A Model of Enclosures: Efficiency, Coordination, and Conflict in the Transformation of Land Ownership*

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Abstract

We study a tractable equilibrium model to frame enduring debates on how customary or informal land tenures are transformed by decentralized or policy-driven 'enclosure' processes into more exclusive, alienable forms of private property. Depending on parameters expressing population density, technology adoption possibilities, and balance of power and costs in claim contests, none, some, or all lands are enclosed with different consequences for output, wages, land rents, resource (mis)allocation, and structural transformation. Potential outcomes include efficient transformation, coordination failure leading to either inefficiently low enclosures, or inefficiently high enclosure driven by wasteful property races and 'land grabs,' and multiple equilibria.

*Supporting materials and code can be found at https://github.com/jhconning/enclosure.

1 Introduction

A common analytical narrative holds that under conditions of low population density the costs to establishing property rights over land typically fall short of the benefits, so land may at first remain in conditions approximating 'open-access.' As population densities increase, as new opportunities to adopt technology or trade arise, as the costs and balance of forces contests of appropriation or defense shift, the benefits to more clearly delineated property rights become more apparent, creating pressures for induced institutional and technological change. This may lead at first, perhaps, to regulated territories and common property resource management, but, over time and under sustained pressure, more individualized and exclusive land rights often emerge (Boserup, 1965; Alchian and Demsetz, 1973; Binswanger et al., 1995).

Much debate, however, surrounds the mechanisms and actor motives that might lead such transformations, their efficiency and distributional consequences, and the desirability and design of state policy to jump-start or expedite more exclusive forms of private property. Such questions have been at the heart of long and thorny debates over how English open fields and commons held under customary law came to be transformed – via processes spanning many centuries – into enclosed alienable forms of property, and the role this may have played in the development of wage labor and land markets, and the rising agricultural productivity and structural transformations that, for some, were the hallmarks of the birth of capitalism itself (Mingay, 1997; Allen, 1992; Heller, 2011).

To some this process, while messy at times, is best described as a long progression of, if not Coasian bargains, at least efficiency improving re-arrangements of property and production that allowed the more capable actors to respond to new opportunities for specialization and trade, leading to higher output and innovation. In this view state policy, such as Parliamentary enclosure acts of the 18th and 19th centuries were necessary primarily to reduce transactions costs in what was mostly a demand-driven process of efficient 'enclosures from below' (Heldring et al., 2021). For others, many enclosures, particularly in the Tudor era, were more acts of land grabbing and dispossession, a result of changes in the balance of class forces. As Tawney writes, what 'produced the [16th century] popular revolts against enclosure was ... enclosing accompanied either by eviction and conversion to pasture, or by monopolizing common rights (1912, p.170).' To Marx and some of his interpreters, the loss of smallholders' rights to land and other means of independent subsistence stimulated the development of capitalism by creating new 'imperatives' that forced former smallholders to enter the wage market and led landlords and tenants to compete in new ways to lower costs and raise productivity to survive (Brenner, 1976; Wood, 2002). This camp often seeks to demonstrate that enclosures were labor displacing, contrary to other observers who claim to find that labor demand stayed steady or even increased.

In all of the above accounts, customary or 'traditional' peasant open field production are portrayed as 'traditional' and inefficient and needing to be replaced by more 'modern' property forms. Some question such premises. Allen (1992) argues that, in the South Midlands at least, agricultural productivity on open-field yeoman plots kept pace with that on enclosed plots. Similarly, Clark and Clark (2001) argue that the reason enclosure processes took centuries is that for most of this period the efficiency gains to be captured were modest relative to the considerable costs of enclosure. In the view of these authors enclosures were more about shifting and private capture rising rents from an agricultural productivity revolution already underway than about setting the bases to create one.

Similar debates have been replicated throughout colonial histories and in modern contexts. Even today, over half the worlds' lands are held by rural communities and indigenous groups, supporting the livelihood of 2.5 billion (Alden Wily, 2018), much of it under informal or customary tenure and common property regimes outside of formal property land registries. Under the pressure of rising populations, resource degradation and climate change, and the challenges and opportunities of new technologies, markets, and new state policies, land values have been pushed up often leading to new clashes of competing claims and insecurity, and political pressures to preserve or transform existing property regimes. Will property customary regimes adapt and transform on their own to to rise to these challenges, or fail to transform. Are state interventions to useful and necessary or do they only open the door to possible wasteful property scrambles or land grabs by the state itself or connected elites?

It seems unlikely any one interpretation can settle these questions and debates. More likely: under some times and circumstances decentralized enclosure processes may emerge to lead institutional innovation that brings the economy to more efficient allocation and higher growth ('from below' or 'from above' and with or without significant shifts in the distribution of income). In other situations, dysfunctional institutions may fail to be transformed, and in yet others, the economy might be tipped into wasteful property scrambles that transform and redistribute property rights without any evident efficiency gain.

Our purpose is to offer a tractable equilibrium model of decentralized or policy-driven enclosure processes that highlights key potential mechanisms, tradeoffs, and outcomes in such property transformation debates. We make just two slight modifications to a canonical equilibrium model of resource allocation to end up with rich predictions about likely outcomes in different contexts parameterized by variables describing population density, technology adoption possibilities before and after enclosure, and cost and balance of power in claims contests.

We build on two earlier seminal studies. Weitzman (1974) demonstrated that is a clear upper bound on the size of mis-allocation that can arise due to the co-existence of enclosed and 'commons' land and why this implies that, in the absence of lump sum transfers, labor "will always be better off with (inefficient)... access rights than under (efficient) private ownership (p.225),' a result also in Samuelson (1974).[1] We generalize this result to much wider contexts and show how this relates to the question of whether enclosures will be labor displacing or absorbing. From de Meza and Gould (1992) we adopt the assumption that enclosure processes are privately costly. This reasonable and seemingly innocuous assumption however gives rise to spillovers and strategic complementarities that can lead to multiple equilibria, contagion cascades, and the possibility of inefficient outcomes. In contrast to these earlier papers that interpret the unenclosed sector as 'open access' or as a non-market output-sharing 'commons,' we allow individual property and competitive factor markets to operate within what we label an unenclosed or customary sector. In our formulation, agents face a choice between two ways to establish and protect property rights that are each costly in their own ways. There is no presumption that one system is inherently more efficient than the others and the relative benefit-cost tradeoff will be endogenous.

We leverage the fact that enclosure processes can be modeled as an aggregative game (Vives, 2005; Acemoglu and Jensen, 2013) and draw on the theory of Global Games (Carlsson and van Damme, 1993; Morris and Shin, 2003) to map comparative statics with multiple equilibria. The end result is a model of enclosure processes rich in predictions and that applies to a wide set of circumstances and interpretations.

Our paper fits into a broader literature on the endogenous evolution of land property rights and the commons too vast to summarize here, but Platteau (1996), Binswanger et al. (1995) and Besley and Ghatak (2010) are good starting surveys. Recent macro models including Chen (2017) and Gottlieb and Grobovšek (2019) explore misallocation and structural transformation in an economy that models customary rights in similar fashion as we do but they confine attention to a narrow subset of the equilibria studied here.

We start with a benchmark one sector agricultural economy, contrasting planner

[1] Cohen and Weitzman (1975) apply the model to study costless enclosures in a medieval economy.

and decentralized enclosure equilibria. We later add a manufacturing sector and study enclosure under other market structures (e.g. by a village authority or a monopolist who can internalize spillovers). We end with a brief discussion of extensions and applications to historical enclosure processes.

2 Model

Production is given by the following constant returns technologies:[2]

$$F(T_c, L_c) = T_c^{1-\alpha} L_c^{\alpha} \tag{1}$$

$$G(T_e, L_e) = \theta F(T_e, L_e) \tag{2}$$

with T_i and L_i and $i \in \{c, e\}$ denoting land and labor inputs employed in the common (or unenclosed) and enclosed sectors. Parameter θ measures total factor productivity (TFP) on enclosed land relative to TFP on unenclosed land. If $\theta > 1$, enclosure facilitates adoption of technological or organizational improvements. If $\theta \leq 1$, enclosure leads to no improvements, or even technological regress (enclosure hampers efficient land use).

The economy has a total endowment of land $\bar{T}$ and labor $\bar{L}$. Let $\bar{l} = \frac{\bar{L}}{\bar{T}}$ indicate the land-labor ratio or population density. If T_e is enclosed land, then $T_c = \bar{T} - T_e$ remains available as common land. Similarly, for labor, $L_c = \bar{L} - L_e$. Define $t_e = \frac{T_e}{\bar{T}}$ and $l_e = \frac{L_e}{\bar{T}}$ so that $t_e \in [0, 1]$ is the share of land enclosed, and $l_e \in [0, 1]$ the share of labor employed on enclosed lands.

Output can be written in terms of the fraction of each factor employed and potential output:

$$\begin{aligned} G(T_e, L_e) &= t_e^{1-\alpha} \bar{l}_e^{\alpha} \cdot \theta \bar{T}^{1-\alpha} \bar{L}^{\alpha} \\ &= F(t_e, l_e) \cdot \theta F(\bar{T}, \bar{L}) \end{aligned}$$

Enclosure costs are modeled simply, as in de Meza and Gould (1992). For a cost of c units of output a claimant can convert a unit of land in the customary sector into an exclusive claim on the land. In WSDG the encloser is always a new outside landlord. To keep our results comparable, we start with that assumption but later show how

[2]Cobb-Douglas functions deliver tractable closed-form solutions. From the theory of aggregative games we know, however, that similar comparative static properties hold for more general technologies so long as agents' profit functions remain quasi-concave (Vives, 2005).

outcomes change when enclosure is more likely to favor existing users.

2.1 (Mis)allocation

The classic argument for why unenclosed lands or commons might lead to mis-allocation rests on the idea that while private property operators on enclosed lands hire labor until the value marginal product of labor equals the market wage w_e, that wage will be given by the average product those workers can earn from production on common property lands (where they also earn an implied rent). If MP_L^e is the marginal product of labor on enclosed land, AP_L^c is the average product on common land, and MP_L^c is marginal product of labor on common land, then:

$$MP_L^e = w_e = AP_L^c > MP_L^c \tag{3}$$

The implied higher labor-intensity in the unenclosed sector is interpreted as 'congestion' or land over-exploitation – key element in the 'tragedy of the commons.'

In some interpretations the 'commons' is a place 'without markets' or even a 'sharing economy' but this is both a-historical and unnecessary. By Euler's Theorem, $AP_L^c = MP_L^c + MP_T^c \cdot \frac{T_c}{L_c}$. If we assume competitive factor markets within the unenclosed sector with equilibrium factors prices $w_c = MP_L^c$ and $r_c = MP_T^c$ we can rewrite equilibrium condition (3) as

$$w_e - w_c = r_c \cdot \frac{T_c}{L_c} \tag{4}$$

Each use-right holder has a land allocation $\frac{T_c}{L_c}$ that generates rents but the maintenance of those claims requires continued possession and residence in the community. Condition (4) states that in equilibrium the value of these rents can be measured by the value of the opportunities the user gives up in order to protect them.

As Coase (1960) reminds us, we cannot proclaim the inefficiency of one institutional arrangement until we specify the costs of its alternative. When most land is under customary tenure and users have few outside opportunities then the cost of property under customary tenure will tend to be low compared to the costly alternative of converting those claims to more exclusive and alienable form via enclosure process.

There is, however, another potential inefficiency. Enclosure decisions will be decided by comparisons of private enclosure costs against private benefits measured as capturable land rents, and not by how enclosure affects total labor and land earnings.

With atomistic decisions, enclosure occurs when:

$$MP_T^e(T_e, L_e(T_e)) > c \tag{5}$$

where MP_T is the marginal (value) product of enclosed land and c is the constant marginal cost of enclosing land. The notation $L_e(T_e)$ reflects that the labor allocations respond to the amount land that has been enclosed. The interaction of (3) and (5) can lead to a surprising array of outcomes.

2.2 Optimal land enclosure

The socially optimal level of enclosure maximizes total output benefit less total costs of enclosure:

$$Y = [\theta \cdot F(t_e, l_e) + F(1 - t_e, 1 - l_e)] \cdot F(\bar{T}, \bar{L}) - cTt_e \tag{6}$$

To facilitate later comparison, it will be useful to break this problem into parts: we first describe optimal labor allocation across sectors for any enclosure rate t_e, and then solve for that optimal enclosure rate.

2.2.1 Optimal labor allocation

A social planner avoids the congestion mis-allocation of labor to the commons. At any level of enclosure T_e, the planner chooses L_e to satisfy instead of (3),

$$MP_L^E(T_e, L_e) = MP_L^C(T - T_e, L - L_e) \tag{7}$$

Differentiating (6) with respect to l_e, setting the result to zero, and rearranging gives (7) as:

$$\theta \left(\frac{t_e}{l_e}\right)^{1-\alpha} = \left(\frac{1 - t_e}{1 - l_e}\right)^{1-\alpha} \tag{8}$$

Solving, we find the efficient labor allocation given enclosure share t_e:

$$l_e^o(t_e) = \frac{\Lambda^o t_e}{1 + (\Lambda^o - 1)t_e}, \quad \text{where } \Lambda^o = \theta^{\frac{1}{1-\alpha}} \tag{9}$$

Note that $\Lambda^0 > 1$ as $\theta > 1$. When this holds, $l_e^o(t_e)$ is concave and hence $l_e^o(t_e) \geq t_e$ for all $t_e \in [0, 1]$, and strictly so for interior points. This implies that at any $t_e \in (0, 1)$ a planner sets labor-intensity *higher* on enclosed lands. In decentralized equilibria below, where incentives lead labor to be mis-allocated, privately enclosed lands will operate with *less* than efficient labor intensity, even where $\theta > 1$ so enclosure raises plot productivity. This will be key to understanding why enclosure processes can lead to inefficiently high 'labor displacement,' increasing congestion on remaining common lands.

Substituting $l_e^o(t_e)$ from (9) into Y from (6), dividing by $\bar{T}$ and simplifying leads to an output net of enclosure costs per unit land as a function of t_e:

$$z(t_e) = \bar{l}^{\alpha} \cdot [1 + (\Lambda^o - 1)\, t_e]^{1-\alpha} - ct_e \tag{10}$$

If $\theta \geq 1$ (so $\Lambda^o \geq 1$), $z(t_e)$ is concave in t_e and we can use the derivative of $z(t_e)$ assess at each endpoint to see whether land enclosure should be zero, partial, or full. There are three possibilities:

1. If $z'(0) < 0$ then $z(t_e)$ is downward-sloping over $t_e \in [0, 1]$, so $t_e^o = 0$ and zero enclosure is efficient;
2. If $z'(1) > 0$ then $z(t_e)$ is increasing over $t_e \in [0, 1]$, so $t_e^o = 1$ and full enclosure is efficient;
3. If $z'(0) > 0$ and $z'(1) < 0$, there is an interior optimum with efficient partial enclosure.

Consider the first case where $z'(0) \leq 0$. Differentiating (10) with respect to t_e and rearranging gives:

$$z'(0) \leq 0 \quad \Rightarrow \quad \bar{l} \leq \left[\frac{c}{(1-\alpha)\,(\Lambda^o - 1)}\right]^{\frac{1}{\alpha}} = l_0^o(c, \theta) \tag{11}$$

Inequality (11) defines a region of the $\theta, \bar{l}$ technology-population density parameter space below which land enclosure is socially not worthwhile. The result has a Boserupian interpretation: when labor intensity $\bar{l}$ is sufficiently low and land is abundant, the productivity gains to enclosure must be high enough to justify enclosure costs. Should society pay c to enclose one more unit of land? When $\theta > 1$, enclosure makes a plot more productive but labor is already relatively productive at low levels of population density, so the opportunity costs of moving labor to newly enclosed land is high.

Consider now the case when $z'(1) > 0$, where full enclosure is optimal. Using the derivative of $z(t_e)$ in (10), we find:

$$z'(1) > 0 \quad \Rightarrow \quad \bar{l} \geq \left[\frac{c\Lambda^o}{(1-\alpha)\,(\Lambda^o - 1)}\right]^{\frac{1}{\alpha}} = l_1^o(c, \theta) \tag{12}$$

Parameter values above the locus l_1^o defined in (12) suggest full enclosure is optimal.

Loci l_0^o and l_1^o are plotted in θ, $\bar{l}$ space in figure 1. The parameter region carved out between them corresponds to economies where partial enclosure is optimal. Suppose the economy were at a point just below the lower l_0^o boundary where no enclosure is optimal but that new migrants then arrive, pushing population density $\bar{l}$ up by enough to cross over the l_0^o locus. The social return to enclosure rises above its cost and some enclosure becomes worthwhile. Since enclosed land is more productive ($\theta > 1$) but is enclosed at marginal cost c it will be efficient to operate enclosed land in more labor-intensive ways compared to unenclosed land. Only as much land as is needed to accommodate the rise in population density will be enclosed.

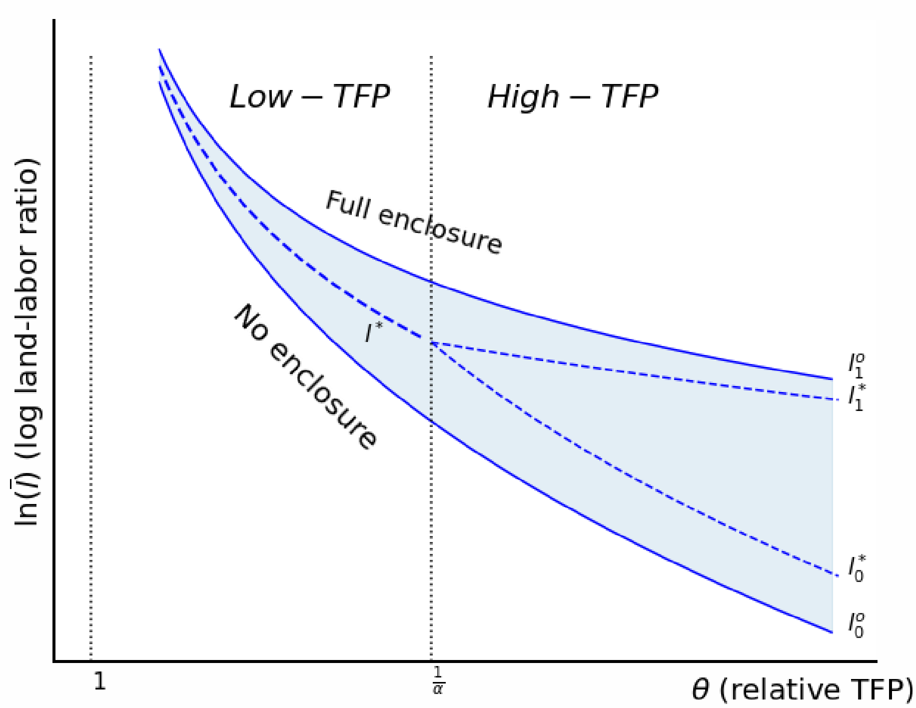

Figure 1: Optimal enclosure with regulated (solid) and un-regulated labor allocation (dashed).

2.2.2 A second-best benchmark

When, as above, a planner can regulate labor movement between enclosed and unenclosed lands and avoid commons overuse, costly enclosure becomes essentially a method to adopt better technology to make lands more productive.

Sstates and local authorities might be able to regulate the rate of enclosure t_e by, for example, setting clear boundaries dividing private enclosed lands from unenclosed. It may, however, be much harder to regulate labor movement between the sectors (e.g. the government may designate an area as not open to settlement and private property but villagers may still slip into the area to extract resources.. Accordingly, we ask: what is the second-best (or conditionally optimal) level of enclosure, when labor remains free to move as described by (3)? In model terms, equation (3) is:

$$\alpha\theta\left(\frac{t_e}{l_e}\right)^{1-\alpha} = \left(\frac{1-t_e}{1-l_e}\right)^{1-\alpha} \tag{13}$$

Solving for l_e gives the equilibrium fraction of labor allocated to the enclosed sector for any t_e:

$$l_e^*(t_e) = \frac{\Lambda t_e}{1+(\Lambda-1)t_e}, \quad \Lambda(\theta) = (\alpha\theta)^{\frac{1}{1-\alpha}} \tag{14}$$

Contrasting (14) with (9) shows that $l_e^* < l_e^o$. Plugging (14) into (6), simplifying and dividing by T yields:

$$z^*(t_e) = \bar{l}^{\alpha}\frac{1-t_e+\frac{\Lambda}{\alpha}t_e}{(1-t_e+\Lambda t_e)^{\alpha}} - ct_e \tag{15}$$

This $z^*(t_e)$ function differs from $z(t_e)$ in (10) in that it can be either concave or convex. If $\Lambda > 1$, or equivalently, $\theta > \frac{1}{\alpha}$, then $z^*(t_e)$ is increasing and concave, so it can be analyzed in the same way as (10) - by evaluating endpoints. If $1 < \theta < \frac{1}{\alpha}$, then $z^*(t_e)$ is increasing and *convex*, implying a corner solution in which either all or no land should be enclosed. Full enclosure should occur when $\theta < \frac{1}{\alpha}$ and when:

$$\bar{l} \geq \left[\frac{c}{\theta-1}\right]^{\frac{1}{\alpha}} = l^* \tag{16}$$

When the expected productivity gain from enclosure exceeds a threashold $\theta > \frac{1}{\alpha}$, we can again check endpoint derivatives to determine where enclosure should be zero, partial, or full. Since this "TFP threshold" plays a key role here and below we explicitly define it:

Definition. *Let $\theta^H = \frac{1}{\alpha}$. An economy with:*

- $\theta \geq \frac{1}{\alpha}$ *: has high plot-level TFP gains to enclosure.*
- $\theta < \frac{1}{\alpha}$ *: has low plot-level TFP gains to enclosure.*

Note that the high TFP threshold can be quite high. For example, for a Cobb-Douglas with labor share $\alpha = \frac{1}{2}$, the threshold would be $\theta^H = 2$, implying the expected TFP would have to at least double. This is a very high number when compared even against high empirical estimates of agricultural productivity gains following enclosure (e.g. Heldring et al., 2021).

In an economy with high TFP gains, derivatives of (15) characterize conditionally optimal enclosure. Enclosure should begin if:

$$l \geq \left[\frac{\alpha c}{(1-\alpha)(\Lambda(1+\alpha)-\alpha)} \right]^{\frac{1}{\alpha}} = l_0^* \tag{17}$$

While enclosure should be complete if:

$$l \geq \left[\frac{c}{(1-\alpha)\theta} \right]^{\frac{1}{\alpha}} = l_1^* \tag{18}$$

These regions of the parameter space are superimposed on Figure 1 as dashed blue lines. The qualitative difference between the full and conditional optimal rates of enclosure is that in economies with low expected TFP gains, optimal enclosure decisions will be binary.

2.3 Decentralized Private Enclosure processes

We now study where the enclosure is under the control of self-interested 'owner-claimants.' We at first follow de Meza and Gould (1992) in assuming that each parcel of land in the unenclosed sector has a potential claimant. The claimant could be an existing user of the commons or an outsider. The claimant compares the expense c needed to win a claim contest to establish exclusive control over the parcel against the rent they can expect to capture. They may, for example, erect a fence or other structure, or they may pay the fees to try to get the land registered under statutory law.

Once a parcel is enclosed, owners capture returns by renting land to a competitive, constant-returns enclosed production sector or by operating the farm themselves, using the technology in (2). With $w = MP_L^e$, and $r = MP_T^e$, income from enclosed production is exhausted in factor payments.[3]

The enclosure process is an aggregative game with the following sequence of events:

1. Owner-claimants independently and simultaneously decide whether to enclose

[3] This contrasts to de Meza and Gould (1992), who inadvertently build a form of scale economies into the enclosure process that complicates interpretations.

each (atomistic) parcel in $\bar{T}$.[4]

2. Labor reallocates between sectors until the wage paid in the enclosed sector equals the average product on unenclosed lands.

Labor will move between sectors until the marginal product of labor in the enclosed sector equals the average product on unenclosed lands, as in 13, so the equilibrium labor share is given by $l_e^*(t_e)$ in (14). We now find the equilibrium level of enclosure. The marginal return to enclosed land, or equivalently the land rental rate, can be expressed as a function of the enclosure rate as follows:

$$r = MP_T^E = (1-\alpha)\left(\frac{l_e^*(t_e)}{t_e}\cdot \bar{l}\right)^\alpha \tag{19}$$

Substituting in l_e^* from (14) into (19) gives r as a function of t_e:

$$r(t_e) = \theta \cdot (1-\alpha) \cdot \Lambda^\alpha \cdot \bar{l}^\alpha \cdot (1 + (\Lambda - 1)t_e)^{-\alpha} \tag{20}$$

This is an aggregative game ase each player's payoff can be written as a function of the player's own strategy and an aggregate of other players strategies, summarized by the enclosure rate t_e. Each would-be claimant compares the expected rent from enclosure in (20) to enclosure costs c. Claimants will choose to enclose when:

$$r(t_e) \geq c$$

with $r(t_e)$ is given by (20). In a Nash equilibrium, each claimant plays a best response to all the other players best responses summarized by the aggregate fraction of enclosed land t_e. Inspection of $r(t_e)$ reveals this function to owe its characteristics to those of (14). In particular $r'(t_e) > 0$, so r is *increasing* in t_e whenever $\Lambda < 1$ (or $\theta < 1/\alpha$). That is, in a low TFP gain economy, incentives to enclose *increase* with the rate of enclosure. There will be strategic complementarities between players in the enclosure decision which leads to the possibility of multiple equilibria and contagion effects (Vives, 2005; Acemoglu and Jensen, 2013). This mechanism is consistent with the labor expulsion story: each new enclosure *reduces* labor demand on the enclosed plot as well as land remaining in the customary sector, leading to labor crowding on the commons and a lower equilibrium wage.

When $\theta < 1/\alpha$, so the rental rate on enclosed land is increasing in the enclosure rate t_e, we can determine the other properties of $r(t_e)$ by testing the function at its endpoints.

[4] Hence (although the model is static) we can think of enclosed land from a previous as reverting to customary tenure if the claimant chooses not to pay c (e.g. taxes not paid, fences not repaired).

If $r(0) > c$, and $r'(t_e) > 0$, then the unique Nash equilibrium is complete enclosure. If $r(1) < c$, and $r'(t_e) > 0$, then the unique equilibrium is no enclosure. Finally, if $r(0) < c$ but $r(1) > c$, then there are multiple equilibria; either no enclosure or complete enclosure are Nash equilibria with the possibility that one Pareto dominates the other.[5] Starting at $t_e = 0$, it is privately unprofitable for any one owner to enclose land. If a large enough fraction of land were to suddenly become enclosed then all owner-claimants would find enclosure profitable.[6] Notice also that as returns to enclosure increase with the enclosure rate, the market equilibrium wage falls as labor returns in the commons are debased.

The analysis thus far is for the low TFP gain economy. Interestingly, something akin to the 'Tory' view prevails when enclosure leads to significantly large improvement, in a high TFP gain economy when $\Lambda > 1$ (or $\theta > 1/\alpha$). Then, $r'(t_e) < 0$, and r is decreasing in the fraction of land enclosed. Each new enclosure now *increases* labor demand on the enclosed plot, lowering congestion on remaining common land, driving up wages and exerting a dampening effect on further enclosures.

Enclosures occur until $r(t_e) = c$, if such a point is attainable. We can then say that if $r'(0) > c$, there will be some enclosure, and if $r'(1) > c$ there will be full enclosure. For enclosure to commence in the high TFP gain economy, it is required that:

$$r'(0) \geq c \quad \rightarrow \quad \bar{l} \geq \left[\frac{\alpha c}{(1-\alpha)\Lambda}\right]^{\frac{1}{\alpha}} = l_0^d \tag{21}$$

The condition $r'(1) > c$ leads to full enclosure, which requires:

$$\bar{l} \geq \left[\frac{c}{(1-\alpha)\theta}\right]^{\frac{1}{\alpha}} = l_1^d \tag{22}$$

All of this is shown on the right hand side of Figure 2, the l_0^d locus lies below the l_1^d locus in $\bar{l}, \theta$ space. For those $\bar{l}, \theta$ combinations above both loci, where population density and expected productivity gains are high, full enclosure occurs. For combinations below l_0^d, there is no enclosure, and between the two lines, partial enclosure occurs.

2.3.1 Private Enclosure as a Global Game

As discussed, in a low-TFP gain economy (if $\Lambda < 1$, or $\theta < \frac{1}{\alpha}$), the l_0^d locus lies *above* the l_1^d locus, and in the region in between strategic complementarities lead to

[5] de Meza and Gould (1992) identified the possibility of multiplicity but left other equilibria and comparative statics unmapped.

[6] There is an additional, interior equilibrium with partial enclosure that is unstable.

multiple equilibria. The theory of Global Games (Carlsson and van Damme, 1993; Morris and Shin, 2003) offers an equilibrium refinement that can be applied to reduce this multiplicity and map model parameters onto a single outcome.

This literature demonstrates the remarkable result that if each player observes some noisy signal of a payoff fundamental, multiple Nash equilibria can be replaced with a single Bayes-Nash equilibrium. The noisy signal can be of arbitrary form and made arbitrarily precise, effectively rendering a full-information game with distinct equilibria that depend on the value of a fundamental parameter. In our case, θ is a natural candidate.

Accordingly, suppose there is uncertainty about θ. Each owner-claimant receives a signal $x = \theta + \sigma\epsilon$ where ϵ has mean zero and finite support; σ scales the noise. As σ approaches zero, θ comes to be known by everyone, and as Morris and Shin (2003) show, a unique equilibrium cutoff strategy remains. If θ is greater than some θ^*, all agents enclose. θ^* can be found by finding the θ at which an owner is indifferent between enclosing or not, given a uniform expectation over the fraction of others enclosing. Thus, the critical θ is found by solving:

$$\int_0^1 \left[(1-\alpha)\frac{\Lambda}{\alpha}\bar{l}^{\alpha}(1+\Lambda t_e - t_e)^{-\alpha} - c\right] dt_e = 0 \tag{23}$$

Simplifying and rearranging (23) reveals full enclosure is an equilibrium if:

$$l \geq \left(\frac{\alpha c}{(1-\alpha\theta)}\frac{1-\Lambda}{\Lambda}\right)^{\frac{1}{\alpha}} = l_g^d \tag{24}$$

This locus is drawn in Figure 2. Full enclosure occurs in the parameter space above the dashed red line in the low TFP gain region. No enclosure occurs in the region below. To the right of the $\frac{1}{\alpha}$ line, there is either full, some, or no enclosure under private decentralized enclosure.

3 The Social Efficiency of Private Decisions to Enclose

We are now equipped to say when decentralized enclosure processes will lead to too little, too much, or efficient levels of enclosure. We can map these outcomes to parameter regions by superimposing Figure 2 upon Figure 1 as shown in Figure 3.

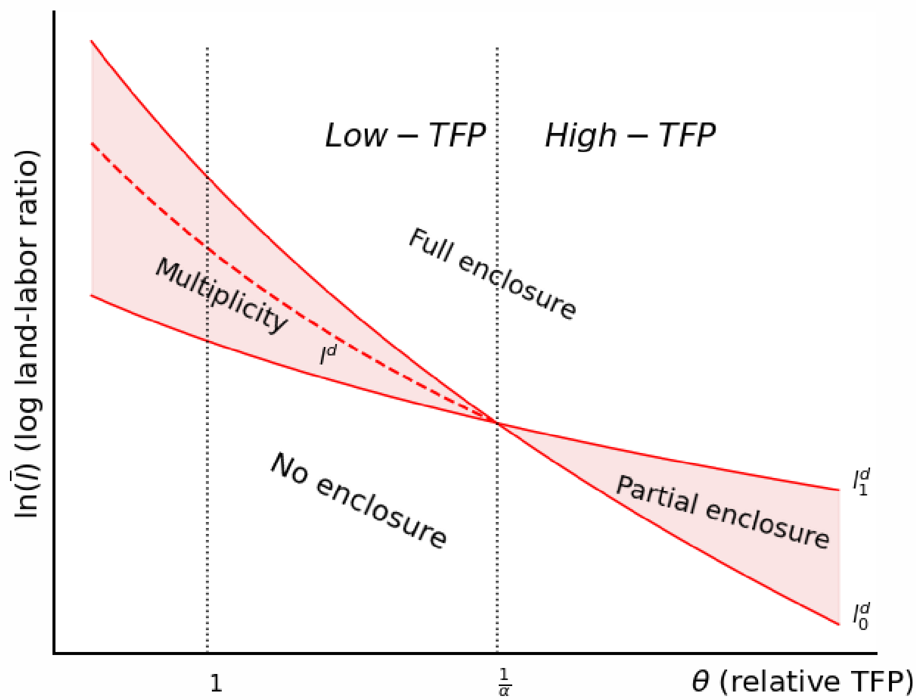

Figure 2: Equilibria with decentralized enclosures. In the low-TFP gain region, equilibria are either wtih full or no enclosure. In the high-TFP gain region, there is either no, partial, or full enclosure.

3.1 Inefficiently High Enclosure - Wasteful Property Scrambles

When the economy is described by parameters above the private l_0^d loci but below the social l_0^0 loci - at a point like X in figure 3 - the private economy is tipped into a race to full enclosure even though the socially optimum is to have no enclosure. A yet more serious social problem is evident for economies to the left of X where at $\theta < 1$ and high enough population pressure, private actors enclose all lands even though enclosures lead to the adoption of *worse* production technologies on every plot!

This happens because enclosure accomplishes three things: (1) technological transformation: it allows the adoption of new technologies, (2) allocative transformation: by establishing exclusion rights it changes labor allocation between sectors; and (3) redistributive transformation: enclosure, in effect, redistributes land from use-rights held by the community to private rights held by a new owner. Even though enclosure in the case above destroys value, if this last rent-shifting effect is large enough it can push private returns to enclosure above the cost of enclosure even when the latter exceeds

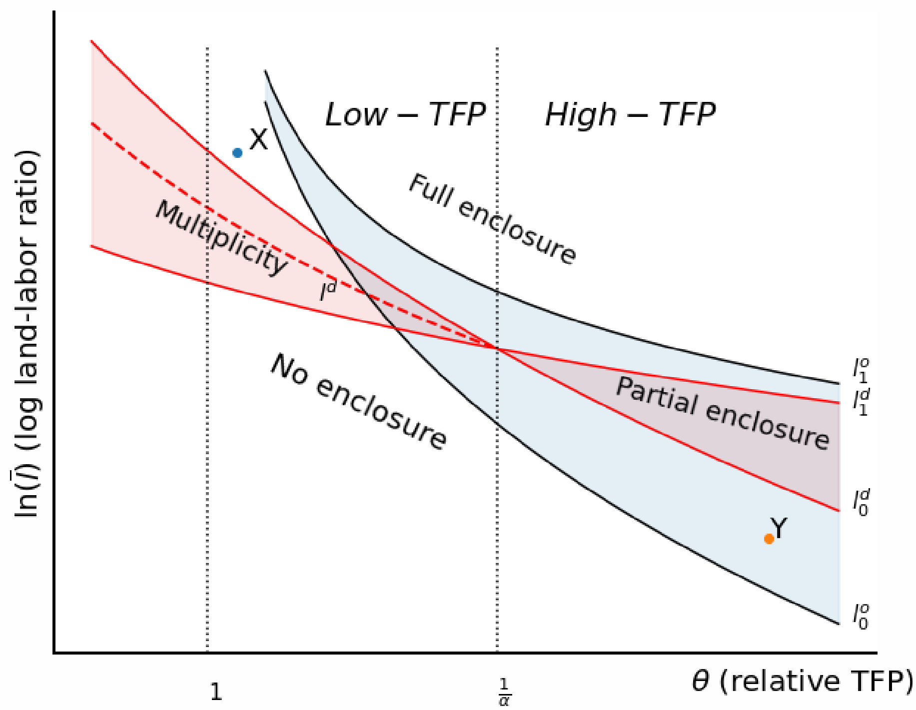

Figure 3: Decentralized and Optimal Enclosures Compared. The red shaded area describes regions where partial enclosure or multiple equilibria. The blue-shaded region describes optimal enclosure.

the social return.

3.2 Inefficiently Low Enclosure – Failures to Transform

Consider instead an economy characterized by point Y in figure 3. This is a high expected TFP gain economy above the l_0^o locus so some enclosure is socially desirable but no private enclosure occurs. The private rental that guides enclosure choices depends, in part, on how easy it is to hire labor into the enclosed sector but here labor/land density is low and returns in the commons are sufficiently high as to make private returns to enclosure fall short of costs. This possibility lies up with the 'agrarian fundamentalist' view that customary regimes hold back economic progress via resource mis-allocaton and an inability to transform from within.

This discussion has highlighted two areas in the parameter space where private and social interests diverge, but there are other interesting possibilities that can be intuited from figure 3 where the private economy either fails or manages to lead to an efficient outcome.

4 Labor displacement, wages, and inequality

In Weitzman (1974) and Samuelson (1974) the non-equalization of marginal products implied by (3) implies 'too much' labor 'crowds' into the unenclosed sector. A simple corollary of this is that labor demand on any given plot must, by necessity, fall as it is enclosed, and the equilibrium wage must therefore fall with the enclosure rate. Cohen and Weitzman (1975) built a 'Marxian Theory of Enclosures' around this kind of labor displacement effect, much studied and discussed in English enclosure debates.

That result is, however, derived under the assumption of unchanged technology (i.e. $\theta = 1$) and costless ($c = 0$), assumptions that also imply that in equilibrium enclosure must be either none or total. We are in a position to describe much more generally how enclosure processes distribution and efficiency. Labor's earnings consist of wages $w_e \cdot \bar{L}$ plus earnings from implied land rents. Using (14) we write this as a function of t_e:

$$Y_L = (1-\alpha) \cdot \theta \cdot F(\bar{T}, \bar{L}) \cdot \left(\frac{1 + (\Lambda - 1)t_e}{\Lambda} \right)^{1-\alpha} \tag{25}$$

In a low TFP state, when $\Lambda < 1$, Y_L is decreasing in t_e. Enclosure reduces earnings directly by extinguishing implied rents from land access and by displacing and crowding labor into what is left of the commons leading the wage to fall. Even where the balance of power is such that enclosure establishes claims for some or all existing users in ways that avoid or mitigate the loss of implied rents, labor demand will still be reduced on enclosed lands leading displaced labor (including, possibly, labor from the encloser) to crowd into what remains of the commons in search of rents. Only in high TFP gain economies, where $\Lambda > 1$ will wages rise.

The ratio of landlord-to-labor income ratio $r(t_e)t_e/Y_l$ can be computed as:

$$\left(\frac{1-\alpha}{\alpha} \right) \frac{\Lambda t_e}{1 + (\Lambda - 1)t_e} \tag{26}$$

In the low TFP economy with $\Lambda < 1$ landlords' relative share increases with t_e at an increasing rate, aggravating income inequality. Enclosure favors wages and the relative income distribution only in high TFP economies.

5 Enclosure by an encompassing interest

What if a single entity - a large 'owner-claimant' - were placed in charge of enclosure? This is a relevant policy question because the enclosure process might be initiated by a village authority acting on behalf of a community, or less-benignly by a large land-grabbing 'investor.' Starting in the 18th century, most English enclosures had to be initiated by a petitioned to Parliament initiated by a majority of landowner-claimants in an area (defined by land value).

A single claimant (or syndicate) makes enclosure decisions to maximize profits from subsequent land sales/rental $t_e r(t_e)$, which can be written, using (20), in per-unit terms:

$$\begin{aligned} \pi(t_e) &= r(t_e)t_e - ct_e \\ &= t_e\left[\frac{1-\alpha}{\alpha}\Lambda\bar{l}^{\alpha}(1+(\Lambda-1)t_e)^{-\alpha} - c\right] \end{aligned} \tag{27}$$

Profit per unit π is either concave or convex in t_e. In a low TFP gain situation the function is convex and the monopolist simply checks whether $\pi(1) > 0$ to enclose all land. Plugging $t_e = 1$ into (27) and solving as before we find this happens when:

$$\bar{l} \geq \left[\frac{c}{(1-\alpha)\theta}\right]^{\frac{1}{\alpha}}$$

This is exactly the conditional optimality condition (22), so a monopolist encloses exactly when it is optimal when $\Lambda < 1$. This makes sense as the monopolist internalizes enclosure spillover effects.

When, however, $\Lambda > 1$, the profit function becomes concave, which may yield none, some, or total enclosure. We again use the derivative test to check whether $\pi'(0) > 0$, so that some enclosure occurs, and whether $\pi'(1) > 0$, suggesting full enclosure. Differentiating (27), plugging in $t_e = 0$ and $t_e = 1$, and solving gives us the two loci:

$$\bar{l} \geq \left[\frac{\alpha c}{(1-\alpha)\Lambda}\right]^{\frac{1}{\alpha}} = l_0^m \tag{28}$$

$$\bar{l} \geq \left[\frac{\alpha c\Lambda}{(1-\alpha)(\Lambda(1-\alpha)+\alpha)}\right]^{\frac{1}{\alpha}} = l_1^m \tag{29}$$

On figure 4 we see where these monopoly lines lie relative to earlier described social and decentralized private optima. The loci for the monopoly case slopes up and is plotted in green.

In the low-TFP gain region, the monopolist encloses whenever it generates suf-

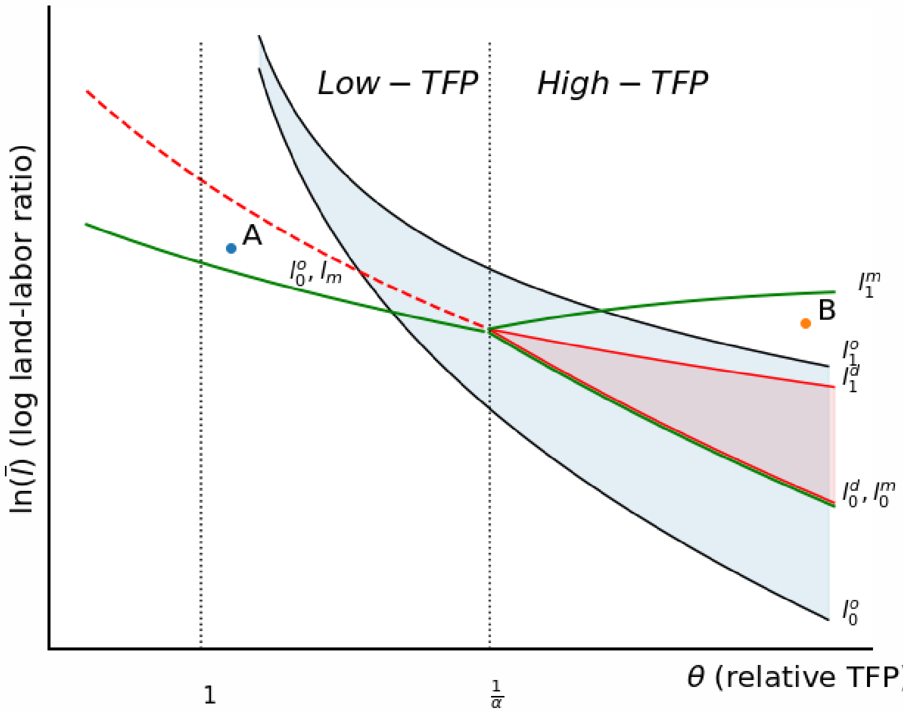

Figure 4: Competitive, Monopolistic, and Optimal Enclosures Compared. Above the green line, the monopolist encloses fully. In the high-TFP region of the space, the monopolist engages in partial enclosure bewteen l_0^m and l_1^m.

ficiently high returns to land. At a point such as A an encompassing interest will inefficiently enclose in situations where more decentralized interests would not. An encompassing interest faces no uncertainty about whether other parcels will also enclose, and hence chooses to enclose in every situation where $r(0) < c$, yet $r(1) > c$.

The situation is, however, very different in the high-TFP economy, when $\Lambda > 1$. At a point like B in figure 4, not all land is enclosedeven though it is efficient to do so, and all lands would be enclosed in the decentralized economy. Acting as a monopolist they enclose less to keep enclosed land scarce and drive up the rental rate.

6 Manufacturing and Structural Transformation

We can add a manufacturing sector to study structural transformation.[7] The labor market is now:

$$L_e + L_c + L_m = \bar{L} \tag{30}$$

In labor share terms:

$$l_e + l_u = 1 - l_m \tag{31}$$

Manufacturing sector production is

$$G(K, L_m) = \bar{K}^{1-\beta} \cdot L_m^{\beta} \tag{32}$$

Let p denote the relative price of manufactures in terms of agricultural goods, determined on world markets.[8] Manufacturing output requires labor and capital specific to manufacturing:

$$\begin{aligned} G(\bar{K}, L_m) &= G\left(\bar{K}, l_m \bar{L}\right) \\ &= l_m^{\beta} \cdot G(\bar{K}, \bar{L}) \end{aligned}$$

The marginal products of labor in manufacturing and enclosed agriculture are:

$$MP_L^M = \beta \cdot \left(\frac{1}{l_m}\right)^{1-\beta} \cdot \bar{k}^{1-\beta}$$

$$MP_L^E = \alpha \cdot \theta \cdot \left(\frac{t_e}{l_e}\right)^{1-\alpha} \cdot \bar{t}^{1-\alpha}$$

and the average product of labor in the customary sector is:

$$\begin{aligned} AP_L^C &= \frac{F(t_c, l_c)}{l_e} \cdot \frac{F(\bar{T}, \bar{L})}{\bar{L}} \\ &= \left(\frac{1 - t_e}{(1 - l_m) - l_e}\right)^{1-\alpha} \cdot \bar{t}^{1-\alpha} \end{aligned}$$

In equilibrium workers will settle with no incentive to move across sectors:

$$w = p \cdot MP_L^M = MP_L^E = AP_L^C > MP_L^C \tag{33}$$

[7] This is a sketch of a topic explored more deeply in a companion paper (Baker, Conning, 2021b).
[8] Alternatively, p can be determined in a closed economy equilibrium (Matsuyama, 2008).

Expanding the $MP_L^E = AP_L^C$ part, which drives mis-allocation:

$$(\alpha\theta)^{\frac{1}{1-\alpha}}\left(\frac{t_e}{l_e}\right) = \left(\frac{1-t_e}{(1-l_m)-l_e}\right) \tag{34}$$

Solving (34) gives:

$$l_e^*(t_e) = \frac{\Lambda t_e}{(1+(\Lambda-1)t_e)} \cdot (1-l_m) \tag{35}$$

which is similar to (14), but now accounting for a manufacturing sector. If we set $\bar{K} = 0$ (or $\beta = 0$) we recover our original model with perfectly inelastic labor supply to agriculture of $\bar{L}$. But with a labor-employing manufacturing sector, labor supply to agriculture $(1 - l_m(w)) \cdot \bar{L}$ becomes elastic.

All other expressions such as the private return to enclosure $r(t_e)$ in (20) can be similarly adapted. The primary effect of adding a manufacturing sector is that the opportunity cost of remaining in the customary sector increases and hence so too does mis-allocation. A failure to enclose can delay the structural transformation of the economy, but capital accumulation and/or productivity growth in manufacturing could actually make enclosure less likely by lowering the return to specific land in the agricultural sector.

7 Applications and Conclusion

A large number of new land property regularization, registration and titling programs have launched around the world (Deininger and Bank, 2003). Enabling national legislation in recent years has generally shifted toward granting statutory recognition to rural communities as collective owners of their lands, acknowledging the existence of community property whether and the operation of customary law (Alden Wily, 2018). This represents an important change from the past where rights of ownership under customary law were often kept limited by declaring such lands as held in trust by the state or, worse in some cases, as *terra nullis,* a practice that in the past enabled large-scale expropriations and transfers to other groups.

These programs aim to identify existing land claims by village entities and individuals, adjudicate disputes, map community and individual plot boundaries, regularize (i.e. zone) areas, and then issue certificates of residency or title to formalize residency or ownership. These are herculean, state building tasks. As James C. Scott points out "[m]ost states are 'younger' than the societies they purport to administer ... patterns of settlement, social relations ... have evolved largely independent of state plans... The result is typically a diversity, complexity, and unrepeatability of social forms that are relatively opaque to the state, often purposefully so (Scott, 1998)." As the quote suggests, in some cases that opaqueness and complexity to outsiders is part of what has protected community property against the predations of outsiders or the state itself, but it also protects local elites and intermediaries such as chiefs who administer and earn rents under customary law (Onoma, 2009). Efforts to formalize customary property and provide options to establish individual claims are challenging and complex because they potentially open the door to claim-shifting and conflict. In terms of our model, to tipping the economy into a scramble for property rights and land grabs. In response to this worry, however, some would say that such scrambles and grabs are already underway, and recognizing and formalizing customary title is in fact a necessary buttress to protect the rights of weaker claimants.

Many such these issues defy easy modeling, but the framework offers insight to a few key tradeoffs. For example, in environments with low population density, low expected TFP gain to enclosure, and/or high enclosure costs, the mis-allocations associated with customary common property regimes will tend to be low relative to the costs of new titles. But it is also in these low TFP gain environments where possibly well-intentioned policies to lower the cost of formalizing individual claims – lowering c in our model, could have the effect of tipping the economy into inefficient property rights scrambles with land-grabbing which risk displacing labor and raising inequality. In terms of the diagrams lowering c just shifts down all the partition lines vertically.

Weaker stakeholders (e.g. women, pastoralists) often stand to lose the most in such scrambles. A safer approach might be to first recognize village and community ownership of land, strengthen the governance, transparency, and administrative capacity of those corporate entities to manage existing customary property regimes. The aim should be, in a way, to strengthen customary institutions to avoid tipping into wasteful property scrambles. Only then later turn to demand-driven individual formalization of property relations that emerge from this customary sector.

The framework does make clear that there are situations, particularly in mid- to high- TFP environments where institutional transformation might get stuck due to coordination failure and where policy might play a role in lowering the cost c to jump-start a move toward more efficient arrangements. But here again, it makes sense to strengthen local governance capacity first to try to make sure that the new more exclusive claims that are established go to existing use-right holders and compensation mechanisms and safety nets are in place to avoid or mitigate distributional costs.

Population pressure and rising economic activity have strained traditional property rights institutions in many parts of the world, particularly in low productivity regions (Holden et al., 2013; Baland and Platteau, 1996). This in turn has led to land degradation. Many policy-makers have turned towards private ownership in the hopes that it might better align use incentives, raising productivity and reducing degradation of common land. The model makes clear that it is important not to just analyze this at the plot level, but to think of the equilibrium effects. From the expression for equilibrium labor-intensity $l_e^*(t_e)$ from (14) and earlier results we can establish that in high-TFP economy ($\Lambda > 1$), enclosure will raise productivity by enough to lead to more intensive labor use on private parcels drawing labor and pressure off less productive and crowded commons. However in the low-TFP economy ($\Lambda < 1$), the opposite is true, with each new enclosure, labor is displaced which leads at first to further crowding and more intensive use of common lands, which may be environmentally fragile. Worse yet, in low TFP gain environments which appear stable at first can be tipped into wasteful enclosure races which threaten to quickly displace existing use-right holders, raising inequality, and possibly crowding those displaced onto ever more crowded remaining common lands.

This relatively compact, tractable model also helps map seemingly quite disparate interpretations of historical experiences onto a common framework. The triumphalist 'Tory' interpretation of the effect of enclosures was that they overcame large inefficiencies, allowed the introduction of new technologies and, overall led to an increase in the overall demand foor labor. Consider figure 4. This interpretation can be identified with economies with relatively high TFP. The model is too stylized to be calibrated to every situation but it's worth noting that the high TFP threshold for labor displacement effects to be avoided is quite high. Assuming $\alpha = 1/2$, the productivity gain from enclosure would need to be $\theta > 1/\alpha = 2$) or a 100 percent gain. Allen (1992) placed the likely differential gains between yeoman farms on unenclosed lands and tenants on enclosed lands at no higher than 10 percent, which falls far short of any reasonable high TFP threshold. He also found, for the South Midlands, that labor displacement effects dominated concluding, in short, that enclosures represented a large scale redistribution, with landlords capturing most of the value from rising rents in this period, in exchange for relatively modest impacts on agricultural productivity. A more recent study by Heldring et al. (2021) finds a significant causal link from enclosure to productivity, but with rising inequality which is consistent with a positive TFP gain. They do not mention labor displacement but they do find rising inequality in parishes most heavily affected by Parliamentary enclosures. Labor displacement, by itself, is of course not necessarily a bad thing, it may be associated with transitions to either more efficient equilibria and the release of resources from agriculture to other sectors. It will be associated with lower equilibrium wages, but whether 'labor' as a group which includes former use-right holders in the customary sector gains or losers depends in part on whether enclosures are 'from below' or not.

The transformation of customary lands over time via various processes of 'enclosure' into more exclusive forms of private property has played an important role in economic history, in debates about land ownership reform, and in arguments over how institutional change impacts relative income distribution. We have shown how many issues in these debates can be usefully framed within an equilibrium model that allows for endogenous property rights transformation and claim-shifting. In contrast to many other treatments before us we have not assumed that customary tenure is inherently less efficient than private property, the relative desirability of managing land under different property regimes boils down to questions of how relative total factor productivity interacts with population density, the costs of enclosure, and market structures which vary greatly across environments. It is our hope that the framework offers a simple tool that sheds light on these complex and fascinating processes.

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