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Keywords: Legal institutions; Property rights; Prisoner’s dilemma; Cooperation; Inequality

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1 Introduction

Many researchers have agreed that institutions impact the performance of economies (e.g., North, 1990; Aoki, 2001; Greif, 2006). In this line of theoretical research, high-quality institutions that ensure property rights are regarded as one of the most important factors for economic growth and development. Countries with low-quality institutions often do not establish the rule of law that protects property rights, and private agents in such economies therefore lack incentives to invest because the return from their investments could be plundered. In fact, many empirical studies have confirmed the importance of institutions for economic growth and development (e.g., Knack and Keefer, 1995; Hall and Jones, 1999; Acemoglu et al., 2001, 2002; Rodrik et al., 2004). These empirical studies suggest that well-established property rights are necessary for markets to function.

Although high-quality institutions have been considered a pre-requisite for economies to perform well, until recently, only a few studies have focused on self-enforcing institutions. A notable exception is Greif (2006), among others, who regards institutions not only as constraints on agents’ behavioral incentives but also as certain equilibrium phenomena in economies. Motivated by Greif’s idea, we investigate how property-right-securing legal institutions endogenously emerge in equilibrium and how such institutions affect the formation of cooperation between individuals.

Our paper contributes to the growing literature on endogenous institutions. Kosfeld et al. (2009) investigate the endogenous establishment of institutions in public goods provision. Although they derive conditions under which an institution that monitors each agent’s misconduct in voluntary public goods provision is endogenously formed, they do not study institutional quality or property right securing. In contrast, Sonin (2003), Hoff and Stiglitz (2004), and Huang (2012) develop models in which the initial political environment (i.e., what kind of party is initially in power) determines institutional quality. Using a Tullock-type rent-seeking model (Tullock, 1980), Sonin (2003) studies the growth effects of property rights
protection. Sonin’s growth model demonstrates that if the rich are politically in power, it is highly likely that they will choose weak property rights protection and economic growth will stagnate. Hoff and Stiglitz’s (2004) model explains why a strong rule of law is established in poorly resourced post-communist states but not in highly resourced post-communist states. Huang (2012) proposes a political economy model in which the legal quality of contract enforcement is determined by legal investment. Her model demonstrates that legal investment tends to be too low under elite rule but too high under majority rule. Although these studies stress the initial political environment when institutions endogenously appear, they do not consider the voluntary establishment of legal institutions that secure property rights under all parties’ agreement. Unlike these studies, our paper demonstrates that incentivized agents voluntarily contribute to the establishment of property-right-securing institutions in a Nash equilibrium.

Our paper is also related to the literature on endogenous property rights. Muthoo (2004) investigates the origins of property rights by constructing a repeated game between two conflicting parties. Grossman (2001) develops a static model and studies how effective property rights come about without legal institutions. Both papers formulate a situation in which property rights are endogenously established in the Hobbesian state of war (Hobbes, 1651). Unlike Grossman (2001) and Muthoo (2004), we do not deal with the Hobbesian state of war but instead study how legal institutions that protect property rights and promote partnership contracts endogenously appear.

High-quality legal institutions are public goods under which markets function well and efficient allocation is achievable. The aforementioned recent studies such as Sonin (2003), Hoff and Stiglitz (2004), and Huang (2012) regard institutions as rules that a specific political party in power prescribes for individuals. Not all individuals, however, are motivated to respect such behavioral prescriptions in their models. As Greif (2006) points out, for prescriptive rules to affect economies, individuals must be incentivized to obey them. Al-

though the aforementioned studies are very useful to understand what kind of institution is established when a specific political party initially takes office, they do not provide any answers to the question of why robust property rights secured by *self-enforcing* institutions endogenously appear. Our model contrasts strikingly with those of the aforementioned studies in the sense that we investigate the mechanism that incentivizes individuals to voluntarily contribute to the establishment of legal institutions.

Our analysis aims to explain how legal institutions endogenously come about in economies given initial productivity conditions. Figure 1 is a simple scatter plot of 106 countries that shows a positive relationship between productivity in 1985 and the quality of institutions associated with the rule of law in 2009.\(^2\) Considering very long developmental histories, we use the log of the gross domestic product (GDP) per capita in 1985 on the horizontal axis as a proxy for countries’ productivity. As seen in the figure, high-quality institutions follow high initial productivity, whereas low-quality institutions follow low initial productivity. Although a quarter century is considered to be enough long for new institutions to evolve, the less productive countries have not been able to improve the quality of the rule of law. This stylized fact regarding the relationship between productivity and institutional quality is explained by our model.

[Figure 1 around here]

In our model, there are two classes: the landowner class and the farmer class. Although both landowners and farmers are endowed with the same production technology, only landowners initially hold land stock, which is the sole input for production. Without partnerships with landowners, farmers are not able to engage in production. Landowners also benefit from partnerships with farmers because the production function exhibits diminishing marginal product, but unsecured property rights motivate farmers to abscond with their output without repaying their obligations to their opponent landowners. Expecting farmers to commit these misdoings, landowners do not lend their land stock to farmers.

\(^2\)The data descriptions of both variables are given in the Appendix.
In other words, individuals fall in a trap of the prisoner’s dilemma without secure property rights. The analysis demonstrates that only when economies are highly productive, do property-right-securing legal institutions, which resolve the prisoner’s dilemma, endogenously appear as a result of both parties’ voluntary contributions to the formation of legal institutions. This implies that initial high productivity is a pre-condition for economies to develop robust property-right-securing institutions. Meanwhile, economies with low initial productivity do not establish property-right-securing legal institutions, and no individuals benefit from partnership contracts. An intermediate productivity level generates two stable Nash equilibria. In the low Nash equilibrium, property rights are not ensured, whereas in the high Nash equilibrium, property rights are protected to some extent. The high Nash equilibrium Pareto dominates the low Nash equilibrium because the total output in the high equilibrium is greater than that in the low equilibrium. In the case of multiple equilibria, it is likely that the economy remains in the low equilibrium because of hysteresis when technological productivity gradually improves from a low level.

The remainder of this paper is organized as follows. In section 2, we present a two-stage game, and in section 3, a Nash equilibrium (or Nash equilibria) is derived. In section 4, we apply our model to investigate the relationship between institutional quality and inequality. We prove that as property rights are more firmly secured, income inequality between landowners and farmers shrinks. We present concluding remarks in section 5. The data descriptions for Figures 1 and 6 and Table 1 are provided in the Appendix. The proofs of lemmas and propositions are also located in the Appendix.

2 Model

2.1 Constrained optimal output allocation

An economy consists of a measure-one continuum of landowners and a measure-one continuum of farmers. Each landowner and farmer holds the same production technology, $y = AF(x)$, where $F(0) = 0$. $x$ is the input called land, $y$ is the output, and $A > 0$ is the pro-
ductivity level of the production function. The function $F : [0, X] \rightarrow \mathbb{R}_+$ is continuous and twice differentiable, where $X$ is the total land stock in the economy. $F : [0, X] \rightarrow \mathbb{R}_+$ exhibits positive and diminishing marginal product, namely, it has the properties that $F'(x) > 0$ and $F''(x) < 0$ in $(0, X)$.

**Assumption 1** \[ \lim_{x \to 0} F'(x) = \infty, \lim_{x \to X} F'(x) = 0. \]

$\lim_{x \to 0} F'(x) = \infty$ is one of the so-called Inada conditions. $\lim_{x \to X} F'(x) = 0$ is also assumed so that the second-order condition is guaranteed for the maximization problem in the game.\(^3\)

Although both landowners and farmers hold the same production technology, only landowners are endowed with land, and $X$ is evenly distributed across the landowners. Without borrowing land from landowners, farmers cannot utilize their production technology. In this case, they produce $\epsilon$ amount of the final goods, which is a very small amount and is considered to be the outside option when they contract with landowners. Throughout our analysis, we assume that $\epsilon = 0$.

The model consists of two stages. In the first stage, the game is non-cooperative, and landowners and farmers make contributions to the formation of a property-right-securing legal institution. In the second stage, the game is cooperative, and each party acquires the share of output determined by the Shapley value (Shapley, 1953). More concretely, the economy exists for three periods ($t = 0, 1, 2$) and the timing of events is described as follows.

- At time 0, landowners and farmers decide how much to contribute to the formation of a legal institution, incurring certain costs.\(^4\)

- At time 1, given the extent of contract enforceability, each landowner goes into partnership with a farmer, lending some proportion of land to the farmer.

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\(^3\)Without the assumption $\lim_{x \to X} F'(x) = 0$, the exposition of the model becomes complicated, but the main results are unchanged.

\(^4\)We assume implicitly that each agent initially holds some funds to pay the costs of forming the institution.
• At time 2, each agent obtains the share of output. Each agent’s share of output is
determined by the Shapley value of this coalition game.

A farmer can partner with only one landowner. Because all individuals are risk-neutral
and extract their utility from the share of the output minus the costs of contributions to
the formation of the legal institution, their utility is transferable, and the output-sharing
manner determined by the Shapley value is supportable.\(^5\)

This two-stage game is solved using backward induction. We start by computing the
Shapley value of the coalition in the second stage. The simple way to compute the Shapley
value is to consider the participation order of this coalition. Suppose that a landowner (l)
leaves a proportion \(\mu\) of the total land \(X\) to a farmer (f). The farmer, then, engages in
production using the land input \(\mu X\). If the participation order of this coalition is \(l \Rightarrow f\), the
marginal contribution of the landowner to production is \(A F(X)\), whereas the marginal con-
tribution of the farmer is \(A[F((1 - \mu)X + F(\mu X) - F(X)]\). Alternatively, if the participation
order is \(f \Rightarrow l\), the marginal contribution of the farmer is \(AF(0) = 0\), whereas the marginal
contribution of the landowner is \(A[F((1 - \mu)X + F(\mu X) - F(0)]\). Accordingly, the Shapley
value of this coalition game is given by:

\[
(S_l, S_f) = \left(\frac{AF((1 - \mu)X + F(\mu X) + F(X)}{2}, \frac{AF((1 - \mu)X + F(\mu X) - F(X))}{2}\right),
\]

where \(S_l\) and \(S_f\) are the gains of the landowner and the farmer, respectively, in this coalition
game.

We present several remarks regarding the allocation of the final output. First, the sum
of the landowners’ gain and the farmers’ gain is equal to the total output. In this sense, the
output allocation is constrained-Pareto optimal. This result is typical of the Shapley value.
Second, the socially optimal land allocation is \(\mu = 1/2\) because \(F(\cdot)\) is strictly concave.
Third, the socially optimal land allocation coincides with the individually optimal land

\(^5\)Alternatively, we may assume that the shares of output given to landowners and farmers are determined
by the Nash bargaining solution. Even if we assume so, however, the main results do not change.
allocation because both parties’ output share includes the common term, $F((1 - \mu)X) + F(\mu X)$. If coalition contracts were perfectly enforceable without any costs, the first-best outcome would be achievable, with each landowner leaving $X/2$ to their opponent farmers. Even if coalition contracts are associated with $\mu \neq 1/2$ for some reason, the participation constraints of both parties are satisfied provided that the coalition contracts are enforceable, as demonstrated by Proposition 1:

**Proposition 1** Consider a coalition contract associated with $\mu \in [0, 1]$. A farmer’s participation constraint in the second stage, given by

$$S_f = A\left[F((1 - \mu)X) + F(\mu X) - F(X)\right]/2 \geq 0,$$  \hspace{1cm} (PCF2)

is satisfied for all $\mu \in [0, 1]$. If the coalition contract is enforceable, a landowner’s participation constraint in the second stage, given by

$$S_l = A\left[F((1 - \mu)X) + F(\mu X) + F(X)\right]/2 \geq AF(X),$$  \hspace{1cm} (PCL2)

is satisfied for all $\mu \in [0, 1]$.

**Proof.** See the Appendix.

The left-hand side of (PCF2) is the farmer’s gain when she participates in the coalition contract, whereas the right-hand side is her gain when she does not. (PCF2) implies that no matter what proportion $\mu \in (0, 1)$ her opponent landowner lends to the farmer, the farmer is better off when she participates in the coalition contract than when she does not. If the coalition contract is unenforceable, however, the farmer has an incentive to abscond with output, breaking this contract with her opponent landowner, because her output, $AF(\mu X)$, is greater than her share, $S_f = A\left[F((1 - \mu)X) + F(\mu X) - F(X)\right]/2$. Thus, the landowner’s participation constraint is not satisfied unless the coalition contract is enforceable, as stated in Proposition 1. Although property rights with respect to output are allocated by the coalition contract, the economy is trapped by the prisoner’s dilemma if the contract is
unenforceable. In the next section, we investigate the establishment of a legal institution by which coalition contracts are enforceable and property rights are ensured.

2.2 Legal institution

In the first stage of the game, both landowners and farmers decide how much to contribute to the formation of a legal institution. The legal institution includes court and police systems. When production is accomplished, a farmer may abscond with her output, $AF(\mu X)$, without repaying her obligations. A thieving farmer is arrested with probability $a \in [0,1]$.\(^6\) If she is arrested, all her stolen output is confiscated.\(^7\) This means that the farmer’s expected gain from not fulfilling the contract is $(1 - a)AF(\mu X)$. The legal institution affects the land allocation depending on the enforceability of coalition contracts. The probability $a$ is regarded as the extent of contract enforceability, with larger values indicating more enforceability.

At time 0, landowners and farmers contribute to the formation of a legal institution. Let $a_l$ and $a_f$ be the contributions of a landowner and a farmer, respectively, where $a_l, a_f \geq 0$ and $a_l + a_f = a$. To contribute $a_i$ ($i = l, f$), each individual incurs costs $T(a_i)$, where $T(0) = 0$. The cost function $T : [0, 1] \to \mathbb{R}_+$ is continuous and twice differentiable, where $T'(.) > 0$ and $T''(.) > 0$. We impose a technical assumption that guarantees that the economy benefits from a legal institution when individuals contribute enough to its formation:

**Assumption 2** \( T'(0) = 0, \ T(1) < A[F(X/2) - F(X)/2]. \)

A farmer’s and a landowner’s final profits are given by $\Pi_f := S_f - T(a_f)$ and $\Pi_l := S_l - T(a_l)$, respectively, and their respective participation constraints in the first stage are as follows:

$$\Pi_f = S_f - T(a_f) \geq 0.$$ \hspace{1cm} (PCF1)

---

\(^6\)Because landowners are based in their land, they can never walk away. They are arrested with probability one if they intentionally misreport to the police that their opponent farmers abscond with the output, cheating their opponent farmers.

\(^7\)In our model, we do not explicitly consider corruption of the court and police systems, which is reflected in the parameter $a$. The confiscated output is assumed to cover costs incurred by arresting criminal farmers.
\[ \Pi_l = S_l - T(a_l) \geq F(X), \quad \text{(PCL1)} \]

From Assumptions 1 and 2, these two participation constraints are redundant for the maximization problems in the first stage. It will be later verified that these participation constraints are satisfied in both the landowner’s and the farmer’s best responses.

The incentive compatibility constraint of a farmer in the coalition contract, which leads the farmer not to break the contract, is as follows:

\[ S_f = A\left[ F((1 - \mu)X) + F(\mu X) - F(X) \right]/2 \geq (1 - a)AF(\mu X). \quad \text{(IC)} \]

The left-hand side of (IC) is the farmer’s gain when she consistently fulfills the contract with her opponent landowner, and the right-hand side is her expected gain when she absconds with her output, breaking the contract. As long as this inequality holds, the farmer does not cheat her opponent landowner. \( T(a_f) \) does not appear in (IC) because \( T(a_f) \) was already sunk in the first stage.

Because \( F(X) \) and \( A \) are constant, \( \arg \max_{\mu \in [0,1]} S_f = \arg \max_{\mu \in [0,1]} S_l \), and thus, a landowner solves the following maximization problem to make a take-it-or-leave-it contract offer associated with \( \mu \) and the share of output to her opponent farmer:

\[ \max_{\mu \in [0,1]} F((1 - \mu)X) + F(\mu X), \]

subject to (IC). Proposition 2 presents the solution to the maximization.

**Proposition 2** Suppose that Assumption 1 holds. The optimal solution of \( \mu \) to the maximization problem is given by:

\[ \mu^*(a) = \begin{cases} 
0 & \text{if } 0 \leq a \leq \frac{1}{2} \\
\hat{\mu}(a) & \text{if } \frac{1}{2} < a \leq G(1/2) \\
1/2 & \text{if } G(1/2) < a \leq 1,
\end{cases} \]

where the function \( G : (0, 1] \rightarrow \mathbb{R} \) is defined such that \( G(\mu) := 1/2 + [F(X) - F((1 - \mu)X)]/[2F(\mu X)] \), and \( \hat{\mu} \) is an increasing function of “a” such that \( \hat{\mu}(a) := G^{-1}(a) \).
Proposition 2 is illustrated in Figure 2. \( \mu^*(a) \) is continuous at \( a = 1/2 \) and \( a = G(1/2) \). Landowners and farmers cannot establish partnerships when the extent of contract enforceability is too low, whereas the first-best land allocation is achievable with a sufficiently high extent of contract enforceability. In the intermediate level of contract enforceability, the land stock allocated to farmers increases as contract enforceability becomes strong.

[Figure 2 around here]

2.3 Best Responses

Before solving the first stage of the game, we impose an assumption on the functional form of \( F(x) \).

**Assumption 3** For \( \mu \in (0, 1/2) \),

\[
2F'(\mu X)F'((1 - \mu)X) + F''((1 - \mu)X)F(\mu X) < 0.
\]

Assumption 3 is a sufficient condition for the second-order condition to hold for both the landowners’ and the farmers’ maximization problems in the first stage.\(^8\) An example of a production function satisfying Assumption 3 is \( AF(x) = A(2X - x^2)^{1/2} \). Because of Assumption 1, Assumption 3 can be consistently assumed even though \( \mu \) is very small.

**Lemma 1** Suppose that Assumptions 1 and 3 hold. Then, the function, \( \tilde{\mu} : (1/2, G(1/2)] \to (0, 1/2] \) in Proposition 2 is strictly concave.

**Proof.** See the Appendix.

From the constrained-optimal land allocation in the second stage of the game, the respective profits of landowners and farmers are given by:

\[
\Pi_l = \begin{cases} 
AF(X) - T(a_l) & \text{if } 0 \leq a_l \leq 1/2 - a_f \\
A\left[F((1 - \mu)X) + F(\mu X) + F(X)\right]/2 - T(a_l) & \text{if } 1/2 - a_f < a_l \leq G(1/2) - a_f \\
AF(\frac{X}{2}) + AF(X)/2 - T(a_l) & \text{if } G(1/2) - a_f < a_l
\end{cases}
\]

\(^8\)Assumption 3 simplifies our analysis. Without Assumption 3, we are able to derive the same main results, but the analysis becomes extremely complicated.
and

\[
\Pi_f = \begin{cases} 
-T(a_f) & \text{if } 0 \leq a_f \leq 1/2 - a_l \\
A[F((1 - \hat{\mu})X) + F(\hat{\mu}X) - F(X)]/2 - T(a_f) & \text{if } 1/2 - a_l < a_f \leq G(1/2) - a_l \\
AF(X/2) - AF(X)/2 - T(a_f) & \text{if } G(1/2) - a_l < a_f.
\end{cases}
\]

The profit functions are continuous at \(a_i = 1/2 - a_j\) and \(a_i = G(1/2) - a_j\), where \((i, j) = (l, f)\) or \((f, l)\). Because \(X\) is constant, these profit functions imply that the best responses of landowners and farmers are symmetrical. The candidates for best responses in each sphere are derived as follows.

\[
\begin{cases} 
a_i = 0 & \text{if } 0 \leq a_i \leq 1/2 - a_j \\
B_i(a_i, a_j) = 0 & \text{if } 1/2 - a_j < a_i \leq G(1/2) - a_j \\
a_i = 0 & \text{if } G(1/2) - a_j < a_i,
\end{cases}
\]

where \(B_i(a_i, a_j) := AX[F'(\hat{\mu}X) - F'((1 - \hat{\mu})X)]\hat{\mu}'(a) - 2T'(a_i)\). The second-order condition is satisfied because of Lemma 1 when deriving \(B_i(a_i, a_j) = 0\). We confirm the best responses by examining each candidate in the following.

We first consider the locus of \(B_i(a_i, a_j) = 0\). By totally differentiating \(B_i(a_i, a_j) = 0\), we obtain:

\[
\frac{da_j}{da_i} = -1 - \frac{2T''(a_i)}{A\Phi(a)},
\]

where \(\Phi(a) := -\left[X^2[F''(\hat{\mu}X) + F''((1 - \hat{\mu})X)][\hat{\mu}'(a)]^2 + X[F'(\hat{\mu}X) - F'((1 - \hat{\mu})X)]\hat{\mu}''(a)\right].\)

It follows from \(\hat{\mu} \leq 1/2\) that \(\Phi(a) > 0\). Hence, \(da_j/da_i < -1\) for all \(a_i \in (0, 1]\). We also note that \(\frac{\partial^2 a_j}{\partial a_i \partial a_i} > 0, \lim_{A \to \infty} \frac{da_j}{da_i} = -1,\) and \(\lim_{A \to 0} \frac{da_j}{da_i} = -\infty.\)

Because the best responses of landowners and farmers are symmetrical, the analysis focuses on a landowner’s best response. When \(1/2 < a_l + a_f \leq G(1/2)\), the locus of \(B_l(a_l, a_f) = 0\) intersects with the vertical axis at the point \((a_l, a_f) = (0, G(1/2))\), as seen in Figure 3.\(^9\)

Figure 3 identifies two cases to be investigated depending upon the positions of the locus of \(B_l(a_l, a_f) = 0\). \textit{Case 1} is the case in which the locus of \(B_l(a_l, a_f) = 0\) intersects with \(1/2 = a_l + a_f\) at the point \(M(\hat{a}_l, \hat{a}_f)\) where \(\hat{a}_l > 0\) and \(\hat{a}_f \geq 0\). \textit{Case 2} is the case in which the locus of \(B_l(a_l, a_f) = 0\) intersects with the horizontal axis at the point \(N(\hat{a}_l, 0)\), where \(1/2 < \hat{a}_l \leq G(1/2)\). As clarified in Figure 3, if \(a_f > 1/2\), the landowner’s best response

\(^9\)We obtain \(B_l(0, G(1/2)) = 0\) because \(\hat{\mu}(G(1/2)) = 1/2, T'(0) = 0,\) and \(\hat{\mu}'(G(1/2)) < \infty.\)
is uniquely determined in both Case 1 and Case 2, which is summarized in Lemma 2.

[Figure 3 around here]

**Lemma 2** Suppose that Assumptions 1-3 hold. The best response of a landowner is \( a_l = 0 \) if \( a_f > G(1/2) \), and \( B_l(a_l, a_f) = 0 \) if \( 1/2 < a_f \leq G(1/2) \) in both Case 1 and Case 2.

**Proof.** The claim follows from (BR) and the illustrations in Figure 3. □

Although Lemma 2 provides the best response of a landowner in the case in which a farmer’s contribution is greater than \( 1/2 \), it is not obvious whether the landowner’s best response is \( a_l = 0 \) or \( B_l(a_l, a_f) = 0 \) when \( 0 < a_f \leq 1/2 \). We first consider Case 1.

**Lemma 3** Suppose that Assumptions 1-3 hold. Suppose that the locus of \( B_l(a_l, a_f) = 0 \) intersects with the line, \( 1/2 = a_l + a_f \), at \( M(\hat{a}_l, \hat{a}_f) \), where \( \hat{a}_l > 0 \) and \( \hat{a}_f \geq 0 \) as shown in Case 1 of Figure 3. Let \( L(\bar{a}_l, 1/2) \) be a point on the locus of \( B_l(a_l, a_f) = 0 \) between \( L \) and \( M \) such that the profit of a landowner, \( \Pi_l \), at \( P(a_l^p, a_f^p) \) is equal to \( AF(X) \).

**Proof.** See the Appendix.

**Remark 1** Consider Case 1 of Figure 3. \( \Pi_l \) is strictly greater than \( AF(X) \) if \( a_f > a_f^p \) on the locus of \( B_l(a_l, a_f) = 0 \), whereas \( \Pi_l \) is strictly less than \( AF(X) \) if \( a_f < a_f^p \) on the locus of \( B_l(a_l, a_f) = 0 \).

**Proof.** The claim follows from the facts that \( S_l \) is an increasing function with respect to \( a = a_l + a_f \) and that \( T(a_l) \) is an increasing function with respect to \( a_l \). □

Because the profit of a landowner, \( \Pi_l \), is equal to \( AF(X) \) at any point on the vertical axis where \( 0 \leq a_f \leq 1/2 \), her best response in Case 1 is \( a_l = 0 \) if \( 0 \leq a_f \leq a_f^p \), whereas it is \( B_l(a_l, a_f) = 0 \) if \( a_f^p \leq a_f \leq G(1/2) \).\(^{10}\) The landowner’s best response is the solid line in Case 1 of Figure 3. It is easily verified that the landowner’s participation constraint (PCL1)

\(^{10}\)When \( a_f = a_f^p \), the best response is indifferent between \( a_l = 0 \) and \( B_l(a_l, a_f) = 0 \).
We summarize the best response of a landowner in her best response. We summarize the result for Case 1 in Proposition 3.

Proposition 3 Consider Case 1 of Figure 3, the case in which the locus of \( B_t(a_l,a_f) = 0 \) intersects with \( 1/2 = a_l + a_f \) at \( M(\hat{a}_l, \hat{a}_f) \) where \( \hat{a}_l > 0, \hat{a}_f \geq 0 \). Suppose that Assumptions 1-3 hold. Then, the best response of a landowner is given by i) \( a_l = 0 \) if \( a_f > G(1/2) \), ii) \( B_t(a_l,a_f) = 0 \) if \( a_f^p \leq a_f \leq G(1/2) \) and iii) \( a_l = 0 \) if \( 0 \leq a_f \leq a_f^p \).

Proof. The claim follows from Lemmas 2 and 3 and Remark 1. \( \square \)

Now, we consider Case 2 of Figure 3 in which the locus of \( B_t(a_l,a_f) = 0 \) intersects with the horizontal axis at \( N(\hat{a}_l,0) \) where \( 1/2 < \hat{a}_l < G(1/2) \). As in the discussion of Case 1, if \( N(\hat{a}_l,0) \) is sufficiently close to \( (1/2,0) \), \( \Pi_t \) at \( N(\hat{a}_l,0) \) is strictly less than \( AF(X) \). On the other hand, if \( N(\hat{a}_l,0) \) is sufficiently close to \( (G(1/2),0) \), \( \Pi_t \) at \( N(\hat{a}_l,0) \) is close to \( A[F(X/2) + F(X)/2] - T(G(1/2)) \), which is strictly greater than \( AF(X) \) from Assumption 2. Because \( \Pi_t \) is continuous with respect to \( a_l \in (1/2,G(1/2)] \) given that \( a_f = 0 \), there exists a point \( Q(q,0) \) between \( (1/2,0) \) and \( (G(1/2),0) \) such that \( \Pi_t \) at \( Q(q,0) \) is equal to \( AF(X) \). This implies that \( \Pi_t \) is strictly greater than \( AF(X) \) if \( N \) is located between \( Q \) and \( (G(1/2),0) \), whereas \( \Pi_t \) is strictly less than \( AF(X) \) if \( N \) is located between \( (1/2,0) \) and \( Q \).

We summarize the best response of a landowner in Case 2 of Figure 3.

Proposition 4 Consider Case 2 of Figure 3. Suppose that Assumptions 1-3 hold. Suppose that the locus of \( B_t(a_l,a_f) = 0 \) intersects with the horizontal axis at \( N(\hat{a}_l,0) \) where \( \hat{a}_l \in (1/2,G(1/2)) \). Then, the following hold.

- If \( N \) is located between \( Q(q,0) \) and \( (G(1/2),0) \), the best response of a landowner is given by i) \( a_l = 0 \) if \( a_f > G(1/2) \) and ii) \( B_t(a_l,a_f) = 0 \) if \( 0 \leq a_f \leq G(1/2) \).

- If \( N \) is located between \( (1/2,0) \) and \( Q(q,0) \), the best response of a landowner is given by i) \( a_l = 0 \) if \( a_f > G(1/2) \), ii) \( B_t(a_l,a_f) = 0 \) if \( a_f^p \leq a_f \leq G(1/2) \) and iii) \( a_l = 0 \) if \( 0 \leq a_f \leq a_f^p \) where the point \( P(a_l^p,a_f^p) \) for \( a_f^p \) is defined as in Lemma 3.
Proof. See the Appendix.

The second part of Proposition 4 is similar to Case 1, and thus, it is proven in the same way as Proposition 3. As in Case 1, it is easily verified that the landowner’s participation constraint (PCL1) in the first stage is satisfied in her best response.

3 Nash Equilibria

The best response of a farmer is completely symmetrical to that of a landowner. Figure 4 illustrates various cases of a Nash equilibrium (or Nash equilibria). Case 1 of Figure 4 is the case in which the technology level, $A$, is very low. In this case, only one Nash equilibrium exists where $a_l = a_f = 0$, which is globally stable. In this economy, no property-right-securing legal institutions come about. Land allocation in this economy is extremely inefficient because only landowners engage in production. Case 2 of Figure 4 is the case in which the technology level, $A$, is neither high nor low. In this case, we have multiple Nash equilibria. One is the low Nash equilibrium where $a_l = a_f = 0$ and no legal institutions exist. The other is the high Nash equilibrium where $a = a_l + a_f > 0$ and a legal institution appears. Both Nash equilibria are locally stable. Although which Nash equilibrium is chosen depends on the expectations of landowners and farmers, it is likely that the society selects the low Nash equilibrium because of hysteresis. The high Nash equilibrium is unlikely to be chosen if the technology level, $A$, gradually improves, because only the low Nash equilibrium had existed for a long time historically. Case 3 of Figure 4 is the case in which the technology level, $A$, is so high that the low Nash equilibrium vanishes. In this case, a property-right-securing legal institution inevitably comes about, and as $A$ increases, the extent of contract enforceability becomes strong. The first best land allocation is still not achieved, however, because in the Nash equilibrium, $a = a_l + a_f < 1/2$. Only when $A$ goes to infinity, does land allocation approach the first best outcome because $\lim_{A \to \infty} \frac{\partial a_j}{\partial a_i} = -1$ where $(i, j) = (l, f)$ or $(f, l)$. The outcomes in these three cases are consistent with the empirical observations in
4 Discussion

Our model can be applied to investigate the relationship between institutional quality and inequality. We prove that inequality within an economy shrinks as the protection of property rights strengthens. This investigation is not the first to discuss a negative relationship between institutional quality and inequality. Chong and Gradstein (2007) and Gradstein (2007) develop a Tullock-type rent seeking model and investigate two-way causalities between institutional quality and inequality.\(^\text{11}\) The choice of institutional quality in their models, however, depends on the political environment, and institutions are regarded as rules prescribed by a specific political party, implying that not all individuals are motivated to respect the prescriptive rules, as discussed in the introduction.

Institutional quality is measured by \(a\) that is the extent of contract enforceability. Inequality between landowners and farmers is measured by the Gini coefficient computed from their output shares. The contribution cost, \(T(a_i)\), is not taken into account to derive the Gini coefficient because both landowners and farmers incur the same cost. From the Shapley value and Proposition 2, the Lorenz curve is given by:

\[
L(x; a) := \begin{cases} 
1 - \frac{F(X)}{F((1-\mu(a))X)+F(\mu(a)X)} x & \text{if } 0 \leq x < \frac{1}{2} \\
1 + \frac{F(X)}{F((1-\mu(a))X)+F(\mu(a)X)} x - \frac{F(X)}{F((1-\mu(a))X)+F(\mu(a)X)} & \text{if } \frac{1}{2} \leq x \leq 1,
\end{cases}
\]

which is illustrated in Figure 5.

The Gini coefficient is measured by \(G_1G_2\) in the figure and is easily computed as:

\[
\text{Gini} := \begin{cases} 
\frac{1}{2} & \text{if } 0 \leq a \leq \frac{1}{2} \\
\frac{F(X)}{2F((1-\mu(a))X)+F(\mu(a)X)} & \text{if } \frac{1}{2} < a \leq G(1/2) \\
\frac{F(X)}{4F(X/2)} & \text{if } G(1/2) < a \leq 1.
\end{cases}
\]

\(^\text{11}\)Amendola et al. (2011) empirically investigate the relationship between institutional quality and inequality in developing countries.
The Gini coefficient is a function of $a$ and it is continuous at $a = 1/2$ and $a = G(1/2)$. Because $\tilde{\mu}(a)$ increases with $a$ when $1/2 < a \leq G(1/2)$, the Gini coefficient decreases with $a$ when $1/2 < a \leq G(1/2)$, which implies that as institutional quality is improved, inequality is reduced. This outcome is consistent with the empirical evidence in Table 1 and Figure 6. Table 1 provides evidence obtained from cross-country estimations for more than 100 countries and indicates a statistically significant negative relationship between institutional quality associated with the rule of law and inequality.\footnote{The panel-data analysis is performed in columns (7) and (8).} Figure 6 illustrates a partial relationship between the two based on the estimation in column (2) in Table 1. The figure clearly shows that as institutional quality is improved, inequality within an economy is reduced.

5 Concluding Remarks

Our analysis has demonstrated that initial productivity conditions in economies determine institutional quality. Low initial productivity does not yield property-right-securing legal institutions, and partnership contracts are not formed. High initial productivity yields legal institutions that ensure property rights, and partnership contracts between landowners and farmers correct inefficient land stock allocation. When initial productivity is at an intermediate level, multiple Nash equilibria arise. In this case, no legal institutions are obtained in the low Nash equilibrium, whereas a legal institution that ensures property rights appears in the high Nash equilibrium. Because of hysteresis, the low Nash equilibrium is more likely to be chosen if technology gradually progresses from the low to the intermediate level. Our analysis also has proven that as institutional quality is improved, inequality within an economy shrinks. All of these outcomes are consistent with empirical observations.

Although endogenous legal institutions are established in our model, our analysis has some limitations. We did not investigate causality from legal institutions to the productivity.
ity level. Two-way causalities between institutional quality and the productivity level are important in the literature on economic growth. A possible extension to investigate the two-way causalities would be to incorporate our analysis on endogenous legal institutions into an infinite-horizon growth model. Such a growth model would enable us to study a developmental history in which productivity and legal institutions interactively grow together. This extension is left for future research.

Appendix

Empirical methods and data

To construct Table 1 in section 4, we empirically examine the relationship between institutional quality and inequality. We perform both cross-country and panel data analyses for 115 countries from 1985 to 2009. Using averaged data over 1985-2009, we estimate the following equation for the cross-country analysis:

$$\text{Inequality}_i = \alpha_1 + \alpha_2 \text{Legal institutions}_i + X_i \beta + \epsilon_i,$$

where $\epsilon$ is an error term. We use the Gini coefficient developed by Solt (2009) as a proxy for inequality. Solt (2009) standardizes the United Nations University’s World Income Inequality Database and creates the net Gini coefficient for more reliable cross-country comparisons of income inequality than those using the existing database.\(^{13}\) The data on institutional quality comes from the Economic Freedom of the World (Gwartney et al., 2011). Gwartney et al. (2011) provide a chain-linked index of “Legal Structure and Security of Property Rights,” which is evaluated based on the rule of law, security of property rights, an independent judiciary, and an impartial court system. The data points for this chain-linked index are available in 1985, 1990, 1995, and 2000-2009, and we averaged all these data points. $X$ encompasses other control variables, including the logarithm of per capita real GDP, democracy, education, and inflation. The real per capita GDP adjusted to purchasing power parity

\(^{13}\)We employ the Standardized World Income Inequality Database (Version 3.0, released July 2010) developed by Solt (2009).
is used as a control variable and is obtained from the World Bank (2011). The level of
democracy is measured by \textit{polity2}, a variable in the Polity IV database (Marshall, 2010).
Education is the average years of secondary schooling over age 15, which is developed by
Barro and Lee (2010). Inflation indicates inflation rates measured by the consumer price
index, which is obtained from the World Bank (2011). To mitigate the simultaneity biases,
we use the data points in 1985 for all control variables, the initial year of our estimation. To
obtain Figure 1, the logarithm of per capita real GDP in 1985 and institutional quality in
2009 are used.

To address the endogeneity problems resulting from reverse causality from inequality to
legal institutions, we conduct an instrumental variables (IV) estimation. As the instrumental
variables for legal institutions, we use legal origins developed by La Porta et al. (1999) and
the logarithm of European settler mortality created by Acemoglu et al. (2001). There are
five categories of legal origins: English common law, the French commercial code, the Ger-
man commercial code, the Scandinavian commercial code, and Socialist/Communist laws.
Acemoglu et al. (2001) provide European settler mortality, which is estimated for European
settlers during the early period of European colonization (before 1850). More concretely,
English legal origin and the log of European settler mortality are used as the instrumental
variables for legal institutions in columns (3) and (4) in Table 1, and German and Scandi-
avanian legal origins are used in columns (5) and (6). In all estimations, the \textit{F}-values for
the tests of the excluded instruments in the first-stage regressions are greater than 10, satisfying
the “rule of thumb” proposed by Staiger and Stock (1997). Moreover, the Hansen tests of
overidentifying restrictions do not reject the orthogonality conditions at the conventional
significance level in all estimations.\textsuperscript{14}

Next, we also conduct a dynamic panel data analysis for columns (7) and (8), which
\begin{footnotesize}
\textsuperscript{14}Since legal origins and European settler mortality may affect inequality through channels other than legal
institutions, we performed a sensitivity analysis to confirm that the instrumental variables do not influence
inequality directly, although we do not document the results of the sensitivity analysis here. Specifically,
following the procedure employed by Tabellini (2010) and Kunieda et al. (2012), we add one of the in-
strumental variables to the second-stage regression directly and confirm that the variable has no impact on
inequality under the condition that the other instrument satisfies the orthogonality condition.
\end{footnotesize}
is a complement to our cross-country analysis, by using the system generalized method of moments (GMM) estimators developed by Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998). The system GMM estimation enables us to control for unobserved country-specific effects. It also enables us to address the endogeneity problems, employing internal lagged variables as instrumental variables. We collect unbalanced panel data from 1985 to 2009 and create five-year averaged data for five non-overlapping periods: 1985-1989, 1990-1994, 1995-1999, 2000-2004, and 2005-2009. The use of the five-year averaged data mitigates noise associated with short-run economic fluctuations. The estimation equation is specified as follows:

\[
\text{Inequality}_{it} = \alpha_1 \text{Inequality}_{it-1} + \alpha_2 \text{Legal institutions}_{it} + X_{it} \beta + \eta_i + \mu_t + \epsilon_{it},
\]

where \(i\) and \(t\) stand for a country and time, respectively. \(\eta\) is a country-specific effect; \(\mu\) is a time-specific effect; and \(\epsilon\) is an error term. \(X\) includes control variables similar to those of the cross-country analysis plus a constant term. In contrast to the cross-country analysis, we use the five-year averaged control variables in this dynamic panel analysis, implying that we regard these variables as endogenous in our regressions.

**Proof of Proposition 1**

It is noted that (PCF2) and (PCL2) are equivalent, and thus, it suffices to show that \(\Psi(\mu) := F((1-\mu)X) + F(\mu X) - F(X) \geq 0\) for all \(\mu \in [0, 1]\). From \(\Psi'(\mu) = X[F'(\mu X) - F'((1-\mu)X)]\), it follows that for \(\mu \in (0, 1/2)\), \(\Psi'(\mu) > 0\) and for \(\mu \in (1/2, 1)\), \(\Psi'(\mu) < 0\). Furthermore, because we have \(\Psi(0) = 0\) and \(\Psi(1) = 0\), it follows that \(\Psi(\mu) \geq 0\) for all \(\mu \in [0, 1]\). □

**Proof of Proposition 2**

To prove Proposition 2, we provide useful lemmas first.

**Lemma 4** The function \(G(\mu)\) is strictly increasing.
Proof. $2G'(\mu)[F(\mu X)]^2/X = \mu XF'(\mu X)F'(1 - \mu X)
\left[F(\mu X)/[\mu XF'(\mu X)] - [F(X) - F((1 - \mu)X)]/[\mu XF'(1 - \mu)X]\right].$
Because $F(.)$ is strictly concave, we have $F'(\mu X)/[\mu X F'(\mu X)] > 1$ and $[F(X) - F((1 - \mu)X)]/[\mu X F'(1 - \mu)X] < 1,$ implying that $G'(\mu) > 0.$ 

Lemma 5 \[\lim_{\mu \downarrow 0} G(\mu) = 1/2.\]

Proof. From L'Hôpital's rule, we have \[
\lim_{\mu \downarrow 0} G(\mu) = 1/2 + \lim_{\mu \downarrow 0} F'((1 - \mu)X)/2F'(\mu X) = 1/2.
\]

Lemma 6 For any $\mu \in (0, 1], G(\mu) \leq 1$ with equality if $\mu = 1.$

Proof. Because $F(.)$ is strictly concave, we have:

\[\Lambda(\mu) := \frac{[F(X) - F((1 - \mu)X)]/(\mu X)}{[F(\mu X) - F(0)]/(\mu X)} \leq 1\]

with equality if $\mu = 1.$ The claim follows from this inequality because $G(\mu) \leq 1$ is equivalent to $\Lambda(\mu) \leq 1.$

Now Proposition 2 shall be proven. The incentive compatible constraint of a farmer, (IC), can be rewritten as $G(\mu) \leq a$ for $\mu \in (0, 1]$ and is satisfied if $\mu = 0.$ The solution to the unconstrained maximization problem of a landowner is clearly given by $\mu = 1/2.$ From Lemma 6, we confirm that $G(1/2) < 1.$ If $G(1/2) < a,$ the incentive compatible constraint of a farmer, (IC), is not binding, which implies that $\mu = 1/2$ is the solution. If $G(1/2) \geq a,$ the incentive compatible constraint is binding. Because $G(\mu)$ is an increasing function (from Lemma 4), $\mu = \tilde{\mu},$ where $G(\tilde{\mu}) = a,$ solves the maximization problem as long as $\tilde{\mu} > 0,$ or equivalently, as long as $a > \lim_{\mu \downarrow 0} G(\mu) = 1/2$ (Lemma 5). If $a \leq \lim_{\mu \downarrow 0} G(\mu) = 1/2,$ the landowner has to choose $\mu = 0,$ or else the incentive compatibility constraint does not hold.

\[\square\]
Proof of Lemma 1

From $a = G(\tilde{\mu})$, we have:

\[
\frac{2F(\tilde{\mu}X)}{X^2} \frac{\partial^2 a}{\partial \tilde{\mu}^2} = F(\tilde{\mu}X) \left[ -F''((1 - \tilde{\mu})X)F(\tilde{\mu}X) - F''(\tilde{\mu}X)[F(X) - F((1 - \tilde{\mu})X)] \right] \\
-2F'((1 - \tilde{\mu})X)F(\tilde{\mu}X) - F'((1 - \tilde{\mu})X)[F(X) - F((1 - \tilde{\mu})X)].
\]

From Assumption 3 and $F(X) - F((1 - \tilde{\mu})X) \geq 0$, we obtain $\frac{\partial^2 a}{\partial \tilde{\mu}^2} > 0$. Hence, $a$ is convex with respect to $\tilde{\mu}$. Then, $\tilde{\mu}$ is concave with respect to $a$ because $\tilde{\mu}(a)$ is an increasing function. □

Proof of Lemma 3

From the landowner’s profit function, it follows that if $(a_l, a_f) = (0, 1/2)$, $\Pi_l = AF(X)$. If $(a_l, a_f)$ is sufficiently close to $L$, $\Pi_l$ is strictly greater than $AF(X)$ because $L(\bar{a}_l, 1/2)$ is an inner solution of the profit maximization problem, given that $a_f = 1/2$. In contrast, if $(a_l, a_f)$ is sufficiently close to point $M$, $\tilde{\mu}$ is sufficiently close to 0 with $a_l > 0$. In this case, the landowner’s profit, $\Pi_l$, is close to $AF(X) - T(a_l)$, which is strictly less than $AF(X)$. By continuity of $B_l(a_l, a_f) = 0$, there exists a point $P(a_l^p, a_f^p)$ on the locus of $B_l(a_l, a_f) = 0$ between $L$ and $M$ such that the landowner’s profit, $\Pi_l$, at $P(a_l^p, a_f^p)$ is equal to $AF(X)$. □

Proof of Proposition 4

Lemma 2 provides the landowner’s best response for the case in which $a_f > 1/2$. For the first part of Proposition 4, if $N$ is located between $Q(q, 0)$ and $(G(1/2), 0)$, any point $(a_l, a_f)$ on the locus of $B_l(a_l, a_f) = 0$ where $a_f \in [0, 1/2]$ gives $\Pi_l$ strictly greater than $AF(x)$. The farmer’s best response, then, is $B_l(a_l, a_f) = 0$ if $0 \leq a_f \leq 1/2$. The second part is proven in the same manner as in Proposition 3. □

References


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Notes.***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively. The numbers in parentheses are heteroskedasticity-robust standard errors in columns (1)-(6) and robust standard errors obtained by Windmeijer’s (2005) finite-sample correction for the two-step covariance matrix in columns (7) and (8). $p$ is the $p$-value of a statistical test. English legal origin and the log of European settler mortality are used as instrumental variables for legal institutions in columns (3) and (4), and German and Scandinavian legal origins are used in columns (5) and (6). To ensure the consistency of the system GMM estimators, we perform two specification tests in columns (7) and (8). First, we test whether the differenced error terms are serially correlated with respect to the second order. The $p$-values are so large that the Arellano-Bond AR(2) tests do not reject the null hypothesis of no second-order serial correlation at the conventional significance level for all estimations. Second, the Hansen tests of overidentifying restrictions do not reject the orthogonality conditions at the conventional significance level for all estimations.
Notes. This scatter plot is created based on 106 countries. The log of GDP per capita in 1985 is used as a proxy for countries’ productivity in 1985, considering very long developmental histories. A high-quality rule of law follows high initial productivity, whereas a low-quality rule of law follows low initial productivity.
Figure 2: Land allocation under partnership contracts

Notes. The solid line is $\mu^*(a)$. 

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Figure 3: The landowner’s best response

Case 1: The technology level, $A$, is relatively low.

Notes. The solid line is the best response. The locus of $B_l(a_l, a_f) = 0$ intersects with $1/2 = a_l + a_f$ at the point $M(\hat{a}_l, \hat{a}_f)$. 

Figure 3 (Continued): The landowner’s best response

Case 2: The technology level, $A$, is relatively high.

Notes. The solid line is the best response. The locus of $B_l(a_l,a_f) = 0$ intersects with the horizontal line at the point $N(\tilde{a}_l,0)$. The graph illustrates the case in which $N(\tilde{a}_l,0)$ is located between $Q(q,0)$ and $(G(1/2),0)$.
Case 1: The technology level, \( A \), is very low.
Figure 4 (Continued): Nash equilibrium

Case 2: The technology level, $A$, is intermediate.
Case 3: The technology level, $A$, is very high.
Notes. The Gini coefficient is measured by $G_1 G_2$. $G_2$ rises as $a$ increases.
Figure 6: Partial relationship between inequality and institutional quality

Notes. This scatter plot is a partial relationship between inequality and institutional quality, which is created based on the results in column (2) in Table 1.