A Moral Hazard Model of Informal Credit

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Declaration

I hereby declare that the contents of this submission is my own work and to the best of my knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the award of any other degree or diploma at UNSW or any other educational institution, except where due acknowledgement is made in the thesis. Any contribution made to the research by others, with whom I have worked at UNSW or elsewhere, is explicitly acknowledged in the thesis.

I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project’s design and conception or in style, presentation and linguistic expression is acknowledged.

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Abstract

The informal credit market exhibits a number of striking features, of which include interlinkage and segmented markets. However, there is little existing theoretical analysis as to how segmentation arises within informal credit markets.

I construct a new theoretical model of interlinkage in the context of the Hold Up Problem and moral hazard. I then utilise this framework to model the endogenous emergence of segmentation.

I find that if the Contested Segment has a sufficient degree of market power, segmentation will arise. Under segmentation, I find the the effort levels are greater within the Home Segment when compared to the Contested Segment. These results are driven by the degree of social capital held between a farmer and trader which the Hold Up Problem encapsulates, and the level of market power that exists within informal credit markets.

Further, I utilise this framework to analyse the impact of an Interest Rate Ceiling, and the entry of a Microfinance Institution, on the welfare of farmers. I find that an Interest Rate Ceiling has the potential to leave farmers worse off due to diminishing outside options, and that a Microfinance policy enhances outside options. These policy predictions are distinct from previous analyses made within the literature.
1 Introduction

It is well established in the economic literature that there is a demand for credit amongst the poor (Banerjee & Duflo, 2007). Credit is especially important to the poor for a number of purposes: it serves to smooth consumption patterns; it assists with unexpected expenses; and importantly, it enables investments in fixed and working capital (Ghosh, Mookherjee & Ray, 1999). However, it is also well established that the poor are often excluded from formal credit markets, reasons for which include lack of acceptable collateral and volatile incomes (Banerjee & Duflo, 2007). A combination of these factors gives birth to an informal credit market. But what is the "informal credit market"?

The phrase “informal credit market” is perhaps a misleading one, for informal credit is not organised like a “market”. This collection of credit transactions exhibits peculiarities that are foreign to formal loan institutions. Oral credit contracts, exclusive long term lending, high interest rates, strong social capital and zero collateral are some of its main features. Additionally, interlinkage of loan agreements with crop agreements, as well as an observed segmentation of markets also persists - but are not examined in detail by the literature. The key questions that this thesis asks is, how do these characteristics within the informal credit market arise? Can we explain the emergence of interlinkage and segmentation? Does this explain how exclusive credit arrangements can arise?

There are strong empirical and theoretical strands of literature that explain interlinkage. However, there are very little papers that take interlinkage into a segmented market context. To the best of my knowledge, only Chaudhuri (2000) and Chaudhuri & Banerjee (2004) examine interlinkage and segmentation simultaneously, but the segmentation is not explained by the framework.

The contribution of this thesis is to establish the microfoundations of segmentation using interlinkage and social capital. I construct a moral hazard model of interlinkage, in the context of the Hold Up Problem. Then, I utilise this framework to establish the market conditions under which segmentation arises, including the emergence of exclusive credit arrangements.

The significance of this thesis is in its ability to make more nuanced policy predictions.
The segmented interlinkage framework can be used to analyse a host of policy interventions within the informal credit market. I examine the effect of an Interest Rate Ceiling, and the entry of a Microfinance Institution on the segmented interlinkage framework. Furthermore, this framework can be extended to study future policy interventions, such as Agent Intermediated Microfinance.

The remainder of this thesis is organised as follows. Chapter 2 provides an overview of the literature on interlinkage and segmentation. Chapter 3 establishes a moral hazard model of interlinkage in the context of the Hold Up Problem, and presents some results. Chapter 4 utilises this interlinkage framework and endogenises the formation of segments within informal credit markets, followed by a discussion of these results. Chapters 5 and 6 analyse an Interest Rate Ceiling and a Microfinance Institution policy respectively using the endogenous segmented interlinkage framework. Finally, Chapter 7 concludes and details some extensions to this model.
2 Informal Credit, Interlinkage & Segmentation

Prior to the 1970s, the informal credit market was largely ignored by economic analysis and policymakers due to its “triviality of operations and (limited) role in economic development” (Daniel, 2000, pp. 1). However, in the face of failed policies which were sought to improve borrower welfare, a wealth of economic literature has emerged since. Informal credit markets are marked with characteristics unfamiliar to formal credit markets, including interlinkage and segmentation. In this chapter, I provide an overview of the characteristics and theories of informal credit markets, followed by an analysis of approaches to modelling interlinkage and segmentation.

2.1 The Informal Credit Market

2.1.1 Nature and Characteristics

Despite the widespread emergence of larger formal credit institutions such as credit co-operations and rural banks, the informal credit market has still thrived in developing agrarian economies. Much of the mechanics of informal credit departs from the features of formal or ‘organised’ credit markets. Both Hoff & Stiglitz (1990) and Ghosh, Mookherjee & Ray (1999) summarise some of these mechanics. Loans are often in oral form; little or no collateral is advanced on loans; there exists segmentation within the market, associated with exclusive long term relationships; interest rates display high variation, but are generally higher than formal rates; there is regular interlinkage between credit and other markets such as crop, land, labour; and there is a significant amount of credit rationing in the sense that borrowers are excluded from credit, or borrowers are unable to obtain enough credit (Ghosh, Mookerjee & Ray, 1999).

Whilst there exists arguments which suggest that these features will be displaced with economic development (Bardhan, 1980), there is an abundance of empirical evidence which suggests otherwise. Madestam (2009) cites evidence reported in Banerjee (2003) which indicates that informal interest rates “ranged from 0 to 80 percent in India, between 26 and 43 percent in Thailand, and between 18 and 200 percent in Pakistan” (Madestam, 2009, pp.19). Deb & Suri (2012), Geron (1989) and Maitra et. al. (2012) all present
empirical evidence of oral loan agreements and interlinkage of credit and output in Ghana, the Philippines and India respectively. Besley (1994) cites the existence of segmentation within the informal credit markets. Pender (1996) uses credit market and experimental data from South India to show that absence of debt amongst some potential borrowers is a consequence of credit rationing rather than a lack of demand. Survey data from Madagascar shows similar results (Zeller, 1994). For an in depth overview of informal credit characteristics in agrarian economies, see Conning & Udry (2005).

2.1.2 Theories of Informal Credit Markets: Exploitation vs. Efficiency

A number of approaches have been undertaken in the theoretical literature to explain the peculiarities of informal credit markets. Broadly, these fall into two categories: theories of exploitation, and theories of efficiency.

The earlier literature characterised informal credit markets as exploitative and anti-developmental (Daniel, 2000, pp. 17). Bhaduri (1977) popularised the ‘default theory’ of high interest rates in informal credit markets. The theory postulates that informal lenders set interest rates such as to induce default, which enables lenders to acquire the borrower’s collateral (Bhaduri, 1977). Bell (1990) further highlights the attitudes towards informal credit, citing a Reserve Bank of India Report from 1954, “the moneylender can be allotted no party in the scheme (of cooperatives) . . . (the) structure is to provide a positive institutional alternative to the moneylender himself, something which will compete with him, remove him from the forefront and put him in his place” (RBI 1954, vol. 2, pp. 481 – 82, as cited in Bell, 1990, pp. 297).

However, more recently, the literature on informal credit has shifted away from models of exploitation, and towards models of efficiency. Part of this movement is a consequence of the failure of rural banks and state owned cooperatives, which did not result in the disappearance of informal credit. Hoff and Stigliz (1990) classify this strand of literature into three categories: adverse selection, moral hazard and contract enforcement issues. For a detailed overview of the efficiency literature on informal credit, see Ghosh, Mookherjee & Ray (1999, pp. 2 – 5).
2.1.3 Social Capital in Informal Credit Markets

Social capital and long term relationships of trust are persistent characteristics within informal credit markets. Bendor & Mookherjee (1990) provide a good theoretical analysis of this. Social capital, or social norms, enhance cooperation for three reasons: they internalise informal codes of behaviour, detail punishment mechanisms where a party reneges, and there exists third-party sanctions (such as tarnishing a reputation) that also enforce the norms (Bendor & Mookherjee, 1990, pp. 34).

The empirical literature verifies the presence of such behaviour. Knack and Stephen (1997) uses the World Values Surveys which examines 29 market economies and construct a measure of trust. The authors find that trust both exists in informal credit markets, and enhances economic performance. A survey of fourteen moneylenders in Pakistan found that 78% of all borrowers were repeat customers for at least four periods of production, indicating the existence of long term relationships of trust (Aleem, 1990). Such evidence illustrates the pivotal role that trust and social capital play in the formation of credit arrangements in informal credit markets, of which include interlinkage credit contracts.

2.2 Interlinkage

“An interlinked transaction is one where two or more interdependent exchanges are simultaneously agreed upon” (Chakabarty & Chaudhuri, 2001, pp. 313). Theories of interlinkage did not emerge until the 1980s. Gangopadhyay & Sengupta (1987) explains the progression of this literature. Earlier empirical studies found evidence of a high degree of variability in informal credit interest rates, ranging from as low as 0%, to as high as 120%. Theoretical literature in the 1980s proposed interlinkage as an explanation for such observations (e.g. Braverman and Srinivasan, 1981; Basu, 1983; Mitra, 1983). The empirical literature on interlinkage has followed, providing evidence for the theories of interlinkage.

2.2.1 Empirical Evidence of Interlinkage

The existence of interlinkage in rural informal credit markets is well established in developing regions. Geron (1989) reports evidence from the Philippines that 34% of all loans to palay growers, and 58% of all loans to coconut growers, were advanced by traders.
Banik (1993) uses village and household level survey data from Bangladesh to conclude that 72% of small farmers and 92% of middle sized farmers in the village of Sirkhat were involved in interlinked credit transactions. Similar results are also found for the village of Choto Asulia. Interlinkage was not present amongst larger farmers, suggesting it is a phenomenon concentrated amongst the smallest and poorest farmers.

Smith & Stockbridge (1999) collect primary data from Sindh, Pakistan to show that approximately 75% of all cotton, urea and di-ammonia phosphate farmers were involved in interlinkage through in-kind loans. Sotomayor & Nelson (2002) use a sample of 88 tomato and corn farmers and 107 traders in Peru to show evidence of interlinkage. Sotomayor & Nelson find that more than 50% of farmers stated that the trader was their preferred lender, and that they voluntarily participated in interlinkage contracts, dispelling exploitation theories. The paper also cites anecdotal evidence of the existence of repeat lending; once a farmer builds trust, they are then offered loans with crop agreements by traders.

Shami (2012) uses logit regressions on household level data from Hafizabad, Pakistan to study the impact of the construction of a motorway on entering into an interlinked contract. Shami finds that being in an isolated village increases the chance of interlinkage by 24% relative to connected villages, however when accounting for interaction effects, there is no statistically significant effect for labour interlinkages. Such evidence highlights the operation of both isolation and efficiency effects in the formation of interlinkage contracts.

Deb & Suri (2012) use data from Ghana to show that a positive exogenous technology shock results in the formation of interlinkage contracts between pineapple farmers and traders, accounting for 42% of Ghanaian pineapple exports. Anecdotal evidence from the study shows that interlinkage served as a mechanism to monitor the quality of the final output. Both Maitra et. al. (2012) and Mitra et. al. (2012) provide empirical evidence for the existence of interlinkage contracts between potato farmers and traders in West Bengal, India.

Collectively, these empirical studies show that interlinkage is present in developing regions globally, and persist for a multitude of reasons. The theoretical literature on interlinkage provides further insight on the latter.
2.2.2 Theoretical Models of Interlinkage

Most of the theoretical attention in the interlinkage literature has been on sharecropping interlinkage models. The shift towards modelling output-credit interlinkage contracts has been relatively recent, and hence aspects of this literature are still relatively unexplored.

2.2.2.1 Sharecropping Interlinkage Models

The analysis of credit, labour, and output interlinkage models in a sharecropping context is well developed in the literature. Braverman & Srinivasan (1981) is one of first papers to model such a relationship. Within a utility framework, the authors model a sharecropping agreement tied with a consumption loan. The authors find that regardless of whether interlinkage exists, as long as the landlord has the ability to vary the size of the plot the tenant cultivates, the optimal contract is such that the utility within this contract, and the utility from an alternative full time labourer contract is equivalent. This result implies no added value of interlinkage. Further, the authors use this framework to analyse the impact of an interest rate floor on the sharecropping arrangement. This analysis finds that “if tying is permitted, the landlord can reduce the tenancy and credit reform to insignificance”, and hence the policy is neutral to interlinkage (Braverman & Srinivasan, 1981, pp. 301). The analysis is simplified largely by assumptions such as no possibility of default, and the exogeneity of interest rates offered by landlords and moneylenders.

Basu (1983) argues that the presence of ‘inherent risk’ results in the interlinkage and isolation in informal credit markets. Basu makes the following argument for isolation. A landlord can always enforce a debt on its labourer due to their ability to sanction, but not where the borrower is not the landlord’s labourer. Hence, if all landlords do not discriminate between borrowers, in equilibrium, tenants will borrow from a landlord they do not work for and default, and hence the landlord only attracts “lemons”. Consequently, landlords will only offer loans to their own labourers, resulting in the “isolation” of credit availability. Basu’s model also reinforces the ability of a landlord to offset lower interest rates by changing other aspects of the contract, such as wages.

Mitra (1983) initiated the strand of literature which utilised a principal-agent framework in analysing sharecropping interlinkage. Mitra devises a two period model in which
a demand for consumption credit arises in period 1 due to wages being paid in period 2. Interlinkage is explained in terms of the moral hazard problem, showing that landlords who cannot observe tenant effort will find it optimal to interlink wage and consumption credit. Mitra argues that interlinkage is Pareto optimal, and that unrestricted access to credit may in fact be Pareto inferior. The framework however assumes that loans are restricted to consumption purposes.

Gangopadhyay & Sengupta (1986) devise a model in which loans are able to be taken out for production and consumption purposes. The paper concludes that if a tenant is risk averse, this results in the distortion of production interest rates, since interest rates are less than the opportunity cost of capital. The result occurs as a consequence of uncertainty in output, and since the demand for credit is a derived demand, this risk aversion affects the interest rates. However, consumption loans are found to equate to the market interest rates. This result diverges from the previous theoretical and empirical literature, which overwhelmingly finds that interest rates are higher on average in the informal credit market. The paper suggests that perhaps interlinkage is not an appropriate framework to analyse high interest rates, however it may be the case that risk aversion alone does not properly characterise interlinkage contracts.

Basu (1987) proposes that interlinkage is an exploitative arrangement that attempts to extract the consumer’s surplus. The paper models the interactions between a monopolist moneylender and borrowers, where the moneylender imposes a “two part tariff”. Basu shows that if a moneylender has a monopoly within the credit market, the moneylender can extract a greater surplus from the borrowers if loans are interlinked, and hence the “two part tariff” arises. However, Basu assumes that the moneylender has monopoly power. An analysis of how such power arises would strengthen Basu’s argument.

2.2.2.2 Output-Credit Interlinkage Models

Unlike the sharecropping interlinkage literature, the output-credit interlinkage literature is still relatively recent and developing. There is typically a different host of issues surrounding output-credit interlinkage contracts when compared to sharecropping interlinkage contracts. Output-credit interlinkage loans are predominantly advanced by traders for the purposes of production rather than consumption; the trader generally acts as an intermediary to competitive wholesale markets, which complicates the sources of uncertainty within models; these loans are of increasing significance with the implementation of land reforms by governments which give larger ownership of land to farmers; and the influence of social capital and differential bargaining positions does not necessarily result in the emergence of monopoly power, as is suggested by some of the sharecropping literature.

Fabella (1992) models an interlinkage loan between a trader and farmer, where repayment of the loan is in-kind. Fabella assumes the trader is monopolistic. Fabella compares the payment of loan cash for cash and in-kind, where there exists wholesale price uncertainty. The in-kind arrangement is found to be preferred with both risk neutral and risk averse farmers, and traders are shown to prefer interlinkage to pure output contracts. Fabella alludes to the existence of a “post-harvest” trading market in addition to ex ante trading; however this is not explored in any detail.

Sotomayor & Nelson (2002) model output-credit interlinkage in a repeated game framework. The paper shows that long term relationships give rise to trust, which helps overcome problems of asymmetric information that preclude the formation of interlinkage contracts in a one period game. The model also incorporates tolerance of small deviations, due the inability of a trader to determine whether default is due to non-cooperation, or random shocks.

Deb & Suri (2012) examines the endogenous emergence of interlinkage in Ghana, as a response to a change in technology. The model is specifically designed to explain empirical evidence from Ghana in the pineapple export industry. Cheaper shipping technology gave rise to a need for better quality control, and interlinkage contracts are used as a mechanism of ensuring the use of fertiliser to maintain quality. The model also utilises a repeated game framework, with in-kind loans (fertiliser) and consumption loans.
2.2.2.3 The Hold Up Problem and Interlinkage

There is very little literature which examines the hold up problem in an interlinkage context. To the best of my knowledge, the only paper which examines this issue is Kranton & Swamy (2008). The model aims to capture the historical contracting of the East India Company in the cotton textiles industry. The paper models a two-way hold up problem: borrowers may not uphold repayment agreements, and producers may not adhere to output sales contracts. This is shown to hinder economic growth in this specific context. In the context of modern trader-farmer relationships, both ex ante and ex post contracts may exist within the informal credit market. A segmentation analysis is needed to model their interactions, which will be presented in Chapter 4.

2.3 Segmentation

2.3.1 Empirical Evidence of Segmentation

It is widely acknowledged that the informal credit market is fragmented, and this is illustrated by the empirical literature. Zeller (1994) cites evidence from Madagascar which reveals that the informal credit sector is “highly heterogeneous with respect to the type of relationship between borrower and lender, such as social cohesion or the existence of an interlinked transaction” (Zeller, 1994, pp. 3). Haugen (2005) points to evidence from Nepal for the existence of segmentation. Haugen observes that the existence of segments is a result of defined personal relationships which induce repeated contracting, and that these segments are geographically defined. The paper also notes that interlinkages within markets are closely related to segmentation as it confers some form of enforcement advantage.

Aryeetey (1998) notes that segmentation is a pervasive feature of informal credit in Africa, “because the various segments serve distinct groups of clients with similar characteristics and needs” (Aryeetey, 1998, pp. 11). Nagarajan & Meyer (1993) uses an econometric analysis of data from the Philippines to show the influence of certain borrower characteristics in the formation of segments of trader-lenders and farmer-lenders. The authors use a logit regression and find that borrowers are more likely to be matched to trader-lenders if they have had previous business relationships and a good reputation.
(long term relationship is less important), but collateral is not important to matching. Opposite results for borrower characteristics are found for farmer-lenders.

### 2.3.2 Theoretical Models of Segmentation

The theoretical literature on segmentation in the context of the informal credit market is limited. Basu & Bell (1991) construct a model of a fragmented duopoly, whereby there exists a captive segment (where each lender enjoys monopoly power), and a contested segment (each lender competes). The customers that each lender is initially trading with are treated as exogenous. The lenders are assumed to engage in Cournot competition. The paper shows that where there is no price discrimination, monopoly prices will be charged in both segments; whereas when there is price discrimination, monopoly prices will be charged in the captive segment, and duopoly prices in the contested segment. The paper then models a two period sequential game, and assumes that each lender/landlord has the power to forbid borrowers from obtaining loans elsewhere. Basu & Bell argue that this gives rise to incentives for interlinkage. The segmentation that arises is assumed to be exogenously determined. The paper provides a theoretical grounding for further work; however it assumes exogeneity of a number of key variables. Mishra (1994) extends this analysis by introducing a fixed cost of operation for lenders, and sequential selection of market sizes, which leads to slightly different characterisations of the equilibrium.

### 2.4 Models of Interlinkage and Segmentation

To the best of my knowledge, there only exists two papers which examine interlinkage and segmentation within the same model. Chaudhuri (2000) uses a principal-agent framework to model a non-cooperative game between a moneylender and a trader-lender who decide the informal interest rate for interlinked and non-interlinked loans. Chaudhuri shows that unless the opportunity interest rate is increasing with the size of the loan, the moneylender will face no demand. The interlinked price is shown to equate to the market price of the goods, and hence the trader makes zero trade profits; all income accrues from credit market activities. Chaudhuri then conducts a subsidy analysis within this framework, and shows that a price subsidy will reduce interlinkage, but a credit subsidy will raise it.
Chaudhuri & Banerjee (2004) construct a model which draws upon the “captive” and “contested” segments from Basu & Bell (1991)’s framework. The paper specifically devises the model to analyse World Trade Organisation liberalisation policies. Chaudhuri & Banerjee find that a reduction in trade subsidies will increase the size of the captive market, which deteriorates farmer welfare, and that an increase in price will improve welfare but has ambiguous effects on productivity.

A shortcoming of both Chaudhuri (2000) and Chaudhuri & Banerjee (2004) is that the existence of segmentation is assumed, or given exogenously. Both models assume that only “captive segment” traders are capable of forming interlinkage contracts. I address this aspect of the literature in the theoretical model that follows in Chapter 4.
3 A Theoretical Model of Interlinkage

In this chapter, I develop a novel theoretical model of credit-output interlinkage. This model is empirically motivated by evidence that credit-output interlinkage arrangements exist in developing economies globally, as noted in Chapter 2. In this model, I utilise the field experiment in Maitra et. al. (2012) as a key example of such interlinkage contracts. The experiment makes the observation that localised traders in West Bengal, India combine informal loan contracts with potato crop purchase agreements. The authors also observe that the traders onsell the potatoes on a wholesale market with some mark up on price. I construct a moral hazard model of interlinkage to capture these empirical observations.

The key contribution of this model is to show the effect that commitment and the hold up problem have on the structure of, and incentives within, interlinkage contracts. I model ex ante and ex post price determination within interlinkage to achieve this. Given the uncertainty of prices on the wholesale market, a trader is able to commit to a price ex ante with a farmer if social capital exists between them. Such a set up is justifiable on three grounds: first, social capital assists with enforcing agreements through social norm punishment, and hence a trader is more likely to commit ex ante if social capital exists; secondly, social capital results in the internalisation of codes of conduct (such as adhering to agreements), enhancing cooperation; and third, the existence of repeated interactions within social groups gives rise to incentives to cooperate today to enter into agreements in the future (see Chapter 2 for an overview of social capital in informal credit).

This chapter continues with a description of the model, followed by an analysis of first best, ex ante and ex post interlinkage contracts. I examine the optimal levels of effort, prices and interest rates, and how those incentives differ across the different contractual structures.

3.1 Description of the Model

Consider a situation where a farmer has some indivisible project that requires some amount of funds $L$ to be viable. For simplicity, I assume that the project size and required funds
is fixed. To abstract from issues of sharecropping, I assume the farmer owns some fixed plot of land available for the project. For explanatory purposes, I make specific reference to the project as the growth of a potato crop, but this project is capable of taking the form of many other agricultural and non-agricultural investments.

The project yields some output level $Q$, which I assume to be binary; output takes the value of $Q$ during a good harvest, and zero when the potato crop fails. Such a set up is commonly found in informal credit contracts. The probability of a successful harvest is given by $s(e)$, where $e$ is the effort level exerted by the farmer on the project. I assume that $s(e)$ is strictly increasing and strictly concave, and hence $s(e)$ exhibits diminishing marginal returns. The cost of exerting effort is given by $C(e)$, which is assumed to be strictly increasing and strictly convex.

To introduce borrowing, I assume that the farmer cannot self finance the project, and hence borrows an amount $L$ from a trader. I let the loan be of limited liability, which is implied by the assumption that $Q$ is zero when the crop fails. Hence, the farmer faces no debt obligation when the crop fails. I let the total amount of debt the farmer owes the trader after one period be denoted by $(1 + r)L$, where $r$ is the interest rate on the loan. I assume that the debt is not secured by any collateral, which more accurately reflects typical informal loans in developing credit markets, due to a lack of acceptable collateral amongst borrowers. For simplicity and without loss of generality, I assume that the trader incurs no additional cost of entering into the loan arrangement, that monitoring of the loan is costless, and that the opportunity cost of capital is zero.

In addition to the loan agreement, the farmer enters into an agreement for the sale of the potatoes after harvest to the trader at price $p$. The trader then sells the potatoes on the wholesale market at a stochastic price $\bar{p}$ with expectation $E[\bar{p}] = p'$, which exogenously determined. All agents in the problem are risk neutral.

\footnote{This assumption does not change any of the main results presented in this chapter and in the following chapter. Introducing sharecropping into this set up would only exacerbate the incentive problems presented here, since the farmer would only receive a share of their output.}
3.2 First Best - Verifiable Effort

With verifiable effort, the effort level is contractible and hence enforced on the farmer. In this section, I examine how verifiable effort affects the use of the incentive instruments of price and interest rate.

3.2.1 Timing of the Model

The timing of the model is as follows:

1. The trader makes an offer \((r, p)\) to the farmer for a loan \(L\) to produce an amount \(Q\) with effort level \(e\). The farmer can choose to accept or reject the offer.

2. If the farmer accepts the offer, the farmer then invests \(L\) and exerts the contracted level of effort on the investment, \(e\). The probability of a successful harvest is a function of effort, \(s(e)\).

3. Output level \(Q\) is realised, and the farmer sells \(Q\) to the trader for price \(p\), and repays debt \((1 + r)L\) if the project is successful. Otherwise, the farmer sells nothing an repays none of the loan. The farmer’s payoff is realised.

4. If the farmer’s project is successful, the trader sells \(Q\) at price \(p'\) in the wholesale market. Otherwise, the trader sells nothing and loses the size of the loan \(L\). The trader’s payoff is realised.

3.2.2 Analysis of the Model

The trader maximises the following:

\[
\max_{e, p, r} \quad s(e)[Q(p' - p) + (1 + r)L] + (1 - s(e))[0] - L \\
\text{s.t.} \\
\quad s(e)[Qp - (1 + r)L] + (1 - s(e))[0] - C(e) \geq 0
\]  

Without loss of generality, I normalise the outside option to zero. Hence, I assume that the opportunity cost of participating is zero. The Participation Constraint holds with equality; given that the trader can contract on \(e\), the trader has no incentive to keep the
farmer above her Participation Constraint, since doing so reduces the trader’s profits (see Appendix A.1 for proof).

The First Order Condition with respect to $e$ is given by the following:

$$\frac{s'(e)}{C''(e)} = \frac{1}{Qp}$$

(2)

This is the first best left of $e$, which is used as a benchmark for subsequent results.

### 3.2.3 Characterisation of the Equilibrium

Suppose now that an equilibrium exists. Optimality requires that any $(e^*, r^*, p^*)$ which solve the maximisation problem must satisfy the following conditions:

$$e^* \text{ solves } \left\{ \frac{s'(e)}{C''(e)} = \frac{1}{Qp} \right\}$$

(3)

any pair $(p^*, r^*) \in \mathbb{R}$ that satisfies $\{s(e^*)[Qp - (1 + r)L] - C(e^*) = 0\}$

(4)

(See Appendix A.3 and A.4 for proofs.)

To keep the interpretation of these results in line with empirical observations, I disregard negative values of $r$ and $p$. There are two distinctive features of this result. The first is that both $p$ and $r$ are absent from the optimal level of effort exerted by the farmer, $e^*$. So why don’t $p$ and $r$ matter? Although they are both incentive instruments, they are not needed in the First Best. Since effort is contractible, the trader decides the optimal level of effort. The trader is not concerned about the effect of $p$ and $r$ on the farmer, since it does not affect $e$, and the trader simply needs to satisfy the Participation Constraint.

Secondly, it should be noted that there exists multiple equilibria, since a continuum of pairwise combinations of $p$ and $r$ satisfy the equilibrium conditions. This suggests that we would observe heterogeneity in $p$ and $r$ in the First Best.

\footnote{Combinations of $p$ and $r$ that are both negative do not give rise to a natural interpretation. Similarly for when $p$ is negative and $r$ is positive. Combinations where $p$ is positive and $r$ is negative characterise a linear, state contingent incentive scheme with a base payment of $(1 + r)L$ and a payment of $p$ for every additional unit of $Q$ produced by the farmer. It is not the purpose of this paper to examine moral hazard in employment contracts, and hence it is ignored.}
3.3 Second Best - Ex Ante Interlinkage

Now consider the case where effort is not verifiable, and there is ex ante interlinkage. Hence, the trader cannot contract an amount of effort, and it is the farmer that will decide an optimal level of effort. In this section, I examine how the use of the price and interest rate change under non-verifiable effort. Further, I explore how the quality of a project affects the intensity of incentives for a farmer, and what incentives exist for a trader to participate in ex ante interlinkage.

3.3.1 Timing of the Model

The timing of the model is as follows:

1. The trader makes an offer \((r, p)\) to the farmer for a loan \(L\) to produce an amount \(Q\), ex ante of investment. The farmer can choose to accept or reject the offer.

2. If the farmer accepts the offer, the farmer then invests \(L\), and makes a decision on the level of effort exerted on the investment, \(e\). The probability of a successful harvest is a function of effort, \(s(e)\).

3. Output level \(Q\) is realised, and the farmer sells \(Q\) to the trader for price \(p\), and repays debt \((1 + r)L\) if the project is successful. Otherwise, the farmer sells nothing and repays none of the loan. The farmer’s payoff is realised.

4. If the farmer’s project is successful, the trader sells \(Q\) at price \(p'\) in the wholesale market. Otherwise, the trader sells nothing and loses the size of the loan \(L\). The trader’s payoff is realised.

3.3.2 Analysis of the Model

Optimal Effort

The farmer’s problem is given by the following:

\[
\max_e s(e)[Qp - (1 + r)L] + (1 - s(e))[0 - C(e)]
\]  

(5)
Hence, the trader solves the following problem:

$$\max_{p,r} s(e)[Q(p' - p) + (1 + r)L] + (1 - s(e))][0] - L$$

(6)

s.t.

$$s(e)[Qp - (1 + r)L] + (1 - s(e)).[0] - C(e) \geq 0$$

(7)

$$e^* \in \arg \max \ s(e)[Qp - (1 + r)L] + (1 - s(e)).[0] - C(e)$$

(8)

I use Backward Induction to solve the model. The First Order Condition with respect to $e$ is given by the following:

$$\frac{s'(e)}{C'(e)} = \frac{1}{Qp - (1 + r)L}$$

(9)

Hence, the optimal level of effort is a function of $p$ and $r$.

**Remark 1** When effort is observable, the price and interest rate do not affect the optimal level of effort, whereas when effort is unobservable, the price and interest rate do affect the optimal level of effort. Hence, unobservable effort makes the use of the instruments of price and interest rate costly; there is a trade off between inducing higher effort and higher profits for a trader.

**Proposition 1** When effort is not contractible, a debt financed farmer with zero collateral will always choose a level of effort which is less than first best.

**Proof.** See Appendix B.3.

The intuition behind Proposition 1 is contained within Remark 1: $p$ and $r$ are now costly. In the Second Best, the farmer must select the optimal level of effort $e$, and hence the trader must create incentives for the farmer to select a high level of $e$. This induces a trade off in the use of $p$ and $r$: higher incentives for the farmer result in lower profits for the trader. Thus, this results in a level of effort that is less than First Best for all $e, p$ and $r$.

Note also that we can infer the sign of $\frac{\partial e}{\partial p}$ and $\frac{\partial e}{\partial r}$ from Equation (7). Using the assumptions on $s'(e)$ and $C'(e)$, we can deduce that $\frac{s'(e)}{C'(e)}$ is a negatively sloped function of effort. Hence, when $p$ increases, $\frac{s'(e)}{C'(e)}$ decreases and hence $e$ increases; therefore $\frac{\partial e}{\partial p} >$
0. When $r$ increases, $s'(e) \frac{C(e)}{C'(e)}$ increases, and hence $e$ decreases; therefore $\frac{\partial e}{\partial r} < 0$. These results make intuitive sense - we would expect that an increase in price $p$ will increase the incentives of a farmer to work hard since they will receive more for their output, and an increase in the interest rate $r$ to decrease incentives, since it will result in a larger repayment to the trader and hence a lesser payoff for the farmer.
Trader’s Participation & Project Quality

Solving for the trader’s problem, the First Order Conditions with respect to \( p \) and \( r \) are given by the following:

\[
s'(e^*).\frac{\partial e^*}{\partial p}.[Q(p' - p) + (1 + r)L] = s(e^*).Q \tag{8}
\]

\[
s'(e^*).\frac{\partial e^*}{\partial r}.[Q(p' - p) + (1 + r)L] = -s(e^*).L \tag{9}
\]

Rearranging Equation (9),

\[
\frac{\partial e^*}{\partial r} = \frac{-s(e^*).L}{s'(e^*).[Q(p' - p) + (1 + r)L]} \tag{10}
\]

From Equation (10), we can infer that \([Q(p' - p) + (1 + r)L] > 0\), which can be interpreted as the participation constraint of the trader (see Appendix B.2).

**Remark 2** The trader will participate in the interlinkage contract if and only if the state contingent payoff during a successful harvest is strictly greater than zero.

We can also deduce the impact project quality has on the effect of incentives. Taking the ratio of Equation (8) and Equation (9) yields the following equation:

\[
\frac{Q}{L} = \frac{\frac{\partial e^*}{\partial p}}{-\frac{\partial e^*}{\partial r}} \tag{11}
\]

**Remark 3** When the productivity of a project (defined by \( \frac{Q}{L} \)) decreases, the effect of interest rates on effort relative to the effect of prices on effort increases.

Hence, a farmer with a high-investment/low-return project (i.e. low productivity) will be relatively more responsive to changes in the interest rate than changes in price. This makes intuitive sense, since the loan size \( L \) is relatively larger than \( Q \), and hence changes in the interest rate will produce a large change in the payoff of the farmer.

### 3.3.3 Characterisation of the Equilibrium

Suppose now that an equilibrium exists. Then, the equilibrium can be characterised as follows:
Lemma 1 All Nash Equilibria \((e^*, r^*, p^*)\) satisfy the following system of equations:

\[
\frac{s'(e^*)}{C'(e^*)} = \frac{1}{Qp - (1 + r)L}
\]

\[
s'(e^*). \frac{\partial e^*}{\partial p}. [Q(p' - p) + (1 + r)L] = s(e^*). Q
\]

\[
s'(e^*). \frac{\partial e^*}{\partial r}. [Q(p' - p) + (1 + r)L] = -s(e^*). L
\]

Lemma 2 Under certain optimality conditions, the Nash Equilibrium \((e^*, r^*, p^*)\) is a maximum. The Nash Equilibrium is never a minimum for all \(e, r, p\).

Proof. See Appendix B.4.

To further characterise the equilibrium, I examine a closed form example of an ex ante interlinkage contract. In the closed form example, I show that an equilibrium exists under standard specifications of the probability of success \(s(e)\) and cost of effort \(C(e)\), and that in this specific case, multiple equilibria can also exist.

3.3.4 A Closed Form Example

Let \(s(e) = 2\sqrt{e}\) and \(C(e) = \frac{1}{2}e^2\). I solve by backwards induction.

Substituting for \(s(e)\) and \(C(e)\),

\[
\max_e \ 2\sqrt{e} (Qp - (1 + r)L) - \frac{1}{2}e^2
\]

Taking the First Order Condition with respect to \(e\),

\[
e^* = (Qp - (1 + r)L)^{2/3}
\]

Which illustrates that the optimal \(e^*\) is a function of \(p\) and \(r\). Substituting into the trader’s problem,

\[
2.(Qp - (1 + r)L)^{2/3}. (Q(p' - p) + (1 + r)L) - L
\]

Taking the First Order Condition with respect to \(p\),

\[
p^* = (1 + r^*) \frac{L}{Q} + \frac{p'}{4}
\]
Taking the First Order Condition with respect to $r$,

$$p^* = (1 + r^*) \frac{L}{Q} + \frac{p'}{4} \quad (16)$$

Equations (15) and (16) are identical, which indicates that again, there is a continuum of pairwise values of $(p^*, r^*)$ that satisfy in equilibrium. Hence, for this example, the solution exhibits multiple equilibria. For further characterisation of this equilibrium, see Appendix B.5.

3.4 Second Best - Ex Post Interlinkage

Now consider the case where effort is not verifiable, and there is ex post interlinkage. Here, the price for the output is determined ex post of investment through Nash Bargaining. This variation of the model potentially captures two situations. First, it captures the Hold Up Problem, whereby the farmer and trader agree on a price ex ante of investment, but the trader then reneges on the agreement and offers some Nash Bargained price $p^{NS}$ ex post investment. The farmer, with no better outside option, is forced to sell at this alternative price $p^{NS}$. I deduce that such a problem would only exist if there is no social capital between the trader and farmer; if social capital existed, the farmer could ruin the reputation of the trader and damage the trader’s ex ante clientele. However, if no social capital exists, the farmer cannot do so, and hence the possibility of Hold Up arises. The second situation this captures is where the wholesale price $p'$ is too uncertain, and no social capital exists to ensure commitment to an ex ante agreement. I ignore the cases where there is farmer or trader integration, on the basis that the empirical evidence in Maitra et al (2012) suggests such ownership structures are not prevalent. I apply the usual axioms of (1) Von Neumann-Morgenstern utility functions, (2) Pareto optimality, and (3) Independence of Irrelevant Alternatives, but relax the Symmetry axiom to model the influence of bargaining power in the model.

3.4.1 Timing of the Model

The timing of the model is as follows:

1. The trader makes an offer $r$ to the farmer for a loan $L$ to produce an amount $Q$. The
trader also makes an agreement to purchase $Q$, however the price is not specified. The farmer can choose to accept or reject the offer.

2. If the farmer accepts the offer, the farmer then invests $L$, and makes a decision on the level of effort exerted on the investment, $e$. The probability of a successful harvest is a function of effort, $s(e)$.

3. Output level $Q$ is realised, and $p'$ is observed by the farmer and trader. If the project is successful, the farmer and trader will Nash Bargain over the price $p^{NS}$ to be paid for output $Q$ by the trader, and the farmer, and repays debt $(1 + r)L$. Otherwise, the farmer sells nothing and repays none of the loan. The farmer’s payoff is realised.

4. If the farmer’s project is successful, the trader sells $Q$ at price $p'$ in the wholesale market. Otherwise, the trader sells nothing and loses the size of the loan $L$. The trader’s payoff is realised.

### 3.4.2 Analysis of the Model

#### Nash Bargaining Price

I first find the Nash Bargaining solution to the price of the output. The Nash Bargaining Problem is given by the following:

$$p^{NS} = \arg \max_p \ [s(e). (Qp - Q(1 - \delta)^n p'')^\beta. [s(e). (Q(p' - p))]^{1-\beta}$$  \hspace{1cm} (17)

Where $\beta$ is the bargaining power of the farmer, and hence $(1 - \beta)$ the bargaining power of the trader; $p''$ is the market price for potatoes offered to farmers by all traders in the market, with expectation $E[p] = p''$; $\delta$ is a discount rate of the output value, $Qp''$; and $n$ is the number of periods the output is stored. Note that a positive value for $\delta$ implies that the output is depreciating, and vice versa. In this case, this payoff implies that the potato crop will receive some trader market price $p''$ for the potatoes in the period they are sold $n$, which will depreciate at a rate of $(1 - \delta)$ due to spoilage over time.

---

3There is generally asymmetric information on the wholesale price $p'$; however, Mitra et. al. (2012) shows that providing farmers with information about the wholesale price does not have a statistically significant effect on the negotiated price the farmer receives for the produce.
Solving, the Nash Bargaining solution is given by the following:

\[ p^{NS} = (1 - \beta)[(1 - \delta)^n p''] + \beta p' \]  \hspace{1cm} (18)

This solution implies that \( p^{NS} \) is some combination of the farmer’s outside option price \((1 - \delta)^n p''\) and the trader’s wholesale market price \(p'\), weighted by the bargaining power (see Appendix C.1).

**Optimal Effort**

Substituting \( p^{NS} \) into the farmer’s problem yields the following:

\[
\max_e s(e)[Q ((1 - \beta)(1 - \delta)^n p'' + \beta p') - (1 + r)L] + (1 - s(e))[0] - C(e) \]  \hspace{1cm} (19)

I use Backwards Induction to solve. Differentiating with respect to \( e \) yields the following condition:

\[
\frac{s'(e)}{C'(e)} = \frac{1}{Q ((1 - \beta)(1 - \delta)^n p'' + \beta p') - (1 + r)L} \]  \hspace{1cm} (20)

**Remark 4** In the generic case, whenever the set of equilibria in ex ante interlinkage does not include the Nash Bargaining price \( p^{NS} \), the ex post contract will always be suboptimal.

Note that \( e \) is a function of \( r \). Since the price is determined through Nash Bargaining, the trader loses the ability to set the price, and hence only has one incentive instrument (i.e. \( r \)) available to him. Given a Nash Bargaining price \( p^{NS} \), the trader may still be able to mimic the ex ante interlinkage contract by adjusting \( r \) if the ex ante interlinkage contract exhibits a continuum of multiple equilibria. However, if the ex ante interlinkage contract has a restricted set of equilibria such that it does not include \( p^{NS} \), then this would not hold in the generic case; instead, the ex ante contract would strictly dominate the ex post contract. In Chapter 4, I explore the impact of this on the market structure of interlinkage contracts.
Interest Rate and Trader’s Participation

The trader’s problem is given by the following:

$$\max_r s(e^*).[Q(1 - \beta)(p' - (1 - \delta)^n p'') + (1 + r)L] + (1 - s(e^*))[0] - L \quad (21)$$

Differentiating with respect to $r$ yields the following expression:

$$\frac{\partial e^*}{\partial r} = \frac{-s(e^*).L}{\frac{\partial s(e^*)}{\partial e^*}.[Q(1 - \beta)(p' - (1 - \delta)^n p'') + (1 + r)L]} \quad (22)$$

From Equation (22), we can infer that $[Q(1 - \beta)(p' - (1 - \delta)^n p'') + (1 + r)L] > 0$, which can be interpreted as the Participation Constraint of the trader (see Appendix C.4). Comparing the Participation Constraints of the farmer and trader in the ex ante and ex post inter-linkage contracts, we can infer that there are less values for $r$ that sustain participation of both the farmer and trader. Since the price is exogenously determined in the ex post case, this restricts the choice of $r$ for the trader in order to maintain optimality. Hence, we can say that the existence of social capital (and hence ex ante contracts) enhances the trader’s flexibility of the use of the instruments $p$ and $r$.

3.4.3 Characterisation of the Equilibrium

Suppose that an equilibrium exists. Then, the equilibrium can be characterised as follows:

Lemma 3 The Nash Equilibrium $(e^*, r^*)$ satisfies the following conditions:

$$\frac{s'(e^*)}{C'(e^*)} = \frac{1}{Q((1 - \beta)(1 - \delta)^n p'' + \beta p') - (1 + r)L}$$

$$\frac{\partial s(e^*)}{\partial e^*} \cdot \frac{\partial e^*}{\partial r}.[Q(1 - \beta)(p' - (1 - \delta)^n p'') + (1 + r)L] = -s(e^*).L$$

Lemma 4 The Nash Equilibrium is a maximum for all $e, r$.

Proof. See Appendix C.5. ■

Again, I will examine a closed form example to further characterise the equilibrium.
3.4.4 A Closed Form Example

Let \( s(e) = 2\sqrt{e} \) and \( C(e) = \frac{1}{2}e^2 \).

I solve by backwards induction. I use the Nash Bargaining solution \( p^{NS} \) from the previous section.

Substituting for \( s(e) \) and \( C(e) \),

\[
\max_e 2\sqrt{e} \cdot (Q ((1 - \beta)(1 - \delta)^n p'' + \beta p') - (1 + r)L) - \frac{1}{2}e^2 \tag{23}
\]

Taking the First Order Condition with respect to \( e \),

\[
e^* = (Q ((1 - \beta)(1 - \delta)^n \beta p' + (1 + r)L)^\frac{3}{2} \tag{24}
\]

Which illustrates that the optimal \( e^* \) is a function of \( r \). Substituting into the trader’s problem,

\[
2 . (Q ((1 - \beta)(1 - \delta)^n(p'' + \beta p') - (1 + r)L) + (Q(1 - \beta)(p' - (1 - \delta)^n p'') + (1 + r)L - L \tag{25}
\]

Taking the First Order Condition with respect to \( r \),

\[
r^* = \frac{1}{L} (1 - \beta) Q(1 - \delta)^n p' + \beta p'] + \frac{Q p'}{L} - 1 \tag{26}
\]

This solution is analogous to the ex ante interlinkage First Order Conditions in the ex ante Example, but with a Nash Bargained price. Since \( \beta, \delta, n, p'', p', Q \) and \( L \) are all determined exogenously, this First Order Condition yields a unique solution for \( r^* \). Further, this solution can be shown to be a maximum (see Appendix C.6).

3.5 Main Results and Discussion

The main result that this chapter illuminates is that the Hold Up Problem changes incentives in interlinkage. Moving from ex ante to ex post results in the loss of an incentive instrument for the trader, and hence this changes the optimality of combinations available for the trader to set. I discuss this result further below.
3.5.1 Loss of Price Incentive Instrument in Ex Post Interlinkage

Ex post price bargaining results in the trader losing the ability to set the price, and hence the trader loses an incentive instrument. The trader only has the interest rate available to him to illicit effort. But does this result in suboptimal effort? The answer is maybe. The trader may still able to mimic an ex ante contract by setting the interest rate such that it yields the ex ante level of effort, where the ex ante contract exhibits multiple equilibria. Hence, the loss of an incentive instrument does not change effort efficiency between ex ante and ex post interlinkage. However, where the solution in the ex ante case is unique or the multiple equilibria does not include the Nash Bargaining price $p^{NS}$, the ex post contract in the generic case cannot match the ex ante contract, and effort is suboptimal - the loss of an incentive instrument affects incentives. In the following chapter, I show how the latter situation contributes to the formation of segmented credit markets.

3.5.2 The Role of Social Capital

It is important to note that whilst this model does incorporate the value of social capital in enhancing efficiency and incentives through price commitment, it by far understates the importance of social capital in ensuring the enforcement of the debt within interlinkage contracts. Social capital plays a significant role in specifying punishment mechanisms where there is strategic default on a loan. Besley and Coate (1992) explore this in detail. The authors devise a social penalty function in a group lending Microfinance set up, and show how social penalties are imposed in differing situations of default. The paper highlights that social capital can have a positive disciplining effect on borrowers.

Hence, a further incorporation of social capital into the model as a mechanism against strategic default would only cause ex ante contracts to further Pareto dominate ex post contracts. A potential extension which achieves this is to incorporate a social penalty, $X$, into the probability of a successful harvest, i.e. $s(e, X)$, where the probability of success is increasing in social penalties.
3.5.3 Testable Predictions

An important conclusion that this analysis yields is that there are lesser values of $r$ in the ex post case that the trader has available to him, when compared to the ex ante case. This is shown twofold: first, the farmer’s and trader’s participation constraints in an ex post interlinkage contract have exogenously given Nash Bargained prices. This restricts the available $r$ that the trader can set to maintain optimality, and hence there are lesser values of $r$ that sustain participation of both the farmer and trader. Secondly, the limitations on $r$ is illustrated in the closed form example of the ex post interlinkage case - the solution is unique.

This gives rise to two testable predictions. First, it leads to the hypothesis that if the discount rate $\delta$ and bargaining power $\beta$ are not too heterogeneous, we would observe less variation in the interest rates of ex post interlinkage contracts. The threat points (i.e. market and wholesale prices) are identical for each farmer and trader, and hence this would not fluctuate over ex post interlinkage contracts. Further, it would not be unexpected to observe consistently low values of $\beta$, given that informal market dealings are characterised by farmers with generally low bargaining power. The second hypothesis that follows is that if a farmer’s $\beta$ and $\delta$ cannot explain variations in interlinkage interest rates, then it must be that the contract is an ex ante interlinkage contract. These hypotheses can be tested by regressing the interlinkage interest rate on the farmer’s characteristics. If the characteristics cannot explain the variation in the interest rate, it follows that the contract is more likely an ex ante interlinkage contract. There exists data which can be used to undertake such an analysis. The authors of Maitra et. al. (2012) are currently collecting data on the interlinkage contracts potato farmers engage in with traders in West Bengal, India, as part of a Microfinance study. The data includes both individual and household level observations which are likely to influence $\beta$ and $\delta$, such as asset and land ownership, religion, caste, and community participation. The data also includes interest rate and price variables.

The analysis in this chapter leaves us with several questions about the structure of interlinkage credit markets. How do incentives and effort change with ex ante and ex post interlinkage in the face of competition? What is the role of social capital in such markets?
And, under what conditions does each contractual structure Pareto dominate? I seek to answer these questions in the following chapter.
4 Modelling Interlinkage & Endogenous Segmentation

In this chapter, I extend the interlinkage framework developed in Chapter 3 to model the endogenous segmentation of informal credit markets. There is a very limited analysis of segmentation in informal credit markets in the literature. Basu & Bell (1990) provide a starting point for the analysis through modelling a fragmented duopoly, and both Chaudhuri (2000) and Chaudhuri & Banerjee (2004) extend this to incorporate interlinkage. However, the segmentation in these models is assumed, and only “captive segment” traders are capable of forming interlinkage contracts in these frameworks. This model seeks to relax these assumptions and endogenise the formation of segments within the informal credit market. Further, I allow all traders the possibility of forming interlinkage contracts with farmers.

The key contribution of this chapter is to show that under conditions where ex ante interlinkage Pareto dominates ex post interlinkage contracts, segmented markets arise. Specifically, I find that where there is a sufficient degree of market power within ex post interlinkage, we will observe segmentation. The significance of this result is further explored in Chapters 5 and 6, where I examine the policy implications of such a segmented interlinkage market.

This chapter continues with a description of the segmentation, followed by an analysis of the menu of ex ante interlinkage and ex post interlinkage contracts a trader can offer a farmer. I then extend this framework to study the formation of Home Segments and the Contested Segment through investment in social capital, thus completely endogenising the formation of segments.

4.1 Description of the Segmentation

Consider a situation where there are $T$ traders and $F$ farmers seeking to participate in credit-output interlinkage contracts. Due to the presence of the Hold Up Problem, a trader is able to offer two types of contracts to farmers: an ex ante interlinkage contract, and an ex post interlinkage contract. A trader can only commit to an ex ante interlinkage contract if there exists some social capital between the trader and farmer; hence, the
trader must invest in social capital with a farmer to offer an ex ante interlinkage contract. Every farmer is able to form an interlinkage contract with every trader. Similarly, every trader is able to invest in social capital with any farmer.

Every trader has the possibility of forming three types of interlinkage clients: first, farmers with whom he has exclusive social capital with, and hence he offers them ex ante interlinkage contracts; second, farmers with whom no one holds social capital with, and hence he offers them ex post interlinkage contracts; and third, farmers that have social capital with the trader and at least one other trader, and hence he offers them ex ante interlinkage contracts. I refer to each of these clienteles of farmers as Exclusive, Floating and Non-Exclusive customers respectively. Note that before any trader has invested in any social capital, all farmers are Floating customers.

I provide a formal analysis of Floating, Non-Exclusive and Exclusive customers in the following sections.

4.2 Floating Customers

Floating customers are those farmers that no trader holds any social capital with. Hence, every Floating customer has the same bargaining power with every trader, since there is no special relationship to enhance it.\textsuperscript{4} I denote this bargaining power as $\tilde{\beta}$. A trader is able to offer every Floating customer an ex post interlinkage contract. I assume that each trader makes some profits $A = \alpha [s(e)Qp' - L - C(e)]$, where $\alpha$ is the share of the total surplus which the trader receives. The formulation of total surplus has a natural interpretation: it is given by the total benefit generated from the production of potatoes minus the investment of the loan, and the costs of exerting effort. We can interpret $\alpha$ as the degree of market power the trader has. This formulation captures a range of market structures. Note that when $\alpha = 0$, the trader makes zero profits and hence the traders are engaged in Bertrand competition; where $\alpha = 1$, the trader is a monopolist, and hence the problem becomes that of the “monopolist” ex post interlinkage contract presented in Chapter 3. Values of $\alpha$ between 0 and 1 denote situations where the trader is engaged in some degree of monopolistic competition. Note that $A$ is lower bound by the case

\textsuperscript{4}This conclusion is for simplicity, and does not change any of the main results.
of perfect competition, and upper bound by the case of a monopoly, where the farmer’s Participation Constraint is zero. I examine both perfect competition and monopoly ex post interlinkage below to illustrate these bounds.

It is important to note that in reality, a degree of monopolistic competition characterises credit-output interlinkage markets (see Smith, Stockbridge & Lohano (1999)). Given that a trader has no social capital with Floating customers to ascertain trustworthiness, traders might only offer contracts to farmers with common characteristics such as caste or religion. Such actions make the transaction unique for each individual, and hence give rise to differentiated products. There may also be the presence of other market imperfections such as transaction costs (search, screening, negotiation, measuring, transfer, enforcement). Smith, Stockbridge & Lohano (1999) present the argument that social capital can overcome transaction costs. Hence, in the absence of social capital, it is reasonable to believe that some degree of market power characterises the Floating customer market.

I continue with the analysis of the bounds for ex post interlinkage. The trader’s surplus under perfect competition is given by the following:

$$s(e) \left[ Q(1-\beta)(p' - (1-\delta)''p'') + (1+r_0)L \right] - L = 0 \quad (27)$$

Hence, the optimal $r_0$ that the trader sets is given by the following:

$$r_0 = \frac{1}{s(e)} - \frac{Q}{L} (1-\beta)(p' - (1-\delta)''p'') - 1 \quad (28)$$

Note that the the interest rate $r$ is decreasing in the probability of a successful harvest $s(e)$. Hence, when a project has a low probability of success, we would expect to observe higher interest rates. Note also that if the wholesale price is larger than the competitive market price, i.e. $p' > (1-\delta)''p''$, then as the bargaining power of the farmers $\beta$ increases, the farmers are able to receive a lower interest rate $r_0$ on the loan.

In the case of a monopoly, an ex post interlinkage contract gives rise to the following value of $A$: 

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\[ A = s(\bar{e}) \left[ Q(1 - \beta)(p' - (1 - \delta)p'') + (1 + \bar{r})L \right] - L \] (29)

Where \( \bar{e} \) and \( \bar{r} \) are the optimal levels of \( e \) and \( r \) in the case of monopoly ex post interlinkage.

Hence, the interest rate in the case of a monopoly is given by the following:

\[ \bar{r} = A s(\bar{e}).L + \frac{1}{s(e)} - Q(1 - \beta)(p' - (1 - \delta)p'') - 1 \] (30)

Note that the interest rate \( r \) is now increasing in the profits of the trader \( A \). Hence, for the monopolistic competition case, we would expect that \( r \) lies within the interval \([r_0, \bar{r}]\) i.e. competition drives down the interest rate; alternatively we can say that the mark up or surplus of the trader,

\[ A \in [0, s(\bar{e}) \left[ Q(1 - \beta)(p' - (1 - \delta)p'') + (1 + \bar{r})L \right] - L] \] (31)

Now consider the Floating customer’s surplus under perfect competition, which can be found by substituting \( r_0 \) into the farmer’s problem:

\[ s(e)Qp' - L - C(e) \] (32)

The optimal level of effort that the farmer selects is given by the following:

\[ \frac{s'(e)}{C'(e)} = \frac{1}{Qp'} \] (33)

**Remark 5** Under perfect competition, an Ex Post interlinkage contract achieves the First Best level of effort.

In the case of perfect competition, Equation (30) becomes identical to the First Best effort defined by Equation (3). Intuitively, this makes sense; when the trader makes zero profits under perfect competition, the farmer is the residual claimant of the entire project, and hence we would not expect there to be any incentive problems, which is consistent with the First Fundamental Welfare Theorem.
4.3 Non-Exclusive Customers

Non-Exclusive customers are those farmers that have social capital with more than one trader. Hence, traders that hold social capital with such farmers are able to offer an ex ante interlinkage contract. In this case, each trader provides an identical product, given that each trader has a relationship of trust with the farmer. Hence, I analyse the case of Non-Exclusive customers under the conditions of Bertrand competition. The optimal interest rate $r^*$ and price $p^*$ that the trader sets for Non-Exclusive customers can be given by the following:

$$r^* = \frac{1}{s(e)} - \frac{Q}{L} (p' - p^*) - 1$$  \hspace{1cm} (34)

In the Non-Exclusive customer case, the trader still has the ability to adjust the price, and hence there exists a pairwise $(p^*, r^*)$ that the trader can offer.

**Proposition 2** In equilibrium, the price and interest rate $(p^*, r^*)$ for Non-Exclusive customers is such that the trader’s profits equal to zero.

**Proof.** See Appendix D.1.  

The intuition behind Proposition 2 is simple: under perfect competition, if traders are making positive profits, there is an incentive for traders to undercut each other in order to acquire the entire market share. Such an interest rate decreasing/price increasing war would ensue until all traders make zero profits, since this is where the price and interest rate would equal to the marginal cost of the ex ante interlinkage contract. Any further cuts beyond this would result in losses, and hence are not pursued by traders.

4.4 Exclusive Customers: A Comparison

The Exclusive customers are those farmers that have social capital with only one trader. Consequently, the equilibrium $p$ and $r$ remains unchanged from the “monopoly” ex ante interlinkage equilibrium presented in Lemma 1 (see Chapter 3). In this section, I compare the surpluses and effort generated by a Floating and Exclusive interlinkage contract. Since Non-Exclusive customers yield zero profits for a trader and are not realised in equilibrium, I omit them from this analysis; however in the following section, I provide detail as to why
this is the case. The key question that this section asks is, “can a trader set an Exclusive interlinkage contract such that it leaves the farmer indifferent between it and a Floating interlinkage contract, but results in a strictly greater profit for the trader?”.

From Chapter 3, we know that in some cases, ex ante interlinkage (Exclusive customers) can be better than ex post interlinkage. For example, if the solution to the ex ante case does not include the Nash Bargaining price $p^{NS}$, then in the generic case ex post interlinkage is Pareto dominated by Exclusive customer interlinkage. Accounting for the role of social capital in preventing strategic default would further illuminate this. For example, if we allow for social capital to also enhance the probability of success, this would cause ex ante interlinkage to strictly dominate ex post interlinkage. However, we also know that under conditions of perfect competition, ex post interlinkage is able to achieve First Best levels of surplus. Hence, there are two surplus reducing effects that are in play for an ex post interlinkage contract: the effect of increasing market power (captured by increasing $A$ and $\alpha$), and the Hold Up Problem. Consequently, we can say the following:

**Lemma 5** There exists some $\bar{A}$ such that when $A > \bar{A}$, an Exclusive customer interlinkage contract Pareto dominates an Ex Post interlinkage contract.

Lemma 5 captures the following: when $\alpha$ is low and hence $A$ is low, we would expect market competition to have a surplus enhancing effect and consequently Floating (ex post) interlinkage performs better than Exclusive (ex ante) interlinkage; when $\alpha$ is high and hence $A$ is high, market power erodes the total surplus, and the Hold Up Problem begins to affect incentives, and hence Exclusive (ex ante) interlinkage performs better than Floating (ex post) interlinkage. Consequently, there must be some threshold value (or values) $\bar{A}$ that define the point at which Exclusive customer interlinkage Pareto dominates ex post interlinkage. Note also that when we account for the effect of social capital on intentional default in Exclusive customer and ex post interlinkage, the threshold $\bar{A}$ is likely to be lower, since social capital will have a greater disciplining effect in the Exclusive customer case.

Given that for some $A > \bar{A}$ the Exclusive customer surplus is greater than the Floating (ex post) surplus, it follows that the effort level in the Exclusive customer case, $\tilde{e}$ is more efficient than that of ex post, $e^*$. More formally:
Lemma 6  For all \( A > \bar{A} \), \( e^* < \bar{e} < e_{FB} \).

Proof. See Appendix D.2.

Essentially, Lemma 6 highlights that the closer to First Best an interlinkage contract is, the higher the effort level is. Since an Exclusive (ex ante) contract is more efficient than a Floating (ex post) contract for \( A > \bar{A} \), it follows that the effort levels of an Exclusive (ex ante) interlinkage contract must be higher than ex post interlinkage. Note that this captures another key element of the Hold Up Problem: inefficient investment of effort. Once the market power is such that the Hold Up Problem becomes dominant, there is underinvestment of effort by the farmer.

Lemma 5 and Lemma 6 lead to Proposition 3:

Proposition 3  When \( A > \bar{A} \), a trader can always offer a farmer an Exclusive customer (ex ante) interlinkage contract such that it leaves the farmer indifferent between it and a Floating customer (ex post) contract, and yields higher profits for the trader.

Proof. See Appendix D.3.

Proposition 3 encapsulates the situation where both Exclusive (ex ante) contracts and Floating (ex post) contracts coexist in the market. The Floating customer contract is the outside option to an Exclusive contract. Where \( A > \bar{A} \) (and hence Exclusive (ex ante) contracts Pareto dominate Floating (ex post) contracts), the additional surplus in the Exclusive customer case is retained by the trader. The logic for this is as follows: if the farmer’s surplus is equivalent in both contracts, and total surplus is larger in the Exclusive customer case, then it follows that the trader must retain the additional surplus.

Given that now the relationship between the surpluses of Floating, Exclusive and Non-Exclusive interlinkage contracts is established, we can now examine how this results in the formation of segments within the interlinkage market.

4.5 Formation of Segments: Social Capital Investment

In this section, I show how the existence of Exclusive, Non-Exclusive and Floating customers motivates social capital investment, and leads to the segmentation of the interlinkage market. To make the problem interesting, I will consider the case when \( A > \bar{A} \).
4.5.1 Description and Analysis of the Model

Consider a situation whereby $T$ traders seek to simultaneously invest in social capital with a number of farmers.\(^5\) As outlined earlier, there are $F$ farmers in the market that can be potentially befriended. Every farmer begins as a Floating customer, but has the potential to become a Non-Exclusive or Exclusive customer once social capital investments are made. If a trader invests in social capital with a farmer, the trader is able to offer an ex ante interlinkage contract to that farmer. An ex ante interlinkage contract yields a benefit of $\pi$ to a trader, where $\pi = s(e).[Q(p' - p) + (1 + r)L] - L$. The development of social capital requires $c$ units of a trader’s time per farmer; however, the trader’s time budget is $X$ units of time. Hence, each trader can only befriend a maximum of $n$ borrowers, such that $n = \frac{T}{c}$, which is the trader’s time constraint. I assume that the investment in social capital is such that even if each trader befriens the maximum amount of borrowers facing the time constraint $n$, they will not be able to befriend all farmers $F$, i.e. $Tn < F$. This assumption captures the well observed phenomenon of macro credit rationing in developing credit markets i.e. some potential borrowers are unable to obtain credit (see Ghosh, Ray & Mookherjee (1999) for an overview of credit rationing). I assume that traders do not collude.

If a single trader invests with a single Floating customer such that the farmer becomes an Exclusive customer, the trader’s payoff is given by the following:

$$\pi - c$$

(35)

Where $\pi$ is the benefit from an Exclusive ex ante contract with effort level $\tilde{e}$. If more than one trader invests with a single Floating customer such that the farmer becomes a Non-Exclusive customer, then by Proposition 2, the trader’s profits are equal to zero. If a trader does not invest in social capital, the trader can profit from a Floating ex post interlinkage contract, given by:

$$A = \alpha [s(e).Qp' - L - C(e)]$$

(36)

\(^5\) I choose to model the game as a simultaneous move game for simplicity. A sequential game with perfect information can also be used to model such a situation; however, it leads to similar results to a simultaneous game, but with more complexity to the analysis.
Remark 6  A trader will only find it profitable to invest in social capital if \( \pi - c > A \).

Proposition 4  When investment is profitable, a trader will only invest in social capital with Floating customers, such that they are converted to Exclusive customers. The trader will continue to invest in social capital with Floating customers until he has befriended the maximum \( n \) Floating customers.

This result makes intuitive sense. The outside option to investment in social capital is not to invest, and hence social capital must derive some benefit larger than what can be achieved in the Floating market. Once this hurdle is surpassed, the trader has the option of investing in a Floating farmer, or a farmer that already holds social capital (Exclusive and Non-Exclusive customers). If he invests in the latter, he will make zero profits. However, if he invests in a Floating customer, he converts them into an Exclusive customer, such that he makes \( \pi - c \). Given that there is an excess of farmers in the market (given by \( Tn < F \)), then there will always be Floating farmers to invest in social capital with. So long as it is profitable to invest, the trader will find it optimal to continue to invest until all time \( T \) is exhausted. Hence, we can say that each trader has \( n \) farmers with whom he exclusively deals with, which can be referred to as a “Home Segment” for each trader.

The excess farmers within the market are able to receive Floating (ex post) interlinkage contracts from traders. Since no trader needs to hold social capital to offer these contracts, all traders compete for these farmers with some degree of market power \( \alpha \), where \( \alpha \in [0, 1] \). Consequently, we can refer to this as the “Contested Segment”.

Hence, the complete endogenisation of segmentation has been achieved through an analysis of ex ante and ex post interlinkage contracts in a market context. When there is sufficient monopoly power in the Floating (ex post) interlinkage market, defined by \( A > \bar{A} \), we can expect the emergence of “islands” of Home Segments, where each trader exclusively deals with a set of farmers and offers ex ante interlinkage contracts. Additionally, due to the presence of credit rationing, we would expect to also see a common market of Floating customers, i.e. a Contested Segment, whereby all traders compete. The Home Segment and Contested Segment interrelate by way of being each other’s outside options.
4.6 Discussion of Main Results

In this section, I discuss some of the main themes that arise from the model presented.

4.6.1 Surplus Enhancers: Competition and Incentives

This model highlights two mechanisms that act to maximise surplus: competition and incentives. When the market power in the Floating (ex post) market is given by $\alpha = 0$, we are in the world of perfect competition, and hence we achieve Pareto Efficiency. In terms of welfare, the farmer receives all the surplus, and hence it is as if the farmer has complete access to the wholesale market for the potatoes. The trader middleman is no longer a problematic part of the story. The market allocates resources efficiently and incentives are aligned, since First Best is achieved.

However, as $\alpha$ increases in the Floating (ex post) market, market imperfections begin to materialise, and the trader is able to extract some surplus for himself. The lack of the price instrument $p$ to incentivise effort further exacerbates the effect of market power on the surplus; renegotiation of price hinders incentives. This is where the Exclusive (ex ante) contracts are able to do better. Although an Exclusive interlinkage contract is such that the trader acts as a monopolist (and hence is “shielded” from competition), this trader has the advantage of providing greater incentives to the farmer to exert effort through $p$ and $r$. The condition $A > \tilde{A}$ defines when the incentivisation advantage an Exclusive (ex ante) contract supercedes the surplus enhancing effect of a more competitive market.

The effect of $p$ and $r$ as incentive tools makes intuitive sense. Tying credit and product markets has a “disciplinary effect” on a farmer by having the incentives in one market also affect incentives in another market. It is also important to note that although Exclusive (ex ante) contracts are such that the trader is a monopolist, the existence of the Floating customers acts as an outside option, and ensures the farmer a utility equivalent contract in both segments. Basu (1983) argues that such a set up removes the label of a “monopolist” from a trader. His argument can be reproduced as follows: suppose the ex ante trader reduces the farmer’s utility from an Exclusive interlinkage contract. Then, this means that these farmers will find Floating contracts more attractive and the Exclusive interlinkage trader will lose his clientele. If the trader is a monopolist, he would face a downward
sloping demand curve and not lose all his clients. Basu suggests the use of the word “isolation” instead to describe the exclusive nature of these clients.

4.6.2 The Hold Up Problem and Underinvestment of Effort

An alternative interpretation of these results is that the Hold Up Problem exacerbates the incentives problems by fostering inefficient investment of effort. Initially when $\alpha = 0$, the effect of perfect competition dominates and the Hold Up Problem is absent from the problem. However, once the threshold value $\tilde{A}$ is exceeded, the effects of the Hold Up Problem dominate in inducing inefficient investment of effort. The possibility of reneging, or ex post negotiation, induces the farmer to make a suboptimal investment of $e$ ex ante. In this case, from Lemma 6, we can infer that the farmer underinvests in effort if the Hold Up Problem arises, which then affects the social surplus achieved. Such a situation makes intuitive sense; a farmer will not have an incentive to exert a large amount of effort on the project if she will lose out on the surplus due to renegotiation. Hence, since effort is costly, the farmer selects a lower, suboptimal level of effort.

4.6.3 Market Power and Segmentation

One of the key implications of this model is that the degree of market power influences when segmentation arises. When there is a high degree of competition within the ex post interlinkage market i.e. $\alpha$ is small, such that $A < \tilde{A}$, then we do not expect to observe segmentation. In such a case, ex post contracts would be more efficient than a monopolist ex ante trader, and hence every trader would prefer to compete in the ex post market rather than invest in social capital to offer ex ante contracts. In such a situation, there is no significant role for social capital investment in enhancing incentives and surplus. Forming exclusive relationships does not improve the payoff of the trader, and hence the trader does not invest in it.

When market power within the ex post interlinkage market $\alpha$ is sufficiently large, such that $A > \tilde{A}$, then we would expect to observe segmentation. The monopoly ex ante contracts in this case will Pareto dominate ex post contracts, and consequently we would expect to see exclusive dealings between farmers and traders, i.e. multiple Home
Segments. In such a situation, social capital proves to be useful in improving the overall surplus from the contract.

These results are crucial in explaining why we may observe that some informal credit markets are segmented, whilst others are not. This is a contribution that is relatively unexplored by the literature. The significance of this segmentation is further explored in Chapters 5 and 6, whereby I undertake a policy analysis of usury and microfinance using this framework.

4.6.4 Social Capital and Social Surplus

It is important to note that whilst this model does incorporate the value of social capital in enhancing efficiency and incentives through price commitment, it by far understates the importance of social capital in ensuring the enforcement of the debt within interlinkage contracts. Social capital plays a significant role in specifying punishment mechanisms where there is strategic default on a loan. Besley and Coate (1992) explore this in detail. The authors devise a social penalty function in a group lending Microfinance set up, and show how social penalties are imposed in differing situations of default. The paper highlights that social capital can have a positive disciplining effect on borrowers.

Hence, a further incorporation of social capital into the model as a mechanism against strategic default would only strengthen these results. A potential extension which achieves this is to incorporate a social penalty, $X$, into the probability of a successful harvest, i.e. $s(e, X)$, where the probability of success is increasing in social penalties. Hence, an Exclusive (ex ante) interlinkage contract strictly dominates a monopoly ex post contract, since there is social capital in the ex ante case. Consequently, we would expect that incorporating $X$ would result in a lower threshold $\tilde{A}$ for which Exclusive interlinkage contracts are more optimal than Floating (ex post) interlinkage contracts.
5 Application 1: An Interest Rate Ceiling Policy

“The results of many of these interventions have been disappointing, and one explanation for this must be that they were based on an inadequate understanding of the workings of rural credit markets.” - Hoff and Stiglitz (1990)

A variety of government policies have been implemented within informal credit markets to address some of the perceived problems associated with informal lending, including interest rate ceiling policies. In this Chapter, I provide a brief overview of these policies, and some of the approaches to analysing their impacts by the previous literature. I then utilise the model presented in Chapters 3 and 4 to provide a new perspective on the impact of these policies. In my analysis, I predominantly focus on interest rate ceilings.

5.1 Government Policies in Agrarian Credit Markets

Since the 1960s and 1970s, governments of developing nations have implemented informal credit policies in an attempt to promote better productivity and borrower welfare. Subsidised rural credit, direct credit programs, and interest rate ceilings are just some of the policies that have had widespread implementation. Conning and Udry (2005) document this well. Subsidised rural credit became a key policy tool for many governments seeking to promote rural credit markets. Many governments set up state owned cooperatives to lend to exclusively to farmers. Strict rules were devised for formal institutions regarding rural finance, which required banks to dedicate a portion of their lending activities to rural credit markets. Often, this was accompanied by an interest rate ceiling imposed on the rural credit market.

The primary function of these policies was to improve access to credit amongst farmers, through lower interest rates $r$ and a greater availability of loans. However, these policies experienced a number failures which Conning and Udry (2005) outline. State owned financial institutions often faced default rates, and required repeated financial bailouts. Lending rules for formal institutions were often distortionary and did not reach the poorest of farmers; a World Bank Report published in 1975 found that 70 - 80% of small farmers did not have access to state owned or subsidised credit. Furthermore, interest rate ceilings
exacerbated the problem of credit rationing within the market. In the next section, I explore the analysis of interest rate ceilings in the literature.

5.2 Previous Theoretical Analysis of an Interest Rate Ceiling

Informal credit lenders have consistently had a reputation for charging very high rates of interest. Many policymakers have taken the view that these practices are exploitative. The term used in the literature to describe exploitative interest rates is “usury”. Policy makers have turned to legally regulated interest rate ceilings in the past to combat usury; by mandating a lower interest rate, the loans become much cheaper for farmers and hence, in theory, this should improve access to credit for farmers. However, the theoretical literature (and empirical evidence) both suggest that the interest rate ceiling leads to further problems within the informal credit market.

The theoretical literature predominantly analyses interest rate ceilings in terms of credit rationing, and interlinkage.

5.2.1 Credit Rationing View

Braverman and Guasch (1986) summarise this view. Interest rate ceilings, whilst reduce the cost of loans, cause an excess demand for loans within the market, and hence credit rationing arises. Formal institutions generally will favour wealthier borrowers due to more acceptable collateral, and hence an interest rate policy causes small farmers from being excluded from credit. This is the very opposite to the aims of an interest rate ceiling.

5.2.2 Interlinkage View

The interlinkage view of interest rate ceilings is that since a trader has the ability to control both prices and interest rates, then a ceiling will simply result in the adjustment of prices in response to the policy (Braverman and Guasch, 1986). Several studies of interlinkage come to this conclusion. Bardhan (1980) outlines that a well meaning policy change in one market only results in adjustments in the other market. Similarly, Braverman and Srinivasan (1981) conclude from their analysis of sharecropping-credit arrangements that interlinkage can "reduce the tenancy and credit reform to insignificance" (Braverman and

The current literature which advocates this view suggests that an interest rate ceiling has no material effects on farmer or trader surplus where interlinkage is present. However, this does not necessarily hold in a segmented markets context. In the discussion that follows, I show that in the interlinkage framework presented in this thesis, an interest rate ceiling does have a material impact on the competitiveness of traders, and the welfare of farmers.

5.3 A Formal Analysis of an Interest Rate Ceiling

In this section, I use the model developed in Chapter 4 to analyse the impact of an interest rate ceiling on the segmented interlinkage market. I will take two cases to examine the effect of the policy: first, when the interest rate ceiling is above the optimal interest rate set in the Contested Segment, and secondly, when the interest rate ceiling is below the optimal interest rate in the Contested Segment. I assume that we are examining the case where segmentation arises, i.e. where $A > \bar{A}$. I let government regulated interest rate ceiling be denoted by $\hat{r}$.

5.3.1 Case 1: Ceiling is Above Contested Segment Interest Rate

Suppose the interest rate ceiling is above the optimal interest rate in the Contested Segment, i.e.

$$\hat{r} \geq r^*$$

If this is the case, then the policy does not change the optimal interest rate setting in the Contested Segment, since the optimal $r^*$ is available to the trader. Hence, he will continue to set it as such and hence there is no effect of the policy on the ex post market. The Home Segment trader will always be able to adjust the price $p$ in order to survive in the market, and hence this policy also has no effect on these traders. Consequently, the trader’s and farmer’s payoffs remain unchanged.
5.3.2 Case 2: Ceiling is Below Contested Segment Interest Rate

Now suppose that the interest rate ceiling is below the optimal interest rate in the Contested Segment, i.e.

\[ \hat{r} < r^* \]

This is the more likely situation that would arise when an interest rate ceiling is implemented. In such a case, the optimal interest rate is no longer available to the trader to set, but furthermore in the Contested Segment, the traders do not have the ability to adjust prices. Given that there is some degree of market power \( \alpha > 0 \) that a Contested Segment trader holds, the trader is making a positive profit. Hence, a trader in the Contested Segment will be forced to lower the interest rate such that he will take a cut in the profits he earns.

As in the previous case, a Home Segment trader will simply adjust \( p \) in a manner that allows him to survive in the market, and although this combination of \( r \) and \( p \) may not be the optimal combination (such as in the case of a unique equilibrium), the ability to adjust \( p \) means the trader guarantees existence within the market.

Consider now the case where the interest rate ceiling \( \hat{r} \) is so low that it implies that a Contested Segment trader is making negative profits. If this occurs, Contested Segment traders will shut down and cease to operate in the market. The Home Segment trader may still be able to survive by adjusting the price \( p \); however, the Home Segment’s outside option is now zero, which leaves the farmers with less utility than when the Contested Segment existed. Given than the Home Segment Pareto dominates the Contested Segment, it follows that for some range of values, the Home Segment trader can still survive by adjusting \( p \).

**Remark 7** When an interest rate ceiling \( \hat{r} \) is sufficiently low that it results in the shutdown of Contested Segment traders but the Home Segment trader survives, the Home Segment farmers will be worse off, since their outside option is equal to zero.

This is a policy implication that previous models of interlinkage have not been able to demonstrate. In the presence of a segmented market with interlinkage contracts, an
interest rate ceiling will leave farmers worse off. Given that the Contested Segment is forced to shut down when the interest rate ceiling is sufficiently low, Floating customers will now be excluded from access to credit; further, this results in a zero outside option for Home Segment farmers. Given that there is strong empirical evidence for the existence of segmentation, such a policy analysis contributes to a greater depth of understanding of the effects of an interest rate ceiling. It is interesting to note that a government would observe the interest rate falling in the informal sector, and hence these welfare effects are not necessarily readily observable.

Now consider the case where the interest rate ceiling is such that it drives the Contested Segment trader’s profits to zero. Recall that the optimal interest rate is given by:

\[
 r_0 = \frac{1}{s(e)} - \frac{Q}{L} (1 - \beta)(p' - (1 - \delta)^n p'') - 1
\]  

(28)

Now consider the case where the competitive (outside option) market for the potatoes yields lower prices than the wholesale market the trader sells on, i.e. \( p' > (1 - \delta)^n p'' \).

Then, as \( \beta \) decreases, the interest rate decreases. This leads to the following conclusion:

**Remark 8** As the price ceiling decreases, farmers with a high bargaining power will be excluded from the Contested Segment before farmers with a low bargaining power.

This is simple to see and makes intuitive sense. A farmer with a high bargaining power is more likely to gain more surplus from the renegotiation stage of prices, and hence the trader cannot gain a sufficient surplus to cover a low \( r \). Hence, the trader will discontinue trade with farmers that possess high bargaining power. Hence, farmers with a low bargaining power are the last to be excluded from credit in the Contested Segment. This is an interesting implication because it suggests that the policy causes the informal sector to disadvantage larger farmers. The conventional analysis focuses on formal institutions.

**5.4 Lessons from Past Policies**

The analysis of an interest rate ceiling policy highlights the importance of understanding how the segmented credit market operates, and the nature of interlinked credit contracts.
The model suggests that one should consider the entirety of the interlinked arrangements, particularly market structures, when considering policy changes. The analysis also suggests that one should consider designing a policy which uses the presence of such a market structure in a constructive fashion. In the next chapter, I show that a Microfinance policy is able to achieve this.
6 Application 2: A Microfinance Policy

Microfinance has been coined as one of the leading economic development strategies to alleviate poverty within the developing world. Microfinance Institutions (MFIs) are characterised by low opportunity costs of capital, high repayment rates and innovative contractual structures to harness social capital, and hence are receiving increasing attention by policymakers. In this section, I provide an overview of some of the theoretical approaches of modelling MFIs and informal credit markets, followed by an analysis of a MFI policy implemented in the informal credit market. I then compare the outcomes of this policy to the interest rate ceiling policy provided in the previous chapter.

6.1 Theoretical Approaches to Modelling Formal and Informal Sectors

The literature generally models MFIs as a formal institution, and then studies the interaction between it and informal lenders. There are two broad categories that these models fall into: models of vertical interaction, and models of horizontal interaction (Andersen and Moller, 2005).

6.1.1 Models of Vertical Interaction

Models of vertical interaction generally hypothesise that either there is a residual demand for informal loans due to credit rationing, or time delays by formal credit institutions; or, they explain the existence of informal credit as a “screening device” for formal loans. Such an example is Jain (1999), who models a formal lender who part finances a loan, forcing the borrower to borrow from the informal market, and hence the formal institution indirectly utilises the informal lender’s informational and enforcement advantages. Jain & Mansuri (2003) provide a model in which formal loans require frequent repayment. As a consequence, borrowers take out loans with informal lenders in order to meet frequent repayment schedules.

6.1.2 Models of Horizontal Interaction

Models of horizontal interactions analyse formal and informal credit institutions as in direct competition with each other. There is larger literature in this area. McIntosh
& Wydick (2005) model a situation where an additional MFI enters into a credit market where an MFI and a moneylender already exist. In this paper, the moneylender is modelled as an exploitative agent that induces borrowers to accept contracts with little returns for them. Demont (2010) model the interaction between a monopoly MFI and a perfectly competitive moneylender market. The literature in the area has yet to analyse MFIs in a segmented informal credit market context.

6.2 Analysis of A Microfinance Policy
In this section, I use the model developed in Chapter 4 to analyse the impact of the entry of an MFI on the segmented interlinkage market. I deliberately use the same framework as in Chapter 5 to highlight the importance of choice of policy. I assume that the MFI interest rate is administratively determined. I will take two cases to examine the effect of the policy: first, when the MFI interest rate is above the optimal interest rate set in the Contested Segment, and secondly, when the MFI interest rate is below the optimal interest rate in the Contested Segment. I assume that we are examining the case where segmentation arises, i.e. where $A > \bar{A}$. Let the MFI interest rate be denoted by $\hat{r}$.

6.2.1 Case 1: MFI Interest Rate is Above Contested Segment Interest Rate
Suppose the MFI interest rate is above the optimal interest rate in the Contested Segment, i.e.

$$\hat{r} \geq r^*$$

Similarly to the case of an interest rate ceiling, this policy does not change the optimal interest rate setting in the Contested Segment, since the optimal $r^*$ is available to the trader. Hence, he will continue to set it as such and hence there is no effect of the policy on the ex post market. The Home Segment trader will always be able to adjust the price $p$ in order to survive in the market, and hence this policy also has no effect on these traders. Consequently, the trader’s and farmer’s payoffs remain unchanged.
6.2.2 Case 2: MFI Interest Rate is Below Contested Segment Interest Rate

Now suppose that the MFI interest rate is below the optimal interest rate in the Contested Segment, i.e.

\[ \hat{r} < r^* \]

As in the case of an interest rate ceiling, the optimal interest rate is no longer available to the trader to set, and the traders do not have the ability to adjust prices in the Contested Segment. Given that there is some degree of market power \( \alpha > 0 \) that a Contested Segment trader holds, the trader is making a positive profit. Hence, a trader in the Contested Segment will be forced to lower the interest rate \( r^* \) such that he will take a cut in the profits he earns.

As in the previous case, a Home Segment trader will simply adjust \( p \) in a manner that allows him to survive in the market, and although this combination of \( r \) and \( p \) may not be the optimal combination (such as in the case of a unique equilibrium), the ability to adjust \( p \) means the trader guarantees existence within the market.

Consider now the case where the MFI interest rate \( \hat{r} \) is so low that it implies that a Contested Segment trader is making negative profits. If this occurs, Contested Segment traders will shut down and cease to operate in the market. The Home Segment trader may still be able to survive by adjusting the price \( p \); there is a possibility that they too will be out of business, but since we do not observe this in reality, I ignore this. The key difference between this situation and the case of an interest rate ceiling is that the this policy does not eliminate an outside option, but rather provides an alternative outside option. The utility a farmer gains from obtaining a loan from an MFI at interest rate \( \hat{r} \) and selling potatoes on the competitive market at \( (1 - \delta)p^o \) must be larger than a Contested Segment ex post contract; otherwise, the Contested Segment traders would not shut down. Furthermore, given than the Home Segment Pareto dominates the Contested Segment, it follows that for some range of values, the Home Segment trader can still survive by adjusting \( p \).

**Remark 9** When an MFI interest rate \( \hat{r} \) is sufficiently low that it results in the shutdown of Contested Segment traders but the Home Segment trader survives, the Home Segment farmers will be better off, since their outside option increases.
This analysis provides a much more nuanced policy implication of the entry of an MFI into the rural credit market. The MFI plays a pivotal role in providing credit to those who do not have exclusive relations with a trader, but also in increasing outside options, such that it improves the farmer’s welfare in the Home Segment. Note that Remark 8 also applies here. An important consideration of the entry of an MFI is, can the non-interlinked MFI arrangement illicit the same level of effort that a Home Segment trader can achieve? The intuitive answer is no. The trader has available to him two incentive instruments, and the interlinkage of output and loans creates overlapping incentives to exert effort, i.e. has a disciplining effect.

Whilst the MFI has a competitive advantage in being able to provide loans with low opportunity costs, the MFI does not have the incentive advantages. This leads to the following consideration: can we design a MFI policy such that it internalises the incentives advantages that a Home Segment trader possesses, but retains the competitive advantages of a MFI? Such a policy is currently being implemented as a field experiment in West Bengal, India, known as “Agent Intermediated Microfinance”. Maitra et. al. (2012) analyse this experiment, and measure the take up rates, repayment rates and crop yields that farmers obtain under Agent Intermediated Microfinance, and Group Lending Microfinance (as a control). The Agent Intermediated Microfinance framework selects localised traders in villages to recommend some of their clients for MFI loans. The interlinked, endogenous segmentation model presented in this thesis can be extended to model Agent Intermediated Microfinance, and tested to see what kinds of borrowers are recommended, as well as a comparison of Agent Intermediated Microfinance and Group Lending structures. Such an extension would have large policy implications on how MFIs structure their loans; but additionally, the Reserve Bank of India is currently considering an Agent Intermediated “Bank Correspondent” model of banking for formal loan institutions.
7 Conclusion and Further Extensions

7.1 Conclusions

This thesis seeks to answer the question: why are credit markets segmented? I constructs a moral hazard model of interlinkage, and utilise the presence of social capital to endogenise the segmentation of informal credit markets. I find that given a threshold amount of monopoly power in the Contested Segment, segmentation will arise. I also find that a trader will always seek to invest in social capital such that he will make exclusive agreements with farmers.

This thesis also makes several policy predictions. Under a segmented framework, I find the an Interest Rate Ceiling has the potential to drive the Contested Segment to shut down, and hence reduces the Home Segment farmer’s utility due to the loss of an outside option. I also find that farmers with a higher bargaining power are more likely to be “let go” by traders when an Interest Rate Ceiling is too low. This result is different to the conventional analysis of such policies and interlinkage, which say that the policy has no effect.

Furthermore, I also analyse the impact of the entry of a Microfinance Institution on the Home Segment and the Outside Segment. I find that a Microfinance Institution becomes an alternative outside option, and enhances the outside option for a Home Segment farmer.

7.2 Further Extensions

As noted in Chapter 3, this model gives rise to testable predictions on whether a farmer has an ex ante or ex post interlinkage contract. One could utilise the data currently being collected by Maitra et. al. (2012) to determine this. Furthermore, as noted both in Chapters 3 and 4, this model can be extended to incorporate strategic default, but including a “social penalty function” within the formulation of the probability of success.

A notable extension that follows naturally from this thesis is to model how a trader would behave in an Agent Intermediated Microfinance context. I could examine how the trader recommends borrowers to the Microfinance Institution, and endogenise landholdings.
to achieve this. Further, I could build upon this framework to model the social welfare induced by an Agent Intermediated Microfinance Loan, and compare this to a Group Lending Loan.

Finally, other possible extensions include accounting for sharecropping, and modelling reciprocity within the framework. If a farmer and trader have a repeated relationship, the may be willing to tolerate a certain degree of non-compliance by each party (e.g. default by the farmer; renegotiating the price on the part of the trader). I could model this in a repeated game framework.
A Appendix: First Best Interlinkage

A.1 Proof that the Participation Constraint Binds with Equality

Given that the trader can contract on $e$, the trader has no incentive to keep the farmer above her participation constraint, since doing so reduces the trader’s profits. Both $p$ and $r$ do not affect the optimal level of effort. If the participation constraint is strictly greater than zero, then the trader can always increase his profits by reducing the payoff of the farmer by some $\varepsilon$. Hence, the trader has an incentive to continue reducing the farmer’s payoff until the participation constraint binds with equality. ■

A.2 Solving First Best

The trader solves the following:

$$
\max_{e,p,r} s(e).[Q(p' - p) + (1 + r)L] + (1 - s(e)).[0] - L
$$

s.t.

$$
\quad s(e).[Qp - (1 + r)L] - C(e) \geq 0
\quad \text{(PC)}
$$

Simplifying the maximisation problem,

$$
\max_{e,p,r} s(e).[Q(p' - p) + (1 + r)L] - L
$$

The Participation Constraint holds with equality. Rearranging the Participation Constraint,

$$
p = \frac{C(e) + s(e).(1 + r)L}{s(e).Q}
$$

Substituting into the maximisation problem,
\[
\max_{e,p,r} \ s(e)[Qp' - (\frac{C(e) + s(e)(1+r)L}{s(e)Q})] + (1+r)L - L = s(e)Qp' - C(e) - L
\]

Differentiating with respect to \(e\),

\[
\frac{s'(e)Qp' - C'(e)}{C'(e)} = 0
\]

\[
\frac{s'(e)}{C'(e)} = \frac{1}{Qp'}
\]

(A.3) Characterisation of the Equilibrium

From Equation (2), \(e^*\) must solve the condition \(\frac{s'(e)}{C'(e)} = \frac{1}{Qp'}\). To find the optimality conditions for \(p\) and \(r\), the unconstrained maximisation problem must be solved, i.e.,

\[
\max_{e,p,r} \ s(e)Qp' - C(e) - L
\]

However, the choice variables \(p\) and \(r\) are absent from this maximisation problem. Hence, the optimal \(p\) and \(r\) must be such that it satisfies the participation constraint with equality, i.e. any pair \((p^*, r^*) \in \mathbb{R}\) that satisfies \(s(e^*)[Qp - (1+r)L] - C(e^*) = 0\).

Hence, the Nash Equilibrium \((e^*, p^*, r^*)\) must satisfy the following conditions:

\[
e^* \text{ solves } \left\{ \frac{s'(e)}{C'(e)} = \frac{1}{Qp'} \right\}.
\]

any pair \((p^*, r^*) \in \mathbb{R}\) satisfies \(s(e^*)[Qp - (1+r)L] - C(e^*) = 0\)

(A.4) Proof that the Equilibrium is a Maximum

The trader maximises the following:
\[
\max_{e,p,r} \ s(e).Qp' - C(e) - L
\]

The First Order Condition with respect to \(e\) is given by the following:

\[
 s'(e).Qp' - C'(e)
\]

The Second Order Condition with respect to \(e\) is given by the following:

\[
 s''(e).Qp' - C''(e)
\]

Since by assumption \(s''(e) < 0\), and \(C''(e) > 0\), then it follows that \(s''(e).Qp' - C''(e) < 0\). Therefore, \(e^*\) maximises the trader’s profits.

Given that \(p\) and \(r\) are absent from the trader’s problem, it follows that the pair \((p^*, r^*)\) must satisfy the Participation Constraint such that it maximises the trader’s profits. The trader’s profits are maximised when the Participation Constraint holds with equality (see Appendix A.1) and hence the pair \((p^*, r^*)\) maximises the trader’s profits.

Hence, the Nash Equilibrium \((e^*, p^*, r^*)\) is a maximum.
Appendix: Ex Ante Interlinkage

B.1 Solving Second Best Ex Ante Interlinkage

Assume the Participation Constraint is satisfied. The trader solves the following:

\[
\begin{align*}
\max_{p,r} & \quad s(e)[Q(p' - p) + (1 + r)L] + (1 - s(e))[0] - L \\
\text{s.t.} & \quad e^* \in \arg\max s(e)[Qp - (1 + r)L] + (1 - s(e))[0] - C(e)
\end{align*}
\] (6)

The farmer’s problem is given by the following:

\[
\max_e s(e)[Qp - (1 + r)L] + (1 - s(e))[0] - C(e)
\] (5)

The First Order Condition with respect to \(e\) is given by the following:

\[
\frac{s'(e)}{C'(e)} = \frac{1}{Qp - (1 + r)L}
\] (7)

From Equation (7), since \(\frac{s'(e)}{C'(e)}\) yields a negatively sloped function, as \(e\) increases, \(\frac{s'(e)}{C'(e)}\) decreases. Therefore, when \(p\) increases, \(\frac{s'(e)}{C'(e)}\) decreases and \(e\) increases and hence \(\frac{\partial e}{\partial p} > 0\); and when \(r\) increases, \(\frac{s'(e)}{C'(e)}\) increases and \(e\) decreases, and hence \(\frac{\partial e}{\partial r} < 0\).

The trader maximises the following:

\[
\max_{p,r} s(e^*)[Q(p' - p) + (1 + r)L] + (1 - s(e^*))[0] - L
\] (6)

Note that the optimal level of effort, \(e^*\), is a function of \(p\) and \(r\). Differentiating with respect to \(p\),

\[
\frac{\partial s(e^*)}{\partial e^*} \cdot \frac{\partial e^*}{\partial p} [Q(p' - p) + (1 + r)L] = s(e^*).Q
\] (8)

Differentiating with respect to \(r\),
\[ \frac{\partial s(e^*)}{\partial e^*} \cdot \frac{\partial e^*}{\partial r} \cdot [Q(p' - p) + (1 + r)L] = -s(e^*)L \]  

(9)

### B.2 The Trader’s Participation Constraint

Rearranging Equation (9) to make \( \frac{\partial e^*}{\partial r} \) the subject yields the following:

\[ \frac{\partial e^*}{\partial r} = \frac{-s(e^*)L}{\frac{\partial s(e^*)}{\partial e^*} \cdot [Q(p' - p) + (1 + r)L]} \]  

(10)

From Equation (7), \( \frac{\partial e^*}{\partial r} < 0 \); hence, since \( -s(e^*)L < 0 \), and \( \frac{\partial s(e^*)}{\partial e^*} > 0 \), then it must be the case that \( [Q(p' - p) + (1 + r)L] > 0 \) (since \( \frac{\partial e^*}{\partial r} < 0 \), the condition must hold with strict inequality).

### B.3 Proof of Proposition 1

Restating Equation (7),

\[ \frac{s'(e)}{C'(e)} = \frac{1}{Qp - (1 + r)L} \]  

(7)

Since \( \frac{s'(e)}{C'(e)} \) yields a negatively sloped function, as \( e \) increases, \( \frac{s'(e)}{C'(e)} \) decreases. Therefore, when \( p \) increases, \( \frac{s'(e)}{C'(e)} \) decreases and \( e \) increases and hence \( \frac{\partial e}{\partial p} > 0 \).

From Equation (6),

\[ \frac{\partial s(e^*)}{\partial e^*} \cdot \frac{\partial e^*}{\partial p} \cdot [Q(p' - p) + (1 + r)L] = s(e^*)Q \]  

(8)

Rearranging Equation (6) to make \( \frac{\partial e^*}{\partial p} \) the subject yields the following:

\[ \frac{\partial e^*}{\partial p} = \frac{s(e^*)Q}{\frac{\partial s(e^*)}{\partial e^*} \cdot [Q(p' - p) + (1 + r)L]} \]  

(10A)

From Equation (5), \( \frac{\partial e^*}{\partial p} > 0 \); hence, since \( s(e^*)Q > 0 \), and \( \frac{\partial s(e^*)}{\partial e^*} > 0 \), then it must be the case that \( [Q(p' - p) + (1 + r)L] > 0 \) (since \( \frac{\partial e^*}{\partial p} > 0 \), the result must hold with strict inequality). Therefore,
\[Q(p' - p) + (1 + r)L > 0\]
\[Qp' - Qp + (1 + r)L > 0\]
\[Qp' > Qp - (1 + r)L\]
\[\frac{1}{Qp'} < \frac{1}{QP - (1 + r)L}\]
\[s'(e_{FB}) \leq s'(e_{SB})\]

Since \(s'(e)\) is negatively sloped and decreasing, and \(C'(e)\) is positively sloped and increasing, hence \(\frac{s'(e)}{C'(e)}\) is a negatively sloped function. Therefore, a lower value of \(\frac{s'(e)}{C'(e)}\) yields a higher value of \(e\). Hence,

\[\frac{s'(e_{FB})}{C'(e_{FB})} < \frac{s'(e_{SB})}{C'(e_{SB})}\]

Therefore, \(e_{FB} > e_{SB}\)

\section{B.4 Proof of Lemma 2}

The farmer’s problem is given by the following:

\[\max_e s(e)[Qp - (1 + r)L] + (1 - s(e)) [0] - C(e)\]  

which is a maximisation problem with one choice variable. Hence, to show \(e\) is maximised, need to satisfy the second order sufficient condition for a maximum:

\[f_{ee} < 0.\]

The FOC w.r.t. \(e\) is given by the following:

\[s'(e)[Qp - (1 + r)L] - C'(e)\]

The SOC w.r.t. \(e\) is given by the following:
By assumption of diminishing returns to effort on the probability of a successful harvest, 
$s''(e) < 0$; also by assumption, $C''(e) > 0$. Therefore, $s''(e)[Qp - (1 + r)L] - C''(e) < 0$. (and 
$f_{ee} < 0$) and hence $e$ yields a maximum.

The trader’s problem is given by the following:

$$\max_{p, r} s(e^*).[Q(p' - p) + (1 + r)L] + (1 - s(e^*))[0] - L \quad (6)$$

Note that $e$ is a function of $p$ and $r$. This is an unconstrained maximisation problem with 
two choice variables. Hence, to prove $p$ and $r$ are maximised, we need to satisfy the second 
order sufficient conditions for a maximum:

$$f_{pp} < 0 \quad (C1)$$

$$\begin{vmatrix} f_{pp} & f_{pr} \\ f_{rp} & f_{rr} \end{vmatrix} > 0 \quad (C2)$$

By Young’s Theorem, if the Second Order cross partial derivatives are continuous, then 
$f_{pr} = f_{rp}$, and hence if Young’s Theorem is satisfied then Condition (C2) simplifies to 
$f_{pp}f_{rr} - f_{pr}^2 > 0$.

The First Order Derivative of Equation (6) with respect to $p$ is given by the following:

$$\frac{\partial s(e^*)}{\partial e^*} \cdot \frac{\partial e^*}{\partial p}[Q(p' - p) + (1 + r)L] - s(e^*).Q \quad (8)$$

The First Order Derivative of Equation (6) with respect to $r$ is given by the following:

$$\frac{\partial s(e^*)}{\partial e^*} \cdot \frac{\partial e^*}{\partial r}[Q(p' - p) + (1 + r)L] + s(e^*).L \quad (9)$$

Hence, the Second Order Derivatives are given by the following:
The trader maximises the following:

\[ f_{pp} = (Q(p' - p) + (1 + r)L) = \left( \frac{\partial e^*}{\partial p} \right)^2 + s''(e^*) + s'(e^*) \frac{\partial^2 e^*}{\partial p^2} \]

\[ f_{rr} = (Q(p' - p) + (1 + r)L) = \left( \frac{\partial e^*}{\partial r} \right)^2 + 2L \cdot s'(e^*) \cdot \frac{\partial e^*}{\partial r} \]

\[ f_{rp} = (Q(p' - p) + (1 + r)L) = \left( \frac{\partial e^*}{\partial r} \cdot \frac{\partial e^*}{\partial p} \right) = \left( \frac{\partial^2 e^*}{\partial p \partial r} \right) + (s(e^*))^2 \left( \frac{\partial^2 e^*}{\partial p^2} - \frac{\partial^2 e^*}{\partial r^2} \right) \]

\[ f_{pp} = (Q(p' - p) + (1 + r)L) = \left( \frac{\partial e^*}{\partial p} \right)^2 + s''(e^*) + s'(e^*) \frac{\partial^2 e^*}{\partial p^2} \]

\[ f_{rr} = (Q(p' - p) + (1 + r)L) = \left( \frac{\partial e^*}{\partial r} \right)^2 + 2L \cdot s'(e^*) \cdot \frac{\partial e^*}{\partial r} \]

\[ f_{rp} = (Q(p' - p) + (1 + r)L) = \left( \frac{\partial e^*}{\partial r} \cdot \frac{\partial e^*}{\partial p} \right) = \left( \frac{\partial^2 e^*}{\partial p \partial r} \right) + (s(e^*))^2 \left( \frac{\partial^2 e^*}{\partial p^2} - \frac{\partial^2 e^*}{\partial r^2} \right) \]

By Young’s theorem, \( \frac{\partial^2 e^*}{\partial p \partial r} = \frac{\partial^2 e^*}{\partial r \partial p} \) and hence the cross partial derivatives of interest here also satisfy Young’s theorem (ie \( f_{rp} = f_{pr} \)).

Now consider \( f_{pp} - f_{rr} - f_{pr}^2 \). This can be simplified to the following expression:

\[ [Q(p' - p) + (1 + r)L]^2 \times \left[ s'(e^*) \cdot s''(e^*) \right] \left( \frac{\partial e^*}{\partial p} \right)^2 + \left( \frac{\partial e^*}{\partial r} \right)^2 - 2L \cdot s'(e^*) \cdot \frac{\partial e^*}{\partial r} + (s'(e^*))^2 \left( \frac{\partial^2 e^*}{\partial p^2} - \frac{\partial^2 e^*}{\partial r^2} \right)^2 \right] + \]

\[ 2 \cdot [Q(p' - p) + (1 + r)L] \times \left[ L(s'(e^*))^2 \left( \frac{\partial e^*}{\partial p} \cdot \frac{\partial e^*}{\partial r} - \frac{\partial^2 e^*}{\partial p \partial r} \right) + Q(s'(e^*))^2 \left( \frac{\partial^2 e^*}{\partial p^2} \cdot \frac{\partial e^*}{\partial p} - \frac{\partial^2 e^*}{\partial p \partial r} \right) \right] - \]

\[ \left( s'(e^*) \cdot \left( \frac{\partial e^*}{\partial p} \cdot L + \frac{\partial e^*}{\partial r} \cdot Q \right) \right)^2 \]

Under the reasonable assumptions of diminishing marginal returns, \( \frac{\partial^2 e^*}{\partial p^2} < 0 \) and \( \frac{\partial^2 e^*}{\partial r^2} < 0 \); and Equation (C1) is satisfied, but whether Equation (C2) is satisfied is ambiguous. Given Equation (C1) is satisfied, the Nash Equilibrium cannot be a minimum; however, the equilibrium will only be a maximum when the expression for \( f_{pp} - f_{rr} - f_{pr}^2 \) is greater than zero. ■

**B.5 Proof that the Closed Form Example is a Maximum**

The trader maximises the following:

\[ 2 \cdot (Qp - (1 + r)L)^\frac{1}{2} \cdot (Q(p' - p) + (1 + r)L) - L \]  

(14)

This is an unconstrained maximisation problem with two choice variables. Hence, to prove \( p \) and \( r \) are maximised, we need to satisfy the second order sufficient conditions for a maximum:

\[ 61 \]
\[ \begin{vmatrix} f_{pp} \\ f_{pp} & f_{pr} \\ f_{rp} & f_{rr} \end{vmatrix} < 0 \]  \hspace{1cm} (C1)

\[ \begin{vmatrix} f_{pp} \\ f_{pp} & f_{pr} \\ f_{rp} & f_{rr} \end{vmatrix} > 0 \]  \hspace{1cm} (C2)

By Young’s Theorem, if the Second Order cross partial derivatives are continuous, then
\( f_{pr} = f_{rp} \), and hence if Young’s Theorem is satisfied then Condition (C2) simplifies to
\( f_{pp} f_{rr} - f_{pr}^2 > 0 \).

The First Order Condition with respect to \( r \) is given by the following:

\[ -\frac{2}{3} \cdot L \cdot [Q (p' - p) + (1 + r) L] \cdot [Qp - (1 + r)L]^{-\frac{2}{3}} + 2L [Qp - (1 + r)L]^{\frac{1}{3}} \]

The First Order Condition with respect to \( p \) is given by the following:

\[ \frac{2}{3} \cdot Q \cdot [Q (p' - p) + (1 + r) L] \cdot [Qp - (1 + r)L]^{-\frac{2}{3}} - 2Q [Qp - (1 + r)L]^{\frac{1}{3}} \]

The Second Order Conditions are given by the following:

\[ f_{rr} = -\frac{2}{3} \cdot L \left( L \cdot [Qp - (1 + r)L]^{-\frac{2}{3}} + \frac{2}{3} \cdot L \cdot [Q(p' - p) + (1 + r)L] \cdot [Qp - (1 + r)L]^{-\frac{2}{5}} \right) - \frac{2}{3} \cdot L^2 \cdot [Qp - (1 + r)L]^{-\frac{2}{3}} \]

\[ f_{pp} = \frac{2}{3} \cdot Q \left( -Q \cdot [Qp - (1 + r)L]^{-\frac{2}{3}} - \frac{2}{3} \cdot Q \cdot [Q(p' - p) + (1 + r)L] \cdot [Qp - (1 + r)L]^{-\frac{2}{3}} \right) - \frac{2}{3} \cdot Q^2 \cdot [Qp - (1 + r)L]^{-\frac{2}{3}} \]

\[ f_{rp} = f_{pr} = -\frac{2}{3} \cdot L \left( -Q \cdot [Qp - (1 + r)L]^{-\frac{2}{3}} - \frac{2}{3} \cdot Q \cdot [Q(p' - p) + (1 + r)L] \cdot [Qp - (1 + r)L]^{-\frac{2}{3}} \right) + \frac{2}{3} \cdot Q \cdot [Qp - (1 + r)L]^{-\frac{2}{3}} \]

Since \([Qp - (1 + r)L] > 0\) and \([Q(p' - p) + (1 + r)L] > 0\), \( f_{rr} < 0 \) and \( f_{pp} < 0 \), and \( f_{rp} > 0 \).
\[ f_{pp} f_{rr} - f_{pr}^2 = \left( -\frac{2}{3} L \left( L \left[ Qp - (1 + r)L \right]^{-\frac{2}{3}} + \frac{2}{3} L \left[ Q(p' - p) + (1 + r)L \right] \left[ Qp - (1 + r)L \right]^{-\frac{2}{3}} \right) - \frac{2}{3} \right) \]

\[ \left( \frac{2}{3} Q \left( -Q \left[ Qp - (1 + r)L \right]^{-\frac{2}{3}} - \frac{2}{3} Q \left[ Q(p' - p) + (1 + r)L \right] \left[ Qp - (1 + r)L \right]^{-\frac{2}{3}} \right) - \frac{2}{3} \right) \]

\[ - \left( \frac{4}{3} Q L \left[ Qp - (1 + r)L \right]^{-\frac{2}{3}} + \frac{4}{9} Q L \left[ Q(p' - p) + (1 + r)L \right] \left[ Qp - (1 + r)L \right]^{-\frac{2}{3}} \right)^2 \]

\[ = 0 \]

Hence, we would need to examine higher order derivatives to ascertain whether \( p \) and \( r \) are maximising values. The purpose of the exercise was to show that the result is not a minimum, and hence I will not further examine this result.
C Appendix: Ex Post Interlinkage

C.1 Nash Bargaining Price Solution

The farmer’s agreement point is given by the following:

\[ s(e)(Qp - (1 + r) L) - C(e) \]

The farmer’s disagreement point (outside option) is given by the following:

\[ s(e)[-(1 + r) L + Qp''(1 - \delta)n] - C(e) \]

The trader’s agreement point is given by the following:

\[ s(e).[Q(p' - p) + (1 + r)L] + (1 - s(e)].[0] - L \]

The trader’s disagreement point (outside option) is given by the following:

\[ s(e).[Q(1 + r)L] + (1 - s(e)].[0] - L \]

The Nash Bargaining problem is given by the following:

\[ p^{NS} = \arg \max_p [s(e).(Qp - Q(1 - \delta)n.p'\beta).[s(e).(Q(p' - p))^{1 - \beta}] \] (17)

Differentiating with respect to \( p \),

\[ \beta[s(e).(Qp - Q(1 - \delta)n.p'\beta)]^{\beta - 1} \times Q.s(e) \times [s(e).Q(p' - p)]^{1 - \beta} + \\
[s(e).(Qp - Q(1 - \delta)n.p'\beta)]^{\beta} \times (1 - \beta).[s(e).Q(p' - p)]^{-\beta} \times -Q.s(e) = 0 \]

\[ Q.s(e) \times \beta[s(e).(Qp - Q(1 - \delta)n.p'\beta)]^{\beta - 1} \times [s(e).Q(p' - p)]^{1 - \beta} = \\
Q.s(e) \times [s(e).(Qp - Q(1 - \delta)n.p'\beta)]^{\beta} \times (1 - \beta).[s(e).Q(p' - p)]^{-\beta} \]

Simplifying further,
\[
\beta \left( \frac{s(e) [Qp - Q(1 - \delta)^n p'']}{s(e) Q(p' - p)} \right)^{\beta-1} = (1 - \beta) \left( \frac{s(e) [Qp - Q(1 - \delta)^n p'']}{s(e) Q(p' - p)} \right)^{\beta} \\
\frac{(1 - \beta)}{\beta} = \frac{s(e) Q(p' - p)}{s(e) Q[p - (1 - \delta)^n p'']} \\
\frac{(1 - \beta) p - (1 - \delta)^n p''}{\beta} = \beta(p' - p) \\
p - (1 - \delta)^n p'' - \beta p + \beta(1 - \delta)^n p'' = \beta p' - \beta p \\
p = (1 - \delta)^n p'' - \beta(1 - \delta)^n p'' + \beta p'
\]

Hence, the Nash Bargaining solution is given by the following:

\[p^{NS} = (1 - \beta)[(1 - \delta)^n p''] + \beta[p'] \quad (18)\]

### C.2 Optimal Effort

Substituting \(p^{NS}\) into the farmer’s problem,

\[\max_{e} s(e) [Q((1 - \beta)(1 - \delta)^n p'' + \beta p') - (1 + r) L] + (1 - s(e))[0] - C(e) \quad (19)\]

I use Backwards Induction to solve. Differentiating with respect to \(e\) yields the following condition:

\[\frac{s'(e)}{C'(e)} = \frac{1}{Q ((1 - \beta)(1 - \delta)^n p'' + \beta p') - (1 + r) L} \quad (20)\]

Note that \(e\) is a function of \(r\).

### C.3 Optimal Interest Rate

The trader’s problem is given by the following:

\[\max_{r} s(e^*) [Q(p' - (1 - \beta)(1 - \delta)^n p'' - \beta p') + (1 + r) L] + (1 - s(e^*))[0] - L \]

\[= \max_{r} s(e^*) [Q(1 - \beta)(p' - (1 - \delta)^n p'') + (1 + r) L] + (1 - s(e^*))[0] - L \quad (21)\]
Differentiating with respect to $r$,

\[
\frac{\partial s(e^*)}{\partial e^*} \cdot \frac{\partial e^*}{\partial r} [Q(1 - \beta)(p' - (1 - \delta)p'') + (1 + r)L] = -s(e^*).L
\]

\[
\frac{\partial e^*}{\partial r} = \frac{-s(e^*).L}{\frac{\partial s(e^*)}{\partial e^*}.[Q(1 - \beta)(p' - (1 - \delta)p'') + (1 + r)L]}
\]

### C.4 Trader’s Participation Constraint

From Equation (22), $\frac{\partial e^*}{\partial r} < 0$; hence, since $-s(e^*).L < 0$, and $\frac{\partial s(e^*)}{\partial e^*} > 0$, then it must be the case that $[Q(1 - \beta)(p' - (1 - \delta)p'') + (1 + r)L] > 0$ (since $\frac{\partial e^*}{\partial r} < 0$, the condition must hold with strict inequality).

### C.5 Proof of Lemma 4

The farmer’s problem is given by the following:

\[
\max_{e} s(e)[Q ((1 - \beta)(1 - \delta)p'' + \beta p') - (1 + r)L] + (1 - s(e)).[0] - C(e)
\]  

which is a maximisation problem with one choice variable. Hence, to show $e$ is maximised, need to satisfy the second order sufficient condition for a maximum:

$f_{ee} < 0$.

The FOC w.r.t. $e$ is given by the following:

\[
|Q ((1 - \beta)(1 - \delta)p'' + \beta p') - (1 + r)L] - C'(e)
\]

The SOC w.r.t. $e$ is given by the following:

\[
|Q ((1 - \beta)(1 - \delta)p'' + \beta p') - (1 + r)L] - C''(e)
\]

By assumption of diminishing returns to effort on the probability of a successful harvest, $s''(e) < 0$; also by assumption, $C''(e) > 0$. Therefore, $s''(e)[Qp - (1+r)L] - C''(e) < 0$. (and $f_{ee} < 0$) and hence $e$ yields a maximum.

The trader’s problem is given by the following:

66
\[
\max_r s(e^*).[Q(1 - \beta)(p' - (1 - \delta)^n p'') + (1 + r)L] + (1 - s(e^*))[0] - L
\]  
which is a maximisation problem with one choice variable. Hence, to show \(r\) is maximised, need to satisfy the second order sufficient condition for a maximum:

\[f_{rr} < 0.\]

The FOC w.r.t. \(r\) is given by the following:

\[
\frac{\partial s(e^*)}{\partial e^*} \cdot \frac{\partial e^*}{\partial r} \cdot [Q(1 - \beta)(p' - (1 - \delta)^n p'') + (1 + r)L] + s(e^*)L
\]

The SOC w.r.t. \(r\) is given by the following:

\[
[Q(1 - \beta)(p' - (1 - \delta)^n p'') + (1 + r)L] \left[ \left( \frac{\partial e^*}{\partial r} \right)^2 s''(e^*) + \frac{\partial^2 e^*}{\partial r^2} s'(e^*) \right]
\]

Given the necessary condition in Appendix C.4, \([Q(1 - \beta)(p' - (1 - \delta)^n p'') + (1 + r)L] > 0\). Under reasonable assumptions of diminishing marginal returns, \(\frac{\partial^2 e^*}{\partial r^2} < 0\), \(\left( \frac{\partial e^*}{\partial r} \right)^2 s''(e^*) + \frac{\partial^2 e^*}{\partial r^2} s'(e^*) < 0\) and hence \(f_{rr} < 0\). Hence, \(r\) yields a maximum.

**C.6 Proof that the Closed Form Example is a Maximum**

The trader maximises the following:

\[
2.(Q ((1 - \beta)(1 - \delta)^n p'' + \beta p') - (1 + r)L)^{1/3}.(Q(1 - \beta)(p' - (1 - \delta)^n p'') + (1 + r)L) - L
\]  
This is an unconstrained maximisation problem with one choice variable. Hence, to prove \(r\) maximises the trader’s problem, we need to satisfy the second order sufficient condition for a maximum:

\[f_{rr} < 0\]

The First Order Condition with respect to \(r\) is given by the following:
\[-\frac{2}{3}L\left[Q(1-\beta)(p'-(1-\delta)p'')+(1+r)L\right]\left[Q\left((1-\beta)(1-\delta)p''+\beta p'\right)-(1+r)L\right]^{-\frac{2}{3}}
\]

\[+2L\left[Q\left((1-\beta)(1-\delta)p''+\beta p'\right)-(1+r)L\right]^\frac{1}{3}\]

The Second Order Condition with respect to \(r\) is given by the following:

\[
f_{rr} = -\frac{4}{9}L^2\left[Q(1-\beta)(p'-(1-\delta)p'')+(1+r)L\right]\left[Q\left((1-\beta)(1-\delta)p''+\beta p'\right)-(1+r)L\right]^{-\frac{5}{3}}
\]

\[-\frac{4}{3}L^2\left[Q\left((1-\beta)(1-\delta)p''+\beta p'\right)-(1+r)L\right]^{-\frac{2}{3}}\]

Since \([Q\left((1-\beta)(1-\delta)p''+\beta p'\right)-(1+r)L] > 0\) (from farmer’s Participation Constraint) and \([Q(1-\beta)(p'-(1-\delta)p'')+(1+r)L] > 0\) (from trader’s Participation Constraint), \(f_{rr} < 0\) and hence \(r\) yields a maximum.
Appendix: Interlinkage & Endogenous Segmentation

D.1 Proof of Proposition 2

Suppose not. Then, if traders are making positive profits, there is an incentive for a trader to reduce profits by some $\varepsilon$ by changing the pairwise combination $(p^*, r^*)$, since it will result in the trader acquiring all of the market share. Since the problem is symmetric, all traders have an incentive to deviate in such a manner under their profit is equal to zero. Since this is where the marginal benefit is equal to the marginal cost and hence there are no further profitable deviations possible.

D.2 Proof of Lemma 6

Assume $A > \bar{A}$.

Consider the general form of the total surplus from an interlinkage contract:

$$s(e).Qp' - C(e) - L$$

The FOC w.r.t. $e$ is given by the following:

$$s'(e).Qp' - C'(e)$$

Hence the optimal level of $e$ is given by the following:

$$\frac{s'(e)}{C''(e)} = \frac{1}{Qp'}$$

Since the RHS is a constant, and the LHS is a decreasing function of effort, this gives rise to a unique value of $e$.

The SOC w.r.t. $e$ is given by the following:

$$s''(e).Qp' - C''(e)$$

Since $s''(e) < 0$ and $C''(e) > 0$, then it follows that $s''(e).Qp' - C''(e) < 0$ and hence the total surplus a concave function of effort $e$ with a maximum at $\frac{s'(e)}{C'(e)} = \frac{1}{Qp'}$ (which corresponds to the First Best level of effort).
From Proposition 1, the First Best level of effort is larger than the Exclusive customer ex ante interlinkage contract, i.e. \( e_{FB} > \bar{e} \). Similarly for an ex post interlinkage contract, rearranging the necessary condition yields the following:

\[
Qp' > Q\left[\beta p' + (1 - \beta) (1 - \delta)^n p''\right] - (1 + r)L
\]

Hence:

\[
\frac{1}{Qp'} < \frac{1}{Q\left[\beta p' + (1 - \beta) (1 - \delta)^n p''\right] - (1 + r)L}
\]

Since \( \frac{s'(e)}{C'(e)} \) is a decreasing function of effort, \( e \), a higher value of \( \frac{s'(e)}{C'(e)} \) leads to a lower value of effort. Hence, it follows that \( e_{FB} > e^* \).

From Lemma 5, the Exclusive customer ex ante interlinkage contract yields a higher total surplus than the ex post interlinkage contract. Over the interval \([0, e_{FB}]\), the surplus is increasing in effort (since the surplus is a concave problem with a maximum at First Best). Hence, a higher value of surplus corresponds to higher effort over the interval \([0, e_{FB}]\). Since both \( \bar{e} \) and \( e^* \) fall within this interval, it follows that since Exclusive customer interlinkage yields a higher surplus than ex post interlinkage, then \( \bar{e} > e^* \).

Hence, \( e^* < \bar{e} < e_{FB} \).

**D.3 Proof of Proposition 3**

The total surplus in the Exclusive customer interlinkage contract is given by the following:

\[
s(\bar{e})Qp' - L - C(\bar{e})
\]

The total surplus in the ex post interlinkage contract is given by the following:

\[
s(e^*)Qp' - L - C(e^*)
\]

By Lemma 5:

\[
s(\bar{e})Qp' - L - C(\bar{e}) > s(e^*)Qp' - L - C(e^*)
\]
The trader’s profits, $A$ are defined as a fraction of total surplus, i.e.:

$$A = \alpha \left[ s(e)Qp' - L - C(e) \right]$$

Hence, the farmer’s payoff is given by the following:

$$A = (1 - \alpha) \left[ s(e)Qp' - L - C(e) \right]$$

Now suppose the Exclusive customer contract is set such that the farmer’s payoff is the same as that of an ex post interlinkage contract, i.e.:

$$\bar{U} = (1 - \alpha) \left[ s(e^*)Qp' - L - C(e^*) \right]$$

Hence, the trader’s payoff from an Exclusive customer contract is given by the following:

$$s(\bar{e}) Qp' - L - C(\bar{e}) - \bar{U}$$

The trader’s payoff from an ex post interlinkage contract is given by the following:

$$s(e^*) Qp' - L - C(e^*) - \bar{U}$$

Using Lemma 5, we can compare the trader’s profits in the two cases:

$$s(\bar{e}) Qp' - L - C(\bar{e}) - \bar{U} > s(e^*) Qp' - L - C(e^*) - \bar{U}$$

Hence the trader makes a strictly larger profit in the Exclusive customer case.

**E References**


Deb, R & Suri, T 2012, ‘Endogenous emergence of credit markets: contracting in
response to a new technology in Ghana’, *Unpublished*.


