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Institutional Reform in the Rural Sector with Labor and Capital Flows: Factor Income Effects, Structural Changes and Misallocations

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Abstract

We analyze the general equilibrium effects of a fundamental property regime transition in the rural sector - agricultural or resource - when both labor and (reproducible) capital are free to move. In contrast to manufacturing, rural production has two characteristic features: it uses a fixed natural asset (land or other natural resources) and operates under one of two property regime types: common property versus exclusive property. Common property is fundamentally characterized with sharing, thus corresponding to such institutions as the family farm (Lewis 1954), free access to resources, and collective use, but adapted for the presence of capital use. We show that labor may actually gain from being effectively forced out of the rural sector. More generally, relative factor intensities determine the factor return effects of the transition, as well as either capital or labor deepening in both sectors. And while the unit cost of effective input efforts decrease, both factors flow out of the rural sector. Under a common property regime, the agricultural productivity gaps for labor and capital are uniquely determined by the output elasticity of land.

Key words: Institutions, Property Rights, Agriculture, Natural Resources, Factor Migration, Factor Returns, Redistribution, Factor Misallocation, Structural Changes, Agrarian Reform, Resource Privatisation

JEL Classification: D02, D23, D33, L16, N50, O13, O15, O17, Q15.

1 Introduction

Among the various processes associated with economic development, the transition from an agrarian or resource-based economy to a manufacturing one arguably constitutes its most remarkable expression. It transforms people's lives - for better or worse - and it is unescapable. Now among the few fundamental factors that together explain this transition, institutional change in the agricultural and resource sectors figures prominently. In this paper, we propose a new analysis of structural change brought about by the adoption of "modern" market institutions in the agrarian or resource sector. It differs from existing ones in that we allow for the free flow of *both* labor and capital, while accounting for the presence of fixed *natural assets* such as land and other natural resources. One significant implication is to show that labor may actually gain from being denied the rents from the natural assets. The economic forces at work provide new insights into the links between institutions and factor misallocation, factor migration, income distribution, factor intensity, capital deepening and productivity gaps. We can't underscore enough the fact that our results hinge on the presence of mobile capital and a fixed natural asset; while both are recognized as crucial to our understanding of structural changes, their *combined* presence seems to have escaped careful general equilibrium consideration in relation to institutional change.

The "traditional" property regime that we consider is referred to as *common property*. Its essential feature is that rents on the natural asset are shared between the users. This sharing property is mainly inspired by two fundamental institutions commonly analysed in two separate strands of the economics literature and it is still widely used in both empirical and theoretical work. One is the institution of the *family farm* as described in Lewis (1954) and Ranis and Fei (1961); it pervades the development economics literature, especially in relation to labor misallocations and rural-urban migration. The other is the regime of *free access* to natural resources as described in Gordon (1954) and Cheung (1970); it constitutes a founding block of the natural-resource economics literature. In the case of Lewis' family farm, we adapt it for the use of capital as an input; this, to our knowledge, constitutes a novelty.[1] This leads us to propose an equivalence result between the sharing family farm and the free-access equilibrium concepts with capital inputs.

Based on a collection of empirical cases provided in the text as illustrative of other "pre-capitalist" institutions, we conclude that the common property regime captures well one of the root causes of factor misallocations between the rural and manufacturing sectors. But

[1]The consideration of the use of capital by farmers in developing economies is consistent with Gollin's (2014) statement that "[Lewis'] assumption that only capitalists can invest productively seems inconsistent with current micro and macro evidence on savings behavior and investment. (83)" Note further that our analysis does not make use of the subsistence wage or surplus labor concepts, as they have not received much empirical support; the sharing property, on the other hand, is considered valid to this day. See the discussions in Ray (1998:360) and Gollin (2014).

while the sharing condition is still extensively used to explain the misallocation of labor by relying on the distinction between labor's average and marginal product values, it has largely ignored the concurrent effects on endogenous capital misallocations. Our analysis fills this gap.

The other property regime that we consider simply corresponds to the exclusive use of land or natural resources by one entity that seeks to maximize rents with the right choice of inputs. This is referred to as *exclusive property* and leads to the first-best allocation of factors.

From a theoretical perspective, our general equilibrium approach is mainly inspired by Weitzman (1974) and Cohen and Weitzman (1975). We consider an economy with two sectors only, referred to as rural and manufacturing here, where production in the rural sector requires the use of a fixed natural asset. We then compare two general equilibria depending on the property regime that prevails on the natural asset: common property versus exclusive property. While Weitzman (1974) considers labor to be the only mobile factor between the sectors, we add (reproducible) capital as a second mobile factor. This simple distinction yields many new results and insights. Foremost among them concerns the famous proposition that resource privatization causes labor wages to decrease. Indeed, we show that this result is not robust to the addition of capital as a mobile factor. The necessary and sufficient condition for wages to increase and capital returns to decrease is that the manufacturing sector be relatively labor intensive (in a way that we define precisely). We then provide empirical evidence to the effect that this condition is likely to be verified in many settings and conjecture that an important distinction may have to be made here between wheat and rice growing agricultural economies.

The fact that labor may gain from being effectively forced out of the rural sector seems paradoxical. But keep in mind that capital follows labor. Hence, as both factors move into the manufacturing sector in (generally) unequal proportions, factor intensities are affected and thus, factor returns change in opposite directions. The distinction is analogous to that made between the specific-factors and the Heckscher-Ohlin models of trade.[2] By analogy, our model may be conceived as providing the long-run effects of institutional change. That said, we retain the realistic and crucial feature that land or natural resources constitute important fixed inputs to the rural sector. Note finally that just like the Hecksher-Ohlin framework, our analysis is static in the sense that total factor endowments are considered fixed throughout.[3]

[2]Recall that the specific-factors model assumes that only labor can move between sectors while capital is riveted to its respective sector and as such, is viewed as delivering the short-run effects of trade. The Heckscher-Ohlin framework posits a free flow of labor and capital between sectors and this is interpreted as delivering a long-term view of the effects of trade. See Jones (1971), Mayer (1974) and Mussa (1974), or standard trade theory textbooks.

[3]It goes without saying that a dynamic version would yield additional insight. This is left for further work. As Temple (2005) rightfully contends, "It is a mistake to think that an understanding of economic

Our analysis yields additional contributions. We derive the conditions that characterize a common property equilibrium in the presence of three factors of production, one fixed and two mobile. In doing so, we propose a novel microeconomic dual approach that yields new insights into the structural changes brought about by a fundamental property regime change. We then show that the transition causes the price of one mobile factor to decrease and the other to increase, the net effect being an overall decrease in the unit cost of effective input efforts in the rural sector. Both labor and capital will nonetheless leave the rural sector. We further show that, under the same conditions that cause wages to increase, the transition causes a general capital deepening of the production processes even though the aggregate capital-labor ratio is unchanged. Finally, with the use of Cobb-Douglas technologies, we show that the agricultural productivity gaps of labor and capital are uniquely dictated by the output elasticity of the natural asset.

In the natural-resource literature, Weitzman's (1974) proposition that wages would be negatively affected by resource privatization while being more efficient has sparked a literature which extended the model's basic assumptions into various directions. This includes Anderson and Hill (1983) on transaction costs, Brooks and Heijdra (1990) on enforcement labor, Intriligator and Sheshinski (1997) on a heterogeneous labor force and Ambec and Hotte (2006) on imperfect enforcement. None of these, however, discusses the role of capital. To our knowledge, de Meza and Gould (1987) is the only paper that hints at the potentially important role of a second variable factor, but the analysis is not carried out. Our model is also inspired by Karp (2005), who argues that when considering the interactions between trade openness, property regimes, and natural resource use, one should treat *both* labor and capital as mobile factors between the resource and manufacturing sectors. This is in response to previous analysis that ignored the role of capital, such as Chichilnisky (1994), Brander and Taylor (1997) and Hotte, Long and Tian (2000). Karp (2005), however, focuses on the link between trade openness and the excludability of capital use.

In the lineage of the Lewis (1954) model and "dualism" in development economics, the literature is quite extensive and the reader is referred to the two excellent reviews by Temple (2005), who "argues that dual economy models deserve a central place in the analysis of growth in developing countries (435)", and Gollin (2014), who believes that "the model remains a powerful and useful tool for thinking about growth because it correctly identifies a key feature of the growth process – namely, the importance of within-country gaps in income and productivity, or dualism. (73)" One noteworthy paper is Drazen and Eckstein (1988) who similarly compare different property regimes but under the assumption that agricultural production does not require capital. Regarding dualism, the closest paper to ours in spirit may be that of Corden and Findlay (1975), who look at the effects of introducing capital mobility into the Harris and Todaro (1970) framework. The Lewis model being considered the main "competing" model to the Harris-Todaro one regarding rural-urban migrations

development can only ever be gained by analysing dynamic models... (439)"

(Ray 1998), performing the exercise in the Lewis context seems overdue.

Our analysis is equally motivated by the burgeoning literature on the economics of growth that looks at factor misallocations between the agricultural sector and other sectors. It generally concludes that a large share of cross-country variations in aggregate total-factor productivity can be explained this way. This work includes Caselli (2005), Temple and Wossmann (2006), Restuccia et al. (2008), Vollrath (2009), Adamopoulos and Restuccia (2014) and Gollin et al. (2014a). This literature has begun to spark renewed interest into the economic determinants of factor misallocations. Young (2013) and Munshi and Rosenzweig (2016), for instance, respectively look at the roles of human capital and networks. Our analysis complements this work and goes some way into addressing the specific grievances expressed in Foster and Rosenzweig (2008) about the call for future work "... to develop a more comprehensive simple general-equilibrium model of a rural economy incorporating factor flows [...] both capital and labor (3052-54)", to account for "the presence of a dominant fixed factor in agricultural production (land) (3053)", and that "... careful consideration needs to be given to the extent to which migrant households lose their claim on local assets when they migrate (3081)".

The paper is organised as follows. In Section 2, the economy is defined with production technologies, endowments, and institutions. Sectoral equilibrium conditions are laid out in Section 3 for each property arrangement. Section 4 presents the factor-payment and displacement effects of a property regime transition. Some empirical implications regarding relative factor intensities and productivity analysis are discussed in Section 5. The conclusion offers avenues for future research.

2 The economy: Endowments, technologies and institutions

Production requires three types of factors: labor, reproducible capital, and natural (non-reproducible) capital, with respective fixed total endowments $\bar{L}$, $\bar{K}$ and $\bar{T}$. We think of $\bar{T}$ as a country's natural resource endowment such as the total extent of its agricultural land surfaces, the size of its fishing grounds, the availability of underground minerals and water, or its forests.[4] To avoid confusion, reproducible capital will be referred to as K-capital.

The economy is composed of two main sectors. While we will refer to them as *rural* (R) and *manufacturing* (M) for concreteness, they are really distinguished by two essential features. One concerns the factor requirements for production: the manufacturing sector needs only labor and reproducible capital; the rural sector needs all three factors. The other concerns the fact that two types of property regimes may prevail over the natural asset. Hence, depending on the reference literature, our rural and manufacturing dichotomy typ-

[4]Note that we abstract from stock-flow dynamics regarding soil quality or other renewable and non-renewable resources. We leave that for required future work as we wish to concentrate on the interactions between the change of institutional setting and capital mobility.

ically corresponds to *agricultural* and *non-agricultural* when discussing structural changes, *rural* and *urban* for migration analysis, *natural resource* and *manufacturing* for property regime changes, *traditional* and *modern* for dual economies, or the distinction made between *agriculture* and *rural non-farm* activities by Foster and Rosenzweig (2008). It should become clear that our analysis is of relevance to all these literatures.

Since both sectors require labor and reproducible capital, we refer to these as the mobile (or variable) factors. The natural capital is called the fixed factor because its size cannot be varied in the rural sector.

2.1 The manufacturing sector

Manufactures are produced using labor L^M and K-capital K^M only, with a constant returns to scale technology. The output Y^M of the entire manufacturing sector is thus represented by the following relation:

$$Y^M = F^M(L^M, K^M), \tag{1}$$

where function F^M is twice continuously differentiable, strictly quasi-concave, homogeneous of degree one, increasing in both arguments and such that $F^M(0,0) = 0$.

2.2 The rural sector

In order to produce rural goods, all three factor types are required: labor L^R, K-capital K^R, and the fixed factor $\bar{T}$.

It is important to keep in mind that even among poor rural communities, reproducible capital may play an important role in farming. Indeed, because the K-capital input in agriculture is often construed as being only composed of machines and structures such as tractors, plows, barns or silos, one is often led to believe that due to their scarcities in developing economies (or in medieval times), agriculture is (was) a predominantly labor-using activity. This is misleading because reproducible capital in agriculture also includes livestock (sheeps, cows, bullocks, etc) and treestock (orchards, plantations, etc).[5] This agricultural capital incorporates all of the fundamental features of machinery: it is a productive asset that can be imperfectly substituted for land and labor; it is produced; it is rival in use; and it depreciates. Of particular relevance to us is the fact that it is the fruit of an investment with "time-to-build" and depreciation.[6] This means that in the medium to long run, a savings stock can be moved from one sector's K-capital investment to another as relative

[5]See, for instance, Jarvis (1974), Jorgenson and Gollop (1992), Rosenzweig and Wolpin (1993), Mundlak (2001) and Mundlak et al. (2012).

[6]See, for instance, Rosen et al. (1994) and Fafchamps (1998).

factor payoffs vary.[7]

We assume constant returns to scale in the three-input vector $(L^R, K^R, \bar{T})$. But because $\bar{T}$ is *fixed*, production in the rural sector really exhibits *decreasing* returns to scale with respect to the *variable* input vector (L^R, K^R). For simplicity, the rural output can simply be represented as a function of the two variable inputs. We accordingly represent the rural production technology as follows.

Let the individual *effective effort* exerted on the fixed asset by individual i be expressed as $Z_i = F^R(L_i^R, K_i^R)$, where L_i^R and K_i^R respectively denote the amounts of labor and K-capital inputs supplied by rural worker i. Function F^R is assumed twice continuously differentiable, strictly quasi-concave, homogeneous of degree one, increasing in both arguments and such that $F^R(0,0) = 0$.

With n individuals active in the rural sector, let the total output produced in the rural sector be given by $Y^R = f(Z)$, where $Z = \sum_{i=1}^n Z_i$ is the total effective effort. Function f is twice continuously differentiable, increasing, strictly concave and such that $f(0) = 0$.[8] To summarize, we have:[9]

$$Y^R = f(Z),\ f' > 0,\ f'' < 0,\ \text{[total rural output]} \tag{2}$$

$$Z = \sum_{i=1}^{n} Z_i \text{ where } Z_i = F^R(L_i^R, K_i^R).\ \text{[rural effective input effort]} \tag{3}$$

2.3 The institutional settings

Producers are price takers throughout, for both inputs and outputs. We assume a small open economy for which output prices are exogenously fixed on world markets. Factor prices will however be endogenously determined by the general equilibrium conditions. Labor and K-capital are free to move between sectors.

In the case of labor and K-capital, we assume that there are no property right issues in the sense that they are both perfectly excludable at no cost. Owners of these factors will thus seek to maximize their respective payoff.

The focus of our analysis will be to compare equilibria when either of two different property regimes prevail over the fixed factor used in the rural sector. For clarity, we refer to the payoff from the fixed asset as a *rent*. We define the two regimes as follows:

[7]The shift in agricultural production observed in England after the Black Death (1348-1350) provides an interesting historical example. The reasoning is that as the plague wiped out close to half of the population, the relative cost of labor increased in such a way that farmers shifted a good share of their land use from arable to (sheep) pasture, the later being much more capital-intensive, and the transition spread-out over many years in part because of the time needed to build up the livestock (Campbell et al. 1996).

[8]The strict concavity assumption for f, combined with constant returns to scale for F^R, insures that we have decreasing returns to scale on (L^R, K^R), where $L^R = \sum_{i=1}^n L_i^R$ and $K^R = \sum_{i=1}^n K_i^R$.

[9]Note that the rural sector is composed of just one site for simplicity. The presence of multiple sites would not alter the qualitative nature of our results given that we assume price-taking behavior throughout.

Definition 1 *Under* exclusive property *(EP), the totality of the rents generated by the natural asset accrue to its owner(s)* independently *of its (their) labor and K-capital inputs. The owner(s) can perfectly and costlessly control the amounts of both labor and K-capital to be used on this asset.*

Definition 2 *Under* common property *(CP), rents are distributed between all individuals who* actively *work on the natural asset with their labor input. Rent shares are proportional to the* effective *input effort. Moreover, no worker can be* expelled *from using the natural asset.*

Exclusive property corresponds to the standard situation of total rent maximization for the fixed asset. Common property, in contrast, does not lead to rent maximization. As we demonstrate below, it rather leads to an equalization between the average return per worker *on the fixed asset* and the wage rate that prevails in the rest of the economy.[10] This equalization result is not new to the literature, to be sure. This literature, however, typically considers labor to be the sole variable factor. With K-capital as a second variable factor, the corresponding equilibrium condition will need to be carefully adapted.

We believe that the equilibrium conditions that we derive for the intersectoral allocation of K-capital and labor in the common property regime constitute a fair representation of traditional or pre-capitalist institutions such as the *family farm* in developing countries in general, *common property* land or resources in medieval Europe, *collective farming*, and *open-acces* to natural resources such as fishing grounds.

Note that we do not mean to imply that the above-mentioned institutions are equivalent in all respects.[11] However, they do share one very fundamental feature, which is that rents tend to be shared between those who work on the land or resource and that the choice of staying or not belongs to the individual rather than the group. The following presents a list of well-known, representative cases.

The sharing argument for the family farm dates back to Lewis 1954 and has a long tradition in the economics of migration (Ray 1998). More recently, Foster and Rosenzweig (2008) provide empirical evidence that suggests "that migrants in fact do give up at least some of agricultural profits when they leave" (3076). In the case of medieval England, Cohen and Weitzman (1975) argue that under open field agriculture, there was an "equalizing tendency" within and between villages and that "We have no evidence that villagers attempted to exclude a newcomer" (298). Zhao (2015) explains that before a rural land reform in 2003 in China, "land [was] collectively owned at the village level" (1) and shows that land was frequently reallocated in order to equalize per-capita output between the village households.

[10] In the normative literature on rules of division, our common property regime corresponds to the *proportional allocation rule* in Roemer (2015).

[11] Carter (1984), for instance, states that due to a lower information burden, incentives to free-ride on the effort of others are less acute on the family farm than for collective farming.

Regarding a land reform in Russia in 1906, Chernina et al. (2014) mention that "[...] the opportunity cost of migration decreases [following a switch from communal to individual ownership] because owners are able to better extract land rent without being physically present" (192). For the decollectivization of agriculture in Eastern Europe that began in 1989, Mathijs and Swinnen (1998) state that "A crucial factor that determines decollectivization is the ratio of the average labor productivity of an individual farm started up by an individual who left the collective farm over the average labor productivity of the collective farm" (7). For the case of open-access to natural resources, the link with the average product of input efforts is well known and is attributed to Gordon (1954). The discussion over *tied rents* in Lucas (1997) is also consistent with our definition of common property.

Note finally that our common property regime is consistent with the Ranis and Fei (1961) assumption of an agricultural wage that is determined by an "institutional force" instead of a "subsistence wage", which Gollin (2014) presents as the more empirically relevant application of the Lewis model. And though we agree with Gollin (2014) that rents are rarely shared perfectly equally, the fact that some sharing is going on between on-site users implies that the assumption of rent maximization and equality of labor's marginal products is not realistic either. Given this, the equilibrium conditions that we will derive under perfect sharing among workers seem like a fair approximation to make in order to contribute to a literature that has generally ignored the role of K-capital mobility with a fixed asset.

3 Equilibrium conditions

We take manufactures as the *numéraire* good. w and r denote the respective prices of labor and K-capital. p is the price of the rural good, exogenously fixed on world markets. We consider only interior solutions in which both sectors are simultaneously active. For the mobile factors, the following market clearing conditions apply throughout:

$$L^M + L^R = \bar{L} \text{ and } K^M + K^R = \bar{K}. \tag{4}$$

3.1 Manufacturing sector

In order to maximize profits, manufacturers simply equate marginal product values with factor prices, i.e.,[12]

$$F_L^M(L^M, K^M) = w \text{ and } F_K^M(L^M, K^M) = r. \tag{5}$$

In order to represent the equilibrium in the manufacturing sector, it will also be convenient to make use of the cost-minimization dual to (5). Given constant-returns to scale, the

[12]The subscript of a function denotes a partial derivative.

unit cost of producing one unit of manufacturing output depends on factor prices only and is denoted $c^M(w,r)$; this function has the usual properties of a cost function. Since manufactured goods are used as numéraire goods, the equilibrium in the manufacturing sector is represented by the following zero-profit condition:

$$c^M(w,r) = 1. \tag{6}$$

3.2 Rural sector

Equilibrium conditions in the rural sector depend on which property regime prevails.

3.2.1 Exclusive property (EP)

Under EP, the rural owner(s) – say a firm with share-holders – gets to choose variable input vector (L^R, K^R) by hiring labor and K-capital in order to maximize profits. The problem of the firm is

$$\max_{L^R,K^R} \pi = pf(Z) - [wL^R + rK^R], \tag{7}$$

where $Z = F^R(L^R, K^R)$. This yields the following pair of first-order conditions:

$$pf'(\hat{Z})F_L^R(\hat{L^R}, \hat{K^R}) = w \tag{8}$$

$$pf'(\hat{Z})F_K^R(\hat{L^R}, \hat{K^R}) = r. \tag{9}$$

These conditions simply state that under EP, the owner equates the marginal product value of each variable factor to its cost. The circumflex symbol will refer to the EP equilibrium.

From the perspective of cost minimization, as a profit maximizer, the owner seeks to minimize the cost of any realized exploitation effort level Z. Now given that $Z = F^R(L^R, K^R)$, that F^R exhibits constant returns to scale, and price taking, the unit cost of Z is considered constant by the firm and dependent on input vector cost (w,r). As a result, letting $c^R(w,r)$ denote the unit cost of Z, the problem of the owner can also be expressed as follows:

$$\max_Z \pi = pf(Z) - Zc^R(w,r). \tag{10}$$

The owner's optimal exploitation effort is thus given by

$$pf'(\hat{Z}) = c^R(w,r). \tag{11}$$

Conditions (8) and (9) are equivalent to (11) as a way to represent the EP exploitation level in the rural sector.

3.2.2 Common property (CP)

In the CP regime, worker i must choose her individual effective effort level $Z_i = F^R(L_i^R, K_i^R)$ to spend on the common asset. We assume that a worker inelastically supplies a total of one unit of labor and that one cannot split her time between the rural and the manufacturing sectors; hence, $L_i^R = 1$ and thus $L^R = n$. In the case of K-capital, each worker can hire any amount at rental cost r. Given that output is shared in proportion to the effective effort, i's net payoff is thus given by:

$$\pi_i = pf(Z)\frac{Z_i}{Z} - rK_i^R, \tag{12}$$

where $Z_i = F^R(1, K_i^R)$ and $Z = \sum_{i=1}^n Z_i$. One notes that under common property, each worker is remunerated according to the average product of effective effort on the fixed asset. For analytical convenience, let us define the following average product function: $\phi(Z) \equiv f(Z)/Z$. In order to simplify the analysis, we assume that each rural worker takes the average product as given when deciding on her individual effort.[13] The first-order condition for i's choice of capital input is thus:

$$\frac{\partial \pi_i}{\partial K_i^R} = p\phi(Z)F_K(1, K_i^{R*}) - r = 0. \tag{13}$$

This condition can be interpreted as follows. Adding one marginal unit of K-capital will increase the effective effort by F_K^R. This increase is then multiplied by the average product of effective effort in order to arrive at the extra output received by user i; this increase exceeds the overall increase because it ignores the cost imposed on other users in terms of reduced average product of effective effort. The only cost that each user accounts for is the direct cost of K-capital r. This contrasts with EP condition (9), where multiplication with the marginal product of effective effort insures that the drop in average product of all users is well accounted for by the exclusive owner.

With identical workers and the fact that function F^R has constant returns to scale, (13) implies that

$$F_K^R(L^R, K^{R*}) = \frac{r}{p\phi(Z)}. \tag{14}$$

[13]This assumption approximates a situation with a large number of users on the fixed asset (Cheung 1970), which greatly simplifies the analysis in the context of a general equilibrium model. It seems reasonable in the case, for instance, of a fishery, a large pasture land, or a large family farm. In the case of a small family farm, one would expect the individual to account for the effect of her decision on the average product. There is no reason to believe, however, that this would alter the qualitative nature of our results in any significant way. Indeed, as we shall see below and in concordance with much of the literature, the main point is that the marginal product of effective effort lies below its opportunity cost in the common property regime.

For given L^R, this condition defines the equilibrium total and individual effective efforts being supplied, respectively Z^* and Z^*/L^R, and the corresponding individual equilibrium payoff $\pi^* = (p\phi(Z^*)Z^* - rK^*)/L^R$. In order to determine the amount of labor active in the rural sector, we impose the condition that a worker receives the same net payoff in both sectors. Since the manufacturing sector brings wage w, we must have $\pi^* = w$, i.e.,

$$\frac{p\phi(\tilde{Z})\tilde{Z} - r\tilde{K^R}}{\tilde{L^R}} = w, \tag{15}$$

where the *overtilde* symbol signifies an equilibrium that satisfies both (14) and (15) for given w and r. Note that equality (15) corresponds to rent dissipation from the fixed asset in the CP regime as it implies that $pf(\tilde{Z}) = r\tilde{K^R} + w\tilde{L^R}$. We have the following proposition:

Proposition 1 *With K-capital and labor as mobile factors, common property, as per definition 2, is characterized by the following two equilibrium conditions, which correspond to (total) rent dissipation:*

$$p\phi(\tilde{Z})F_L^R(\tilde{L^R}, \tilde{K^R}) = w, \tag{16}$$

$$p\phi(\tilde{Z})F_K^R(\tilde{L^R}, \tilde{K^R}) = r. \tag{17}$$

Proof: Equality (17) has already been derived in (14). We now derive equality (16). Because $F^R(L^R, K^R)$ has constant returns to scale, we have $Z = LF_L^R + KF_K^R$. Substituting (14), this gives $Z = LF_L^R + rK/(p\phi(Z))$ or, equivalently, $p\phi(Z)Z = p\phi(Z)LF_L^R + rK$. Making use of the rent dissipation result, this gives $p\phi(Z)LF_L^R + rK = rK + wL$, which simplifies to $p\phi(Z)F_L^R(L^R, K^R) = w$. *Q.E.D.*

One notes from (16) and (17) that the CP equilibrium is characterized by the following cost minimization condition for effective effort: $r/w = F_K/F_L$. Hence the following corollary which will prove useful:

Corollary 1 *Given the opportunity costs of labor and K-capital, the total effective effort level in the common property equilibrium $\tilde{Z}$ coincides with cost minimization.*

Recalling that with cost minimization, the unit cost of effective effort can be represented by function $c^R(w, r)$ and combining this with the rent dissipation condition, we obtain that the CP equilibrium in the rural sector can be conveniently summarized by the following condition:

$$p\phi(\tilde{Z}) = c^R(w, r). \tag{18}$$

The above condition is the common property regime analog of condition (11) for the exclusive property regime. *While both property regimes subsume cost-minimization of effort, the EP regime maximizes rents on the fixed asset while the CP regime drives them down to zero.*

Those familiar with the natural-resource economics literature may have noticed the similarity between equilibrium condition (18) and the one derived by Gordon (1954) for a common property fishery. The two are indeed equivalent if one assumes that in choosing its fishing effort, each firm, by minimizing costs over labor and K-capital, acts as if the cost of effort were constant at $c^R(w,r)$. However, when comparing expression (11) with (18), one should be cautious to conclude that equilibrium effort under CP exceeds that of EP simply because the average product curve lies above the marginal product curve, which is the essence of Gordon's (1954) argument. Things are not as simple in a general equilibrium setting. Indeed, with mobile factors, a change of property regime will affect factor prices, as noted by Weitzman (1974). The unit cost of effort $c^R(w,r)$ thus differs between (11) and (18), which means that more information is needed in order to determine whether Z increases or decreases following rural privatization. A further complication with respect to Weitzman (1974) is that we now have two factors whose prices move in opposite directions, as will be seen below.

To summarize, under EP, the economy's general equilibrium is characterized by the following set of nine equations: (1), (2), (3), (4), (5), (8) and (9). It contains nine endogenous variables: $w, r, L^M, K^M, L^R, K^R, Z, Y^M$ and Y^R.

The general equilibrium under CP is characterized by the following set of nine equations: (1), (2), (3), (4), (5), (16) and (17). A comparison with the EP conditions shows that only two conditions differ, i.e., (8) and (9) have been replaced by (16) and (17).

A comparison of the two pairs of conditions that differentiate between property regimes underscores the crucial role played by the presence of the fixed natural asset for institutional change. Indeed, in the absence of a fixed factor, effective efforts Z in the rural sector are not subject to decreasing returns anymore. This means that marginal and average products are equalized, i.e., $f'(Z) = \phi(Z)$, and consequently, nothing differentiates the two property regimes. Hence the following proposition, which we state without further proof:[14]

Proposition 2 (Fixed assets and institutional change) *In the absence of a fixed asset in the rural sector, the exclusive and common property equilibria are identical.*

In section 5 below, we will add further structure to this proposition by highlighting the important role played by the output elasticity of the fixed asset.

4 The general equilibrium effects of a property regime change

Our core result is presented in Section 4.1 in the form of Theorem 1. For expository purposes, in order to demonstrate Theorem 1 in Section 4.1, we impose *a priori* that the rural sector's

[14]This result is consistent with Demsetz (1967), who points out "the close relationship between property rights and externalities. (347)" Indeed, in our setting, the presence of a fixed factor is necessary for negative externalities to be present between the users of the natural asset under the common property regime.

total effective effort level under EP is lower than under CP, i.e., $\hat{Z} < \tilde{Z}$. The demonstration that this inequality must hold in equilibrium is deferred to Section 4.2.

4.1 Factor payment effects

Let us define factor intensity as follows:

Definition 3 *Let $l^S \equiv L^S/K^S$ and $k^S \equiv K^S/L^S$ respectively denote labor and K-capital intensity of use in sector S, $S \in \{M, R\}$.*

Theorem 1 (Factor returns) $\hat{w} \geq \tilde{w} \Leftrightarrow \tilde{l}^M \geq \tilde{l}^R$ *and* $\hat{r} \geq \tilde{r} \Leftrightarrow \tilde{k}^M \geq \tilde{k}^R$.

Theorem 1 states that the transition from a common property regime to an exclusive property regime will benefit (harm) the factor that is initially used more (less) intensively in the manufacturing sector relative to the rural sector. In order to demonstrate this theorem, let us introduce some lemmas.

Lemma 1 states that both sector's factor intensities vary in the same direction when access is restricted:

Lemma 1 $\tilde{l}^M \leq \hat{l}^M \Leftrightarrow \tilde{l}^R \leq \hat{l}^R$ *and, equivalently,* $\tilde{k}^M \leq \hat{k}^M \Leftrightarrow \tilde{k}^R \leq \hat{k}^R$.

Proof: Regardless of the prevailing property regime, cost minimization in the production of manufactures and rural exploitation effort requires the following condition to hold:

$$\frac{F_L^M}{F_K^M} = \frac{w}{r} = \frac{F_L^R}{F_K^R}.$$

Now marginal products F_L and F_K are respectively decreasing and increasing in labor intensity. Hence if the factor price ratio w/r decreases (increases), labor intensity must be increasing (decreasing) in both sectors. *Q.E.D.*

Lemma 1 can be illustrated with the help of Figure 1. Here, O^R and O^M denote the origins for the rural and manufacturing sectors respectively, and $\bar{L}$ and $\bar{K}$ are the economy's total factor endowments. One notes that the manufacturing sector is relatively labor (K-capital) intensive for all factor allocations above (below) the diagonal line $O^R O^M$. Lemma 1 therefore implies that if the manufacturing sector is relatively labor (K-capital) intensive under CP, as with the point labeled CP (CP′), then the EP equilibrium must fall in either of areas A or B (A' or B'). One consequence is that *the sectors' factor intensity rankings are independent of the prevailing property regime.* Hence the following corollary:

Corollary 2 *There is* **no factor intensity reversal** *associated with a property regime change.*

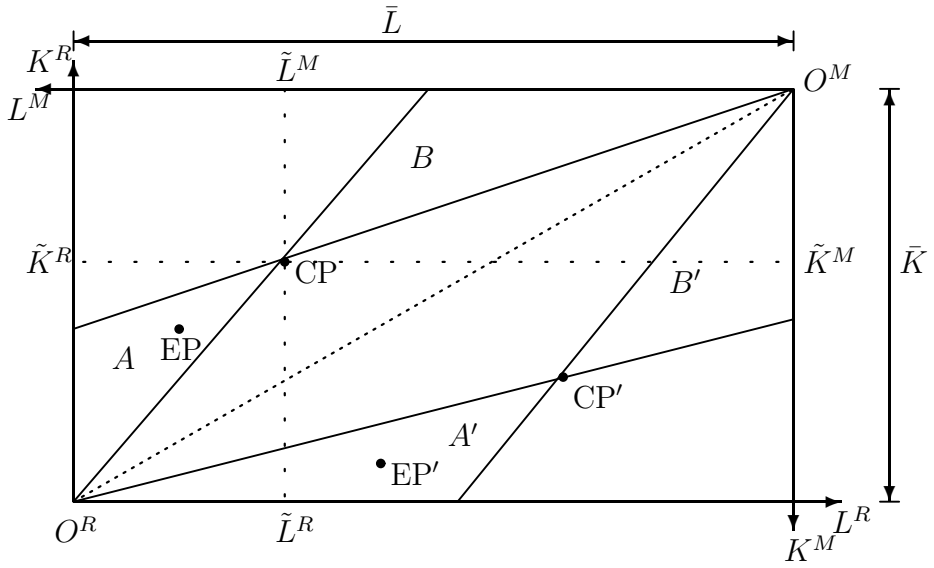

Figure 1: Property regimes, factor allocations, and factor intensities

Proof: A reversal of relative factor intensities between sectors implies that equilibria in each property regime are located on opposite sides of the diagonal line $O^R O^M$ in Figure 1. This violates Lemma 1. *Q.E.D.*

The following proposition states that when EP is consistent with a drop in rural total effective effort as compared to CP, then EP leads to a decreased use of *both* factors in the rural sector.[15]

Proposition 3 $\hat{Z} < \tilde{Z} \Leftrightarrow (\hat{L}^R, \hat{K}^R) \ll (\tilde{L}^R, \tilde{K}^R)$ *and, equivalently,* $(\hat{L}^M, \hat{K}^M) \gg (\tilde{L}^M, \tilde{K}^M)$.

Proof: i) $\Rightarrow$ Given that $\hat{Z} < \tilde{Z}$, then either $\hat{L}^R < \tilde{L}^R$ or $\hat{K}^R < \tilde{K}^R$, or both. However, if one factor increases while the other decreases in the rural sector, market clearing implies that the opposite happens in the manufacturing sector, which means that factor intensities move in opposite directions, thus violating Lemma 1. Consequently, it must be the case that $\hat{L}^R < \tilde{L}^R$ and $\hat{K}^R < \tilde{K}^R$, and as a result of market clearing, we have $\hat{L}^M > \tilde{L}^M$ and $\hat{K}^M > \tilde{K}^M$.

ii) $\Leftarrow$ is obvious. *Q.E.D.*

[15]Note that Lemma 3 does not demonstrate that effective input efforts in the rural sector decrease under EP. This demonstration is deferred to Section 4.2.

The following lemma states that if, under CP, the manufacturing sector uses one factor more intensively than the rural sector, then the intensity of use of that factor must be lower under EP, and conversely.

Lemma 2 *If* $\hat{Z} < \tilde{Z}$ *then* $\tilde{l}^M \geq \tilde{l}^R \Leftrightarrow \tilde{l}^M \geq \hat{l}^M$ *and, equivalently,* $\tilde{k}^M \geq \tilde{k}^R \Leftrightarrow \tilde{k}^M \geq \hat{k}^M$.

Proof: i) $\Rightarrow$ According to Lemma 1, given that $\tilde{l}^M \geq \tilde{l}^R$, as depicted by point CP in Figure 1, the new equilibrium with EP must fall strictly within either of areas A or B. Lemma 3, however, rules out area B as a possibility when $\hat{Z} < \tilde{Z}$. As a result, the EP equilibrium is such that $\tilde{l}^M \geq \hat{l}^M$.

ii) $\Leftarrow$ a) Begin with the strict inequality $\tilde{l}^M > \hat{l}^M$. According to Lemma 1, we also have $\tilde{l}^R > \hat{l}^R$. It is straightforward to verify then that when $\tilde{l}^M < \tilde{l}^R$, the preceding two inequalities imply $\hat{Z} > \tilde{Z}$, which we ruled out.

b) In the case of a strict equality $\tilde{l}^M = \hat{l}^M$, Lemma 1 implies $\tilde{l}^R = \hat{l}^R$. Therefore $\tilde{F}_L^M = \hat{F}_L^M$ and $\tilde{F}_L^R = \hat{F}_L^R$. From (5), (9), (8), (16) and (17), this implies that $pf'(\hat{Z}) = p\phi(\tilde{Z})$ and thus $\hat{Z} < \tilde{Z}$. Suppose now that $\tilde{l}^M < \tilde{l}^R$. It is straightforward to verify then that equal factor intensities under both regimes requires that $\hat{L}^R = \tilde{L}^R$ and $\hat{K}^R = \tilde{K}^R$, and thus $\hat{Z} = \tilde{Z}$. A contradiction. *Q.E.D.*

Since a decrease in a factor's intensity can only come about with an increase in the relative cost of that same factor, we have the following corollary, which we can state without proof:

Corollary 3 *If* $\hat{Z} < \tilde{Z}$ *then* $\tilde{l}^M \geq \tilde{l}^R \Leftrightarrow \hat{w}/\hat{r} \geq \tilde{w}/\tilde{r}$ *and, equivalently,* $\tilde{k}^M \geq \tilde{k}^R \Leftrightarrow \hat{r}/\hat{w} \geq \tilde{r}/\tilde{w}$.

The next lemma states that an increase in the use of a factor's intensity in the manufacturing sector is associated with a lower return to that factor in equilibrium.

Lemma 3 $\tilde{l}^M \leq \hat{l}^M \Leftrightarrow \tilde{w} \geq \hat{w}$ *and* $\tilde{k}^M \leq \hat{k}^M \Leftrightarrow \tilde{r} \geq \hat{r}$.

Proof: Observe that $\hat{w} = \hat{F}_L^M$ and $\tilde{w} = \tilde{F}_L^M$. Therefore $\tilde{w} \geq \hat{w}$ is equivalent to $\tilde{F}_L^M \geq \hat{F}_L^M$. Because marginal product F_L^M is decreasing in labor intensity, this is also equivalent to $\tilde{l}^M \leq \hat{l}^M$. An analogous argument applies to K-capital. *Q.E.D.*

We can now prove Theorem 1.

Proof of Theorem 1: From Lemma 2, we have $\tilde{l}^M \geq \tilde{l}^R \Leftrightarrow \tilde{l}^M \geq \hat{l}^M$. From Lemma 3, the latter inequality is equivalent to $\hat{w} \geq \tilde{w}$. A similar argument applies for K-capital. *Q.E.D.*

We next turn to the demonstration that the rural total effective effort level will drop in the transition from common property to exclusive property.

4.2 Effective input efforts in the rural sector

In order to demonstrate Theorem 1, we have imposed that the EP regime's effective effort level in the rural sector would be lower than under CP. This may appear like an obvious consequence of access restriction. However, given that one factor cost is lower under EP than CP, we cannot *a priori* rule out the possibility that the net effect will be such that the unit cost of input efforts $c^R(w,r)$ drops by so much under EP that the total effective effort exceeds the one under CP. In this section, we show that the total the effective effort under EP is lower than under CP. But beforehand, we establish that *the transition from a common to an exclusive property regime causes a drop in the unit cost of effective effort in the rural sector*, i.e.,

Proposition 4 (effective effort cost reduction) $c^R(\hat{w},\hat{r}) \leq c^R(\tilde{w},\tilde{r})$.

Before demonstrating Lemma 4, the graphical representations of figures 2 and 3 provide a helpful visualization of the effects of the transition. Figure 2 represents the rural sector only and identifies the CP equilibrium at the intersection between the unit effort cost $c^R(\tilde{w},\tilde{r})$ and its average product value $p\phi(\tilde{Z})$, according to (18).

Making use of the dual approach, equilibrium factor costs can be illustrated on a graph with the use of isocost curves $c^M(w,r)=1$ and $c^R(w,r)=p\phi(\tilde{Z})$, as in figure 3. Indeed, at intersection point CP, both sector's equilibrium conditions (6) and (18) are respected and the corresponding factor price vector is the equilibrium one. Note that vectors $\tilde{\mathbf{a}}^M$ and $\tilde{\mathbf{a}}^R$, respectively normal to isocost curves $c^M(w,r)=1$ and $c^R(w,r)=p\phi(\tilde{Z})$, represent the input vectors per unit of manufactured output and rural effort respectively.[16] Consequently, assuming that the isocost curve of the manufacturing sector crosses that of the rural sector from below, we have that the manufacturing sector is relatively labor intensive at the common property equilibrium point CP, which is consistent with point CP of figure 1 because it lies above the box's diagonal line. (The converse would hold if the isocost curve of the manufacturing sector were to cross from above.) Note that we consider throughout that production is diversified under both property regimes; this requires that the economy's total factor endowment $(\bar{L},\bar{K})$ vector falls within the *diversification cone* formed by the area between vectors $\tilde{\mathbf{a}}^M$ and $\tilde{\mathbf{a}}^R$ and with origin at point CP.[17]

Proof: Lemma 4 is formally demonstrated in Appendix A. The following provides a graphical interpretation. Assume instead that $c^R(\hat{w},\hat{r}) > c^R(\tilde{w},\tilde{r})$. Then according to (18) and (11), we have $pf'(\hat{Z}) > p\phi(\tilde{Z})$ and thus $\hat{Z} < \underline{Z} < \tilde{Z}$, where $\underline{Z}$ is defined as $f'(\underline{Z}) = \phi(\tilde{Z})$ (see Figure 2). If the manufacturing sector is relatively labor intensive in the CP equilibrium,

[16] This is a consequence of Shephard's lemma which states that $\tilde{\mathbf{a}}^S = (\tilde{c}^S_w, \tilde{c}^S_r)$. See, for instance, Chapter 3 of Woodland (1982).

[17] Note also that if the cost functions were to intersect at multiple points, only one would be compatible with a specific total factor endowment.

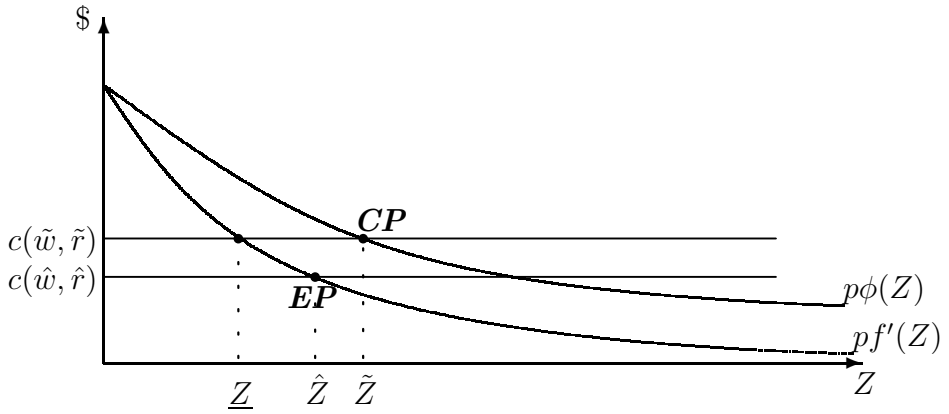

Figure 2: Rural sector, property regimes, and unit cost of effort

curve $c^M(w,r) = 1$ intersects curve $c^R(w,r) = p\phi(\tilde{Z})$ from below (see Figure 3). Now with $c^R(\hat{w},\hat{r}) > c^R(\tilde{w},\tilde{r})$, the rural sector's unit effort isocost curve under EP must be above that under CP; this is illustrated by the dotted curve in Figure 3. The new equilibrium at point D is characterized by a drop in the relative price of labor and thus a higher intensity in the use of labor in both sectors. As a consequence, the EP equilibrium falls in region B of Figure 1, which corresponds to an increased use of both factors in the rural sector and therefore $\hat{Z} > \tilde{Z}$. A contradiction. *Q.E.D.*

Proposition 4 implies that the rural sector's EP regime isocost curve lies below that of the CP regime's. Consequently, the EP equilibrium cost vector $(\hat{w},\hat{r})$ must be located above the CP one $(\tilde{w},\tilde{r})$ along the manufacturing sector's isocost curve, which is consistent with Theorem 1, i.e., in the case where the manufacturing sector is labor intensive under CP, labor (K-capital) is more (less) costly under EP than CP. It also implies that *the transition from a common to an exclusive property regime will lead to a contraction of the total effective effort in the rural sector*, i.e.,

Proposition 5 $\hat{Z} < \tilde{Z}$.

Proof: A formal proof is provided in Appendix B. Graphically, it can be readily verified from Figure 1 that since the relative cost of labor increases under EP, a lower intensity of its use in both sectors requires that the EP equilibrium factor allocation must fall into area A, which is characterized by $(\hat{L}^R,\hat{K}^R) \ll (\tilde{L}^R,\tilde{K}^R)$, and therefore $\hat{Z} < \tilde{Z}$. *Q.E.D.*

When combined, propositions 5 and 3 lead us to assert that *the transition from a common to an exclusive property regime will lead to a reallocation of both labor and K-capital from the rural sector into the manufacturing sector, thereby causing a contraction of the former*

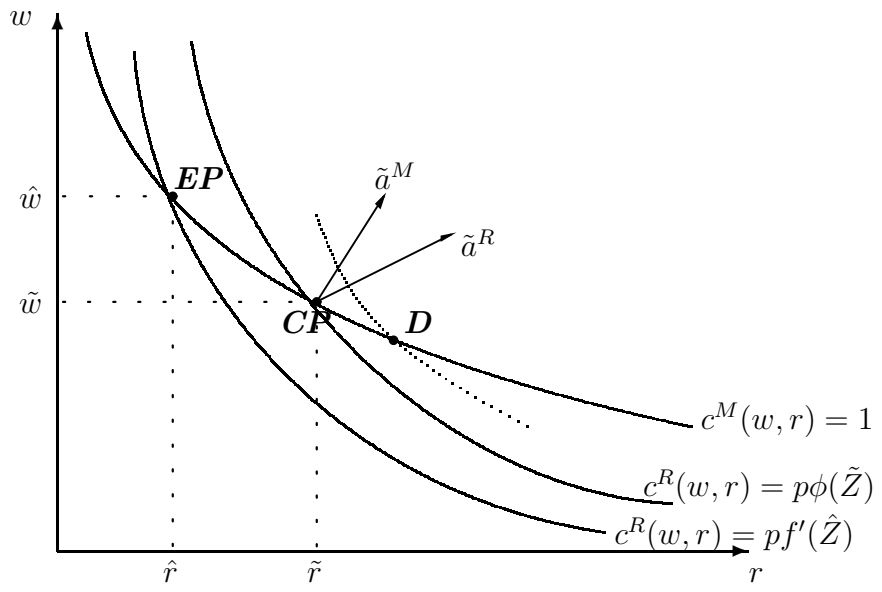

Figure 3: Isocost curves, property regime equilibria, and factor prices

and an expansion of the latter. This is summarized in the following proposition which we state without proof:

Proposition 6 (Rural factors exodus) $(\hat{L}^R, \hat{K}^R) \ll (\tilde{L}^R, \tilde{K}^R)$ *and* $(\hat{L}^M, \hat{K}^M) \gg (\tilde{L}^M, \tilde{K}^M)$

It is interesting to note that the contraction in the rural sector takes place despite the drop in the unit cost of the rural effective input effort (proposition 4).

Lemmas 1 and 2 combined with proposition 5 lead us to conclude that *if the manufacturing sector is initially more intensive in one factor, then the transition from a common property regime to an exclusive property regime will cause both sectors to use the other factor more intensively.* This result is referred to as *factor deepening* and stated as follows without proof:[18]

Proposition 7 (Factor deepening) $\tilde{l}^M \geq \tilde{l}^R \Leftrightarrow \tilde{l}^M \geq \hat{l}^M$ *and* $\tilde{l}^R \geq \hat{l}^R$

[18]Note that factor deepening is defined here as a situation where all sectors of the economy will use one factor more intensively. It should be contrasted with factor deepening at the aggregate level, which cannot occur here because total factor endowments are considered fixed.

5 Implications and discussions

5.1 Evidence on relative factor intensities

The fact that labor may gain from being denied the rents from the natural capital is a striking finding. While the mechanism is now quite clear, the fact that it requires the manufacturing sector to be relatively labor intensive implies that it would still remain a purely theoretical exercise if this condition were never fulfilled in practice. In this section, we investigate this empirical question and conclude that it is indeed more than a mere theoretical possibility. To this end, we next propose a representative overview of the relevant empirical literature which lead us to the following three observations: i) In many settings – rich and poor, old and new – the agricultural sector may quite realistically be more K-capital intensive than the non-agricultural sector; ii) There is no general consensus in the literature, not even for the well-studied case of the US economy; iii) Approaching the question on a case-by-case basis seems most appropriate.

As discussed in section 2.2, it is first important to dispel the notion that the agricultural and natural-resource sectors in poorer societies make little use of capital. Indeed, even when the aggregate capital endowments are low and natural assets are held in common, capital may still play a relatively important role. Take the case of sheep farming in medieval England. As mentioned in footnote 7, sheep farming is much more capital-intensive than the cultivation of arable land. And though we do not have actual numbers to precisely compare the capital intensity of pastoral farming with that of the rest of the economy in medieval England, one is hard-pressed to imagine many other activities that could have used much more capital-intensive techniques of production. We are therefore led to presume that in its early stages at least – i.e., before industrialization – the enclosure of the open fields may not have had the wage depressing effect envisioned in Cohen and Weitzman (1975). Moreover, as Power (1955) argues that England came to dominate the wool trade because of its *natural endowments*, there is a suggestion here that whether rural privatization benefits labor or not may, in the end, largely hinge on an economy's *natural* endowments, in support of a case-by-case approach.[19] Other rural activities that similarly require a significant amount of capital include fishing and tree crop farming.

Turning now to the case of the US economy, the highly cited papers by Valentinyi and Herrendorf (2008) (VH) and Caselli and Coleman (2001) (CC) are representative. Upon dividing the economy into two sectors only, VH (CC) obtain the factor income shares presented in Table 1.[20]

[19]This may have long-term consequences for an economy in line with Sokoloff and Engerman's (2000) argument for "... the possibility that initial conditions, or factor endowments broadly conceived, could have had profound and enduring impacts on long-run paths of institutional and economic development in the New World. (220)"

[20]Both papers make the explicit distinction between land and reproducible capital incomes. Reproducible capital includes structures and equipment for both, while CC additionally includes livestock (as it is based

	Agricultural		Nonagricultural	
	CC	VH	CC	VH
Labor	.46	.60	.67	.60
K-capital	.36	.21	.28	.34
Land	.18	.19	.05	.06

Table 1: Factor income shares for the US economy

The income share of factor i in sector S being defined as $s_i^S = w_i x_i^S / py^S$, we have $K^S = s_K^S py^S / r$ and $L^S = s_L^S py^S / w$. Labor intensity in sector S can thus be expressed as $l^S = (s_L^S / s_K^S)(r/w)$, and consequently:

Proposition 8

$$l^M \geq l^R \Leftrightarrow \frac{s_L^M}{s_K^M} \geq \frac{s_L^R}{s_K^R}.$$

Hence, a relatively labor intensive manufacturing sector must have a larger labor-to-K-capital income share *ratio*. Note that this result holds *regardless of the property regime or the presence of a fixed factor*. The estimates of VH (CC) yield $s_L^M / s_K^M = 2.39$ (1.76) and $s_L^R / s_K^R = 1.28$ (2.85): the numbers in VH denote a nonagricultural sector that is significantly more labor intensive than the agricultural sector, but CC has the opposite.

Such discrepancies extend beyond the case of the US economy. For instance, in his analysis of the East Asian miracle, Ventura (1997) argues that the high growth experience of East Asian economies can be explained by the movement of productive resources from labor-intensive industries towards capital-intensive ones, the first being associated with agriculture and the second with manufacturing. Braude and Menashe (2011), on the other hand, point out that in its initial phase, high growth in the same economies was mostly based on an expansion of labor-intensive industries and contraction of capital-intensive ones. They cite the case of a growing apparel industry which was labor intensive relative to a declining rubber industry.

The foregoing discussion is illustrative of the commonly found discrepancies in the relative labor intensities of the agricultural and nonagricultural sectors, both assumed or estimated. Uncovering its source goes beyond our intent here; our purpose is rather to highlight an existing lack of consensus - even for the case of the US economy - and, given our results, their important economic implications.

on Jorgenson and Gollop (1992)). However, both seem to ignore the importance of treestocks. They are thus under-estimating the importance of capital in the agricultural sector to a certain extent. Note further that both find a 5-6% income share for land in the non-agricultural sector; in line with most of the relevant literature, we have chosen to ignore this role in our analysis.

In the case of multi-country studies, Mundlak (2001) is a leading reference on the estimation of agricultural production functions at the sectoral level. The author underscores the fact that the assumption of an identical production function for all countries "lacks empirical support" (20), in support of our view that a case-by-case approach may be more suitable. He nonetheless provides pooled estimates of output elasticities for land, labor, and K-capital, and obtains surprisingly high estimates for both land and K-capital. To illustrate, we present the more recent (but similar) estimates published in Mundlak et al. (2012) regarding a panel of 30 developed and developing economies. The originality of the approach is that it accounts for capital of agricultural origin (livestock and treestocks) as well as the usual structures and equipment. They obtain that "The sum of the [output] elasticities of the two types of capital is 0.46, and the elasticity of land is 0.44. With the sum of the elasticities of 0.90 for capital and land, there is little scope left for labor and fertilizer" (143). Now given that the standard estimates for the K-capital share of income in the GDP of the average economy is 0.33, such numbers would suggest that agriculture is much more K-capital intensive on average.[21]

Vollrath (2011) similarly considers multiple countries but takes to the letter the proposition that agricultural production functions should be estimated separately. He presents convincing evidence to the effect that rice production is significantly more labor intensive than wheat production and argues that this matters when comparing the agricultural sectors of European countries and rice-growing Asian ones. Given that such differences are valid going back to pre-industrialization times, we can draw implications for a comparative analysis of institutional reform in the rural sectors.

Vollrath (2011) uses CD technologies but does not make the explicit distinction between land and K-capital. We therefore adapt our model using CD technologies in order to infer the distinction. Based on the assumptions made in section 2.2, the agricultural CD production function is $Y^R = A^R(L^R)^a(K^R)^b\bar{T}^c$, with $a+b+c=1$. In line with expressions (2) and (3), we have:

$$Y^R = A'Z^\beta \text{ where } A' = A^R\bar{T}^c \text{ and } \beta = 1-c, \tag{19}$$

$$Z = (L^R)^\theta(K^R)^{1-\theta} \text{ where } \theta = \frac{a}{a+b}. \tag{20}$$

In the manufacturing sector, we have

$$Y^M = A^M(L^M)^\alpha(K^M)^{1-\alpha}. \tag{21}$$

The labor-elasticity estimates provided in Vollrath (2011) are $a^E = 0.4$ and $a^A = 0.55$, where superscript E and A respectively stand for Europe and "predominantly rice-growing

[21] Keep in mind that the use of factor income shares as estimators for the parameters of the Cobb-Douglas production function requires that all input uses respect the first-order conditions for profit maximization. This is an unrealistic assumption to make for most developing countries as the land and labor markets are often non-competitive. We understand that it is for this reason that Mundlak (2001) chooses to concentrate the discussion mostly on elasticities.

regions of Asia". Following Table 1, we set the land output elasticity at $c = 0.185$ for both regions. We therefore infer the following respective labor elasticities for output (Y^R) and effective efforts (Z): $b^E = 0.415$, $b^A = 0.265$, $\theta^E = 0.49$ and $\theta^A = 0.67$. As for the non-agricultural sector, standard labor elasticity estimates are $\alpha = 0.66$ and are used quite consistently for all countries.

We therefore have that while the manufacturing sector is labor-intensive relative to the manufacturing sector in European countries ($\alpha > \theta^E$), the opposite holds for rice-growing Asian countries ($\alpha < \theta^A$). Consequently and in accordance with theorem 1, while the adoption of "modern" land market institutions in the rural sector may have tended to raise wages and lower capital returns in Europe, we find the opposite prediction for rice-growing Asian countries. Hence, while Vollrath (2011) shows that differences in agricultural labor intensity help us explain per-capita growth, we have the complementary result that it can also be useful in explaining income distribution.

5.2 Natural capital, institutions, and productivity analysis

Recently, many growth economists have sought to estimate the extent to which the misallocation of workers between the agricultural and the nonagricultural sectors can explain existing total factor productivity (TFP) differences between countries. To this end, a common method has been to measure the *agricultural productivity gap of labor* (APGL) while assuming a CD technology for both sectors.[22] In this section, we look at how our analysis can inform that literature.

The APGL is defined as the ratio of the values of labor's marginal products (MPL) between the two sectors. Making use of the CD technology introduced in section 5.1, the MPLs are given by $MPL^M = \alpha Y^M/L^M$ and $MPL^R = \beta\theta p Y^R/L^R$. We thus have:

$$APGL \equiv \frac{MPL^M}{MPL^R} = \frac{\alpha\frac{Y^M}{L^M}}{\beta\theta\frac{pY^R}{L^R}} \tag{22}$$

Under a regime of exclusive property, the MPL in each sector being equal to the prevailing wage rate, we have $\widehat{APGL} = 1$. Since this corresponds to the efficient allocation of labor between the two sectors, the extent of the deviation from unity in the APGL is interpreted as a measure of the severity with which labor is being misallocated between sectors. Now under the common property regime, equilibrium condition (16) implies that $\theta p Y^R/L^R = w$, and consequently:

$$\widetilde{APGL} = \frac{1}{\beta}. \tag{23}$$

[22] See, for instance, Temple (2005), Vollrath (2009), Adamopoulous and Restuccia (2014), and Gollin et al. (2014b). Note that in this literature generally, the APG implicitly refers to the case of labor misallocations only. Given the equally important role that we assign to the misallocation of reproducible capital in our analysis, we make the explicit distinction between APGL for labor and APGK for capital.

The corresponding calculations for the case of capital yield $\widehat{APGK} = 1$ and $\widetilde{APGK} = 1/\beta$. Since $\beta = 1 - c$, where c denotes the elasticity of output with respect to natural assets, we have the following proposition:

Proposition 9 (Natural capital output elasticity and the APG) *Under a CP property regime in the rural sector, the extent of the misallocation of both labor and reproducible capital, if measured by the agricultural productivity gap under Cobb-Douglas technologies, is* uniquely *determined by the elasticity of output with respect to the natural asset.*

This proposition has some interesting implications. Observe first that although the APGs depend on the *importance* of the natural asset for production – as per parameter c – they do not depend on its abundance: land *scarcity* – say in per capita terms $\bar{T}/\bar{L}$ – makes no difference for the APGs.

Secondly, APG differences between countries can be of two types. If, on the one hand, two countries use the same production technology, observed differences in the APGs are entirely caused by property regime differences, and their magnitude increases with the elasticity of output with respect to the natural asset. If, on the other hand, two countries have the same property regime, any observed difference in the APG must be caused by a difference in the rural production technology that affects the value of c *and* the fact that they both have a common property regime (recall that there is no APG under exclusive property).

6 Conclusion

The existing literature on the general equilibrium effects of agrarian reforms or resource privatisation has largely ignored its induced effects on capital flows. To our knowledge, no existing model allows for the free, endogenous flow of reproducible capital. Yet, one would expect that labor displacements would in turn exert forces on the allocation of capital, at least in the medium to long run. Our model accounts for these interactions and this yields new results and insights.

We started out by deriving general equilibrium conditions for the allocation of labor and capital under a common property regime in the presence of a fixed factor. Based on the evidence, we have argued that these conditions may provide a fair representation of such institutions as the sharing family farm, free access to natural resources, tied rents and collective farming.

We have shown that with mobile capital, the adoption of "modern" market institutions can raise labor wages and lower capital returns if, and only if, the manufacturing sector is relatively labor-intensive. Rural reform can therefore have opposite income redistributive effects at different times and places. This provides a new mechanism that can help explain the variety of experiences regarding the redistributive effects of economic development. We

have also shown that, under the same condition, the transition can lead to an overall capital deepening of the production processes even though the aggregate capital-labor ratio is unchanged.

Our results highlight the importance of the presence of a fixed natural asset in the rural sector. Indeed, as this introduces decreasing returns to input efforts, the property regime becomes relevant. As a consequence, we obtained that the agricultural productivity gaps of labor and capital are uniquely linked to the output elasticity of land. Since this elasticity may vary with geography and technology, this also provides a way to explain the observed variety of productivity gaps.

While our simplified modelling approach was helpful in highlighting some important forces at play in relation to institutional change, it raises new questions. Some are linked to dynamic effects. Indeed, it may be important to consider the presence of stock-flow dynamics inherent in natural-resource use. In the agricultural sector for instance, much insight could be gained with the introduction of biomass soil dynamics in a common property context (Lopez 1997). Dynamic models of aggregate capital deepening (Acemoglu and Guerrieri 2008) or differential productivity growths (Alvarez-Cuadrado and Poschke 2011) may interact with institutional change and capital mobility in yet unknown manners. Similarly, the development of transportation facilities between the sectors, as analysed by Adamopoulos (2011), is likely to interact with capital mobility while yielding different result depending on the property regime.

As we have argued throughout this paper, the use of productive capital in the rural sector of developing countries can be quite significant. This use is, however, impacted by the presence of credit constraints, riskiness, and consumption smoothing (Rosenzweig and Wolpin 1993; Dercon 1998). Introducing this consideration into our setting seems like another potentially productive avenue of research.

A Proof that $c^R(\hat{w}, \hat{r}) \leq c^R(\tilde{w}, \tilde{r})$

Recall that equilibrium conditions for factor payments must respect condition (6) and either of (18) or (11). Let us express those by the following set of two equations, where parameter α is either equal to $p\phi(\tilde{Z})$ or $pf'(\hat{Z})$:

$$c^M(w, r) - 1 = 0, \tag{24}$$

$$c^R(w, r) - \alpha = 0. \tag{25}$$

Differentiating these two expressions with respect to parameter α and making use of

Cramer's rule yields:

$$\frac{\partial w}{\partial \alpha} = \frac{-c_r^M}{c_w^M c_r^R - c_w^R c_r^M}, \tag{26}$$

$$\frac{\partial r}{\partial \alpha} = \frac{c_w^M}{c_w^M c_r^R - c_w^R c_r^M}. \tag{27}$$

Now according to Shephard's lemma, c_w^S and c_r^R denote respectively the quantity of labor and capital used in sector S per unit of output, i.e., $Y^S c_w^S = L^S$ and $Y^S c_r^S = K^S$, $S \in \{M, R\}$. Inserting this into the above two equations yields:

$$\frac{\partial w}{\partial \alpha} = \frac{-Y^R K^M}{L^M K^R - L^R K^M}, \tag{28}$$

$$\frac{\partial r}{\partial \alpha} = \frac{Y^R L^M}{L^M K^R - L^R K^M}. \tag{29}$$

We consequently have:

$$\frac{\partial w}{\partial \alpha} < 0 \text{ iff } l^M > l^R, \tag{30}$$

$$\frac{\partial r}{\partial \alpha} > 0 \text{ iff } l^M > l^R. \tag{31}$$

Without loss of generality, we posit that $l^M > l^R$.[23] The above therefore implies that an increase in α leads to a decrease in w/r.

Assume now that $c^R(\hat{w}, \hat{r}) > c^R(\tilde{w}, \tilde{r})$. This implies that α must take on a larger value under EP than CP and thus, according to the above result, $\hat{w}/\hat{r} < \tilde{w}/\tilde{r}$. But $c^R(\hat{w}, \hat{r}) > c^R(\tilde{w}, \tilde{r})$ also implies that $\hat{Z} < \tilde{Z}$, as can be readily seen from Figure 2. Now according to Corollary 3, $l^M \geq l^R$ implies $\hat{w}/\hat{r} \geq \tilde{w}/\tilde{r}$ when $\hat{Z} < \tilde{Z}$. A contradiction. *Q.E.D.*

B Proof that $\hat{Z} < \tilde{Z}$

Assume to the contrary that $\hat{Z} \geq \tilde{Z}$. Then, it must be the case that $c^R(\hat{w}, \hat{r}) < c^R(\tilde{w}, \tilde{r})$. In line with the analysis of Appendix A above, this calls for a lower value of α under EP as compared to CP and therefore $\hat{w}/\hat{r} > \tilde{w}/\tilde{r}$. Consequently, labor is used less intensively under EP than CP and, as can be readily seen in Figure 1, this requires $(\hat{L}^R, \hat{K}^R) \ll (\tilde{L}^R, \tilde{K}^R)$ and thus $\hat{Z} < \tilde{Z}$. A contradiction. *Q.E.D.*

[23] Note that the problem is undefined for $l^M = l^R$.

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