) and World Bank (2007) provide a good review; also see the studies on the effects of capital grants, such as de Mel et al. (2008), McKenzie and Woodruff (2008), Fafchamps et al. (2011).

[2] For example, in China.

[3] For example, in the Philippines (David, 1984) and India's Integrated Rural Development Program (Meyer, 2002; Pulley, 1989).

[4] Cole (2009).

[5] World Bank (2007) provides a short review.

[6] Banerjee et al. (2010), Karlan and Zinman (2011) and Crépon et al. (2011).

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emergence of an informal credit market via which farmers were able to acquire both loans for inputs and for consumption smoothing from pineapple exporters–credit contracts commonly referred to as contract farming.[7] We then develop a model of informal contracting which explains why a credit market functioned after, but could not function before the technology change. Using this theoretical framework, we show that not only did the credit benefit the smallholder farmer, but the form of the loan additionally allowed the credit provider to better control the farmer's actions. Moreover, our model explains the nature of the offered credit contracts by showing that the provision of credit through multiple channels (cash and in-kind) can facilitate contracting and lead to higher profits for the loan providers. This sort of credit institution is common in developing economies. It is known that the quality of institutions determines economic progress and development.[8] Hence, we feel that our results may be important for policy makers who seek to understand the factors which lead to the emergence of institutions where they are absent.

In particular, we develop a model of informal credit through contract farming aimed at explaining both the reasons behind its emergence in our anecdote from Ghana and the form that the credit contracts took. Present in the model are three of the main issues which could lead to a breakdown of informal contracting. The first is that a farmer who receives credit may default and end up selling her output to a buyer other than the one with whom the farmer is contracting (side selling or extra-contractual marketing). By holding up the buyer, the farmer does not have to repay her loan obligation. The second is the moral hazard problem that stems from the buyer's inability to monitor the farmer's production process. There is no guarantee that the farmer will use the inputs provided on the crop as opposed to using them on a different crop or selling them for cash in the market. Lastly, in spite of the farmer's best efforts, the crop may end up being of poor quality in which case the exporter cannot recover his loan or, in other words, the farmer has limited liability. This implies that providing loans is always risky for the exporter. Since contracting is informal, the exporter must provide dynamic incentives to overcome these hurdles. Providing dynamic incentives is tricky as farmers in developing countries are often myopic.[9]

Firstly, the model uncovers how the difference in observable quality at the time of shipping altered the hold-up problem which affects informal contracting. We argue that this made contracting possible under sea freight when it wasn't under air freight. In the case of air freight, the quality of the fruit was observable to the farmer when she was deciding whether to default on the loan or not. Thus, if the fruit was of high quality, there were large gains to be had by holding-up the exporter and selling the fruit to someone else. By contrast, at the time of shipment by sea, the farmer could not foresee the end quality of the fruit once it arrived at Europe. Therefore, the expected gains from holding-up the exporter were lower and this made the prospect of default less attractive. We argue that for myopic farmers, this easing up of the hold-up problem was necessary in order for the exporters to provide them with credit without the fear of default.

Secondly, the model shows that, under certain conditions, it is profitable for the exporter to offer credit not just in the form of inputs to production but also cash for consumption. Put differently, the exporter can benefit by providing the farmer with money in consumption emergencies, knowing that it would not be spent on production. This is a counterintuitive result as it seems that by providing the farmer with a cash loan for consumption, that the exporter is needlessly bearing additional risk from credit provision without receiving any benefits from improved production. Hence, such behavior might seem to be altruistic. However, we argue that this additional credit raises the value of the relationship for the farmer and makes her more reluctant to default. This in turn allows the buyer to provide higher amounts in-kind credit without fearing default thereby increasing profits. That the type of transfer may have critical implications in the functioning of informal contracts is an important implication of our model and, to our knowledge, is a result that hasn't been identified in previous theoretical work. We discuss how this result may be relevant in other settings in Section 6 where we provide concluding remarks.

We provide anecdotal evidence from the field in the form of a case study[10] from Ghana where in 1996, refrigerated sea freight became an option for pineapple exporters to ship their produce to European markets. The cost savings to the exporters of using sea freight as compared to the only other option, air shipping, was substantial. However, we argue from our qualitative interviews that this technological innovation meant that the quality of the pineapple at the time it was shipped was no longer observable. This is because the transit time to Europe took ten to twelve days by sea as opposed to a few hours by air. 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 (due to the short freight time) and so was observable for the intent and purposes of the exporter. However, for the case of sea shipping, due to the long transit time, the quality of the pineapple by the time it was received in Europe could no longer be predicted in advance by either the exporter or the farmer. We argue is that it was precisely this unobservable quality that both necessitated and facilitated the advent of credit arrangements.

In response to this change in shipping technology, as the model predicts, credit arrangements emerged between the exporters and the pineapple growers in which farmers were offered cash loans (for consumption) and in-kind loans of high quality fertilizer (for production) in exchange for a contract on the fruit. This allowed the farmers to apply fertilizer in production which they otherwise could not afford — the application of high quality fertilizer increases the odds that the ripe fruit is of high quality. This case study is thus an instance where credit institutions tailored to particular markets seemed to emerge endogenously without government interventions in response to market needs.

1.1. Related literature

Related to our work is the chapter by Ghosh et al. (2001) which summarizes the incentives uncovered by the theory of credit in developing countries. They construct separate theories incorporating moral hazard (with implications for debt overhang) and self-enforcement in credit contracts (with implications for credit rationing). The framework of our model, its underlying economics and our final goal are different from theirs. Our model simultaneously incorporates both

[7] Contract farming is a ubiquitous agricultural institution not just in Africa but across most developed and developing economies and involves both large and small scale farmers. It is prevalent in the market for tree and cash crops, fruits and vegetables, poultry, dairy products and even fish. In essence, it is an agreement (formal or informal) between farmers and buyers (private or public) of produce. It serves as an important source of credit for farmers across the developing world and provides them not just with inputs for production but also with loans which allow them to smooth consumption. See for example Bijman (2008).

[8] See for example North (1989), Acemoglu et al. (2004) and Acemoglu and Robinson (2005).

[9] For example, Schaner (2011) finds that discount factors are quite low in Western Kenya, with weekly discount factors ranging between 0.79 and 0.8. Also for Western Kenya, Dupas and Robinson (2011) who report that only 10% of their sample are somewhat patient and 22% are present biased. Other estimates for discount factors are provided by Tanaka et al. (2010) and Ashraf et al. (2006) are for Asia and are a little higher. An example of myopic behavior is the fact that poor farmers borrow repeatedly at extremely high interest rates. See Banerjee (2004) for a survey of the evidence of high interest borrowing in developing countries.

[10] While we would have liked to provide more micro level regression based evidence on the impacts of the technology change on the credit contracts, the data to do so is simply not available. The pineapple market in Ghana collapsed in 2004 due to a shift in world demand away from the variety produced in Ghana. The Goldstein and Udry (1999) data provides evidence before the shift, but there are no relevant surveys conducted between 2000 and 2003 to provide evidence post the change.

moral hazard and strategic default. In addition, the lender in our model sets the terms of the debt contract thereby controlling both profits and repayment. Most importantly, our main contribution is the development of a single model of myopic borrowers which can explain how changes in the shipping technology in Ghana allowed credit contracts to function. In addition, our model allows for multiple channels of credit, an aspect which (to the best of our knowledge) has been largely ignored by the literature.[11]

This last aspect bears resemblance to Spagnolo (1999) (which while having a fundamentally different setup most notably without moral hazard), argues that surplus generated by one type of repeated transaction can help to enforce another. The basis for our results differs in at least two aspects. Firstly, the provision of cash credit in our model is always detrimental to the seller in the stage game. By contrast, in Spagnolo's setting both agents benefit from cooperation. Secondly, in our model, the exporter only offers credit through multiple channels when the farmer is sufficiently impatient. An implication is that the additional channel of credit remains strictly beneficial to the exporter even when the farmer's discount factor is close to zero. This contrasts with Spagnolo's result (and the broader literature on multimarket contact) where extreme impatience nullifies the enforcement effect of harsher punishment.

Since our model is one where there is repeated borrowing without legal enforcement, it is related to the works of Clay (1997), Greif (1989, 1993), Greif et al. (1994) and McMillan and Woodruff (1999) who provide historical and empirical evidence of trade and credit in countries without well developed legal institutions. Ghosh and Ray (1996) develop a theoretical framework for studying cooperation in communities with incomplete information about past conduct. The problem we study is also similar to that of sovereign debt (Eaton and Gersovitz, 1981). Lender countries cannot enforce loan repayment from borrowing countries and default is deterred solely by the threat of lack of future access to credit.

This paper is also related to the vast literature on interlinked markets in developing economies. Bell (1988) and Binswanger and Deninger (1997) provide a review of interlinked transactions, defined as "one in which the two parties trade in at least two markets on the condition that the terms of all such trades are jointly determined." Examples of such interlinkages include the commonly known sharecropping contract and the interlinking of a credit and a tenancy contract as in Braverman and Stiglitz (1982). Another example is the model of labor-tying in Mukherjee and Ray (1995).[12] Our paper is different in that we study a linkage between output and credit markets. There is a literature on this particular kind of interlinked market but these works mostly document case by case the successes and failures of such interlinkages. Recently, there has been some empirical work showing that such contracts can be welfare improving for farmers (a good overview is in Barrett et al., in press). To the best of our knowledge, the theoretical work on this type of linkage, when it emerges and can be sustained is limited.

Finally, another related work is the insightful article of Kranton and Swamy (2008) who develop a static model which examines the role played by intermediaries in informal contracting. Specifically, they develop a model which identifies some of the issues that resulted in the breakdown of contracting in the procurement of cotton textiles by the East India Company in the second half of the eighteenth century. The East India Company employed local agents to serve as intermediaries who could monitor and transact with the (weavers) producers of cotton textiles. Of course, there are no intermediaries in our model who have the ability to monitor farmers. One of the primary purposes of contract farming is that it gives buyers and farmers the ability to interact directly without intermediaries. Thus in contrast to their work, our focus is on the dynamic incentives that determine the success of contracting when farmers are myopic.

The paper is organized as follows. Section 2 describes the anecdotal evidence on the emergence of contracting in the Ghanaian pineapple industry. In Section 3, we set up the model formally. Section 4 analyzes the model under sea freight and presents the conditions under which contracting can function successfully and the conditions under which the provision of both cash and in-kind credit are profitable. In Section 5, we describe how air freight alters the result and makes contracting hard with myopic farmers. Section 6 provides concluding remarks.

2. Contract farming in the Ghanaian pineapple industry

While our main contribution is theoretical, we first present an anecdotal case study that motivates our model. In 2001, we visited Ghana and interviewed a number of pineapple exporters. Prior to our visit, Goldstein and Udry (1999, henceforth referred to as GU) had conducted a field survey of pineapple growers before 1996. Our contrasting evidence highlights the twofold changes in the Ghanaian pineapple industry between 1995 and 2001 — the total quantity of exports had significantly increased and there had been a dramatic rise of contract farming. In this section, we describe these changes in the Ghanaian pineapple export industry in further detail and postulate an argument for the underlying cause. This argument will be substantiated by the theory we develop in subsequent sections.

In their study of the horticultural sector of Ghana for the World Bank, Voisard and Jaeger (2003) examine the progress of horticultural exports from 1997 to 2002. Their study shows that there was a marked increase in the total value of exports, however, this progress was not even and was restricted to a few products. They highlight pineapple exports as one of the main drivers of this growth and argue that the root cause of this success was the advent of sea freight as a shipping option in 1996. Fig. 1, which is taken from their report, shows the marked increase in the total quantity of pineapple exports after 1995. The figure clearly shows that this increase is driven by the quantity of exports by sea and shows that by 2002, sea freight accounted for the vast majority of exports.

As Fig. 1 suggests, the only option for pineapple exporters in Ghana prior to late 1995 was air freight. In early 1996, Union Bananière Africaine's chartered reefer vessels began stopping regularly in Cameroon for bananas and in Ghana to load pineapples, making sea freight available to pineapple exporters. 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 of 800 kg. However, sea freight involved a longer transit time of ten to twelve days as opposed to the few hours it took by air. This implied that the quality of the fruit at the end of the journey by sea could not be predicted by the

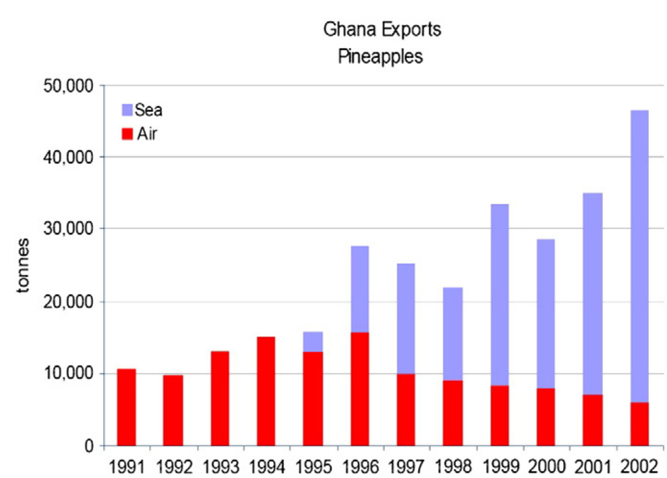

Fig. 1. Total pineapple exports from 1991 to 2002, source: Voisard and Jaeger (2003).

[11] For a good review of other forms of informal credit systems prevalent in developing countries, see Besley (1995).

[12] For a more general review of contracts in agricultural contexts and their role in rural organization, see Hoff and Stiglitz (1993).

exporters or the farmers prior to shipping — the fruit were unripe at the time of sea freighting and were susceptible to bruising, browning and hence rotting when in transit. This contrasted with the case of air freight where the fruit were ripe at the time of shipping and the short transit time meant little to no damage to the fruit. Hence, under air freight, the exporter could observe the quality of the fruit prior to shipping. Our argument for the rise of contract farming centers around this difference in observable quality at the time of shipping.

GU's survey[13] showed that in 1996, there was little evidence of any contracting between exporters and farmers — a fact that they found surprising. 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." In addition, their survey shows that prior to 1996, farmers used little to no fertilizer on their crop. Only about 49% of the pineapple farmers in their sample used any fertilizer at all and the mean amount used was about 40 kg per hectare, compared to the recommended amount of 400 kg per hectare.

Our evidence from 2001 tells a different story. We interviewed and conducted farm visits with a number of exporters (see Appendix table 1 for details). 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). In contrast to GU's survey, *all but one* exporter mentioned that they had contracting relationships with a specific group of farmers from whom they regularly purchased fruit. These were informal, verbal contracts which involved a provision of credit, guaranteed a price for the fruit and usually agreed to purchase the entire pineapple crop of each farmer. The offered price varied by season and the outgrowers weren't paid until the exporters received payment for the fruit from their European buyers, which usually took about four to six weeks. Credit was provided to the farmers both in-kind and in cash. The in-kind credit was in the form of fertilizer. Cash advances were given for emergencies/shocks, like school fees, health problems, etc. The value of the credit was recouped by deducting it from the final price paid to the outgrower for the fruit. Two exporters of those interviewed had, in fact, underwritten loans to their outgrowers from commercial banks and they ensured that these loans were honored at the time the farmer was being paid.

Contracting with farmers was a way for an exporter to provide them with fertilizer, an input which is crucial in determining the final quality of the fruit. Without credit, poor budget constrained farmers could not afford to use fertilizer even though there were financial benefits from producing a higher quality output (this fact is highlighted by the lack of fertilizer usage in GU's survey). Thus, providing farmers with credit was the only way to increase the supply of export quality pineapples. The demand in Europe for Ghanaian pineapples at this time was high[14] and therefore there were profits to be made by increasing exports. Naturally, contracting was only lucrative to an exporter when the farmer honored the terms of the contract by not defaulting. Default, however, was a big concern as poor farmers may be myopic and there is no legal recourse for broken informal contracts.

We argue that the shipping innovation facilitated contracting by reducing the farmers' incentives to default. Under air freight, a farmer could observe the quality of her output when the time came for her to supply the fruit to the exporter. In the event that her output was observed to be of high quality, she could sell her fruit to a different exporter and avoid her loan repayment obligation. By contrast, in the case of sea freight, default was a gamble. There was always a chance that post default, the fruit turned out to be below export quality in which case it would have been rejected in the European market and as a result the farmer would had forsaken future contracts for no immediate benefit (due to her limited liability, the farmer wouldn't have had to repay the loan if her output was poor).[15] Thus, the easing up of the hold-up problem under sea freight made default less of an issue which encouraged exporters to provide credit through contracting.

In addition, we argue that there was a profit motivation behind the provision of cash credit to farmers for consumption emergencies.[16] On the surface, this seems to be altruistic behavior on the part of the exporters; they bear the risk of these loans but explicitly allow the farmers to use the money for nonproduction purposes. However, the fact that farmers knew that they can count on the exporter for loans in the case of future emergencies made the contractual relationship with the exporter quite valuable. This discouraged farmers from breaking the relationship by defaulting. Strengthening the relationship through cash credit in turn allowed the exporter to increase profits by the provision of higher in-kind credit. In the absence of cash loans, a myopic farmer could only be provided with a small amount of in-kind credit; any larger amount of credit would not have been repaid. The provision of cash credit to such a farmer could in turn allow the exporter to induce her to use a higher level of fertilizer while avoiding default.

In the next section, we develop a model to explain the successful contracting under sea freight. Later in Section 5, we use the model to show how contracting cannot be sustained under air freight. We also provide a brief summary of the changes in the Ghanaian pineapple industry since 2002 in Appendix A.

3. The model

In this section, we set up the model based on the conditions during sea freight and we argue in Section 4 that (under sea freight) contracting can be successful even when farmers are myopic. In addition, our model also explains the nature of the offered contracts by showing that there are conditions under which the exporter can profit by offering both in-kind and cash credit. In Section 5, we discuss how the model changes under air freight where we show that contracting cannot work with myopic farmers.

Before introducing the notation, we present a brief summary of framework of the model. We consider the infinitely repeated interaction between an exporter of a fruit and a farmer who grows it.[17] At each time period, the farmer produces a fixed quantity of a crop which can either be of high or low quality. The probability of high quality output depends on the amount of fertilizer applied. It is assumed that the farmer does not have the resources to purchase the inputs to production. Thus, in order to get export quality fruit, the exporter needs to provide the farmer with credit. 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. The farmer however could choose to spend the credit on consumption instead of inputs as the exporter cannot monitor the amount of fertilizer the farmer chooses to apply. In addition to the credit, the exporter also offers the farmer a guaranteed price for high quality fruit.

At the time of delivery to the exporter, the farmer could choose to default and sell her fruit to another buyer. Since, contracts are informal, only the future value of the relationship provides any incentive to prevent the farmer from doing so. However, at the time the farmer makes the default

[13] Even though the GU sample is not representative, it covers four villages in the main pineapple growing region of the country.

[14] Fig. 1 shows how the European market was able to absorb the big jump in exports from 1995 to 1996 after sea freight took off — Ghana was less than 0.5% of the world market at the time.

[15] This uncertainty makes default even less attractive to risk averse farmers. See de Brauw et al. (2011) and references therein for evidence on risk aversion in farmers in developing countries.

[16] Such behavior is fairly common in contracts across the developing world.

[17] In the event that the exporter contracts with multiple farmers, each interaction can evaluated separately.

decision she cannot observe the quality of the fruit — delivery must be made prior to the long transit by sea. If the farmer chooses not to default, the exporter ships the fruit and once it reaches the export market, the quality of the fruit is revealed. If it turns out to be of high quality, the exporter gets paid and in turn pays the farmer the contracted price.

3.1. Notation and the stage game

We begin by describing the moves in the stage game sequentially. We then discuss each move in detail.

At the beginning of the stage game, the consumption state of the farmer is realized. The consumption needs of poor farmers vary over time. To formally model this, we assume that there are two consumption states — high (h) and low (l). In the high state, the farmer has emergency consumption needs (money for health care, fees for schooling for children etc.) and this state occurs with probability $\gamma_h \in (0,1)$. The low state occurs with complementary probability $\gamma_l = 1 - \gamma_h$. The farmer's utility in state $i \in \{h,l\}$ from a level of consumption c_i is

$$\mu_i c_i,$$

The stage game

1. The state $i \in \{h,l\}$ 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 and both get utility 0.
3. The exporter offers the farmer a price p_i for her output, a cash loan L_i^c and/or an in-kind loan L_i^k.
4. The farmer decides whether or not to accept the contract. If the farmer rejects the contract, the game ends and both get utility 0.
5. The farmer selects the amount of the loan k_i to spend towards production and the amount c_i 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_i.
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 once it reaches the export market, the exporter is paid a price q. He, in turn, pays the farmer the contracted price p_i less the loan amount $L_i^c + L_i^k$.

where μ_i is the marginal utility of consumption in state i. The marginal utility of consumption in the high state is greater than that in the low state. Specifically, we assume

$$\text{(Marginal Utility)} \quad \mu_l = 1 \text{ and } \mu_h > 1.$$

The average marginal utility of consumption $\gamma_h \mu_h + \gamma_l \mu_l$ is denoted by $\bar{\mu}$. The consumption state is observed by both the farmer and the exporter.

Having observed the consumption state i, the exporter decides whether to contract with the farmer or not. If the exporter chooses to contract with the farmer, he offers credit either in cash or in kind (by loaning the farmer fertilizer) or by offering a combination of the two. In state i, the dollar amount of cash credit and in-kind credit is denoted by L_i^c and L_i^k respectively. In addition, the exporter offers a price $p_i \geq L_i^k + L_i^c$ for high quality output. The loan is recovered by deducting it from the final amount owed to the farmer.

The farmer can choose to either accept or reject the contract offered by the exporter. Upon accepting, she decides whether to use the credit for consumption or whether to invest in production. We use the term *diversion* to refer to credit utilized by the farmer for consumption. We now describe the farmer's budget set. The farmer is assumed to have no wealth to use for consumption or to invest in inputs. In particular, this implies that she can only apply fertilizer if the exporter provides credit.[18] Prices for consumption and fertilizer are both normalized to 1. If the exporter offers the farmer only cash credit, her budget set is simply

$$k_i + c_i \leq L_i^c,$$

where k_i is the amount of fertilizer used by the farmer in state i.

By contrast, the farmer cannot efficiently divert in-kind credit to consumption. Formally, we model this by assuming that a dollar worth of fertilizer can only be converted to $\alpha < 1$ units of consumption. This assumption can be interpreted as follows. Firstly, due to lack of efficient markets for inputs, it is unlikely that the farmer would be able to resell 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. Lastly, 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 are lower. To summarize, when the loan is in-kind, the farmer's budget set becomes

$$k_i + \frac{c_i}{\alpha} \leq L_i^k.$$

When credit is offered in a combination of cash and in-kind, the farmer's budget set becomes[19]

$$\text{(Budget Set)} \quad k_i + \min\{L_i^c, c_i\} + \frac{1}{\alpha} \max\{c_i - L_i^c, 0\} \leq L_i^k + L_i^c.$$

We denote the set of fertilizer consumption pairs that satisfy the above constraint by $B(L_i^k, L_i^c)$.

The farmer produces a fixed quantity of fruit which we normalize to 1. We assume that the quality of the fruit depends on the amount of fertilizer applied, however the quantity does not. Quality can either be high or low — only high quality fruit can be exported, low quality fruit cannot be sold. The optimal level of fertilizer for production is $\mathbf{k}$. The probability of high quality fruit after the application of $k_i < \mathbf{k}$ units of the fertilizer is

$$\text{(Prob. of high quality)} \quad \phi k_i.$$

An application of more than $\mathbf{k}$ units of fertilizer is harmful to the crop or put differently, it decreases probability of high quality output. It is assumed that even an application of the optimal level of fertilizer does not lead to a sure success or

$$\text{(Optimal input level)} \quad \phi \mathbf{k} < 1.$$

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.

[18] It is possible to do our analysis when the farmer has nonzero wealth. The success of contracting would then depend on the amount of wealth and the farmer's discount factor.

[19] All of our results hold for the case where the farmer cannot buy fertilizer due to a lack of an input market. In this case, the farmer can never spend cash on inputs and can only divert in-kind credit to consumption.

Having chosen consumption c_i and inputs k_i, the farmer can decide whether to default or not. If she chooses not to default, her expected utility at the time she delivers the fruit to the exporter is

$$\text{(Farmer's Utility[no default])} \quad \phi k_i\left[p_i-\left(L_i^k+L_i^c\right)\right]+\mu_i c_i.$$

The first term is the expected profit from production — since the quality of the fruit is not observable at the time of delivery, returns are not assured. If the fruit turns out to be of high quality (which happens with probability ϕk_i), the exporter pays the farmer the promised price less the loan amount. By contrast, if the fruit turns out to be of poor quality, the farmer does not get paid[20] but also does not have to repay the loan. Thus, the farmer has limited liability. Lastly, notice that for a given price, larger loan amounts reduce the marginal benefit the farmer receives from investing in fertilizer.

If the farmer chooses to default, she can sell her fruit to a different buyer and thereby forego repayment of the loan. This sale could be made either to another exporter or the farmer could simply wait for the fruit to ripen and then sell it on the spot market. We assume that there is always a buyer available willing to pay the farmer p_i for her output.[21] Thus the expected utility from default is

$$\text{(Farmer's Utility [default])} \quad \phi k_i p_i+\mu_i c_i.$$

If the farmer chooses to honor the contract by not defaulting, the exporter ships the fruit. Once the fruit arrives at the export market its quality is revealed. If the fruit is of high quality, the exporter is paid q and he pays the farmer the promised price less the loan amount. Otherwise, the exporter neither gets paid nor pays the farmer but cannot recover the loaned amount. Thus, the expected utility of the exporter at the time he offers the contract is[22]

$$\text{(Exporter's profit)} \quad \phi k_i[q-p_i]-[1-\phi k_i]\left[L_i^c+L_i^k\right].$$

Recall that, even with the optimal level of fertilizer provision, $\phi\mathbf{k}<1$ which implies that the provision of credit is always risky even without default.

Finally, we should point out the fact that our model explicitly prohibits the exporter from holding up the farmer. Since the quality upon arrival isn't observed by the farmer, the exporter can always claim the fruit was damaged and thus refuse payment. Of course, if the exporter were to always do this, contracting could not function. We defer discussion of extensions of the model which accommodate exporter hold-up to Section 6 after the results have been presented.

We end this subsection with Table 1 which summarizes the notation for easy reference.

Table 1
Summary of notation.

$i\in\{h,l\}$ = Consumption state of the farmer	
q = Price paid to the exporter in the export market	p_i = Price offered by exporter to farmer
L_i^c = Cash loan amount	L_i^k = In-kind loan amount
c_i = Consumption of the farmer	k_i = Amount of fertilizer
ϕ = Marginal increase in quality from fertilizer application	k = Optimal quantity of fertilizer
μ_i = Marginal utility of consumption	α = Return from diversion of fertilizer

[20] In our fieldwork, every exporter mentioned in the interviews we conducted that they did not pay the farmer if the fruit turned out to be below export quality.

[21] It is possible to take this price as an exogenous spot market price. We discuss this briefly when providing concluding remarks in Section 5.

[22] 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

In a onetime play of the stage game, the farmer will always default. Thus in order for contracting to function, interaction between the exporter and the farmer must be repeated. Specifically, we analyze perfect public equilibria[23] of the infinitely repeated game where the stage game is the extensive form game we defined in the previous subsection. In the interest of simplicity and transparency, we focus on *stationary equilibria* of this infinitely repeated game. In a stationary equilibrium, 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 contracts offered in the high state and low state may be different. The discount factor of the farmer is denoted by $\delta\in(0,1)$. The class of equilibria we study allows us to ignore the exporter's discount factor.

We first describe how stationary equilibrium strategies depend on histories. The exporter never observes the farmer's choices of fertilizer and consumption and thus 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. Formally, a stationary equilibrium strategy for the exporter can be defined as follows.

i. Offer contract $(p_i^*, L_i^{k*}, L_i^{c*})$ at the first period if the realized state is i.
ii. At histories where he has always offered this contract $(p_i^*, L_i^{k*}, L_i^{c*})$ in state i at all times in the past and the farmer has never defaulted, the exporter will continue to offer this contract.
iii. At any other history, the exporter will choose to not contract with the farmer.

Notice that stationarity requires the exporter to offer the same contract to the farmer (as long as she does not default), 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 current and previous 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. A stationary equilibrium strategy for the farmer depends on histories as follows.

i. The farmer chooses (k_i^*, c_i^*) in state i and does not default at all histories where the exporter has currently offered $(p_i^*, L_i^{k*}, L_i^{c*})$ and at all points of time in the past, the exporter had offered $(p_i^*, L_i^{k*}, L_i^{c*})$ in state i, the farmer had accepted, chosen (k_i^*, c_i^*) and not defaulted.
ii. At any other history, if the exporter were to offer the farmer a contract, she would accept the contract, choose consumption and inputs to maximize profits and default on the loan.

A short way of denoting the above stationary strategies is simply by the behavior on the equilibrium path, that is, $\{(p_i^*, L_i^{k*}, L_i^{c*})\}_{i\in\{h,l\}}$ for the exporter and $\{(k_i^*, c_i^*)\}_{i\in\{h,l\}}$ for the farmer. It is important to point out that these stationary strategies involve the most severe punishments for deviations off the equilibrium path — default by the farmer and cessation of future contracting by the exporter respectively. Of course, it is well known that focusing on strategies with the harshest punishments is without loss of generality (Abreu, 1988).

[23] 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). The exporter has incomplete information in the stage game as he cannot observe the consumption, fertilizer choice of the farmer.

Stationary strategies $\{(p_i^*, L_i^{k*}, L_i^{c*})\}_{i\in\{h,l\}}$ for the exporter and $\{(k_i^*, c_i^*)\}_{i\in\{h,l\}}$ for the farmer constitute a *stationary equilibrium* if they satisfy the following conditions for $i\in\{l,h\}$

$$(\textit{Positive exporter profit})\quad \phi k_i^*\left[q-p_i^*\right]-\left[1-\phi k_i^*\right]\left[L_i^{c*}+L_i^{k*}\right]\geq 0$$

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

$$(\textit{No default})\quad \phi k_i^*\left[p_i^*-\left(L_i^{c*}+L_i^{k*}\right)\right]+\mu_i c_i^*+$$
$$\frac{\delta}{1-\delta}\sum\nolimits_{j\in\{h,l\}}\gamma_j\left\{\phi k_j^*\left[p_j^*-\left(L_j^{c*}+L_j^{k*}\right)\right]+\mu_j c_j^*\right\}\geq \max_{(k,c)\in B\left(L_i^{k*},L_i^{c*}\right)}\left\{\phi k p_i^*+,\mu_i c\right\}$$

The first condition just says that the exporter has nonnegative expected profit at the beginning of each state of the stage game. Notice that this condition implies that the contract offered need not maximize static expected profits for the exporter. In addition, this condition implies that the exporter will never offer cash credit alone in state i as it would lead to a loss in that state. Critically, this condition ensures that any contract which satisfies the above constraints is an equilibrium *irrespective of the exporter's discount factor*. This is an important property as to the best of our knowledge, there is no consensus in the literature about whether this parameter should be high or low. The explanation is the following.

Equilibrium strategies of the game are such that were the exporter to deviate and instead offer any other contract, the farmer would immediately respond by accepting and defaulting following which the exporter would not contract with her in the future. This would yield the exporter a loss and hence he has no incentive to deviate. Put differently, the fact that the stage game has an extensive form ensures that any deviation by the exporter can be immediately punished by the farmer and as a result there are neither gains from deviation in the current period nor in the future. That said, we should point out however, that it is possible for equilibrium to exist in stationary strategies where the exporter makes a loss in one of the two states but still has an overall positive expected profit. Of course, this would require the exporter to have a high enough discount factor which would make him willing to bear the loss in the current period in order to gain positive expected profits in the future.

The second condition states that the farmer chooses inputs and consumption optimally. Since the exporter does not condition his strategy on the history of the revealed quality of the fruit, the equilibrium choices of fertilizer, 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. This term is the sum of the utility of the current period (which depends on the current state i) and the future expected utility. On the right side is the utility that the farmer gets from optimal default. This involves selling her fruit to a different exporter at price p_i thereby forgoing her repayment obligations. But the fact that she does not have to repay the loan increases the marginal returns to investing in production. Thus the consumption, fertilizer choices of the farmer may differ depending on whether she is planning to default or not. 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.

Clearly, there could potentially be a continuum of stationary equilibria. Our analysis focuses attention on the stationary equilibrium which yields the maximum expected profit to the exporter and we term this equilibrium the *exporter best stationary equilibrium* (EBSE). Policy makers are often concerned about allowing farmers to contract with private buyers fearing that the interests of both parties may be misaligned. Restricting attention to this equilibrium allows us to make the case that the profit motive alone may be sufficient for contracting to function successfully thereby providing poor farmers with inputs and a guaranteed market for their produce and with informal cash credit for emergencies. Specifically, the examination of this equilibrium allows us to argue that welfare improving contract farming emerged in Ghana without government intervention, driven purely by profit motives.

4. Successful contracting with sea freight

In this section, we show how contracting was possible under sea freight even if farmers are myopic and we demonstrate the role played by cash credit in sustaining the relationship. We start off by making the following intuitive observation, the proof of which is in Appendix B.

Lemma 1. *There is always an EBSE such that* $L_i^{k*}=k_i^*$ *and* $L_i^{c*}=c_i^*$ *for* $i\in\{h,l\}$.

This lemma states that there is no benefit for the exporter to provide in-kind credit knowing that the farmer is diverting some or all of it to consumption. This is because the exporter can achieve the same quality output at a lower cost by just offering cash credit for consumption instead. Similarly, the exporter cannot get higher profits by providing cash credit to the farmer to purchase inputs. However, it is possible for there to be an EBSE where the exporter only offers cash credit. For example, if α is close to 1 (diversion is almost efficient), the price offered by the exporter to prevent default may be high enough so that the farmer prefers to use cash credit for production as opposed to consumption.[24] In this case, providing either cash or in-kind credit would result in the same outcome.

Since we are interested in when credit emerges and when the exporter offers cash credit *for consumption*, the above lemma is useful in simplifying notation and henceforth we refer the loan amounts L_i^{k*} and L_i^{c*} as simply k_i^* and c_i^*. If $c_i^*>0$, then we can conclude that the exporter is offering cash credit that is being used by the farmer for consumption and not to buy inputs. This allows us to summarize the strategies of both the farmer and the exporter in the EBSE by the tuple $\{(p_i^*, k_i^*, c_i^*)\}_{i\in\{h,l\}}$. We can now use Lemma 1 to write down the following optimization problem, the solution to which yields the EBSE.

$$(\bigstar)\quad \{(p_i^*, k_i^*, c_i^*)\}_{i\in\{h,l\}}\in \underset{\{(p_i,k_i,c_i)\}_{i\in\{h,l\}}}{\operatorname{argmax}}\left\{\sum_{i\in\{h,l\}}\gamma_i(\phi k_i[q-p_i]-[1-\phi k_i][k_i+c_i])\right\}$$

subject to

$$(PP_i)\quad \phi k_i[q-p_i]-[1-\phi k_i][k_i+c_i]\geq 0$$
$$(Div_i)\quad \phi[p_i-(k_i+c_i)]\geq \alpha\mu_i$$
$$(Cash_i)\quad \phi[p_i-(k_i+c_i)]\,c_i\,[\mathbf{k}-k_i]\leq \mu_i c_i\,[\mathbf{k}-k_i]$$
$$(Def_i)\quad \phi k_i[p_i-(k_i+c_i)]+\mu_i c_i+$$
$$\frac{\delta}{1-\delta}\sum\nolimits_{j\in\{h,l\}}\gamma_j\left\{\phi k_j\left[p_j-\left(k_j+c_j\right)\right]+\mu_j c_j\right\}\geq \max_{(k,c)\in B(k_i,c_i)}\left\{\phi k p_i+\mu_i c\right\}$$

for $i\in\{h,l\}$.

Essentially, 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 constraint (PP_i) is merely the requirement that the exporter earns nonnegative profits in both states, a condition that ensures equilibrium irrespective of his discount factor. The fourth constraint (Def_i) is simply the no default

[24] If farmer does not have access to input markets then she can never spend cash credit on fertilizer. Then it will always be the case that $L_i^{k*}=k_i^*$ and $L_i^{c*}=c_i^*$ for $i\in\{h,l\}$ in the EBSE.

condition we stated when defining stationary equilibria and it ensures that the farmer prefers not to renege on the contract. We term this the *default constraint*.[25]

The second constraint (Div_i) 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 in state *i*, the farmer would use both the cash and the in-kind credit for consumption and as a result, the exporter would make negative profits in state *i* which cannot happen in stationary equilibrium.[26] We term this the *diversion constraint* of state *i*. Notice that the diversion constraint is more restrictive in the high state as the right hand side is larger than that of the low state. 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.

Similarly, the third constraint ($Cash_i$) ensures that the farmer uses cash for consumption and not for inputs. Notice that both sides of the constraint are multiplied by the same term $c_i[\mathbf{k}-k_i]$. This ensures that this constraint is satisfied whenever $c_i=0$ or $k_i=\mathbf{k}$. When $k_i=\mathbf{k}$, the exporter is already offering the optimal amount of in-kind credit. Thus the farmer will never use any of the offered cash loan for production as this does not further improve quality and hence will not benefit her irrespective of the price p_i.[27]

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.

4.1. Conditions for successful contracting

In this subsection, we derive conditions under which contracting occurs in the EBSE. Of course, if contracting does not occur in the EBSE, it implies that contracting can never be profitable for the exporter and hence it cannot be sustained in *any* stationary equilibrium.

It is possible to isolate the conditions where contracting is profitable by examining the profit maximizing contract for the exporter when he is only allowed to offer in-kind credit and not cash credit in addition ($c_i=0$). The reason is the following. If the exporter cannot profit from the provision of in-kind credit alone in state *i*, he will not provide any credit in this state in the EBSE. We will show that in-kind credit is not profitable only when the price that the farmer has to be offered to prevent diversion is higher than the export market price. Offering cash credit in addition would then require an even higher price to prevent diversion which would result in losses in state *i* which is ruled out by our definition of stationary equilibrium.

Conversely, if the exporter can benefit from offering in-kind credit alone in state *i* when $c_i=0$, then he will also offer a positive amount of in-kind credit in state *i* in the EBSE. Of course, in the EBSE, the amount of in-kind credit offered in state *i* may be different and the exporter may offer cash credit as well. Our main result from this subsection is that a high enough price *q* in the export market can allow for successful contracting even if the farmer is extremely impatient.

[25] If farmer does not have access to input markets then we can drop the max on the right side of the default constraint and it is simply $\phi k_i p_i+\mu_i c_i$. This does not affect any of our results.

[26] Note that if $k_i=0$, then the price offered can always be chosen to satisfy the diversion constraint ($\phi p_i=\alpha\mu_i$) as the fruit will never end up being of high quality and as a result the price will never be paid.

[27] The constraint ($Cash_i$) is not necessary if we assume the farmer has no access to input markets. This constraint doesn't affect any results in the paper.

We can now mathematically define the maximization problem corresponding to the highest profit that the exporter can achieve in stationary equilibrium without offering cash credit. We do so by setting $c_i=0$ in (★).

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

subject to

$$\phi k_i[q-p_i]-[1-\phi k_i]k_i \ge 0$$

$$(IKDiv_i)\quad \phi[p_i-k_i]\ge \alpha\mu_i,$$

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

The objective function and the first two constraints follow trivially from (★) by setting $c_i=0$. Also $c_i=0$ implies that ($Cash_i$) will always be satisfied. Without cash credit, the default constraint (Def_i) can be simplified to obtain ($IKDef_i$) as the solution to the maximization problem on the right side of (Def_i) always involves the farmer spending her in-kind credit on production. This is because the diversion constraint ($IKDiv_i$) ensures that the price is sufficiently high. We now analyze the above problem.

The diversion constraints ensure that the right side of the default constraints is positive. This implies that, for sufficiently patient farmers, the default constraints ($IKDef_i$) will not bind even when the amount of in-kind credit offered is $\mathbf{k}$. 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. As the profit of the exporter is decreasing in price p_i, this implies that for very patient farmers the diversion constraints ($IKDiv_i$) will bind in each state *i*.

Thus, for sufficiently patient farmers, the exporter will offer price and credit such that they satisfy the diversion constraint ($IKDiv_i$) with equality or $p_i=k_i+\alpha\mu_i/\phi$. We can then plug this equation into the objective function and rewrite the exporter's problem as

$$(\Delta)\quad \max_{k_h,k_l}\left\{\sum_{i\in\{h,l\}}\gamma_i k_i[\phi q-(1+\alpha\mu_i)]\right\}.$$

This immediately shows that if $\phi q<\min_{i\in\{h,l\}}\{1+\alpha\mu_i\}=1+\alpha$, the exporter will not provide any in-kind credit in either state in the EBSE or, in other words, he will 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 and the exporter is allowed to offer cash credit as well. The intuition is straightforward; both farmer's discount factor and cash credit only play roles in the default constraint which is ignored in maximization problem (Δ). In fact, cash credit makes the diversion constraint harder to satisfy. This result is summarized in the following proposition.

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

Proposition 1 argues that the moral hazard problem stemming from the inability of the exporter to monitor the farmer is sufficient to break down contracting. Thus this result states that contracting is more likely to break down if the price in the export market drops, a fact that has been documented in case studies of contract farming.

As an aside, it should be pointed out that with nonstationary strategies, it might be possible for the exporter to generate positive social surplus in a repeated interaction even when $\phi q<1+\alpha$. 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 provide additional incentives discouraging the farmer from diverting the credit. This observation 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 stationary contracts.[28]

From a further examination of (Δ) and by repeating the previous argument, we can conclude that when $1+\alpha<\phi q<1+\alpha\mu_h$, the exporter will not offer in-kind credit in the high state of the EBSE irrespective of the farmer's discount factor. In this case, however, we show that the export price is high enough to make it profitable for the exporter to always offer in-kind credit in the low state for all $\delta\in(0,1)$. This can be seen as follows.

Suppose the exporter offers the farmer an in-kind loan k_l along with a price $p_l=k_l+\alpha/\phi$ in state l. 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 ($IKDef_l$) and get

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

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. 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. Of course, if the farmer is very patient, the exporter can offer the optimal amount of credit $\mathbf{k}$ in equilibrium. This result is summarized in the following proposition. The proof to Part (3) of Proposition 2 follows the same logic as that of Part (3) of Proposition 3, the proof of which is in Appendix B.

Proposition 2. *If $1+\alpha<\phi q<1+\alpha\mu_h$, the EBSE has the following properties*:

(1) *The exporter does not provide credit to (does not contract with) the farmer in the high state, for all $\delta\in(0,1)$.*
(2) *The exporter provides in-kind credit in the low state or $k_l^*>0$, for all $\delta\in(0,1)$.*
(3) If the farmer is sufficiently patient (there exists a $\delta>1$ such that whenever $1>\delta>\underline{\delta}$), the exporter offers the optimal level $\mathbf{k}$ of in-kind credit in the low state.

We are now in a position to state the main result of this subsection — contracting can function successfully when the price or equivalently the demand in the export market is high enough. When $\phi q>1+\alpha\mu$, we show that for all $\delta\in(0,1)$, the EBSE will feature positive amounts of in-kind credit in both states. The argument is similar to that of Proposition 2. In this case, the export market price q is high enough to allow the exporter to provide incentives to prevent diversion in both states without suffering losses. Impatient farmers can always be offered small enough amounts of credit in both states so that they do not default. Of course, sufficiently patient farmers will be offered the optimal level of in-kind credit $\mathbf{k}$ in the EBSE.

Proposition 3. *If $\phi q>1+\alpha\mu_h$, the EBSE has the following properties*:

(1) *The exporter provides in-kind credit in both states or $k_h^*,k_l^*>0$, for all $\delta\in(0,1)$.*
(2) *The exporter offers weakly more in-kind credit in the low state* or *$k_l^*\geq k_h^*$, for all $\delta\in(0,1)$.*
(3) *If the farmer is sufficiently patient (there exists a $\underline{\delta}<0$ such that whenever $1>\delta>\underline{\delta}$), the exporter offers the optimal level $\mathbf{k}$ of in-kind credit in both states.*

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

In addition to stating the conditions under which contracting can function for all $\delta\in(0,1)$, Proposition 3 also states that the exporter offers weakly more in-kind credit in the low state. The intuition for this is the following. We will show below in Proposition 4 that the exporter sometimes offers cash credit in the high state but never does so in the low state. Since, the exporter doesn't offer cash credit in the low state, he provides higher in-kind credit than that in the high state without inducing default which leads to higher profits. The proof of Proposition 3 is in Appendix B.

4.2. Conditions for the provision of cash credit

In this subsection, we build on Proposition 3. We show that under certain conditions, providing cash for consumption along with in-kind credit can result in higher equilibrium profits for the exporter. As in Proposition 3, we assume that the export market price is high enough so that the exporter profits from providing in-kind credit to the farmer in both states or that

$$\phi q>1+\alpha\mu_h.$$

It is easy to show that if this condition does not hold, offering cash credit for consumption can never result in higher profits.

It is widely observed that along with in-kind credit, poor farmers receive cash credit for emergency expenditures through contract farming. Cash credit, as mentioned previously, was part of most of the contracts we observed in Ghana. As with in-kind credit, the risk of the loan is borne entirely by the exporter—in the event of poor quality output, 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 be 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 only slackens the default constraint but always 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 following proposition provides conditions under which myopic farmers are offered cash credit and describes the nature of cash credit. The proof can be found in Appendix B.

Proposition 4. *The EBSE has the following properties when farmers are sufficiently impatient (there exists a $\bar{\delta}<1$ such that whenever $0<\delta<\bar{\delta}$)*:

(1) *The exporter does not offer cash credit in the low state or $c_l^*=0$.*
(2) *If $2\bar{\mu}-1>\phi q>2\alpha\bar{\mu}+1$, the exporter offers cash credit for consumption in the high-state or $c_h^*>0$.*

The first point of the proposition states that the exporter does not offer cash credit to myopic farmers in the low state of the EBSE. This is because it is cheaper for the exporter to discourage default in the low state by offering a higher price rather than cash credit. The second point of Proposition 4 provides conditions under which the exporter offers cash credit in the high state to myopic farmers.

We end the section by providing some intuition for the range of parameters for which cash credit is profitable. When the farmer is impatient, default is the predominant issue. The first inequality $2\bar{\mu}-1 > \phi q$ implies that the export price is not very high in relation to the marginal utility of consumption for the farmer. If this were not the case, then a higher price instead of providing cash credit becomes the more attractive way for the exporter to reduce default incentives. The second inequality $\phi q > 2\alpha\bar{\mu} + 1$ implies that diversion is sufficiency inefficient. Cash credit provides additional profits by lowering incentives to default, thereby allowing the exporter to provide more in-kind credit. However, additional credit implies that the exporter has to offer a higher price to prevent diversion. If α is close to 1 then the cost to the exporter from having to offer a higher price wipes out the gains from better quality output.

5. Lack of contracting with air freight

The intuition for the lack of contracting with air freight builds on the results of the previous sections. Under air freight, the quality of the fruit was observable at the time of shipping which meant that there were sure gains to be had from defaulting if the fruit was of high quality. For sufficiently myopic farmers, these sure gains from default supersede the long term benefits from maintaining the relationship with the exporter. This is in contrast to the case of sea freight where there was always a chance that the fruit would turn out to be bad quality anyway in which case default would have yielded no benefit.

Mathematically, the only difference between air and sea freight is a change in the default constraint from (Def_i) to ($AFDef_i$). This is highlighted in the following maximization problem corresponding to the EBSE $\{(p_i{}^*, k_i{}^*, c_i{}^*)\}_{i\in\{h,l\}}$ under air freight.

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

subject to

$$(AFPP_i) \quad \phi k^i \left[q-p^i\right] - \left[1-\phi \mathbf{k}^i\right] \left[k^i + c^i\right] \geq 0$$

$$(AFCash_i) \quad \phi[p_i-(k_i+c_i)]\, c_i\, [k-k_i] \leq \mu_i c_i\, [\mathbf{k}-k_i]$$

$$(AFDiv_i) \quad \phi[p_i-(k_i+c_i)] \geq \alpha\mu_i$$

$$(AFDef_i) \quad k_i + c_i \leq \frac{\delta}{1-\delta} \sum_{i\in\{h,l\}} \gamma_i[\phi k_i(p_i-[k_i+c_i]) + \mu_i c_i] \quad \text{for} \quad i \in \{h,l\}.$$

In the case of air freight, the default constraint is simpler than (Def_i). The farmer only considers default when the fruit is revealed to be of high quality. By selling her fruit to a different exporter, she can avoid repaying the loan amount $k_i + c_i$. Thus the default constraint simply states that this sure gain from default should be outweighed by the long term value of the relationship. The following proposition demonstrates that for myopic farmers, the hurdle of default cannot be overcome and contracting cannot emerge.

Proposition 5. *Under air freight, the exporter will not contract with sufficiently impatient farmers (there exists a* $\bar{\delta}<1$ *such that whenever* $0<\delta<\bar{\delta}$*) in any stationary equilibrium.*

We end this section by providing some intuition for the above result; the proof is in Appendix B. An examination of the default constraint shows that for low δ's cash credit cannot lessen default risk which is in contrast to the case of sea freight. An additional dollar of cash credit provides a dollar's worth of sure gain from default whereas the future benefits from the additional dollar depend on the discount factor. For low enough δ's, additional cash credit ends up tightening the default constraint which does not aid contracting.

Thus the exporter needs to offer incentives only through in-kind credit k_i and the price p_i. Once again, the sure benefits from default imply that the exporter needs to offer a high enough price p_i to prevent default. For very myopic farmers, the price p_i that would prevent default exceeds the export market price q making contracting nonprofitable for the exporter.

6. Concluding remarks

In future work, we hope to test our theoretical framework empirically. The data required to test our model is quite intensive and unfortunately, such data does not exist for the pineapple industry in Ghana during the period we study. That said, it would be easy to construct an experiment around our framework which would allow for a testing of the model using a randomized control trial. More generally, we feel that empirical work aimed at uncovering the conditions under which contract farming can function successfully is an important topic for future research.

There a few obvious ways in which the model can be generalized. We could allow the production function to be nonlinear and allow the application of inputs to affect not just quality but also quantity. If the probability of high quality fruit remains 0 when $k_i = 0$, most of our results can still be obtained. The essential parameter determining the success of contracting would then by the marginal returns to investing in fertilizer when $k_i = 0$. Similarly, utility from consumption can also be made nonlinear and once again the marginal utility of consumption at $c_i = 0$ would be a critical parameter. In addition, we could explicitly model the shipping cost s of the fruit. This too would not affect our results as all this would do is make the effective price q–s in the export market. Our results show that contracting is facilitated by a high export market price. Thus the higher shipping cost under air freight is an additional reason why there was contracting in Ghana before the advent of sea freight. Lastly, we could endow the farmer with nonzero wealth. Once again, we could obtain our results if farmers are sufficiently poor.

An important extension of the model would allow for the exporter to hold-up the farmer. Here we suggest one way in which the model can be adapted to account for this. Suppose, the exporter contracts with a positive measure of infinitesimal identical farmers each of whom draws her consumption state independently. In a symmetric equilibrium, the law of large numbers would ensure that the proportion of high quality fruit upon arrival of the shipment would be exactly $\gamma_h\phi k_h{}^* + \gamma_l\phi k_l{}^*$. If the farmers were able to communicate among themselves, any profitable hold-up by the exporter would be detectable. Hence, a sufficiently patient exporter would not want to cheat the farmers as this would result in the loss of future supply. Such a model would be a reasonable approximation of our case where farmers are closely clustered smallholders and each exporter contracts with many farmers. That said, we consider the development of a general model of contract farming with two sided hold-up to be an important extension and we hope to do so in future work.

While we use the case study from Ghana to motivate our theoretical framework, our model of contracting under sea freight could be used to explain other instances of successful contracting schemes. There is a literature consisting of specific case studies and a vast body of work that describes more generally when and where contract farming will be successful (see, for example, Grosh, 1994; Little, 1994; Minot, 2007; Poulton et al., 1998; Watts, 1994). Overall these studies generally point to the following being important[29]:

[29] 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.

a. It works where there are large buyers (exporters, large scale processors and supermarkets), but with competition among the buyers.
b. 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. where spot markets cannot convey information on aspects of quality that final consumers care about.
c. It 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.[30]
d. Contract farming cannot be sustained if there is easy leakage (farmers side selling)—strong repayment incentives are needed.
e. A strong demand for the crop.

Our model has points a–c built into it. Of particular importance is point b which is precisely the difference we highlight between the air and sea freight in Ghana. Of course, the primary goal of the model is to demonstrate how repayment incentives (point d) can be generated in the absence of formal legal enforcement. Lastly, Proposition 3 shows that contracting only emerges if the price for the crop is high (point e). High demand implies a high price q which we have argued can be sufficient for contracting to function even if farmers are myopic.

Our model can also be used to analyze certain failures of contract farming in the developing world (Daddieh, 1994; Grosh, 1994; Jaffee, 1994; Poulton et al., 1998). Most of these failures occurred due to disparities between the prices offered in the contract and those in the spot market. Recall that in our model the price offered to farmers upon default is endogenous—it is assumed that there is always another buyer willing to match the price offered in the contract. That said, it is easy to write down the model with an exogenously specified spot market price p_s available to farmers who default. The only way this alters problem (★) is by changing the right side of the default constraint (Def_i) which becomes

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

It is possible to show that even when $\phi q>1+\alpha\mu_h$, if the spot market price $p_s>q-1/\phi$, then credit will not be offered to myopic farmers in stationary equilibrium. Put differently, if the spot market price were unexpectedly to jump above $q-1/\phi$, myopic farmers will default and contracting will break down.

To conclude, economies in Sub-Saharan Africa are characterized by the lack of formal financial markets, in particular credit and insurance markets. Households thus have very poor access to these formal institutions and the ranges of products they offer. In addition, the governments in these economies do not play a strong role in improving financial access and there is a lack of public banks that could potentially play this role. As a result in these economies, informal institutions often endogenously arise to fill these gaps and it is important for policy makers to understand the reasons behind their emergence. We think models like the one presented in this paper can be applied to, for instance, the literature on informal risk sharing institutions (the seminal piece in this literature is Townsend, 1994; other important work is De Weerdt and Dercon, 2006; Fafchamps and Lund, 2003; Goldstein, 1999; Grimard, 1997; Ligon, 1998, 2001; Morduch, 1999, 2001; Suri, 2011 among others).

All these models of informal risk sharing depend on there being transfers between households that can maintain the informal contracts and thereby lead to consumption smoothing which results in welfare gains. These risk sharing institutions may not be fully efficient, for reasons such as moral hazard, limited liability, hidden income and transaction costs see (for example Jack and Suri, 2011; Kinnan, 2010; Ligon et al., 2000, 2002). However, there has been no work that we are aware of in this literature that examines whether the form of these transfers matter—they can be either in cash or in-kind (labor sharing for example) or both. The form of the transfer may have important ramifications both for static and dynamic incentives on both sides of these contracts. We see this as a natural next extension of our theoretical contributions in this paper.

As an elaboration on this, consider Ligon et al. (2002) who present a model studying informal insurance arrangements under limited commitment. Here, people may join a risk-pooling network because welfare gains can be derived from their participation, yet they are tempted to default afterwards when they realize they have to make a positive contribution to the network. As in our model, default is avoided only if the long-term benefits exceed the short-term costs, that is, if promises of future reciprocation are perceived to be credible and sufficiently attractive. Ligon, Thomas and Worrall's model can fully explain the dynamic response of consumption to income, however, it is unable to explain the distribution of consumption across households. Thus, there seems to be scope to generalize their model potentially leading to a closer fit of the data. Our results suggest one such avenue. Mutual aid among households need not be strictly financial, it can also be in the form of time and labor that may be required during emergencies, illness or death.[31] This can be incorporated into their model by allowing for household production which depends both on capital and labor where both are subject to shocks.

The type of transfers also plays a crucial role in direct studies of transfers and remittances. Here, migrants need to overcome the moral hazard problem arising from the fact that they cannot observe or control how the money remitted is being spent. This moral hazard problem arises as members of the household need not have aligned preferences. In an interesting empirical paper, Ashraf et al. (2011) use a field experiment to study what happens to remittances when migrants sending money to their families can do so through multiple channels which gives them more control over how the money will be spent. They find that the additional control induces migrants to accumulate more in savings (i.e. they remit more). In our model, buyers provide both cash and in-kind credit for similar reasons. Thus, a potentially promising direction for future work is a theoretical analysis aiming to uncover the role played by the types of transfers in general risk sharing and investment relationships between individuals in developing economies.

Appendix Table
Main pineapple exporters (>80 tons/annum), 2000.

Exporter	Quantity	Value ($) (000's)	Value (cedis) (m)	Interview	Have outgrowers
Jei River	6342.5	2544	12931	No	No
Milani Impex	2907.5	1314	7065	Yes	Yes
Farmapine	2974.98	1.303	6828	Yes	Yes
Koranco	3147.4	1115	6122	No	–
Georgefields	2113.5	968	5177	Yes	Yes
Prudent	2124.97	788	4438	No	–
Unregistered	1368.4	596	2657	No	–
Greenspan	1365.5	570	2848	Yes	Yes
John Lawrence Farms	734.2	334	1872	No	–
Pioneer Quality Farms	852.7	326	1766	Yes	Yes
	535.4	239	1244	Yes	Yes

[30] 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.

[31] An interesting example of such behavior can be seen among Senegalese small-scale fishermen (Dock et al., 1993).

Appendix Table (*continued*)

Exporter	Quantity	Value ($) (000's)	Value (cedis) (m)	Interview	Have outgrowers
Integral Ghana Ltd.					
Burt & Baker Farms	500.9	220	1227	Yes	Yes
Combined Farmers	397.96	179	937	No	–
Gannat Farms	372.2	152	923	Yes	Yes
Ultrafresh Farms	309.4	121	764	No	–
Bomart Farms	294.2	107	570	No	–
Mashaco Limited	200.1	88	454	Yes	Yes
Lartey Associates	144.8	82	316	No	–
Jesflam Farms	137.5	68	343	No	–
SOA Farms	143.8	64	410	Yes	Yes
Horizon Farms	153.1	62	381	No	–
Kalmoni Farms	151.3	48	292	No	–
Chartered Impex	87.8	47	312	Yes	Yes
Opintin Farms	103.8	40	217	No	–
KA Farms & Mechanical	83.6	39	184	No	–
Vilawoe Farms	99.99	37	163	No	–
Farmex Limited	97.0	31	141	No	–
Evelyn Farms	117.5	18	103	No	–
Average per Main Exporter	995.1	410.7	2167.3		
Average per Main Exporter Interviewed	1095.9	481	2568.5		
Industry Total	28,511.6	11,853	62,674		

Source: Ghana Export Promotion Council (2001).

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. (in press) 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 $i \in \{h,l\}$. Since the farmer's utility is linear in k_i and c_i and diversion of fertilizer is inefficient she will never simultaneously use cash for fertilizer and divert fertilizer towards consumption. 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 $L_i^{c*} + L_i^{k*} - k_i^* = c_i^*$ 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 and the price offered remains the same, this will not affect either the diversion or default constraint. This also does not affect the exporter's profit.

Case II. $k_i^* < L_i^{k*}$ or the farmer is diverting some or all of the 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 EBSE. It basically states that when the exporter cannot offer the optimal amount of credit $\mathbf{k}$ in state i, the determining factor is the default incentives of the farmer. All the lemmas in this subsection assume that the condition of Proposition 3 is true i.e. $q > 1 + \alpha\mu_h$.

Lemma 2. *When $k_i^* < \mathbf{k}$, the default constraint (Def_i) binds in the EBSE for $i \in \{h,l\}$.*

Proof. We show that the high state default constraint (Def_h) binds at the EBSE when $k_h^* < \mathbf{k}$; the identical argument can be used for the low state default constraint (Def_l) as well. Let us assume to the contrary that (Def_h) does not bind. We first show that if this were the case then the high state diversion constraint (Div_h) must bind. We examine two cases—when ($Cash_h$) is slack and when it binds.

Let us first examine the case when ($Cash_h$) is slack. If (Div_h) didn't bind then we could increase k_h^* by a small amount ε 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 the low state default constraint (Def_l). Since (Div_h), ($Cash_h$) and (Def_h) are all slack, a small enough change ε would not violate them. This change, however, would increase exporter profit in the high state which is a contradiction. This can be seen by examining the expression for high state exporter profit

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

The second term is unchanged and the first term increases as $\phi q > 1$.

The second case is when ($Cash_h$) binds. This implies that $\phi(p_h^* - k_h^* - c_h^*) = \mu_h$ which in turn implies $q > 1 + \mu_h$ as otherwise the exporter would be making a loss in the high state. We can now increase k_h^* by a small amount ε and decrease c_h^* by the same amount ε keeping high state price p_h^* the same. This change keeps farmer utility in the low state the same and hence does not affect (Def_l). In addition this change does not affect ($Cash_h$) or (Div_h). For a small enough ε, (Def_h) is not violated as it is slack. Once again, this change raises profits as the quality of the fruit is improved without changing the total loan or the price. Hence we have shown that (Div_h) must bind which in turn implies ($Cash_h$) is slack.

Having shown that (Div_h) binds, the price p_h^* must be given by

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

Plugging this into the expression for the exporter's profit in the high state, we get

$$k_h^*[\phi q - \alpha\mu_h - 1] - c_h^*.$$

Now, we can increase both p_h^* and k_h^* by ε. The high state diversion constraint (Div_h) continues to hold with this change. This change does not result in a violation of the low state default constraint (Def_l) as it increases its left side. For a small enough ε, slack constraints (Def_h) and ($Cash_h$) will continue to hold. Since $\phi q > \alpha\mu_h + 1$, this change would result in higher equilibrium revenue for the seller which is a contraction. Therefore, we conclude that at the EBSE, (Def_h) must bind. Since $\phi q > \alpha + 1$ as well, the identical argument can be made to show (Def_l) binds.

The next lemma derives some properties of the EBSE which are stated in Propositions 3 and 4.

Lemma 3. *In the EBSE, if $k_l^* < \mathbf{k}$, then $c_h^* \geq c_l^* = 0$. Also, in the EBSE $k_h^* \leq k_l^*$.*

Proof. We first show by contradiction that the exporter never provides a cash loan in the low state of the EBSE when $k_l^* < \mathbf{k}$. Suppose the exporter offered positive cash credit in the low state or $c_l^* > 0$. The exporter's profit in the low state can be rewritten as

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

Consider now that the exporter instead offers no cash loan and instead offers a higher price p along with in-kind credit k_l^* such that

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

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,

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

Therefore when the exporter offers a price p and an in-kind loan k_l^*, (Div_l) is slack. Also ($Cash_l$) now holds vacuously. Notice also that the left side of the high state default constraints (Def_h) remains unchanged by our choice of p and hence it continues to be satisfied.

We now show that this change does not violate the low state default constraint (Def_l). Since the original contract $\{(p_i^*, k_i^*, c_i^*)\}_{i\in\{h,l\}}$ satisfies (Def_l), we get

$$\begin{aligned}\frac{\delta}{1-\delta}\sum_{j\in\{h,l\}}\gamma_j\left\{\phi k_j\left[p_j^* - \left(k_j^* + c_j^*\right)\right] + \mu_j c_j^*\right\} &\geq \max_{(k,c)\in B\left(k_l^*, c_l^*\right)}\left\{\phi k p_l^* + c\right\} - \left\{\phi k_l^*\left[p_l^* - \left(k_l^* + c_l^*\right)\right] + c_l^*\right\} \\ &\geq \left\{\phi k_l^* p_l^* + c_l^*\right\} - \left\{\phi k_l^*\left[p_l^* - \left(k_l^* + c_l^*\right)\right] + c_l^*\right\} \\ &= \phi k_l^*\left(k_l^* + c_l^*\right)\end{aligned}$$

When the low state contract is (p, k_l^*), the low state default constraint becomes

$$\begin{aligned}\frac{\delta}{1-\delta}\sum_{j\in\{h,l\}}\gamma_j\left\{\phi k_j\left[p_j^* - \left(k_j^* + c_j^*\right)\right] + \mu_j c_j^*\right\} &\geq \max_{(k,c)\in B\left(k_l^*, 0\right)}\{\phi k p + c\} - \left\{\phi k_l^*\left[p - k_l^*\right]\right\} \\ &= \phi k_l^* p - \phi k_l^*\left(p_l^* - k_l^*\right) \\ &= \phi k_l^{*2}\end{aligned}$$

Since $k_l^{*2} < k_l^*[k_l^* + c_l^*]$, the low state default constraint now becomes slack. By examining the rewritten profit expression, we can conclude that the profit of the exporter is unaffected by this alternate contract.

But now if $k_l^* < \mathbf{k}$, we can increase k_l^* by a small amount ε and adjust p in a way keeping $\phi k_l^*(p - k_l^*)$ constant. This increases profits and does not affect (Def_h). Moreover, since both the diversion and the default constraint in the low state are slack, small enough changes will not violate them. This provides the requisite contradiction and shows that $c_l^* = 0$ whenever $k_l^* < \mathbf{k}$.

We now show the second part of the lemma by contradiction. Assume to the contrary that $k_l^* < k_h^* \leq \mathbf{k}$. We have already shown that this implies $c_l^* = 0$. Since (Def_h) holds, the low state default constraint (Def_l) is slack. If in addition, the low state diversion constraint (Div_l) is also slack, we can repeat the above argument and once again increase k_l^* by a small amount ε and adjust p_l^* in a way keeping $\phi k_l^*(p_l^* - k_l^*)$ constant but thereby increase profits. On the other hand if (Div_l) binds, then profits can be increased by raising both k_l^* and p_l^* by a small amount ε. This change does not affect (Div_l), it further slackens (Def_h) by increasing its left side and since (Def_l) is slack, a small enough increase ε will not violate it. This shows the contradiction and completes the proof of the lemma.

We can now prove Proposition 3.

Proof of Proposition 3. The first part follows from the argument in the text. 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 $\mathbf{k}$ in both states. In the text, we have argued that when $\phi q > 1 + \alpha\mu_h$, profits are increasing in k_i when only the diversion constraints bind. Thus for patient enough farmers the exporter can offer the optimal amount of in-kind credit $\mathbf{k}$ along with prices $p_i^* = \alpha\mu_i/\phi + \mathbf{k}$ without inducing default and can thereby maximize profits.

B.3. Proof of Proposition 4

The strategy for the proof is as follows. Subject to the conditions in Proposition 4 part (2), we first derive the maximum profit that the exporter can achieve in equilibrium by offering only in-kind credit. This is the solution to problem ($\bowtie$). We then show that for a low enough δ the exporter can derive higher profits in equilibrium by offering cash credit for consumption in the high state $c_h^* > 0$. This implies that cash credit must feature in the EBSE.

Proof of Proposition 4. Before beginning, we should point out that we repeatedly use the qualifier "for low enough δ" throughout the proof. Each time we use this qualifier, it implies that there is a discount factor $\hat{\delta}$ such that the statement follows for $\delta \in \left(0, \hat{\delta}\right)$. Then the $\overline{\delta}$ in the statement of the proposition can be obtained by taking the minimum over all these $\hat{\delta}$'s.

We begin by observing that for low enough δ, the exporter cannot offer the optimal amount of in-kind credit $\mathbf{k}$ in either state. This is because there is an upper bound on the amount of utility the farmer can enjoy in equilibrium. Sufficiently myopic farmers will default to avoid repaying the loan even though they are offered the maximum possible surplus in the future. Henceforth, we focus on the case where farmers are myopic enough so that $k_l^*, k_h^* < \mathbf{k}$ in the EBSE. Part (1) of the proposition then follows from Lemma 3. We now prove part (2) of the proposition.

We start off by examining the maximum profit the exporter can obtain in equilibrium without offering cash credit. We can use the identical argument in the proof of Lemma 2 to conclude that in this case the default constraints in both states must bind. Using this observation, we can simplify the problem (⋈) corresponding to the maximum exporter profit without cash credit by imposing $k_l = k_h = k$. The objective function then becomes

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

There is only one default constraint which holds with equality

$$\phi k^2 = \frac{\delta}{1-\delta}[\phi k(\gamma_h p_h + \gamma_l p_l - k)]$$
$$\equiv \frac{k}{\delta} = \gamma_h p_h + \gamma_l p_l$$

and two diversion constraints

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

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

The argument in the text shows that the solution to (⋈) will involve at least an amount of credit $\tilde{k}$ so that the above three constraints hold with equality. We can then solve for $\tilde{k}$ to obtain

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

We have already taken δ low enough so that $\tilde{k} < \mathbf{k}$. For any level of credit $k > \tilde{k}$, the diversion constraints are slack. This is because when the offered level of credit offered in both states satisfies $k > \tilde{k}$, we can always choose prices p_h and p_l which satisfy the default constraint but leave the diversion constraints slack. The following equation shows this,

$$\frac{k}{\delta} = \gamma_h p_h + \gamma_l p_l > \gamma_h \left[\frac{\alpha\mu}{\phi} + k\right] + \gamma_l \left[\frac{\alpha}{\phi} + k\right].$$

Thus the solution to (⋈) can be rewritten only in terms of the default constraint. In addition, this allows us to rewrite the maximization problem in terms of a single price $p = \gamma_h p_h + \gamma_l p_l$ as this is the only price that appears in the constraint and in the objective function.

In order for a higher level of in-kind credit than $\tilde{k}$ to be optimal it must be the case that the derivative of the profit equation at $\tilde{k}$ is positive along the default constraint. Plugging in the default constraint and differentiating the profit equation we get

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

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

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

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

$$\phi\left[q - \frac{\hat{k}}{\delta}\right] - \frac{\phi\hat{k}}{\delta} - \left[1 - 2\phi\hat{k}\right] = 0,$$
$$\Rightarrow \hat{k} = \frac{\delta(\phi q - 1)}{2\phi(1-\delta)}.$$

Once again, we have taken a low enough δ so that $\hat{k} < \mathbf{k}$.

We now examine whether the level of credit $\hat{k}$ along with the price $\hat{p} = \frac{\hat{k}}{\delta} = \frac{\phi q - 1}{2\phi(1-\delta)}$ is the solution to the problem (★) corresponding to the EBSE. We first observe that this price is such that

$$\frac{\phi\hat{p}}{\gamma_h} < \mu_h.$$

This implies that if the exporter provides cash credit in the high state with price close enough to $\hat{p}$, the farmer will use the cash credit for consumption as opposed to in production. In other words, ($Cash_h$) is satisfied. In addition, this also shows that for a price close to $\hat{p}$ optimal default corresponding to the right side of the default constraints (Def_i) will involve using cash credit for consumption. Plugging in the expression for $\hat{p}$, we get

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

When $\delta = 0$, the above inequality reduces to $\phi q < 2\bar{\mu} + 1 - 2\gamma_l$ which holds since by assumption $\phi q < 2\bar{\mu} - 1 < 2\bar{\mu} + 1 - 2\gamma_l$. Thus for low enough δ, $\frac{\phi\hat{p}}{\gamma_h} < \mu_h$.

This observation allows us to simplify the maximization term in the high state default constraint (Def_h) in (★). When $k_l = k_h = \hat{k}$, $\gamma_h p_h + \gamma_l p_l = \hat{p}$ and $c_h > 0$, (Def_h) can be simply expressed as

$$\phi\hat{k}\hat{p} + \left[\gamma_h\mu_h - \frac{\phi\hat{k}}{\delta}(1-(1-\gamma_h)\delta)\right]c_h \geq \frac{\phi\hat{k}^2}{\delta}. \quad (2)$$

We start off by showing that $\gamma_h\mu_h > \phi\hat{k}(\gamma_h + \frac{1-\delta}{\delta})$. An examination of the above default constraint shows that unless this is true cash credit cannot slacken (2). Plugging in the expression for $\hat{k}$, we get

$$\begin{aligned}&\gamma_h\mu_h > \phi\frac{\delta(\phi q - 1)}{2\phi(1-\delta)}\left(\gamma_h + \frac{1-\delta}{\delta}\right) \\ &\equiv \phi q < \frac{2\gamma_h\mu_h(1-\delta)}{1-\delta+\delta\gamma_h} + 1 \\ &\equiv \phi q < \frac{2\gamma_h\mu_h}{1 + \frac{\delta\gamma_h}{1-\delta}} + 1\end{aligned} \quad (2)$$

Notice the right side of the above inequality is decreasing in δ and therefore attains a maximum at $\delta = 0$ at which point it reduces to $2\gamma_h\mu_h + 1$. Thus for low enough δ, the above inequality is satisfied as we have $\phi q < 2\gamma_h\mu_h + 1 - 2\gamma_h < 2\gamma_h\mu_h + 1$ by assumption.

We now argue that

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

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

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

The last inequality is true by assumption.

Finally, we show that the exporter can get higher profits than the contract $\left(\hat{p}, \hat{k}\right)$. We show this by arguing that profit can be increased by decreasing the price $\hat{p}$ by a small amount and instead providing some cash credit c_h. Consider a small reduction in the price $\hat{p}$ by $\frac{\varepsilon}{\phi\hat{k}} > 0$ where ε is small. If $c_h = 0$, this would lead to a violation of the high state default constraint (2). Hence, c_h can be increased in order to satisfy the high state default constraint (Def_h). Since cash credit is not being offered in the low state, this change will slacken (Def_l). A decrease in $\hat{p}$ by $\frac{\varepsilon}{\phi\hat{k}}$ leads to a decrease of the left side of (Def_h) by ε. Therefore, (Def_h) continues to hold if we increase c_h by $\frac{\varepsilon}{\gamma_h\mu_h - \frac{\phi\hat{k}}{\delta}(1-(1-\gamma_h)\delta)}$. For small enough ε, the diversion constraints will not be violated as we have already argued that they are slack at $\left(\hat{p}, \hat{k}\right)$.

Adjusting the price and offering cash credit instead will changes profit by

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

Therefore profits can be increased above the maximum attainable profits via in-kind loans alone and this implies that at the EBSE cash credit for consumption will be offered in the high state. This completes the proof.

B.4. Proof of Proposition 5

Proof. Suppose the exporter offers a contract $(p_i, k_i, c_i)_{i\in\{h,l\}}$ in which the exporter contracts in at least one of the two states. This implies that $k_h + k_l > 0$, c_h, $c_l \geq 0$. Since the default constraint ($AFDef_i$) must hold in both states, we can add them up to get

$$\begin{aligned}
&\sum_{i\in\{h,l\}}(k_i + c_i) \leq \frac{2\delta}{1-\delta}\sum_{i\in\{h,l\}}\gamma_i[\phi k_i(p_i - [k_i + c_i]) + \mu_i c_i] \\
&< \frac{2\delta}{1-\delta}\sum_{i\in\{h,l\}}\gamma_i[\phi k_i p_i + \mu_i c_i] \quad [\text{As } k_h + k_l > 0] \\
&\leq \frac{2\delta}{1-\delta}\sum_{i\in\{h,l\}}\gamma_i[\phi k_i q + \mu_i c_i] \quad [\text{As } p_i \leq q]
\end{aligned}$$

Hence, if

$$\sum\nolimits_{i\in\{h,l\}}\left\{\frac{2\delta}{1-\delta}\gamma_i[\phi q + \mu_i]\right\} < 1,$$

the above constraint will not hold for any k_h, c_h, k_l, c_l. Clearly for low enough δ this will be the case and hence contracting will not emerge with sufficiently impatient farmers.

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