The de Soto Effect*

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Abstract

This paper explores the effects of a policy of creating and improving property rights to facilitate the use of fixed assets as collateral, popularly attributed to the influential policy advocate Hernando de Soto, in an equilibrium model of a credit market with moral hazard. We then use data for Sri Lanka to calibrate the effects empirically. Our theoretical analysis shows that these effects are heterogeneous by the wealth level of the borrower and depend on the extent of competition between lenders. Indeed, if competition is absent completely, then improving property rights can actually be welfare decreasing. Our calibration results find moderate effects of property rights improvements on interest rates and loan size, but the welfare gains are surprisingly small.

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1 Introduction

Developing countries are plagued with market and institutional imperfections. A key symptom of this that has received significant recent attention is the finding that the marginal product of capital is higher than prevailing interest rates.[1] Such capital market imperfections result in the misallocation of capital, lower productivity, and can even lead to poverty traps. No wonder, therefore, that policy initiatives have focused on dealing with the underlying causes of capital market frictions.

One important such initiative aimed at improving the workings of capital markets involves extending and improving property rights so that assets can be pledged as collateral for loans. This has become a *cause célèbre* of Hernando de Soto[2] whose view is stated succinctly in the following quote:

> "What the poor lack is easy access to the property mechanisms that could legally fix the economic potential of their assets so that they could be used to produce, secure, or guarantee greater value in the expanded market...Just as a lake needs hydroelectric plant to produce usable energy, assets need a formal property system to produce significant surplus value." (de Soto, 2001).

This idea has captured the imagination of policy makers, is frequently proclaimed as a magic bullet and has been taken up all over the world. We therefore refer to the idea that better access to collateral through improving property rights improves the workings of credit markets as the *de Soto effect*.[3]

This paper develops an applicable theoretical model to explore the nature and magnitude of the de Soto effect. The model looks at the effect of improving property rights on credit contracts in an equilibrium setting. This approach brings out the central role played by competition in the credit market to understanding the de Soto effect. Indeed, we show that if competition is weak, improving property rights can, in theory, actually be welfare decreasing. The model is quantified using a data set for Sri Lanka collected by de Mel, McKenzie and Woodruff (2008) which we use to estimate the key parameters of the model. This permits us to explore the heterogeneity of the effects with respect to market competition, wealth inequality and the initial state of property rights.

The results vividly illustrate the proposition that introducing improved property rights for poor borrowers in uncompetitive credit markets is unlikely to yield significant

[1] See Banerjee (2003), Banerjee and Duflo (2010) for overviews and de Mel, McKenzie and Woodruff (2008) for evidence from a randomized control trial in Sri Lanka.

[2] See, for example, de Soto (2000, 2001). See Woodruff (2001) for a review of de Soto's argument.

[3] It is arguable that this should really be called the Bauer-de Soto effect since this link was also spotted by Peter Bauer in his perceptive account of West African trade wherein he argues that:

> "Both in Nigeria and in the Gold Coast family and tribal rights in rural land is unsatisfactory for loans. This obstructs the flow and application of capital to certain uses of high return, which retards the growth of income and hence accumulation." (Bauer, 1954 p 9).

welfare gains and could even reduce borrower welfare. As competition improves, welfare will likely increase. But the order of the welfare gains that we estimate are disappointing – around 2% of the value of the average annual labor endowment of a small business owner in the de Mel et al (2008) data set. Of course, such gains might still be worth generating if the costs of such interventions are small and the take-up of titling and registration is high. But the results do suggest that improving property rights in order to enhance the performance of credit markets does not, according to our approach, look like a magic bullet for economic development. They also point to the importance of policies aimed at improving competitiveness in credit markets, and their complementarity with policies that seek to improve property rights.

The paper fits into a much an older tradition in development economics which explores contracting models for low income environments (see Stiglitz, 1988 and Banerjee, 2003 for reviews). However, in contrast to most of that literature, we offer an innovative twist by developing an application which provides a bridge between empirical work and policy evaluation. This allows us to demonstrate that ideas from the theory of the second-best can indeed have practical relevance for policy. Trying property rights reform in an environment where there is an additional distortion, i.e. competition is weak, can be quite a different proposition from doing so when competition is strong. So while there is a compelling theoretical logic to the de Soto effect, its quantitative significance and welfare consequences depend on the environment in which property rights improvements are being contemplated. This can explain the rather mixed empirical findings from the regression evidence linking measures of credit market performance to property registration possibilities.

The functioning of capital markets is now appreciated to be a key determinant of the development process (see Banerjee, 2003 for a review). Within this, the issue of how legal systems support trade in credit, labour, and land markets is a major topic. For example, Kranton and Swamy (1999) show how the introduction of civil courts in colonial India increased competition among lenders while undermining long-term relationships among borrowers and lenders by making it easier for borrowers to switch lenders. Genicot (2002) shows how banning bonded labour generates greater competition between landlords and moneylenders thereby improving the welfare of poor farmers. Genicot and Ray (2002) study the effects of a change in the outside options of a potential defaulter on the terms of the credit contract, as well as on borrower payoffs in the presence of enforcement constraints.

Our work is also related to the macro-economic literature which studies how aspects of legal systems affect the development of financial markets. One distinctive view is the legal origins approach associated with La Porta et al (1998). They argue that whether a country has a civil or common law tradition is strongly correlated with the form and extent of subsequent financial development with common law countries having more developed financial systems. In similar vein, Djankov et al. (2007) find that improvements in rights which affect the ability of borrowers to use collateral are strongly positively correlated with credit market development in a cross-section of countries. The economics literature now recognizes the fundamental importance of improving property rights in the process of economic development. The well-known paper of Acemoglu, Johnson and Robinson (2001) provided fresh impetus to these ideas and found robust correlations between measures of expropriation risk in the macro data.

The empirical evidence on the impact of property rights improvements using micro-data is somewhat equivocal in its findings.[4] And, in similar vein, Acemoglu and Johnson (2005) find that contracting institutions appear to do a less good job in explaining income differences. This is consistent with the findings here where we would expect effects to be heterogeneous across households and institutional settings. Specifying the underlying model is helpful in pin pointing potential sources of heterogeneity and exploring how they might affect the magnitude of reduced-form estimates.

A number of papers have empirically explored the effect that collateral improvement has on credit contracts (see, for example, Liberti and Mian, 2009). Looking at the literature as a whole, the empirical estimates vary widely and are context specific. There is very little in the existing literature to help think about why this might be. Our theoretical model and the quantitative application can help to think about some of the reasons why this might be the case.

The remainder of the paper is organized as follows. The next section introduces our core model of credit market contracting and section three uses this to study second-best efficient credit contracts. This section also characterizes the market equilibrium where lenders compete to serve borrowers. Section four provides a quantitative assessment of the effects that we identify by applying the model to parameters estimated from Sri Lankan data. Section five discusses welfare effects both in theory and using the quantitative model. Section six concludes.

2 The Model

The model studies contracting between borrowers and lenders. We use a variant of a fairly standard agency model (see Innes, 1990) that is frequently used to analyze contractual issues in development. The borrower's effort is subject to moral hazard and in addition, he has limited pledgeable wealth resulting in limited liability. We focus on the way that contract enforcement is limited due to imperfections in property rights protection which reduce the collateralizability of wealth.

Borrowers There are n identical potential borrower-entrepreneurs whose projects can be enhanced by access to working capital provided by lenders. Each borrower is assumed to be endowed with the same level of illiquid wealth w (e.g., a house or a piece of land).[5]

[4] Besley and Ghatak (2009) review these ideas in general and discuss different theoretical mechanisms. Deininger and Feder (2009) provide a detailed review of the empirical literture. Contributions to the empirical literature include Besley (1995), Field (2005, 2007), Field and Torero (2006), Galiani and Schargrodsky (2010), Goldstein and Udry (2008), Hornbeck (2008), and Johnson, McMillan, and Woodruff (2002).

[5] We could straightforwardly allow borrowers to be heteregeneous and allow contracts to dependent on *observable* borrower characteristics.

We assume that property rights are poorly defined which affects the borrowers' ability to pledge their wealth as collateral. We introduce a parameter τ that captures this. Specifically, we assume that if a borrower has wealth w then its collateral value is only $(1-\tau)w$. So $\tau = 0$ corresponds to perfect property rights whereas $\tau = 1$ corresponds to the case where property rights are completely absent. We will refer to $(1-\tau)w$ as a borrower's *effective wealth.*

Each borrower supplies effort $e \in [0, \overline{e}]$ and uses working capital $x \in [0, \overline{x}]$ to produce an output. Output is stochastic and takes the value $q(x)$ with probability $p(e)$ and 0 with probability $1-p(e)$. The marginal cost of effort is normalized to 1 and the marginal cost of x is γ.[6] Expected "surplus" is therefore:

$$p(e)q(x) - e - \gamma x.$$

Throughout the analysis we make the following regularity assumption which ensures a well-behaved maximization problem with interior solutions.

Assumption 1 *The following conditions hold for the functions $p(e)$ and $q(x)$:*

(i) Both $p(e)$ and $q(x)$ are twice continuously differentiable, strictly increasing and strictly concave for all $e \in [0, \overline{e}], x \in [0, \overline{x}]$.

(ii) $p(0) > 0$, $p(\overline{e}) < 1$, $q(0) \geq 0$, and $q(\overline{x}) \leq \overline{q}$ where $\overline{q}$ is a finite positive real number.

(iii) The following endpoint conditions hold: $\lim_{e \to 0} p'(e)$ and $\lim_{x \to 0} q'(x)$ are sufficiently large, $p'(\overline{e})q(\overline{x}) < 1$, and $q'(\overline{x})p(\overline{e}) < \gamma$.

(iv) $p(e)q(x)$ is strictly concave for all $(e, x) \in [0, \overline{e}] \times [0, \overline{x}]$.

Most standard examples of concave functions of one variable (or their affine transformations) satisfy these properties.[7] They are sufficient conditions to ensure that we have a well-defined optimization problem with interior solutions. The restriction on $p(e)$ to lie in the open interval $(0, 1)$ is make sure that the effort level cannot be inferred perfectly for any outcome (i.e., it is the common support assumption).

Lenders We use the simplest possible set-up that can allow for competition in the credit market and assume that there are two lenders ($j = 1, 2$) who borrow funds from depositors or in wholesale markets to fund their lending.[8] The more efficient lender has

[6] In the empirical analysis, we will allow for the cost of effort to be ηe where η is a parameter that is estimated in the data from the wage rate.

[7] For example, they hold for Cobb-Douglass ($p(e) = p_0 + e^\alpha$ and $q(x) = x^\beta$ where $\alpha \in (0, 1)$, $\beta \in (0, 1)$, $\alpha + \beta < 1$, $p_0 > 0$ and $p_0 + (\overline{e})^\alpha < 1$). With suitable choice of parameters, they are satisfied by the quadratic (e.g., $p(e) = p_0 + p_1 e - p_2 e^2$ where $p_i > 0$ for $i = 0, 1, 2$), and CES (e.g., $p(e) = p_0 + p_1(1 + e^{-\alpha})^{-\frac{1}{\alpha}}$ where $-1 \leq \alpha \neq 0$) as well.

[8] Specifying only two lenders is not as restrictive as it may seem as the relevant competition for a borrower will always be between one lender and the next most attractive alternative lender.

marginal cost of funds $\underline{\gamma}$ while the less efficient lender has marginal cost $\bar{\gamma}$ with $\bar{\gamma} \geq \underline{\gamma}$. We assume that each lender has unlimited capacity to supply the market.[9]

In the case where $\bar{\gamma} = \underline{\gamma}$, these market lenders are equally efficient and we are effectively in the case of Bertrand competition with identical costs. To the extent that $\bar{\gamma}$ is greater than $\underline{\gamma}$ the low cost lender may be able to earn a rent relative to the outside option of borrowers of borrowing from the less efficient lender. Thus $\bar{\gamma} - \underline{\gamma}$ will effectively be a measure of market competitiveness.

We can interpret this set up as one where lenders are financial intermediaries which borrow money from risk neutral depositors whose discount factor is δ. Financial intermediary j repays depositors with probability μ_j. This could reflect intrinsic trustworthiness or the state of the intermediary's balance sheet, e.g. its wealth. In this case $\gamma_j = 1/\left(\delta\mu_j\right)$ is intermediary j's cost of funds which is lower for more trustworthy intermediaries. Naturally, $1/\delta$ sets a natural lower bound for the marginal cost of capital.

3 Contracting

We assume that e is not contractible. This would not be a problem if a borrower had sufficient wealth to act as a bond against non-repayment. However, limits on the amount of wealth on this will be an important friction preventing the first-best outcome being realized. Even if the borrower's liquid wealth is sufficient for this purpose, poorly defined property rights, as argued by de Soto (2001), may place a further limit.

A credit contract is a triple $\{r, c, x\}$ where r is the payment that he has to make when the project is successful, c is the payment to be made when the project is unsuccessful, and x is the loan-size.[10] It will be useful to think of r as the repayment and c as collateral.

The payoff of a borrower is:

$$p(e)\left[q(x) - r\right] - (1 - p(e))\, c - e$$

and of a lender is:

$$p(e)r + (1 - p(e))\, c - \gamma x.$$

Let the borrower's outside option be $u \geq 0$. In the next two subsections, we will solve for the first and second best efficient contracts offered by a lender with cost of funds γ, taking u as exogenous. The outside option will be determined endogenously once we permit lenders to compete to serve borrowers.[11] We assume that lenders must make non-negative profits in order to be active in the credit market.

[9] The assumption of two lenders is without loss of generality given these assumptions by applying the standard logic of Bertrand-competition.

[10] As Innes (1990) shows, even if output took multiple values or was continuous, the optimal contract has a two part debt-like structure as here.

[11] Observe that we are defining borrower payoffs net of any consumption value that he gets from his wealth which may, for example, be held in the form of housing.

3.1 The First Best

In the absence of any informational or contractual frictions so that effort is contractible will see effort and lending chosen to maximize the joint surplus of borrower and lender. This first-best $(e^*(\gamma), x^*(\gamma))$ allocation is characterized by the following first-order conditions:

$$p'(e^*(\gamma))q(x^*(\gamma)) = 1 \quad (1)$$

$$p(e^*(\gamma))q'(x^*(\gamma)) = \gamma \quad (2)$$

where the marginal product of effort and capital are set to equal to their marginal costs.[12] Effort and credit are complementary inputs in this framework. So a fall in γ or anything that increases the marginal product of effort or capital will raise the use of *both* inputs.

The first-best surplus is denoted by

$$S^*(\gamma) = p(e^*(\gamma))q(x^*(\gamma)) - e^*(\gamma) - \gamma x^*(\gamma) \quad (3)$$

which is decreasing in γ.[13] It is efficient in this case to have all credit issued by the lowest cost lender who has cost of funds $\underline{\gamma}$. The profit of this lender, denoted by π, is equal to $\max\left\{S^*\left(\underline{\gamma}\right) - u, 0\right\}$, i.e. respects the lender's option to withdraw from the market.[14]

3.2 Second Best Contracts

In reality contracts are constrained by information and limited claims to wealth that can serve as collateral. Given the contract $\{r, c, x\}$, the borrower will choose effort as the solution to:

$$\max_e p(e)\left[q(x) - r\right] - (1 - p(e))\, c - e.$$

The first-order condition yields the **incentive compatibility constraint (ICC)** on effort by the borrower:

$$p'(e)\{q(x) - (r - c)\} = 1 \quad (4)$$

defining e implicitly as $e(r, c, x)$.

Efficient contracts between a lender and a borrower now solve the following problem:

$$\max_{\{r,c,x\}} \pi(r, c, x) = p(e)\, r + (1 - p(e))\, c - \gamma x.$$

[12] We show in the Appendix that Assumption 1 guarantees that an interior solution $(e^*(\gamma), x^*(\gamma))$ exists and is unique.

[13] By Assumption 1, so long as γ is finite, an interior solution exists such that $S^*(\gamma) > 0$.

[14] Notice that since the borrower's outside option is to either go to the other lender, or autarchy, which is characterized by an effort level $e_a = \arg\max_e p(e)q(0) - e$ and gives the autarchic utility level $u_a = p(e_a)q(0) - e_a$ which is non-negative, and zero when $q(0) = 0$. However, since under our assumption the first-best is characterized by an interior solution, it must be the case that $u = \max\{S^*(\overline{\gamma}), u_a\} = S^*(\overline{\gamma})$.

subject to:
(i) the **participation constraint (PC)** of the borrower

$$p(e)\{q(x)-r\}-(1-p(e))c-e \geq u. \tag{5}$$

(ii) the **ICC**:

$$e=e(r,c,x).$$

(iii) the **limited liability constraint (LLC)**

$$(1-\tau)w \geq c. \tag{6}$$

We describe the optimal second best contract in two parts. First, we consider when the first best can be achieved (Proposition 1). We then consider what happens when this is not the case (Proposition 2). It is useful to define

$$v \equiv u+(1-\tau)w. \tag{7}$$

as the sum of the borrower's outside option and his effective wealth.

Intuitively, we would expect the first best to be achievable when the borrower has sufficient effective wealth to pledge as collateral. To make this precise, define

$$\bar{v}(\gamma) \equiv S^*(\gamma)+\gamma x^*(\gamma).$$

as the level of v equal to the first best surplus plus the cost of credit where the amount lent is at the first-best level. This yields:[15]

Proposition 1 *Suppose that Assumption 1 holds. Then for $v \geq \bar{v}(\gamma)$ the first-best outcome is achieved with*

$$\begin{aligned} r=c &= \max\{S^*(\gamma)+\gamma x^*(\gamma)-u,0\} \\ x &= x^*(\gamma) \\ e &= e^*(\gamma). \end{aligned}$$

It is straightforward to check that the condition stated in Proposition 1 that $v \geq \bar{v}(\gamma)$ is equivalent to $(1-\tau)w \geq S^*-u+\gamma x^*(\gamma)$. This says that the borrower's effective wealth must be greater than the part of the surplus which the lender can extract plus the cost of credit. In this case, it is possible for the borrower to make a fixed payment to the lender by pledging a portion of his wealth against default. He then becomes a full residual claimant on the returns to effort, a requirement for the first-best effort level to be chosen by the borrower. The fact that the wealth threshold includes the outside option of the borrower implies that the first best will be easier to achieve in competitive credit markets where the outside option is high.

If $(1-\tau)w < \bar{v}(\gamma)-u$, or, $v < \bar{v}(\gamma)$, the constraint $c \leq (1-\tau)w$ will be binding and it will not be possible to achieve the first best. To analyze what happens then, we make the following regularity assumptions on the effort production function $p(e)$:

[15] The proof of this and all subsequent results is in the Appendix.

Assumption 2 $\epsilon(e) \equiv -p''(e)p(e)/\{p'(e)\}^2$ is bounded and continuous for $e \in [0, \bar{e}]$, and $p''' \leq -\frac{p''p'}{p}$.

The first part is a technical assumption which ensures a unique interior solution. The second part stipulates that the degree of concavity of the function $p(e)$ does not decrease too sharply. This ensures that the richer is the borrower, the costlier it is to elicit effort.

Our result for this case is given by:

Proposition 2 *Suppose that Assumptions 1 and 2 hold. There exists* $\underline{v}(\gamma) \in (0, \bar{v}(\gamma))$ *such that for* $v < \bar{v}(\gamma)$ *the optimal contract is as follows*:

$$\begin{aligned} c &= (1-\tau)w, \\ r &= \left\{ \begin{array}{ll} \rho(v,\gamma) + (1-\tau)w & v \in [\underline{v}(\gamma), \bar{v}(\gamma)] \\ \rho(\underline{v}(\gamma), \gamma) + (1-\tau)w & v < \underline{v}(\gamma) \end{array} \right. > c, \\ x &= \left\{ \begin{array}{ll} g(v,\gamma) & v \in [\underline{v}(\gamma), \bar{v}(\gamma)] \\ g(\underline{v}(\gamma), \gamma) & v < \underline{v}(\gamma) \end{array} \right. \end{aligned}$$

where $\rho(v,\gamma) = q(g(v,\gamma)) - \frac{1}{p'(f(v))}$ *and* $g(\cdot,\gamma)$ *and* $f(\cdot)$ *are strictly increasing. It implements*

$$e = \left\{ \begin{array}{ll} f(v) & v \in [\underline{v}(\gamma), \bar{v}(\gamma)] \\ f(\underline{v}(\gamma)) & v < \underline{v}(\gamma). \end{array} \right.$$

Since $v < \bar{v}(\gamma)$, the level of wealth is insufficient to achieve the first best – both effort and credit granted are below their first best levels. All effective wealth is pledged as collateral and the repayment made when the project is successful exceeds that when it fails. The level of that payment reflects the standard theoretical trade-off between extracting more rent from the borrower by raising r and reducing the borrower's effort as a consequence.

Within this second best solution, there are two sub-cases which play a role throughout the ensuing analysis.

For $v \leq \underline{v}(\gamma)$, the participation constraint is not binding, i.e. the lender finds it worthwhile to offer the borrower an "efficiency utility" level, analogous to an efficiency wage in the literature on labor markets. The lender offers an amount of credit and elicits an effort level which is independent of the actual value of u or $w(1-\tau)$. The lender does not want the borrower's effort to fall below a threshold and he therefore avoids raising the interest rate above a certain level. And this allows the borrower to earn a positive payoff from the credit contract. As $(1-\tau)w$ increases the lender can extract more from the borrower in the event of default (leaving the effort level unchanged) making the borrower worse off.

This first case will tend to apply when either a borrower's outside option is very poor or their effective wealth is extremely low a case where the de Soto effect logic is frequently applied. For example, in the extreme case where $u = w = 0$, the participation constraint clearly cannot bind since that would require giving no loans to the borrower or, setting $r = q(x)$ both of which will yield the lender zero profits. The lender's best strategy is to offer a small-sized loan and charge a high interest rate. The gain from a successful project $r-c$ is constant in this range of v. So a rise in $(1-\tau)w$ induces a rise in c and r by the same amount.

In the second case $v \in [\underline{v}(\gamma), \bar{v}(\gamma)]$, where $\underline{v}$ is defined by the point where the outside option is high enough, such that r can no longer be set as above and must be reduced the satisfy the borrower's participation constraint. This is a more conventional case where both the incentive compatibility and participation constraints are both binding. The lender will still want to charge $c=(1-\tau)w$, as charging a lower c instead of a lower r would reduce the borrower's effort. A higher wealth level or a better outside option now increase effort and the amount of credit supplied by the lender.

Let

$$S(v,\gamma) \equiv \begin{cases} S^*(\gamma) & v \geq \bar{v}(\gamma) \\ p(f(v))q(g(v,\gamma)) - f(v) - \gamma g(v,\gamma) & v \in [\underline{v}(\gamma), \bar{v}(\gamma)) \end{cases}$$

be the total surplus of the lender and the borrower with the contract described in Propositions 1 and 2.[16]

3.3 Market Equilibrium

We now allow lenders to compete to attract borrowers by posting contracts $\{r,c,x\}$ with borrowers picking the lender that gives him the highest level of expected utility. This market game resembles a model of Bertrand competition between the lenders. The contractual terms will be selected from the set of second-best Pareto efficient contracts described in Propositions 1 and 2. Otherwise, the lender can make a greater profit without the borrower being worse off. The outside option is given by the utility received if he were to choose to borrow from the other lender.

Let the market equilibrium payoffs for the borrower borrowing from the efficient and inefficient lender be denoted by $u_{\underline{\gamma}}$ and $u_{\bar{\gamma}}$ with corresponding profits for the lenders being denoted by $\pi_{\underline{\gamma}}$ and $\pi_{\bar{\gamma}}$. (Feasibility further requires that $\pi_{\underline{\gamma}}, \pi_{\bar{\gamma}} \geq 0$.) It is also clear that $u_{\underline{\gamma}}, u_{\bar{\gamma}} \geq u_a$.

Since the contractual terms are characterized by Propositions 1 and 2, the payoffs of the borrowers and lenders must exhaust the available surplus in the borrower-lender relationship and hence solve:

$$S(u_{\bar{\gamma}} + (1-\tau)w, \underline{\gamma}) = \pi_{\underline{\gamma}} + u_{\underline{\gamma}} \tag{8}$$

$$S(u_{\underline{\gamma}} + (1-\tau)w, \bar{\gamma}) = \pi_{\bar{\gamma}} + u_{\bar{\gamma}}. \tag{9}$$

Now define $\bar{u}((1-\tau)w, \bar{\gamma})$ from $S(u+(1-\tau)w, \bar{\gamma}) = u$ as the maximum utility that the high cost lender can offer consistent with him making non-negative profits. The lenders will compete by offering higher utility levels up to this point.

[16] Since effort $f(v)$ is increasing in v when the participation constraint is binding, and it is under-supplied relative to the surlpus maximizing level, $S(v,\gamma)$ is strictly increasing in v for $v \in [\underline{v}(\gamma), \bar{v}(\gamma)]$. If the participation constraint is not binding ($v < \underline{v}(\gamma)$) or the first-best is attainable ($v \geq \bar{v}(\gamma)$) then $S(v,\gamma)$ is constant with respect to v. Also since the amount of the loan $g(v,\gamma)$ is always decreasing in γ, so is, $S(v,\gamma)$. (See Lemma 1 in the Appendix for a proof.)

Market equilibrium divides up the surplus between lenders and borrowers. The intensity of competition is determined by $\bar{\gamma} - \underline{\gamma}$, the difference in the cost of funds of the efficient and inefficient lenders. The following result describes the outcome:

Proposition 3 *In a market equilibrium, the least efficient lender always makes zero profit. For borrower utility, there are two cases:*

1. *If competition is weak enough, he receives his efficiency utility level from the efficient lender.*
2. *If competition is intense enough, then the borrower receives his outside option available from the inefficient lender.*

So if there is little competition, the lender now captures most of the surplus and the borrower is driven down to his efficiency utility. Formally, $\bar{u}((1-\tau)w, \bar{\gamma}) + (1-\tau)w < \underline{v}(\underline{\gamma})$ with $u_{\underline{\gamma}} = \underline{v}(\underline{\gamma}) - (1-\tau)w$. The credit contract now resembles the first case in Proposition 2 above. This happens when the efficient lender enjoys a significant cost advantage. If the efficient and inefficient lenders have similar costs of funds, most of the surplus in the relationship is captured by the borrower (the first case) and efficient lenders make small profits. Formally, $\bar{u}((1-\tau)w, \bar{\gamma}) + (1-\tau)w \geq \underline{v}(\underline{\gamma})$, so that $u_{\underline{\gamma}} = u_{\bar{\gamma}} = \bar{u}((1-\tau)w, \bar{\gamma})$. The credit contract in this market equilibrium is then the second case in Proposition 2.

3.4 Predictions

Pulling together what we have learned so far, allows us to make a number of predictions about what happens as τ is lowered thereby increasing the fraction of wealth that can be collateralized. There are basically two effects to consider: the relaxation of the limited liability constraint and changes in the outside option of the borrower.

We begin by studying the case where the outside option of the borrower is binding. For this case, we have:

Proposition 4 *(The Efficiency Effect) Suppose that the outside option is binding for borrowers* ($v \geq \underline{v}(\gamma)$). *Then holding u constant, the borrower's utility is unchanged while the payoff of the lender is strictly greater. There is an efficiency improvement from improving property rights with more lending (higher x) and an increase in the borrower's unobserved effort e.*

This mirrors precisely the route for property rights that secure collateral to affect productive efficiency as emphasized by de Soto (2000). A fall in τ raises the collateral value of a given amount of wealth. This allows the lenders to offer a larger loan by reducing the spread between the repayment demanded from a successful project and the collateral offered. This, in turn, leads to an increase in effort and, given the complementarity between x and e. Thus expected output increases too.

If the outside option of the borrower is not binding, we have:

Proposition 5 *(The Predatory Effect) Suppose that the outside option is not binding on the borrower beforehand ($v < \underline{v}(\gamma)$). Then the borrower is strictly worse off if property rights improve while the lender gains.*

When the outside option is not binding, the lender is offering the borrower an "efficiency utility" which exceeds his outside option. Imperfect property rights protect the borrower, in effect protecting his wealth. Thus, it increases his efficiency utility. When property rights to assets are improved, the power of the lender is increased and he can force the borrower to put up more of his wealth as collateral as well as pay a higher interest rate, while the size of the loan remains unchanged. But this makes the borrower worse off.

It is often pointed out that under informal contracting arrangements there are some accepted norms of subsistence which are sometimes undermined by the impersonal legal system enforced by the state (see, for example, Bardhan, 2007). Our model formalizes this effect and shows why one cannot be Panglossian about the impact of property rights improvements. For economies where credit markets are not very competitive ($\overline{\gamma} - \underline{\gamma}$ is large), or borrowers are poor ($w(1-\tau)$ is low) this effect is likely to be important.

In both of these cases, we would expect the benefits of improved legally enforced property rights that allow greater use of collateral to accrue to lenders rather than borrowers. However, this ignores two further market equilibrium effects.

First, if the participation constraint is binding, then the outside option of borrowers improves since trading with the higher cost lender becomes more attractive. This is stated in:

Proposition 6 *(The Competition Effect) The outside option, $\overline{u}((1-\tau)w, \bar{\gamma})$, increases when property rights improve. This will increase effort and the loan size, and reduce the repayment net of collateral ($r - c$).*

The fact that trading with the less efficient lender is now more desirable results in the borrower being able to capture more surplus when he trades with the efficient lender. This changes the contract that he is offered and creates more surplus in the lending relationship.

Second, in our model there is a potential extensive margin effect: an improvement of property rights will improve access to capital to those borrowers who were not borrowing to start with. An interesting implication of our model is that the very poor are not credit rationed in the sense of being totally excluded from the credit market. They are credit-constrained in the sense of receiving a loan size that is less than the first-best level. This is a consequence of our assumption that the marginal product of capital is very high at low levels of capital. However, borrowers whose outside options are above a certain threshold will not borrow if the surplus from borrowing is small (which will be the case if $w(1-\tau)$ is small or γ is high). In particular, when a borrower's outside option is higher than the surplus $S(v,\gamma)$, then there cannot be any borrowing since otherwise the lender will make a negative profit.[17] The extensive margin effect does not strictly arise

[17] The characterization of who borrows is formally presented as Lemma 2 in the Appendix.

in our model when the only outside options of a borrower are to borrow from the high cost lender or autarchy, which is what we have assumed so far, because under borrowing from the low cost lender dominates these two options. However, if we were to introduce an alternative occupation which yields the borrower $u(\theta)$ which is an increasing function of some characteristic of the borrower, θ, (say, working for a wage, as opposed to being a small producer/farmer with θ being productivity in this occupation) then a reduction in τ will increase $S(v, \gamma)$ and at the margin, some individuals will switch occupations. This is stated as:

Proposition 7 *(The Extensive Margin Effect) When property rights improve, the number of borrowers in the market increases.*

The last two results show that unlike the more equivocal contracting results in Proposition 4, the outside-option effect and the extensive margin effect generally benefit borrowers and increase expected output. To the extent that these kind of market equilibrium effects are observed, the improvement of property rights will tend to increase efficiency.

Taken together these results in this section predict a range of possibilities differentiated principally according to the wealth level of the borrower and whether his/her outside option is binding. The role of theory is to lay bare these possibilities. However, it cannot establish whether they are practically relevant. Nor can a purely theoretical analysis go beyond qualitative possibilities, i.e., identifying the direction effects. Hence to get a feel for what the theory predicts in practice, we now apply the framework to a concrete context using data from Sri Lanka.

4 A Quantitative Assessment

We now apply the model to get a feel for the quantitative significance of the main effects that the theoretical model generates. We accomplish this by deriving estimates of our key parameters from a study of Sri Lankan microenterprises by de Mel, McKenzie and Woodruff (2008) (MMW hereafter). In principle, we could vary all of the parameters in the model to get a global sense of the de Soto effect but using estimated values of the productivity parameters helps to sharpen the relevance of these findings. This is a specific context, but it will offer a further sense of what the model predicts. It will also be helpful in thinking through the interpretation of conventional regression estimates which assess the impact of improving property rights.

We look at the quantitative predictions for three different wealth groups (low, medium, and high based on tertiles in the data) and look at the impact of changing τ over the whole unit interval, i.e. over the full range over which the extent of collateralizability may vary. This will give a sense of how the effects that we identify can depend on the starting point for reform.

For calibration purposes, we assume that $p(e) = e^{\alpha}$ and $g(x) = Bx^{\beta}$ with α and $\beta < 1$. We use data from MMW to estimate the key parameters. Their estimate of β, the elasticity of profits with respect to capital is 0.379 (Table IV, p.1351). To incorporate the role of e, which we need to measure α, we use their data on hours worked per week. If we express this as a proportion of the maximum hours worked (110) then this creates a measure which lies in the unit interval. We then re-estimate their equation (2) which expresses profits as a function of this variable, e_{it} as well as total capital, x_{it}, i.e., as MMW, we instrument for x with the instrument they use, namely, the capital grants provided experimentally:

$$\text{Profits}_{it} = \delta_t + \delta_i + \alpha \log(e_{it}) + \beta \log(x_{it}) + \nu_{it}$$

where i refers to an individual micro-enterprise, t refers to the time period (a wave),[18] (δ_i, δ_t) are enterprise and wave fixed effects, and ν_{it} is the error term.

This exercise yields an estimate for α of 0.226 and for β of 0.350. The latter is reassuringly close to the MMW estimate of β. Since e_{it} is likely to be endogenous, we would regard this estimate of α to be an upper bound on its true value. That said, measurement error due (say) to a failure to measure intensity of effort might lead to downward bias.[19] We assume a two year horizon for the project that we study, which seems reasonable for the kind of context and projects that we have in mind.

To obtain a measure of the marginal cost of effort, we use the hourly wage rate as reported in the MMW data. For the project as whole, we scale this to reflect the two year horizon assuming a 52 working weeks a year. MMW provide two estimates for the wage rate for different groups. Based on these, we decide to fix the wage at 6 LKR (Sri Lankan Rupees) per hour in our calibration.[20]

Finally, we need to estimate B. Here, we use the observation that expected profits are $Bx^\beta e^\alpha$. MMW estimates that a 10,000 LKR cash transfer increases the capital stock by 9,100 LKR (from a median capital stock of 26,500 LKR) and increases hours worked by 5 hours (from a median of 50). They then estimate the returns to capital to be 5.85% per month. Assuming that these accrue over two years with no interest on previous profits, we get an estimate of B of 4.7.[21]

We obtain our estimate of γ the deposit rates of banks, the central bank rate or inter-bank rates. We use a nominal interest rate of 8% which is the average of two yearly deposit rates (which is the relevant time horizon for us) stated in the government publication for April 2005.[22]

Insert Figure 1 here.

[18] There are nine waves between March 2005 and March 2007.

[19] The results (available from the authors on request) are not particularly sensitive to modest variations in α and β.

[20] One estimate ranges from 0 to 9 LKR/hour for the and the the other ranges from 7.9 to 17.3.

[21] Specifically, the calculation used is:

$$B = \frac{(24 \times 0.0585 \times 10000 \times 0.91)/\eta}{(\frac{55}{110})^\alpha (\frac{26500+(10000\times 0.91)}{\eta})^\beta - \left(\frac{50}{110}\right)^\alpha \times \left(\frac{26500}{\eta}\right)^\beta}$$

where $\eta = 6 \times 110 \times 52 \times 2$ is the marginal cost of effort (which was set to 1 for notational simplicity in the theory section).

[22] The data is downloadable at http://www.cbsl.gov.lk/htm/english/08_stat/s_5.html.

Our first set of calibrated estimates of the de Soto effect are for the case where the outside option is autarky, i.e., $\bar{u} = 0$. Figure 1 presents the predicted interest rate $\left(\frac{r}{x} - 1\right)/100$, indebtedness $\left(\frac{x}{w}\right)$, and profits per unit borrowed $\left(\frac{q(x)}{x} - \gamma\right)$ as a function of the extent to which capital can be collateralized as measured by $(1 - \tau)$. They are shown for three wealth levels: $\{0.3113, 1.1934, 3.2185\}$ expressed as a proportion of the value of the total labour endowment based on 110 hours worked.[23] These values correspond to the medians of the tertiles of the wealth distribution in the MMW sample.

Quantitative estimates of the de Soto effect are represented by movements along the horizontal axis in Figure 1. Interest rates predicted for the case without competition are greater than 100%. These rise with τ the left hand panel we see that for higher wealth groups, the interest rate is lower for almost all values of τ. For the lowest wealth group these increase these rise from over 400% to nearly 500% for high τ but fall thereafter. While such rates are very high, a substantial fraction of respondents in these data report themselves as only being able to borrow at interest rates of the order of 200%. The increasing range in the left hand panel of Figure 1 corresponds to the case in the theoretical model where the borrower is worse off from improvements in property rights which make it easier for the lender to extract surplus from the borrower. The falls in interest rates for the middle and high wealth groups are quite substantial form above 400% to around 150%. These remain high principally because competition is weak in this case.

The amount borrowed increases in all three wealth groups over most of the range. However, the increases are modest for the middle and low wealth groups with leverage relative to wealth only rising from about 0.10 to 0.12 for the high wealth group. The poor will only borrow more when property rights are sufficiently good. Their leverage rises from around 0.7 to 0.9.

Average realized profit rates on the projects fall for all groups as property rights improve and borrowing increases. The fall is from over 5 to less than 3 for the rich. However for the poor, the fall is more modest, from 5 to 4. However, these represent improvements in efficiency with which capital is allocated in the economy.

Insert Figure 2 here.

Our assumption that $\bar{u} = 0$, makes Figure 1 essentially a partial equilibrium analysis. We now consider what happens when we allow the outside option to improve as τ changes. This requires that there is sufficient competition in the credit market.

In Figure 2, we assume that the competitor has a cost of funds of 8% and is subject to the same τ. Now as we change τ, the outside option of the borrower changes endogenously. The three panels report the same variables as Figure 1 and the comparison between Figures 1 and 2 demonstrates the effect of increased competition.

In Figure 2, improving property rights is welfare improving throughout the whole range of τ. Moreover, the level of interest rates is dramatically lower compared to Figure 1. Even when property rights are very poorly enforced, interest rates are close

[23] Labour endowment is calculated as two years of labour income while working 110 hours per week.

to 60% below the interest rate with perfect property rights enforcement in the absence of competition. Increases in leverage are now very modest suggesting that property rights in this setting are not likely to be associated with large increases in the amount borrowed relative to wealth for any group. As in the case of no competition, average profit rates fall and the magnitude of this effect is similar to what we find in Figure 1.[24]

Two features of the results are worth emphasizing. First, the effects are non-linear making it difficult to infer much about the effect of large changes by studying only local affects. This is a potentially important lesson for empirical studies which study marginal changes. Second, the effects are heterogeneous with respect to wealth.

While trying to fit a specific theoretical model to the data has its limitation, it is a useful complement to other empirical methods. It is helpful in thinking about the interpretation of results derived from regression methods where economic outcomes, such as interest rates or the amount borrowed is regressed on changes in property rights improvements that increase the extent to which wealth can be collateralized (e.g., Field and Torrero, 2006 and Galiani and Schargrodsky, 2010). While these examples are well-identified, interpreting the magnitudes is likely to be context specific and our model can highlight sources of heterogeneity. A predominance of poor households where τ is initially very low and only modestly improved and where competition is weak is likely to yield a different finding from situations where competition is strong and most borrowers are not very poor in terms of wealth. While wealth heterogeneity has been a focus previously, our emphasis on heterogeneity in credit market competition does not seem to have been noted before.

5 Welfare Implications

We now turn to consider the welfare implications of the model. This will allow us to think about determinants of the economic returns to policies aimed at improving property rights. Our contracting model can be used to calibrate the welfare effects using the Sri Lankan data of MMW.

To evaluate welfare, we need to take a stance on the weight that is attached to borrowers and lenders. We consider a policy objective which allows the weight on the welfare of borrowers and lenders to vary and use λ to denote the relative weight on the welfare of borrowers:

$$W(\tau; \lambda) = (\lambda - 1)\, u + S(u + (1 - \tau)w, \gamma).$$

In general, we expect most policy makers to set $\lambda \geq 1$, i.e. a greater concern for the borrowers' welfare rather than the profits made by the lender. The case of $\lambda = 1$ corresponds to the case of pure utilitarianism where the policy maker puts equal weight on borrowers and lenders.

[24] Varying α and β reveals that the broad picture is not particularly sensitive to reasonable variations in these parameters.

Our welfare results depend on the extent of competition in the credit market. Our first result is:

Proposition 8 *If competition is intense enough, welfare is increasing when property rights improve for all values of λ. Moreover, borrowers and the efficient market lender are both strictly better off.*

The reasoning is clear. The surplus generated by trading with any lender in the market increases, and with sufficient market competition, most of this surplus goes to borrowers who are therefore strictly better off. This result shows that with sufficient market competition, not only overall welfare (as defined above) goes up, but even the low cost lender benefits, that is, reducing τ creates a Pareto improvement. Below, we will look at the likely size of such effects.

We now consider what happens when market competition is limited. For this case we have:

Proposition 9 *If competition is weak enough, the outside option is not binding and for λ greater than or equal to one, welfare is decreasing when property rights improve.*

In this case, the more efficient lender has market power and borrowers receive an efficiency utility. When property rights to enable using assets as collateral improve, the lender is able to demand more wealth as collateral. This is a pure transfer – there is no efficiency improvement and total surplus is unchanged. Thus any welfare function which puts more weight (however small) on borrower welfare will register a welfare reduction when property rights improve.

These results emphasize the complementarity between market competition and market-supporting reforms to improve property rights. In the absence of competition, it may be optimal to keep property rights under-developed. Improving them only increases the prospect of exploitation of borrowers by lenders.

Insert Figure 3 here.

The likely magnitude of these welfare effects can be assessed using the approach from the last section. The results are in Figure 3 where we break this out by wealth group. The top line in each figure corresponds to the result in Proposition 6. We look at the case where the lender makes zero profits and all gains accrue to the borrower (high competition). Utility is measured as a proportion of the value of the labour endowment (assuming 110 hours potential hours worked per week). The Figure suggests that the welfare gains in this case are modest – each wealth group gains only around 2% of their labour endowment when property rights move from the worst possibility to the best.[25]

[25] We tested the sensitivity of this result to varying the parameters (particularly $\bar{\gamma}, \underline{\gamma}, \alpha$, and β). Welfare gains in competition tended to be much more substantial (of the order of 10% of the value of the labour endowment) when α was doubled to around 0.5, i.e. when there is much bigger elasticity of project success with respect to effort, compared to the estimate that we derived from the MMW data.

The dashed line in Figure 3 represents total surplus for the case where there is no competition, corresponding to Figure 1 above, while the solid black line is the utility of the borrower in this case and correspond to Proposition 5. The decreases in welfare here are of the order of 10% of the value of the labour endowment while lenders' profits increase by the order of 10% to 15% of this value. While total surplus is higher, it is clear that in this case distributional judgements matter. Even a slight preference for borrower over lender welfare is going make it unlikely that improving property rights is welfare enhancing unless competition in the credit market can be increased simultaneously.

All of these welfare effects abstract from the costs of reducing τ. In practice this would correspond to the costs of titling programs. The calibrations that we have developed here could be used to a generate a cost-benefit analysis were such costs known. Hence, we believe that they provide a useful tool in policy analysis in this area.

Taken together, these welfare results have some interesting implications for policy discussions. If competition in the credit market is weak, then the de Soto effect is likely to be welfare decreasing over some range of τ and only if sufficient weight is placed on gains in lender profits will it ever be welfare increasing to introduce improved property rights. However, if competition in the credit market is strong, the calibration suggests that gains from introducing improved property rights are modest.

Obviously, in any specific context, the model should use parameter values that are tailored to the particular relevant features of the setting, and preferably based on local data. In that sense, the case study from Sri Lanka that we have developed here is only illustrative.[26] Nonetheless, it does demonstrate the utility of the approach. Moreover, by capturing some of the welfare effects in a quantitative way, it can serve as useful tool for policy evaluation.

6 Concluding Comments

This paper has developed an applicable model to explore the consequences of extending the use of collateral to support trade in credit markets. We have combined this with data from Sri Lanka to look at the consequences of improving collateralization for interest rates, lending and welfare. Somewhat surprisingly given the many advocates of such policies, the results are not very encouraging to the view that there are large welfare gains to be had from increasing the collateralization of wealth. While this is based on only one specific calibration in a particular context, it does underscore the importance of subjecting such proposals to some form of quantitative evaluation.

This analysis does not, of course, mean that there are not good reasons to improve property rights in other dimensions in economies where they are weak. However, it underlines the need to think carefully about the channels at work.[27] Even in the narrower context of improving the use of collateral, it is likely to be quite difficult to make

[26] Sensitivity checks suggest that much larger values of β and α can yield steeper increases in welfare as τ is reduced.

[27] Besley and Ghatak (2009) discuss the wide range of economic mechanisms that have been identified. In a fascinating study, Di Tella et al (2007) look at the impact on beliefs.

unequivocal pronouncements on the impact of improving property rights without being clear about the underlying economic environment, in particular, the extent of credit market competition, the distribution of wealth, and how imperfect property rights are to begin with. On the other hand, policies that improve competitiveness in credit markets are likely to be welfare enhancing, and in particular, are complementary to policies aimed at improving property rights.

The approach developed here is quite portable and could be used in other contexts to assess the impact of improving property registration. The model gives a sense of the conditions when the de Soto effect may be large and when there is likely to be a significant welfare improvement. But overall the analysis serves as reminder that, when it comes to policy reform in environments with many institutional failures, there are unlikely to be any magic bullets and policy reform needs to be assessed in light of the specific context and its features.[28] Our paper underscores the potentially important role of marrying theory with quantitative evaluation in this process.

[28] This is a theme of a strand of the recent development policy literature – see, for example, Rodrik (2008).

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A Proofs

We first show that Assumption 1 implies that an interior solution exists in the first best. Let

$$e(x) = \arg\max_{e\in[0,\bar{e}]} p(e)q(x) - e \quad \text{and} \quad x(e) = \arg\max_{x\in[0,\bar{x}]} p(e)q(x) - \gamma x.$$

They denote the explicit solutions to the implicit equations given by the first-order conditions (1) and (2). Given our assumptions about the functional forms of $p(e)$ and $q(x)$, they are continuously differentiable functions. By Assumption 1(iii), $e(0) \geq 0$ and $x(0) > 0$, $e(\overline{x}) < \overline{e}$, and $x(\overline{e}) < \overline{x}$. Let $\tilde{e}(x)$ be the inverse of $x(e)$. It is straightforward to show that

$$e'(x) = -\frac{p'(e)q'(x)}{p''(e)q(x)} \text{ and } \tilde{e}'(x) = -\frac{p(e)q''(x)}{p'(e)q'(x)}.$$

Both $e(x)$ and $\tilde{e}(x)$ are therefore strictly increasing. The intersection of $e(x)$ and $\tilde{e}(x)$ defines the first best. Strict concavity of $p(e)q(x)$ implies that at any (x, e) we have $p''qpq'' - (p'q')^2 > 0$, which is equivalent to $e'(x) < \tilde{e}'(x)$ wherever $e(x) = \tilde{e}(x)$. By the continuity of $e(x)$ and $\tilde{e}(x)$ we know that $e(x)$ crosses $\tilde{e}(x)$ only once, and from above. Hence an interior solution exists and is unique.

Proof of Proposition 1. The first best (x^*, e^*) is the solution to (1) and (2). Note that $r = c$ is a necessary condition for the first best to be implemented. Suppose not, so that $r \neq c$ and yet, if possible, the first-best is implemented. Given $r \neq c$ it follows from the ICC that given x^*, an $e \neq e^*$ would be optimal for the borrower. This contradicts the first best being implemented. So $r = c$. Then the lender's optimization problem is to maximize $c - \gamma x^*$ subject to the LLC

$$(1 - \tau)w \geq c,$$

and the PC given by

$$p(e^*)q(x^*) - e^* - u \geq c.$$

The lender will want to choose c as high as possible, subject to the constraints. It is useful to rewrite $p(e^*)q(x^*) - e^* = S^* + \gamma x^* = \bar{\nu}$. If $(1 - \tau)w \geq \bar{\nu} - u$, then the PC will be the binding constraint. Hence c will be set to $S^* - u + \gamma x^*$, the lender gets the first-best surplus minus the reservation payoff of the borrower, and he cannot do better than that. ■

Proof of Proposition 2: The proof of Proposition 2 proceeds in 4 steps.

Step 1 *(i) At the optimal contract $r \geq c$. (ii) If $r > c$ under the optimal contract, then $c = (1 - \tau)w$. (iii) If $c < (1 - \tau)w$ under the optimal contract, then $r = c$ and effort is at the first-best level.*

Proof of Step 1 (i) Suppose not. Consider a small increase in r to $r + dr$ and a small decrease in c to $c + dc$ that keeps the borrower's payoff constant, so $p(e)dr + (1 - p(e))dc = 0$. Hold x constant. This contract is feasible as the collateral constraint $c \leq w(1-\tau)$ will be satisfied if it was before and the participation constraint is satisfied by construction. The contract will decrease e via the incentive compatibility constraint. Using the envelope theorem we can ignore the effect of this change on the borrower's payoff via e. The change in the lender's payoff is given by

$$p'(e)(r-c)de + p(e)(dr - dc) + dc = p'(e)(r-c)de$$

as $p(e)(dr - dc) + dc = 0$ from above. As $r - c < 0$ by assumption and $de < 0$ this expression is positive and so the lender is better off, implying a contradiction.

(ii) Suppose not. Then it is possible to increase c by a small amount (this is feasible as by assumption $c < (1-\tau)w$) and decrease r so as to keep the borrower's payoff constant. Effort will be higher due to the ICC. Furthermore, as $r > c$ by assumption the lender will be strictly better off, a contradiction.

(iii) Notice that, given the binding LLC, the statement "$r > c$ implies $c = (1-\tau)w$" is equivalent to the statement "$c < (1-\tau)w$ implies $r \not> c$". Also by (i), $r > c$, and so $r \not> c$ is equivalent to $r = c$.

Step 2: *For any $v < \bar{v}(\gamma)$, the optimal contract satisfies $c = (1-\tau)w$.*

Proof of Step 2: Suppose it did not. Then by step 1(iii) the contract would implement the first best (x^*, e^*). From the proof of proposition 1 we know that for any $v < \bar{v}(\gamma)$, when implementing the first best the LLC will be binding, yielding a contradiction.

Step 3: *There exists* $\underline{v}(\gamma)$ such that *for $v \in [0, \underline{v}(\gamma)\,)$, the optimal contract is characterized by $e = e_0 < e^*(\gamma)$, $x = x_0 < x^*(\gamma)$, $r = r_0 > c = (1-\tau)w$.*

Proof of Step 3: Suppose that for the optimal contract the PC does not bind. Using the binding LLC the optimal contracting problem can be written in the following modified form:

$$max_{\{x,e\}}\, p(e)(q(x) - \frac{1}{p'(e)}) + (1-\tau)w - \gamma x. \tag{10}$$

The optimal effort level and input supply (e_0, x_0) will solve

$$\begin{aligned} p'(e_0(\gamma))q(x_0(\gamma)) &= 1 + \epsilon(e_0(\gamma)) &(11)\\ p(e_0(\gamma))q'(x_0(\gamma)) &= \gamma &(12) \end{aligned}$$

with $\epsilon(e) \equiv -p''(e)p(e)/\{p'(e)\}^2$ which is strictly positive given the strict concavity of $p(e)$ (Assumption 1(i)). First we show that an interior solution e_0 and x_0 exists, and is unique. Let $\hat{e}(x)$ be defined by (11). Let $x(e)$ denote the solution to (12), which is identical to the solution to (2) and, as before, let $\tilde{e}(x)$ denote the inverse of $x(e)$. As in the case of the first-best, $x(0) > 0$, and $x(\overline{e}) < \overline{x}$. Also, as $p'(\overline{e})q(\overline{x}) < 1$ (Assumption 1), $\hat{e}(\overline{x}) < \overline{e}$. By Assumption 2, ϵ is positive and bounded above, and also, from Assumption 1, $\lim_{e\to 0} p'(e)$ is sufficiently large. Therefore, $\hat{e}(0) \geq 0$ and $\hat{e}(x) > 0$ for $x > 0$, however small. Next we show that the slope of $\hat{e}(x)$ continues to be higher than that of $\tilde{e}(x)$ wherever the schedules cross. The slope of $\hat{e}(x)$ is:

$$\hat{e}'(x) = -\frac{q'p'}{p''q + \Omega}$$

where $\Omega = -\frac{\partial \epsilon}{\partial e} = \frac{p'''p+p''p'}{(p')^2} + (-2)\frac{(p'')^2 p}{(p')^3}$. By Assumption 2, $\Omega \leq 0$. Hence $\hat{e}'(x) < \tilde{e}'(x)$ at any crossing point. This completes the proof that an interior solution e_0 and x_0 exists, and is unique.

Next we show that $e_0 < e^*(\gamma)$ and $x_0 < x^*(\gamma)$. Note that $e_0 \neq e^*$. Otherwise (12) implies $x_0 = x^*$, which contradicts (11). Therefore by (12) as well $x_0 \neq x^*$. As $\epsilon(e) > 0$, the schedule $\hat{e}(x)$ defined by (11) is higher than the one defined by (2), namely, $e(x)$. Therefore the intersection, which defines (e_0, x_0), is such that $e_0 < e^*$ and $x_0 < x^*$.

Using (11) the ICC (4) can be rewritten as:

$$r_0 = \frac{\epsilon(e_0)}{p'(e_0)} + (1-\tau)w > c_0 = (1-\tau)w.$$

Lastly, we need to ensure that with this contract the PC is not binding. Using the binding LLC together with the ICC, the PC can be written as

$$\frac{p(e_0)}{p'(e_0)} - e_0 \geq v.$$

As $p(e)$ is strictly concave by Assumption 1(i), $p(e) > ep'(e)$ for all $e > 0$ and hence, rearranging terms, $p(e)/p'(e) - e > 0$ for all $e > 0$. Also, due to strict concavity of $p(e)$, it follows directly upon differentiation that $p(e)/p'(e) - e$ is strictly increasing for $e > 0$ (its slope is $\epsilon(e) > 0$ for all $e > 0$). Hence any $e_0(\gamma) > 0$ will define a $\underline{v}(\gamma)$, given by $\underline{v} \equiv p(e_0)/p'(e_0) - e_0$, such that for any $v < \underline{v}$ the PC will not be binding and hence the above derived contract is indeed feasible and optimal. As $e_0 > 0$, it follows that $\underline{v} > 0$.

Step 4: *For $v \in [\underline{v}(\gamma), \bar{v}(\gamma)\,)$ the optimal contract is characterized by:*

$$\begin{aligned} r &= q(g(v,\gamma)) - \frac{1}{p'(f(v))} + (1-\tau)w > (1-\tau)w \\ c &= (1-\tau)w \\ x &= g(v,\gamma) < x^*(\gamma) \end{aligned}$$

with $e = f(v) < e^*(\gamma)$.

Proof of Step 4: We first show that for any $v \geq \underline{v}(\gamma)$ the participation constraint is binding at the optimal contract. Suppose it is not. Let the optimal contract be denoted as $(\hat{e}, \hat{x})$ with $\hat{e} > f(v)$.[29] The lenders problem can then be written as in (10). Given $\hat{e}$, the optimal x needs to satisfy the first-order condition: $p(\hat{e}))q'(x) = \gamma$. As $\hat{e} > f(v) \geq f(\underline{v})$ surely $\hat{x} > x_0$. However, we know that at any $(\hat{e}, \hat{x})$, where $(\hat{e}, \hat{x})$ satisfies the FOC w.r.t. x and $\hat{x} > x_0$, it will be true that $p'(\hat{e})q(\hat{x}) - \epsilon(\hat{e}) < 1$. This follows from strict concavity of $p(e)q(e)$ (see step 3). Therefore the FOC w.r.t. e is not satisfied at $(\hat{e}, \hat{x})$ and the lender would want to decrease $\hat{e}$. As the PC is not binding this is possible, contradicting the optimality of $\hat{e} > f(v)$.

As the LLC is binding by step 3, using the ICC we can write the binding PC as:

$$\frac{p(e)}{p'(e)} - e = v.$$

Recall from step 2 that the left hand side is strictly positive and increasing. We can hence define $f(v)$ as the solution for e which solves the binding PC. As $f(\bar{v}) = e^*$ and $f(v)$ is strictly increasing for all $v \leq \bar{v}$ we know that the optimal contract satisfies $e = f(v) < e^*$.
Using the binding PC we can rewrite the maximization problem as

$$max_{\{x\}} p(f(v))q(x) - f(v) - u - \gamma x \tag{13}$$

yielding the FOC

$$p(f(v))q'(x) = \gamma. \tag{14}$$

Let $g(v, \gamma)$ be the solution for x, defined by $p(f(v))q'(g(v, \gamma)) = \gamma$. As $f(v) < e^*$ it follows that $x = g(v, \gamma) < x^*$. It is readily verified that $\frac{dx}{de} > 0$ and hence $g_v = \frac{dx}{de} f'(v) > 0$. It is straightforward to verify that $g_\gamma(v, \gamma) < 0$. From the ICC

$$r = q(g(v, \gamma)) - \frac{1}{p'(f(v))} + (1 - \tau)w$$

Note that $q(g(v, \gamma)) - \frac{1}{p'(f(v))} \neq 0$ as otherwise $q(g(v, \gamma))p'(f(v)) = 1$ together with (14) would imply that the first best would be implemented, contradicting $f(v) < e^*$. This implies $r \neq c$, implying, by step 1(i) that $r > c$. ■

The following two results are useful in studying the comparative-static implications of the model:

Lemma 1 Suppose Assumptions 1 and 2 hold. Then (i) $S(v, \gamma) > 0$ for any $v \geq 0$; (ii) $S(v, \gamma)$ is strictly increasing in v for $v \in [\underline{v}(\gamma), \overline{v}(\gamma)]$, constant at $S(\underline{v}(\gamma), \gamma)$ for $v \leq \underline{v}(\gamma)$, and constant at $S^*(\gamma)$ for $v \geq \overline{v}(\gamma)$; (iii) $S(v, \gamma)$ is everywhere strictly decreasing in γ.

[29] The contract is a tuple (r, c, x), but as c is determined by the binding LLC and the ICC holds, the contract can be written in terms of (e, x).

Proof of Lemma 1. Note that $S(\underline{v},\gamma) = p(e_0)q(x_0) - \gamma x_0 - e_0$ where (x_0, e_0) is defined by (11) and (12). By the definition of concavity of $p(e)q(x)$ we know $p(e_0)q(x_0) \geq p'(e_0)q(x_0)e_0 + p(e_0)q'(x_0)x_0$. From the definition of (x_0, e_0) it follows $p'(e_0)q(x_0)e_0 = e_0 + \epsilon(e_0)e_0$ and $p(e_0)q'(x_0)x_0 = \gamma x_0$. Hence $S(\underline{v},\gamma) \geq \epsilon(e_0)e_0 > 0$ as long as $e_0 > 0$. Observe that

$$\frac{\partial S}{\partial v} = \left(p'(f(v))q(g(v,\gamma)) - 1\right) f'(v).$$

For $v > \overline{v}$, $p'(e^*)\, q(x^*(\gamma)) = 1$ and also, $f(v) = f(\overline{v})$. Therefore, $\frac{\partial S}{\partial v} = 0$. Similarly, in the case where the participation constraint does not bind, i.e., $v < \underline{v}$ from the proof of Proposition 2, e_0 and x_0 are independent of v. Therefore, for $v < \underline{v}(\gamma)$, $\frac{\partial S}{\partial v} = 0$. For $\underline{v} < v < \overline{v}$, $p'(f(v))q(g(v,\gamma)) > 1$ and as $p(e)/p'(e) - e$ is increasing in e, $f'(v) > 0$ and so $\frac{\partial S}{\partial v} > 0$. As $v \to \overline{v}$, $\frac{\partial S}{\partial v} \to 0$ as $p'(f(v))q(g(v,\gamma)) \to 1$. As $v \to \underline{v}$, $\frac{\partial S}{\partial v} \to 1$ as $f'(v) = \frac{1}{\epsilon(e)}$. However, for $v < \underline{v}$, $\frac{\partial S}{\partial v} = 0$. Therefore, $S(v,\gamma)$ has a kink at $v = \underline{v}$. Given that we have proved that $S(\underline{v},\gamma) > 0$, this shows that $S(v,\gamma) > 0$ for all $v \geq \underline{v}$. To check that $S(v,\gamma)$ is decreasing in γ, by the envelope theorem: $\frac{\partial S}{\partial \gamma} = \left(p(f(v))q'(g(v,\gamma)) - \gamma\right) g_2(v,\gamma) - g(v,\gamma) = -g(v,\gamma)$.This expression being negative for all $v \geq 0$ and $\gamma \geq 0$, the proof is complete. ■

Lemma 2 For a given level of $(1-\tau)w$ there is a unique threshold $\tilde{u}((1-\tau)w,\gamma)$ where $\tilde{u} + (1-\tau)w > \underline{v}(\gamma)$, such that there is no borrowing if and only if $u > \tilde{u}$.

Proof of Lemma 2. Assume $v < \overline{v}$. Let g and f denote the optimal choices of x and e as derived in Proposition 2, suppressing the arguments for notational simplicity. For a lender to make a non-negative profit his expected revenue needs to exceed his cost of funds. This is the case if and only if:

$$\begin{aligned}
(1-p(f))(1-\tau)w + p(f)\left((1-\tau)w + q(g) - \frac{1}{p'(f)}\right) &\geq \gamma g \\
\Leftrightarrow (1-\tau)w + p(f)q(g) - f - \gamma g - \left(\frac{p(f)}{p'(f)} - f\right) &\geq 0
\end{aligned}$$

Consider the case where $v \leq \underline{v}$. We can rewrite the condition as

$$\pi_0 \equiv (1-\tau)w + p(e_0)\left(q(x_0) - \frac{1}{p'(e_0)}\right) - \gamma x_0 \geq 0.$$

Showing that the above holds for $(1-\tau)w = 0$ is sufficient for showing that it holds for $(1-\tau)w > 0$. Assume $(1-\tau)w = 0$. Recall that by the definition of (e_0, x_0), they maximize

$$p(e)\left(q(x) - \frac{1}{p'(e)}\right) - \gamma x. \tag{15}$$

Recall that x and e are complementary. Lets take $e = \delta > 0$ be as small as possible. Then by Assumption 1 on the end point condition, $\frac{1}{p'(\delta)}$ is close enough to zero and also,

$p(\delta) > 0$. Given this, again by the endpoint condition stipulated in Assumption 1, there exists $x_\delta > 0$ which solves

$$\arg\max_x p(\delta)\left(q(x) - \frac{1}{p'(\delta)}\right) - \gamma x.$$

Therefore, we must have $p(e_0)\left(q(x_0) - \frac{1}{p'(e_0)}\right) - \gamma x_0 > 0$ and as a result, credit will be given for all $v \leq \underline{v}$.

Now consider the case where $\underline{v} < v < \overline{v}$. Then $p(f)/p'(f) - f = v$ and the condition can be rewritten as

$$p(f)q(g) - f - \gamma g - u \geq 0$$

or, $S(v, \gamma) \geq u$. Recall that $S(v, \gamma) > 0$ from Lemma 1 and therefore, credit will be given for all $S(v, \gamma) \geq u$. By an analogous argument, for $v \geq \overline{v}$, the condition for credit to be given is $S^*(\gamma) \geq u$.

From Lemma 1 we know that for $v \geq \overline{v}$ and $v \leq \underline{v}$ we have $\frac{\partial S}{\partial v} = 0$. We show that $\frac{\partial S}{\partial v} < 1$ for $v \in (\underline{v}, \overline{v})$. He have

$$\frac{\partial S(v,\gamma)}{\partial v} = (p'(f(v))q(g(v,\gamma)) - 1)f'(v) + (p(f(v))q'(g(v,\gamma)) - \gamma)g'(v,\gamma)$$

By the Envelope Theorem $p(f(v))q'(g(v,\gamma)) - \gamma = 0$ and we know $f'(v) = \frac{1}{\epsilon(e)}$. Hence we need to show that

$$p'(f(v))q(g(v,\gamma)) < 1 + \epsilon(f(v))$$

for $v \geq \underline{v}$. From the proof of step 3 of Proposition 2 we know that the schedule $x(e)$ defined by (11) is below the equivalent schedule defined by (12) for values of $e > e_0$. From Proposition 2, $f(v) > e_0$ for $v > \underline{v}$ and from the proof of step 3 of Proposition 2, ϵ is non-decreasing. As $g(v, \gamma)$ is defined by (12), it follows that $p'(f(v))q(g(v,\gamma)) < 1+\epsilon(f(v))$ and therefore $\partial S/\partial v = \partial S/\partial u < 1$ for $v \in (\underline{v}, \overline{v})$. The PC does not bind for $v \leq \underline{v}$ and so the utility received by the borrower, namely, $\underline{v} - w(1-\tau)$ is greater than the outside option u. Also, by definition, $S(\underline{v}, \gamma) = \pi_0 + \underline{v} - w(1-\tau)$ and so $S(\underline{v}, \gamma) > u$. Therefore, if a u exists such that the borrower does not borrow, it must be the case that $u > \underline{v} - w(1-\tau)$. Given the slope $\partial S/\partial u$ derived before, and in particular, given that $\partial S/\partial u < 1$ for $\underline{v} < v < \overline{v}$ there exists a unique $\tilde{u}$ for given values of the other parameters (w, τ, γ) such that $S((1-\tau)w + \tilde{u}, \gamma) = \tilde{u}$ and $S(v, \gamma) \geq$ (or $<$) u iff u is $\leq$ (or $>$) $\widetilde{u}$. ■

Proof of Proposition 3. Suppose that the high cost lender earns a profit of $\pi_{\bar{\gamma}} > 0$. Then we must have $u_{\bar{\gamma}} \geq u_{\underline{\gamma}}$ for the borrower to contract with him. But then $S(u_{\bar{\gamma}} + (1-\tau)w, \underline{\gamma}) > S(u_{\underline{\gamma}} + (1-\tau)w, \bar{\gamma})$ by Lemma 1 and so the more efficient lender can offer $u_{\bar{\gamma}}$ while earning a profit $\pi_{\underline{\gamma}} > \pi_{\bar{\gamma}} > 0$. Therefore in equilibrium, we must have $\pi_{\bar{\gamma}} = 0$. Now consider the two cases. First assume that the PC is binding in equilibrium as far as the low cost lender is concerned, i.e. $u_{\overline{\gamma}} + (1-\tau)w \geq \underline{v}(\underline{\gamma})$. Then by the previous argument, $u_{\underline{\gamma}} = u_{\bar{\gamma}}$ and $u_{\bar{\gamma}}$ will be given by $\overline{u}((1-\tau)w, \overline{\gamma})$. Hence it must be true that

$\overline{u}((1-\tau)w,\overline{\gamma})+(1-\tau)w \geq \underline{v}(\underline{\gamma})$. Conversely, assume that $\overline{u}((1-\tau)w,\overline{\gamma})+(1-\tau)w \geq \underline{v}(\underline{\gamma})$. Then it cannot be the case that the efficient lender offers a contract which gives utility smaller than $\overline{u}((1-\tau)w,\overline{\gamma})$ to the borrower, as this would allow the inefficient lender to make a profit. However, then it needs to be the case that the PC is binding. Hence, the PC is binding if and only if $\overline{u}((1-\tau)w,\overline{\gamma}) + (1-\tau)w \geq \underline{v}(\underline{\gamma})$. If the condition fails to hold, then the PC is not binding and the borrower's utility is given by $\underline{v}(\underline{\gamma}) - (1-\tau)w$. The monotonicity result follows from the fact that holding $\underline{\gamma}$ constant, reducing $\overline{\gamma}$ will increase $\overline{u}((1-\tau)w,\overline{\gamma})$ (again, from Lemma 1). ■

Proof of Proposition 4. This follows directly from the Lemma 1: $S(v,\gamma)$ is increasing in v and v is increasing in τ. Since the outside option of the producer is unchanged, the supplier receives all the gain in surplus. ■

Proof of Proposition 5. The payoff of a borrower in this case is given by:

$$u = \underline{v}\left(\underline{\gamma}\right) - (1-\tau)\, w$$

which is clearly increasing in τ. ■

Proof of Proposition 6. This follows directly from Proposition 2. ■

Proof of Proposition 7. This follows directly from Lemma 2 by which those borrowers for whom $u(\theta) > \tilde{u}((1-\tau)w,\gamma)$ will not borrow. As $\partial S/\partial v \geq 0$ it follows that given u a borrower is less likely to satisfy $S(u+(1-w)\tau) < u$ when $(1-\tau)w$ increases. ■

Proof of Proposition 8. Assume that the result postulated in Proposition 8 does not hold. Then it must be the case that for some w small enough an efficiency utility is offered (i.e., the PC does not bind). From the proof of Lemma 2 recall that $S(\underline{v},\gamma) = \pi_0+\underline{v}-w(1-\tau)$. As $\pi_0 = p(e_0)\left(q(x_0) - \frac{1}{p'(e_0)}\right) - \gamma x_0 + w(1-\tau)$ and $p(e_0)\left(q(x_0) - \frac{1}{p'(e_0)}\right) - \gamma x_0 > 0$ it follows that $S(\underline{v}(\overline{\gamma}),\overline{\gamma}) > \underline{v}(\overline{\gamma})$. For $\overline{\gamma}$ close to $\underline{\gamma}$ we know $\underline{v}(\underline{\gamma})$ is close to $\underline{v}(\overline{\gamma})$ by continuity and monotonicity. Hence it must be true that $S(\underline{v}(\overline{\gamma}),\overline{\gamma}) > \underline{v}(\underline{\gamma})$. As the outside option is at least $S(\underline{v}(\overline{\gamma}),\overline{\gamma})$ and $v = w(1-\tau)+u$, even for $w=0$ the PC will be binding, i.e. $v > \underline{v}(\underline{\gamma})$. As their outside options go up, borrowers are better off. To show that the efficient lender is better off, observe that his profits are given by

$$\pi(z) = S\left(z,\underline{\gamma}\right) - S\left(z,\bar{\gamma}\right)$$

where $z \equiv \overline{u}((1-\tau)w,\overline{\gamma}) + w(1-\tau)$. Now observe that:

$$\frac{\partial \pi(z)}{\partial z} = S_1\left(z,\underline{\gamma}\right) - S_1\left(z,\bar{\gamma}\right)$$

which is positive if $S_{12}(z,\gamma) < 0$. This indeed is the case as using the envelope theorem, we have:

$$\frac{\partial S}{\partial \gamma} = -g(v,\gamma) \text{ and } \frac{\partial^2 S}{\partial \gamma \partial v} = -g_1(v,\gamma) < 0.$$

Therefore, $\partial \pi(z)/\partial z > 0$. ■

Proof of Proposition 9. This follows directly from Proposition 5. ■

Figures

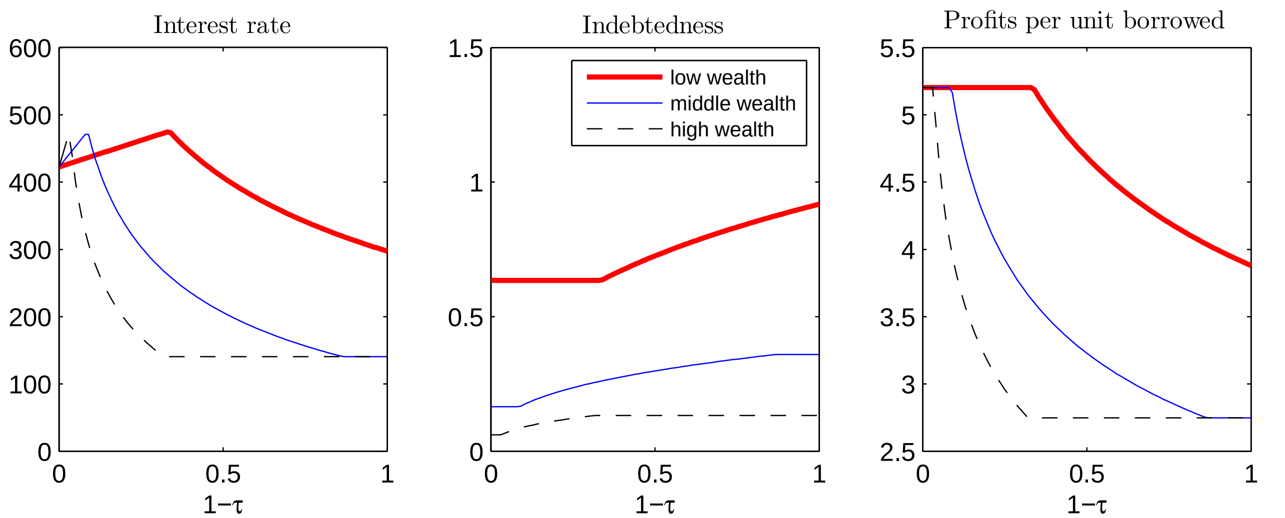

Figure 1: Monopolistic Lender

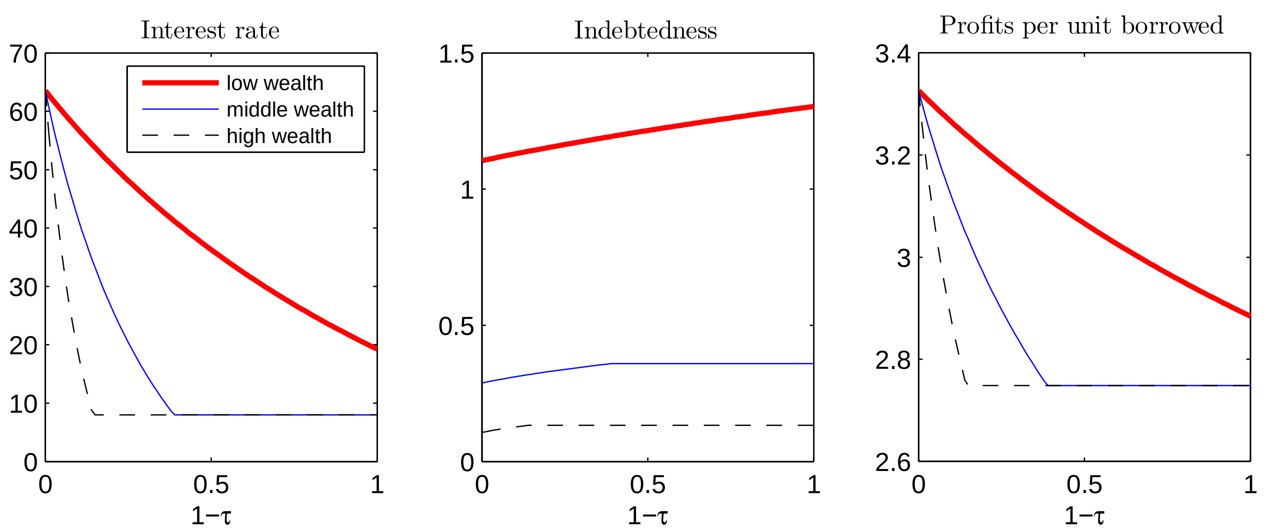

Figure 2: Competitive Credit Markets

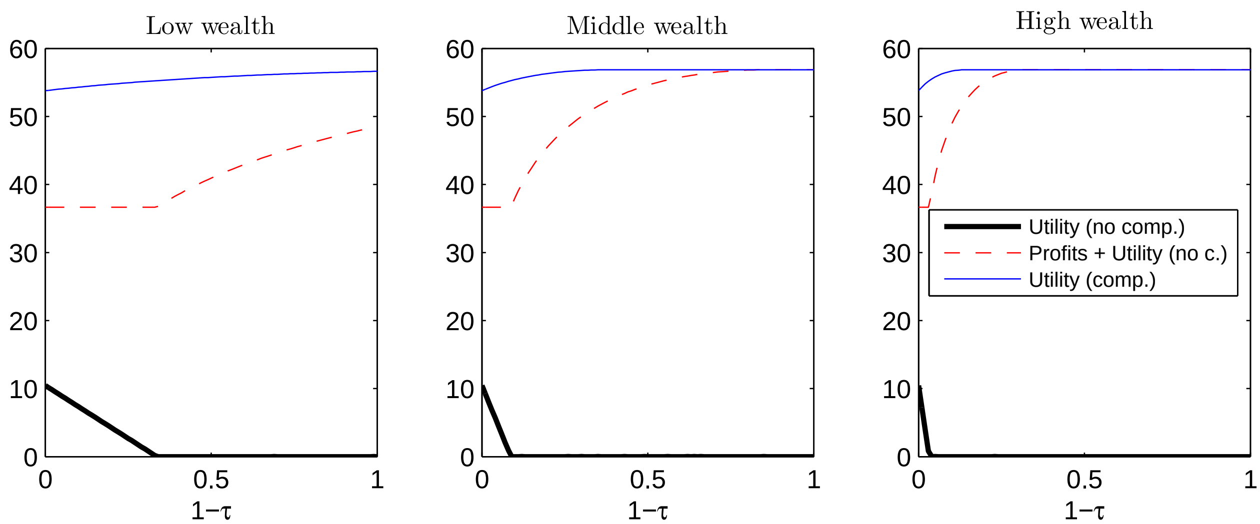

Figure 3: Welfare Implications