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Land Use Restrictions, Misallocation in Agriculture, and Aggregate Productivity in Vietnam

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Abstract

We evaluate the effects of restricted land use rights on aggregate productivity using micro-level data within a quantitative model. In particular, we exploit the Rice Land Designation Policy in Vietnam, which forces farmers to produce rice on almost 45% of plots of land. The policy provides a natural setting for investigating the aggregate effects of land use misallocation. We quantify the impacts of this system by formulating a two-sector model featuring production and occupation choices. We also use digitized versions of Vietnam's Local Land Use Atlas and Global Agro-Ecological Zones database to construct a micro-spatial dataset that shapes important features of the model and allows us to compare the restricted against a counterfactual efficient allocation. The main findings suggest that eliminating all land use restrictions leads to 10.6% gain in agricultural total factor productivity and 4.36% increase in real GDP per capita. While misallocation in agriculture has been studied extensively, our research highlights a novel source of misallocation that is prevalent in other countries such as China, Myanmar, Uzbekistan, among others.

Keywords: Agriculture, misallocation, land use restrictions, aggregate productivity, Vietnam.
JEL classification: O11, O13, O4.

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1 Introduction

Labor productivity gaps are much more significant in the agricultural sector than in the non-agricultural ones (Caselli, 2005; Restuccia et al., 2008). Despite such substantial differences, less-developed countries tend to have a majority of their labor share employed in agriculture. Seeking a deeper understanding of the sources of this inefficient resource allocation is necessary if one has to explain the persistence of large productivity gaps. In many prior studies, land rights have been shown to have significant impacts on economic development.[1] However, much of focus has been placed on *land transfer rights* (sell, rent, bequeath, mortgage), and little attention has been given to *land use rights*. Focusing on the latter under-explored area of research, this paper illustrates the quantitative effects of land use restrictions on productivity and resource allocation.

In particular, we study the impacts of Rice Land Designation Policy of Vietnam (RLDP).[2] Vietnam requires that 3.8 million hectares, i.e. 39% of its agricultural land, to be devoted to rice production by 2020 (Resolution 17/2011/QH13). This centralized land use planning system is referred to as Rice Land Designation Policy. This policy plays a significant role in supporting the National Food Security program whose objective is to ensure the national food supply sources.

In this paper, we investigate the extent to which the practice of RLDP to stimulate rice production can generate distortions in both land use and labor allocation, thus, lowering productivity at both the sectoral (agriculture) and aggregate level. To quantify the distortionary effects of RLDP, we develop a two-sector model with three final goods. Two of the three final goods are produced in the agricultural sector: rice and non-rice crops (other agricultural commodities). The third final good is produced in the non-agricultural sector by a representative firm. Individuals with heterogeneous ability can choose to be farmers or workers. In agriculture, a production unit is a farm. Each farmer maximizes profit by choosing which crop to produce and how much quality-adjusted land to rent. In non-agriculture, the representative firm requires only effective labor as an input. Regarding RLDP, plots of agricultural land can be restricted in land use. The restricted plots must be devoted to

[1] Examples include Adamopoulos and Restuccia (2014a), Adamopoulos et al. (2017), Chen (2017), Gottlieb and Grobovsek (2015).

[2] The term Rice Land Designation Policy is first used in Giesecke et al. (2013). In Vietnamese, this land policy is known as *'Dat Chuyen Trong Lua'*, which is translated to Specialized Land for Rice Production.

rice production only. In the model, we take land use restrictions as exogenously given. To quantify the effects of the restrictions, we exploit both household level surveys (Vietnam Access to Resources Household Survey) and spatial datasets (Local Land Use Atlas and Global Agro-Ecological Zones) to account for heterogeneity in labor and land characteristics. Our primary results concern the effects of entirely removing RLDP on agricultural productivity, economy-wide productivity, and resource reallocation. To do so, we compare the current economy of Vietnam to a hypothetical economy where RLDP does not exist.

Our approach to quantifying the misallocation effects of RLDP on productivity and resource allocation builds upon the recent macro-development literature which studies the impact of micro-level distortions on aggregate outcomes. However, we differ from other studies in two main aspects. First, we consider a specific type of distortionary policy (land use restrictions) in a particular context (Vietnam). Second, our model is constructed in a way that allows us to incorporate spatial characteristics of land, which is essential to agricultural production. Our main findings suggest that eliminating all restrictions coming from RLDP leads to 10.6% increase in the agricultural TFP. This improvement is highlighted by 16.4% gain in agricultural labor productivity, 4.36% increase in real GDP per capita, 13.4% reduction in agricultural employment, and 15.5% increase in average farm size.

The paper proceeds as follows. The next section provides an overview of land reforms in Vietnam, background information on RLDP, and a brief discussion of related literature. Section 3 outlines the model that we use in our quantitative analysis. In Section 4, we define an equilibrium of the model and discuss mechanisms of resource reallocation. Section 5 provides steps to connect the model and data. Section 6 presents our main results along with a series of robustness checks and extensions. Then, Section 7 concludes our paper.

2 Background and Literature Review

We are interested in RLDP of Vietnam to illustrate the effects of land use restrictions for several reasons. First, as rice remains the country's primary staple food and export commodity, its production involves approximately two-thirds of rural households, leading to wide-spread impacts of adjustments in rice-related policies (Ha et al., 2015). Second, income from rice production is too low leading to the phenomenon of abandoned rice fields across rural areas.[3] Hence, policies promoting the conversion of low-yielding rice fields into land growing high-value cash crops are necessary. Third, the early gains from market-oriented reforms have diminished over time highlighted by a TFP slowdown in rice production, and remnants from past institutional arrangements have created constraints to the efficient allocation of resources, all calling for improvements in land use rights (Kompas et al., 2012).

2.1 Major Reforms in Vietnam's Agricultural Land Policy

Dated by most authors, Vietnam's era of central planning ended in 1986 as the State started to introduce a series of market-oriented agricultural and industrial reforms. In agriculture, a critical reform was the enactment of the Directive No.10 in 1988, which abolished collective farming and recognized household as an autonomous unit in the economy. With the issuance of the Directive, parcels of agricultural land were allocated to families along with certificates of land use rights (CLUR) for 10-15 years.[4] It is worth noting that any crop choice restriction is stated in the land use purpose of CLUR. For the first time, farmers were granted the right to make their own decision related to the sales of outputs, or the purchases and uses of inputs; thus, offering a significant incentive for agricultural production.

A drawback of the Directive No.10 was that households could not trade their land use rights. Thus, another significant agricultural reform, the Law on Land 1993, took place and granted farmers five fundamental land use rights. These rights consisted of transfer, exchange, lease, inheritance, and mortgage right. Since then, the process of land allocation has been steadily proceeding, along with several adjustments to the Law on Land in 1998, 2001, 2003 and 2008 to encourage the development of the land market. However, the allocated lands remain the State's property and must be returned to the State when farmers stop using them. Technically speaking, farmers are only able to transfer, exchange, lease, bequeath, or mortgage the right to use land, not the land itself.

The reforms in Vietnam's land policy was partially motivated by years of struggling with food

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[3] Stated by the Director of Cooperative Department of The Ministry of Agricultural and Rural Development in the Voice of Vietnam on 15/08/2013. Available in Vietnamese at www.vov.vn/kinh-te/vi-sao-nong-dan-bo-ruong-274215.vov.

[4] A CLUR can be thought of as a license that permits a recipient to use his/her allocated plot of land. Detail information of the assigned plot is printed on the CLUR issued to its operator including plot code, address, size, blueprint, acquirement source, expiration date, land use purpose, and personal information of the operator. The section of land use purpose in CLUR, in which crop choice restrictions are clearly stated (if any), is the focus of this paper.

security. Before the reforms, the country experienced severe food shortages, and domestic subsistence consumption mostly relied on the USSR's food aid. By 1988, malnutrition become a widespread phenomenon, 3 million people faced starvation, 12 million people were short of food, and million tons of rice had to be imported to fight hunger. Since the issuance of Directive No.10 and Law on Land 1993, privatizing production and granting land use rights have created a significant incentive for farmers to allocate labor and land more efficiently leading to as much as 50% of TFP gain during the peak of the reform period. Such remarkable improvement is underlined by the successful transformation from a rice-importer to become the second largest rice-exporter in 1997 (for an in-depth review, see World Bank, 1998).

2.2 Land Use Restrictions and RLDP in Vietnam

Although the series of extensive reforms has remarkably changed the landscape of Vietnam's agriculture, the State has continued to direct policies towards securing food supply rather than improving the rural living standard. One of the most prevalent practices is to constraint farmers' right to choosing which crop to cultivate. A dominant type of this land use restriction is RLDP that requires farmers to grow rice on their land. The objective of producing enough rice to ensure national food sources has been widely stated and repeated. For example, in 2008, the Central Committee of the Communist Party issued Resolution 26/NQ-TW on agriculture, farmers and rural affairs expressing its determination of keeping land permanently under rice to ensure national food security. In 2009, the Party Politburo approved the nation's food security project aiming to keep rice cultivation area at 3.8 million hectares by 2030, said Director Nguyen Tri Ngoc of the Ministry of Agriculture and Rural Development.[5] Two years later, the project was finalized by the National Assembly and officially part of the Land Use Master Plan up to 2020 (Resolution 17/2011/QH13).

It is crucial to understand how the process of RLDP works. First, the restriction quota (e.g., 3.8 million hectares by 2020) is established through the 10-year land use plan by the central government. After the aggregate target is set, following a top-down approach, the Ministry of Natural Resources and Environment governs the restriction process by splitting the total amount among provincial, district and commune levels of its administration. At the lowest level, communal land offices are responsible for creating detailed land-use plans for each household in their commune, parcel by parcel and year to year. The specific plan is officially

[5] The announcement is also available in English at: www.vietnammarkets.com/vietnamnews.php?nid=3886.

documented in CLUR issuing to the farmers. Any adjustment, renewal or new issuance of land and CLUR is regulated following the quota set by the central government.

According to Article 74.1 of the Law on Land 2003, the State plays a leading role in implementing RLDP by providing protection of specialized land for wet rice cultivation and preventing illegal conversions to other use purposes. Land users are also required to participate in RLDP. Article 74.2 asserts that the holders of the specialized land for wet rice cultivation must be responsible for the land and not convert it to other use purposes such as perennial crops, forests, aquaculture, and others. There is a strong incentive for farmers to comply with their assigned plans because violating the State's direction may lead to land or crop confiscation. Besides, evaluation by the local authorities is critical for farmers to renew their current CLUR or apply for other ones. To get farmers involved in RLDP, the State provides subsidies to rice cultivation at the expense of the production of other crops. For example, irrigation system, credit, fertilizers, and agricultural services are provided preferentially to rice farmers (World Bank, 1998).[6]

2.3 Related Literature

Our work contributes to the emerging literature on institutions, misallocation and aggregate agricultural productivity. Notably, we connect the misallocation and institution-growth literature by investigating the distortionary consequences of a specific land policy, RLDP of Vietnam. To the best of our knowledge, our paper is the first to quantify the aggregate effects of this particular type of institution for a specific context exploiting micro-level data. The main strands of literature that our paper can be related to are as follows.

The first and broader strand of literature quantifies the role of agriculture in explaining income differences across countries. For example, Gollin et al. (2002) and Restuccia et al. (2008) suggest that productivity gains in the agricultural sector greatly enhance growth and development. The reason is that a significant share of labor activity takes place in agriculture where the productivity gaps are the largest. Caselli (2005) reports a ratio of 45 to 1 in agricultural labor productivity between countries in the 90th and 10th percentile of the income distribution. Placing focus on the dual economy structure, Chanda and Dalgaard (2008) and Vollrath (2009) find that aggregate productivity is depressed by a large share of resources being devoted to agriculture activity, thus, accounting for a large portion of the

[6] In Appendix B, we show that our model is affected only by RLDP, not other types of distortions.

variation in income per capita across countries. Other studies include the work of Lagakos and Waugh (2013) and Herrendorf and Schoellman(2015).

The second and more recent line of research attempts to explain these large productivity gaps in agriculture through the lens of resources misallocation caused by specific policies or institutions.[7] For example, Adamopoulos and Restuccia (2014a) shows that the Philippines 1988 land reform imposing a ceiling on land holdings lowers farm size by 34% and agricultural productivity by 17%. Studying the case of China, Adamopoulos et al. (2017) documents that Chinese land institutions can account for approximately 46% of agricultural productivity loss. Chen (2017) finds that land titling can raise agricultural productivity by up to 82.5%, with 42% coming from land reallocation and the remaining stemming from efficient-occupational choice. Gottlieb and Grobovsek (2015) report that removing the communal land tenure system lowers agricultural employment by 19% and increases aggregate output by 7%.

In this paper, we employ micro-data to shape important features of the model and to perform quantitative experiments. Therefore, our work is also related to a recent literature on macro-development including Hsieh and Klenow (2009), Gollin et al. (2014), Buera et al. (2014), among many others. However, we differ from them in two ways. First, we focus on a specific type of institution in a particular context, i.e. land use restrictions in Vietnam. Second, we incorporate spatial characteristics of agricultural land into the model allowing us to account for land quality. The paper is also related to the empirical development literature studying the effect of land institution at the micro level such as Goldstein and Udry (2008).

Despite the widespread influence of RLDP in Vietnam, its impacts have not been documented extensively. At the sectoral level analysis, Nielsen (2003) employs a computable trade model (GTAP) to stimulate the effect of freeing 5% of the rice land area. This particular liberation raises production of the other crops by about 3.8%, which in turn leads to a gain of $52 million in welfare driven by exports. Giesecke et al. (2013) apply another computable general equilibrium model (MONASH) to perform their analysis across industries. Their simulated results suggest that removing RLDP can increase private consumption by 0.4% per annum between 2011 and 2030, while also reducing poverty, improving food supply as well as nutritionally balanced diets. However, the analysis in both papers are conducted at

[7] Without specifying underlining sources of misallocation, some studies emphasizes on equating marginal products to quantify the overall misallocation. Notably, if inputs were allocated efficiently, agricultural TFP would increase by a factor of 3.6 in Malawi (Restuccia and Santaeulalia-Llopis, 2017), and by a factor of 2.4 in Ethiopia (Chen et al., 2017).

the aggregate levels, and the gains are driven by international trade after removing RLDP.

Turning to microeconomic evidence, Markussen et al. (2011) empirically investigate impacts of RLDP on the behavior of Vietnamese farmers. They conclude that RLDP is positively correlated with household labor supply due to higher quality inputs being effectively compensated by the local authorities. They also find that restrictions do not affect household income due to the compensation, but farmers tend to switch to other crops when restrictions are lifted. Several studies consider other aspects of land rights on Vietnam's socio-economic outcomes. Do and Iyer (2008) find that progress in land titling raises the production of multiyear crops and household labor supply in nonfarm work. Menon et al. (2017) document that land-use rights held exclusively by women or jointly by couples result in lower household vulnerability to poverty, and increased household expenditures as well as womens self-employment.

Beyond Vietnam, a significant portion of farmers is also coerced into growing rice in Myanmar. According to Chapter X of the country's Farmland Law 2012, farmers are prohibited from growing alternative crops without permission of the government. Exploiting within-village variations under regression framework, Kurosaki (2008) finds that being restricted to grow rice is associated with a decrease of about 8.3% in crop income of Burmese farmers. In another context, China has a system called "*zeren tian*" (responsibility land), in which parcels of agricultural land are allocated to households on the basis of the number of laborers and households' ability to engage in agriculture. However, farmers need to deliver a mandatory quota of grain at a below market price to the authorities in exchange for use rights. The responsibility land is a major component of Chinese farmland, which accounts for 70% of total farmland in 2008 (Gao et al., 2017). In several Central Asian countries, such as Uzbekistan, Tajikistan, and Turkmenistan, the States still own the land and severely restrict many farmers to grow cotton through production quotas. The combination of miserable incomes and compulsion to produce cotton in these Central Asian countries lead to many social issues including widespread child labor and forced labor (ILO, 2015).

3 Model

We consider a static economy in which three final goods are produced: (i) rice, (ii) all other agricultural commodities, and (iii) a non-agricultural product. The two final agriculture goods are produced in the agricultural sector by heterogeneous farms, and the final non-agricultural good is produced in the non-agricultural sector by a representative firm. In the model, individuals with heterogeneous ability can choose to work as workers in the non-agricultural sector or farmers in the agricultural sector.

In agriculture, farmers require land to produce. However, a fraction of land is subject to RLDP, i.e. reserved for rice production only. Consequently, RLDP creates resource misallocation through two channels. First, it prevents the restricted land from being optimally used, thus, decreasing land productivity. Second, it distorts the allocation of labor by reducing the number of workers and increase the number of farmers.

Two essential features of our model are built on previous studies. First, in a spirit of Restuccia et al. (2008), we model the mechanism that misallocation in agriculture can lower the share of the non-agricultural worker to satisfy the subsistence consumption. Second, we incorporate a theoretical contribution of Garcia-Santana and Pijoan-Mas (2014) in modeling individual choices of occupation. In particular, we borrow one of the key implications of their model in which the reassignment of individuals between sectors can dampen the gain in sectoral TFP after moving to the efficient level.[8] We proceed to describe the model in more detail below.

3.1 Endowment Description

There are N individuals in the economy. Adopted from Garcia-Santana and Pijoan-Mas (2014), we assume that individuals are differentiated by their ability $z \in \mathbb{R}_+$ and an idiosyncratic tax distortion $\tau \in [0, 1]$ on non-agricultural income. This distortion serves as an individual-specific barrier to mobility out of agriculture. We assume the set $\{z, \tau\}$ is drawn from a cumulative distribution function $H(z, \tau)$. Individuals supply their labor inelastically and choose to work in one of the two mutually exclusive jobs: (i) farmers maximize profit from operating farms, and (ii) workers work in the non-agricultural sector.

Agricultural land comprises a fixed number of plots indexed by $j \in J \equiv \{1, 2, ..., J\}$. The plots are heterogeneous in a two-dimensional suitability $\{e_R, e_O\}$ and a restriction status δ drawn from a spatial distribution $F(e_R, e_O, \delta)$. Here, we let e_{Rj} and e_{Oj} denote plot j's productivity in producing rice (R) and other crops (O) respectively. The indicator δ_j takes a value of one if plot j is RLDP-reserved for rice production, and zero otherwise. Farmers then use the rented plots to produce either rice or other crops to maximize their profits. As shown

[8] Garcia-Santana and Pijoan-Mas (2014) quantify the effect of firm-size restriction in India (The Small Scale Reservation Laws). In a calibrated version of their model, they find that eliminating these laws increases output per worker by 2% and the overal TFP by 0.75%.

later, the optimal use of a plot is jointly determined by its two-dimensional suitability and common crop prices. However, RLDP-restrictions prevent such optimal allocation giving rise to both land and labor misallocation. To simplify our discussion, all plots are assumed to be of equal size, normalized to one. Such simplification implies that the total agricultural land and the total number of plots coincide, i.e. $L = J = \int_{j \in J} dj$.

3.2 Technology and Production

Agriculture Sector - It is important to note that plots of land vary in crop-specific productivity. Since all plots have the same size of one, the effective units of a plot is thus determined by its crop-specific productivity. For example, the effective units of plot j in cultivating rice is e_{Rj}, and in growing other crops is e_{Oj}. In agriculture, the production unit is a farm. Suppose a farmer rents two plots $j = \{1, 2\}$ to produce rice, then his/her total effective units of land utilized in rice production is $e_{R1} + e_{R2}$.

Formally, a farmer needs to incorporate his/her ability in deciding how many effective units of land to rent and which crop to cultivate. Let us consider a farmer i endowed with ability z_i. If the farmer chooses to produce rice, he/she rents E_{Ri} effective units of land. Based on the logic discussed above, the effective units of land demanded can also be written as $E_{Ri} = \int_{j \in J_R^i} e_{Rj}\, dj$, with J_R^i denoting the set of plots being rented in rice production. His/her real output in producing rice (y_R) is given by,

$$y_R(z_i) = \kappa z_i^{1-\alpha} \left(\int_{j \in J_R^i} e_{Rj}\, dj \right)^{\alpha} = \kappa z_i^{1-\alpha} E_{Ri}^{\alpha} \tag{1}$$

where the relative importance of land in production $\alpha \in (0, 1)$ governs the production functions in producing both rice and other agricultural goods. The constant term $\kappa^{-1} = \alpha^{\alpha}(1-\alpha)^{1-\alpha}$ is here to simplify expressions later on. The integral term depicts the total effective units of land that farmer i employs if he/she chooses to cultivate rice. Analogously, if the farmer decides to produce other agricultural goods, he/she rents a set of plot J_O^i. His/her real output in producing other crops (y_O) can be expressed as follows,

$$y_O(z_i) = \kappa z_i^{1-\alpha} \left(\int_{j \in J_O^i} e_{Oj}\, dj \right)^{\alpha} = \kappa z_i^{1-\alpha} E_{Oi}^{\alpha} \tag{2}$$

In our model, RLDP restrictions happen at the plot level, not farm level (further discussion is provided in Section 3.4). Here, farmers solve the usual profit maximization problem. We let $\{q_R, q_O\}$ depict the unit costs of an effective unit of land in producing rice and other crops respectively. Farmer i's profit maximization problem in producing rice is given by,

$$\pi_R(z_i) = \max_{E_R} \left\{ p_R \kappa z_i^{1-\alpha} E_{Ri}^{\alpha} - q_R E_{Ri} \right\} \tag{3}$$

with $\{p_R, p_O\}$ are the prices of rice and non-rice crops. First order conditions imply,

$$\pi_R(z_i) = z_i \left(\frac{p_R^{1/\alpha}}{q_R} \right)^{\frac{\alpha}{1-\alpha}} \tag{4}$$

Analogously, if he/she chooses to produce other agricultural goods, the profit is given by,

$$\pi_O(z_i) = z_i \left(\frac{p_O^{1/\alpha}}{q_O} \right)^{\frac{\alpha}{1-\alpha}} \tag{5}$$

Non-Agriculture Sector - Since our focus is on the agricultural sector, we keep production in the non-agriculture simple. The output is produced by a representative firm with access to constant returns to scale technology. To produce, this firm requires only effective labor as an input. The production function simply takes the form,

$$Y_M = \int_{i \in N_M} z_i di \tag{6}$$

where Y_M is the total amount of non-agricultural output produced and N_M is the set of workers (the set of farmers is then N_A). The representative firm maximizes profit by deciding how many efficiency units of labor to hire. Denoting w and p_M the unit prices of efficient labor and non-agricultural good respectively, firm optimization implies $w = p_M$. Thus, the representative firm pays a worker with ability z_i an amount of $z_i p_M$.

Next, we incorporate the idiosyncratic distortion τ_i into the model as an non-agricultural income tax of rate $[1-\tau_i]$ for working in the non-agricultural sector. This distortion is a wedge in the occupational choice decision between farmer and non-agricultural worker. It allows us to reproduce two important targets including: (i) the distribution of farm value-added, and (ii) the sectoral gap in labor productivity. Therefore, the net income of an individual i if he/she chooses to be a worker is given by $\widetilde{w}(z_i, \tau_i) = (1 - \tau_i) z_i p_M$.

Instead of assuming a joint cdf $H(z, \tau)$, there are different approaches taken by prior studies. For example, we can have just one common fixed cost of mobility such as the work of Adamopoulos and Restuccia (2014a). However, doing so will change the shape of individual ability distribution when requiring the model to reproduce the distribution of individual earnings.[9] Another approach is to have a joint distribution of agricultural and non-agricultural ability as implemented in Lagakos and Waugh (2013) and Adamopoulos et al. (2017). This approach will require two more moments for our model to match relevant targets.[10] Since our focus is on land use misallocation in agriculture and labor moving out of agriculture, we shy away from the second method to avoid unnecessary complication. Therefore, as in Garcia-Santana and Pijoan-Mas (2014), we prefer the use of the idiosyncratic distortion for two reasons: (i) it provides a straightforward setup in our context, and (ii) it allows for an extra degree of freedom in reproducing individual earnings, thus, keeping the ability distribution from being compromised.

3.3 Labor Allocation

In this section, we turn our discussion to the allocation of labor across sectors. The individuals choose between one of the two mutually exclusive jobs: farmer and non-agricultural worker. In addition, if an individual decides to become a farmer, he/she can further choose to produce either rice or other crops.

- **Proposition 1** *There exist a threshold, denoted by $\bar{\tau}$, such that individual i becomes a farmer if $\tau_i \geq \bar{\tau}$, and a worker otherwise. Conditional on being a farmer, the individual is indifferent about which crop to produce, i.e. $\pi_R(z_i) = \pi_O(z_i)$.*

The proof of Proposition 1 comes from the indifference conditions between the choices of occupation and production. Let us first consider the problem of choosing which crop to produce by a farmer. From equations (4) and (5), it can be shown that the profit difference across crop production choices for any farmer depends only on the output prices and rental

[9] The ability distribution will be discontinuous at the threshold of occupational choice with the lowest ability of non-agricultural workers being higher than the highest ability of farmers.

[10] These moments include the sectoral earnings correlation and the dispersion in non-agricultural earnings.

rates of effective units of land. In particular,

$$\pi_R(z_i) - \pi_O(z_i) = z_i \left[\left(\frac{p_R^{1/\alpha}}{q_R} \right)^{\frac{\alpha}{1-\alpha}} - \left(\frac{p_O^{1/\alpha}}{q_O} \right)^{\frac{\alpha}{1-\alpha}} \right] \tag{7}$$

Here, farmer i will produce rice if $\pi_R(z_i) - \pi_O(z_i) \geq 0$, and other agricultural goods otherwise. It is clear that the production choice is independent from individual endowment $\{z_i, \tau_i\}$. If the inequality $p_R/q_R^\alpha > p_O/q_O^\alpha$ is satisfied, then all farmers would choose to produce rice. Conversely, if $p_R/q_R^\alpha < p_O/q_O^\alpha$, all farmers would engage in production of other agricultural goods. We assume that the indifference curve for consumption goods does not cross the consumption axes. In this way, corner solutions will not be possible, and the case where $p_R/q_R^\alpha \neq p_O/q_O^\alpha$ cannot constitute an equilibrium. Therefore, in an equilibrium where the equality $p_R/q_R^\alpha = p_O/q_O^\alpha$ must be satisfied, a farmer is indifferent about which crop to produce $\pi_R(z_i) = \pi_O(z_i) = \pi(z_i)$. This profit indifference condition also suggests a common price ratio $\lambda = q_R/p_R^{1/\alpha} = q_O/p_O^{1/\alpha}$ across farms and crops.

An individual i with a set $\{z_i, \tau_i\}$ maximizes his/her earnings by choosing to be a non-agricultural worker for an amount of $\widetilde{w}(z_i, \tau_i)$ or a farmer for a profit of $\pi(z_i)$. Thus, individuals' occupational choice can be described by the indifference condition between earnings across the two occupations. Equalizing $\widetilde{w}(z_i, \tau_i)$ and $\pi(z_i)$ gives us the threshold $\bar{\tau}$, such that,

$$(1 - \bar{\tau}) p_M \lambda^{\frac{\alpha}{1-\alpha}} = 1 \tag{8}$$

Intuitively, the idiosyncratic distortion τ_i can be thought of as any type of barriers to labor mobility across sectors. For example, the set of farmers $i \in N_A$ includes those whose face a high enough migration cost, i.e. $\tau_i \geq \bar{\tau}$, so that they decide to stay in agriculture. Analogously, the set of workers $i \in N_M$ are those enjoying lower cost of mobility, i.e. $\tau_i < \bar{\tau}$, thus, moving to the non-agricultural sector. Utilizing the common price ratio $\lambda = q_R/p_R^{1/\alpha} = q_O/p_O^{1/\alpha}$ and solutions to farm profit maximization as in equation (3), we can express the optimizing rules for farmer i as follows,

$$\pi(z_i) = \frac{z_i}{\lambda^{\alpha/1-\alpha}} \tag{9}$$

$$p_R y_R(z_i) = p_O y_O(z_i) = \frac{z_i}{(1-\alpha)\lambda^{\alpha/1-\alpha}} \tag{10}$$

$$q_R E_R(z_i) = q_O E_O(z_i) = \frac{\alpha z_i}{(1-\alpha)\lambda^{\alpha/1-\alpha}} \tag{11}$$

By presenting this way, it is clear that farm profit (9), value-added (10), and expenditure on effective units of land rented (11) are equal across crop choices for each farmer. With α and λ being common across farms, equation (10) states that variation in farm value-added linearly depends on variation in individual ability. This characterization provides a simple mapping between the model distribution of farmers' ability and the micro-data's distribution of farms' value-added in our calibration.

3.4 Restrictions and Land Allocation

In this section, we turn to discuss land use allocation. There are J size-one plots of agricultural land in the economy, such that $L = \int_J dj$ is the total agricultural land (Section 3.1). The plots are heterogeneous in a two-dimensional suitability $\{e_R, e_O\}$ and a restriction status δ drawn from the spatial distribution $F(e_R, e_O, \delta)$. Here, δ is an indicator, with the convention that $\delta_j = 1$ if plot j is subject to RLDP. Therefore, the total restricted area in agriculture can be expressed as $\int \delta_j dj$, and the total unrestricted land is simply $\int (1 - \delta_j) dj$.

In the absence of land use restrictions, all farmers maximize their profits implying that plots of land are optimally utilized. This means the land supplier (household) rents out the plots at their highest values, and the plot renter (farmers) will put the plot to its best use. However, due to RLDP restrictions, plots with $\delta = 1$ can only be used in rice production. Consequently, the values of these plots are distorted. Consider plot $j \in J$ with a suitability set $\{e_{Rj}, e_{Oj}\}$, the value of this plot is equal to $q_R e_{Rj}$ if it is used in rice production. Similarly, if plot j is utilized for non-rice production, its value is given by $q_O e_{Oj}$. Thus, the optimal value of plot j follows a rule given by,

$$\max \left\{ q_R e_{Rj},\ q_O e_{Oj} \right\} = \lambda \max \left\{ p_R^{1/\alpha} e_{Rj},\ p_O^{1/\alpha} e_{Oj} \right\}, \qquad \forall j \in J \tag{12}$$

where we make use of the equality $\lambda = q_R / p_R^{1/\alpha} = q_O / p_O^{1/\alpha}$ (see Proposition 1) to derive the right hand side of equation (12). Nevertheless, if plot j is reserved for rice production, i.e. $\delta_j = 1$, then its value is simply fixed at $[q_R e_{Rj}]$. Put it differently, there is no other choices regarding land use for the restricted plots.

Equation (12) also states that the optimal use of a plot is determined by the relative suitabilities and crop prices. For example, if $(e_{Rj}/e_{Oj})^{\alpha} > p_O / p_R$, then it is efficient to devote plot j for rice production, and vice versa. Let D be a dummy variable indicating the optimal use of all plots, with the convention that $D = 1$ if it is optimal for a plot to produce rice.

Then, the optimizing rule for land use in equation (12) can also be described by,

$$D_j \in \arg\max \left\{ D_j p_R^{1/\alpha} e_{Rj} + (1 - D_j) p_O^{1/\alpha} e_{Oj} \right\}, \qquad \forall j \in J \tag{13}$$

With this way of denotation, we can express the total land rent, which is aggregated from equation (12), in a more compact form. Particularly, the total land rent in rice production, denoted by Q_R, is given by,

$$Q_R = \lambda p_R^{1/\alpha} \left(\int e_{Rj} \delta_j \, dj + \int e_{Rj} (1 - \delta_j) D_j \, dj \right) \tag{14}$$

and in the production of other agricultural goods, denoted by Q_O, is as the following,

$$Q_O = \lambda p_O^{1/\alpha} \int e_{Oj} (1 - \delta_j)(1 - D_j) \, dj \tag{15}$$

In equation (14), the first and second integral terms are the total effective units of land used in rice production for the restricted plots and unrestricted plots respectively. Analogously, the value of the integral in equation (15) represents the total effective units of land utilized for the production of other agricultural commodities, conditional on not being restricted.

3.5 Consumption

The representative household uses all of its income to purchase consumption goods. Its total income can stem from three main sources: (i) individual income from workers and farmers $W = \int_{i \in N_M} \widetilde{w}(z_i, \tau_i) di + \int_{i \in N_A} \pi(z_i) di$, (ii) a lump sum transfer T coming from idiosyncratic distortions, and (iii) land income from renting out plots of land for farm production $Q = Q_R + Q_O$. The household seeks to maximize its utility subject to the budget constraint $p_R C_R + p_O C_O + p_M C_M = W + T + Q$. It has preferences over the consumption of agricultural and non-agricultural goods described by the following utility function,

$$\ln U = (1 - \beta) \ln C_M + \beta \ln \left(\left[\phi C_R^{\frac{\zeta - 1}{\zeta}} + (1 - \phi) C_O^{\frac{\zeta - 1}{\zeta}} \right]^{\frac{\zeta}{\zeta - 1}} - \psi \right) \tag{16}$$

where $\{C_R, C_O\}$ denote the total consumption of each agricultural good, and C_M is the total consumption of the non-agricultural good. The parameters $\{\phi, \beta\} \in (0, 1)$ govern the preference weights across consumption goods, and $\zeta > 0$ is the elasticity of substitution across crops. Finally, the parameter ψ depicts the subsistence requirement for agricultural goods in the spirit of Restuccia et al. (2008). Thus, the household always prioritizes the consumption of agricultural goods up to ψ level. After that, it may allocate the remaining income to all goods according to their weights. A standard argument from first order conditions implies,

$$\frac{p_R}{p_O}\left(\frac{C_R}{C_O}\right)^{1/\zeta} = \frac{\phi}{1-\phi}\ , \qquad\qquad \frac{p_M C_M}{p_R C_R + p_O C_O - \chi(p_R, p_O)} = \frac{1-\beta}{\beta} \tag{17}$$

where we let $\chi(p_R, p_O) = \psi\left[p_R\left(\frac{\phi}{p_R}\right)^{\zeta} + p_O\left(\frac{1-\phi}{p_O}\right)^{\zeta}\right]^{1/1-\zeta}$. Intuitively, the right hand equality of equation (17) states that the household always devote $\chi(p_R, p_O)$ amount of its income to agricultural goods in order to survive. After meeting the subsistence requirement, it can freely allocate the remaining income to non-agricultural goods $p_M C_M$ and non-subsistent agricultural goods $p_R C_R + p_O C_O - \chi(p_R, p_O)$ according to the preference weights.

4 Equilibrium and Misallocation

In this section, we first define a competitive equilibrium of the model where RLDP is prevalent. Then, we describe the effects of the land use restrictions on both land and labor allocation. To do so, we compare the current economy of Vietnam to a hypothetical economy where all areas subject to RLDP are liberated.

4.1 Equilibrium

We consider the static competitive equilibrium of the model in the presence of RLDP, consisting of: (i) an output price set $\{p_R, p_O, p_M\}$, (ii) an input price set $\{w, q_R, q_O\}$, (iii) a set of farmer decision functions $\{E_g(z), y_g(z)\}_{g\in\{R,O\}}$, (iv) a threshold characterizing occupational choices $\bar{\tau}$, (v) a set of indicators $\{D_j, \delta_j\}\ \forall j \in J$ describing plots' uses and restriction status, and (vi) a bundle of consumption choices $\{C_R, C_O, C_M\}$, such that,

- Given prices, the threshold $\bar{\tau}$ is the optimal occupational choice for all individuals, and $D_j\ \forall j \in J$ is the optimal use for all unrestricted plots.
- Given prices, the allocation rules $\{E_g(z), y_g(z)\}_{g\in\{R,O\}}$ are profit maximizing for all individuals choosing to be farmers.
- Given prices, the bundle $\{C_R, C_O, C_M\}$ is utility maximizing for the representative household, subject to the budget constraints.

- Representative firm optimizes, budget balances, and all markets clear,

  1. Output markets from equation (6, 10) and budget balance,

$$p_M C_M = p_M \int_{i \in N_M} z_i di \ , \qquad \sum_{g \in \{R,O\}} p_g C_g = \frac{\lambda^{\alpha/\alpha-1}}{1-\alpha} \int_{i \in N_A} z_i di \tag{18}$$

  2. Land market from equation (11, 14, 15) and the household's land income,

$$Q_R + Q_O = \frac{\alpha \lambda^{\alpha/\alpha-1}}{1-\alpha} \int_{i \in N_A} z_i di \tag{19}$$

4.2 Misallocation

In this section, we describe the productivity effects of RLDP through two channels: land use misallocation and distortions in occupational choice. We compare the current economy of Vietnam to a hypothetical economy where all restrictions are liberated. To keep our discussion intuitive and straightforward, we provide examples in which we abstract from the offsetting effects caused by changes in prices.

- **Proposition 2** *Liberating RLDP raises the aggregate agricultural output and agricultural TFP by increasing the average effective stock of agricultural land.*

The intuition is quite simple. Removing restrictions means that plots of agricultural land can be put to their best use. As a result, the effective stock of agricultural land is maximized, leading to an increase in the agricultural total factor productivity. Let us proceed to denote by $Y_A = p_R Y_R + p_O Y_O$ the aggregate agricultural output (real agricultural GDP), and by TFP_A the agricultural total factor productivity. Then, we proceed to formalize an equation that allows us to quantify the value of TFP_A. First, we derive the total agricultural output Y_A from equation (10) as follows,

$$Y_A = \bar{z}_A N_A \frac{\lambda^{\alpha/\alpha-1}}{1-\alpha} \tag{20}$$

where $\bar{z}_A$ is the average farmer ability, and $\bar{z}_A N_A = \int_{i \in N_A} z_i di$ is the total stock of farmer ability. Analogously, we proceed to denote by $\bar{E} = (Q_R + Q_O)/\lambda L$ the average effective stock of land (please refer to equations (14) and (15) for full expressions). Then, the land market's clearing condition from equation (19) can be rewritten as the following,

$$\lambda^{\frac{1}{\alpha-1}} = \frac{\bar{E}L}{\bar{z}_A N_A}\,\frac{1-\alpha}{\alpha} \tag{21}$$

Combining equations (20) and (21), we are able to express the aggregate agricultural output as a function of total agricultural land (L), total number of farmers (N_A), and agricultural TFP. The function takes a familiar form given by,

$$\begin{aligned} Y_A &= \left[\left(\frac{\bar{E}}{\alpha}\right)^{\alpha}\left(\frac{\bar{z}_A}{1-\alpha}\right)^{1-\alpha}\right] L^{\alpha} N_A^{1-\alpha} \\ &\equiv \left[TFP_A\right] L^{\alpha} N_A^{1-\alpha} \end{aligned} \tag{22}$$

where the term TFP_A representing the agricultural TFP will be our primary focus when performing a quantitative analysis. In addition, the functional form of TFP_A states that any improvement in the average effective stock of land ($\bar{E}$) or farmer ability ($\bar{z}_A$) will raise the agricultural TFP. Next, for the purpose of simplicity, let us consider a simple case where all prices and labor allocation are held fixed. We denote by $\bar{E}^*$ the average effective stock of land at the efficient level. From the discussion in Section 3.4, the total gain in the average effective stock of land stemming from RLDP liberation is given by:

$$\begin{aligned} \bar{E}^* - \bar{E} &= \frac{1}{L}\int \delta_j \left[\max\left\{p_R^{1/\alpha} e_{Rj},\ p_O^{1/\alpha} e_{Oj}\right\} - p_R^{1/\alpha} e_{Rj}\right] dj \\ &= \frac{1}{L}\int \delta_j (1-D_j)\left(p_O^{1/\alpha} e_{Oj} - p_R^{1/\alpha} e_{Rj}\right) dj \end{aligned} \tag{23}$$

Here, the effective units of land are weighted by the corresponding constant prices. The dummy δ indicates plots' restriction status. Thus, there is no gain in the effective stock of land stemming from the unrestricted plots with $\delta = 0$. As in equation (12), the maximization term here regulates the optimal land use for all of the plots.

First, equation (23) states that not all restricted plots are distorted in land use. For example, if plot j's optimal choice is to produce rice, i.e. $\max\left\{p_R^{1/\alpha} e_{Rj},\ p_O^{1/\alpha} e_{Oj}\right\} = p_R^{1/\alpha} e_{Rj}$, then RLDP does not change its optimal use. Thus, the term in the square bracket of equation (23) takes a value of zero. However, if the optimal choice of plot j is to produce other crops, i.e. $\max\left\{p_R^{1/\alpha} e_{Rj},\ p_O^{1/\alpha} e_{Oj}\right\} = p_O^{1/\alpha} e_{Oj}$, then RLDP prevents the plot from being optimally utilized. It is clear that the loss in the effective stock of land is captured by the difference term $\left[p_O^{1/\alpha}e_{Oj} - p_R^{1/\alpha}e_{Rj}\right]$. Therefore, in this simple case, a gain in the agricultural TFP and aggregate output from eliminating RLDP is entirely induced by an increase in the average effective stock of land, given by,

$$\frac{Y_A^*}{Y_A} = \frac{TFP_A^*}{TFP_A} = \left(\frac{\bar{E}^*}{\bar{E}}\right)^\alpha \tag{24}$$

This gain equation also suggests that our productivity gain is sensitive to the parameter value α. In the calibration section, we take a conservative approach by choosing a low value of parameter α. In addition, we cautiously note that there are price effects offsetting the gain from resource reallocation. The reason is that inputs (labor and land) and output (rice and others) are not perfect substitutes. These price effects manifest themselves through both crop choice and occupational choice. In the example given above, we abstract from the price effects for the sake of simplicity. However, we do allow prices to change in our actual analysis.

In the next stage, we turn to discuss changes in occupational choice. As the agricultural sector becomes more productive due to RLDP liberation, there will be a reallocation of labor across sectors. This movement has non-negligible impacts on both agricultural and non-agricultural productivity.

- **Proposition 3** *Liberating RLDP releases farmers out of agriculture, thus, raising the total output in the non-agricultural sector.*

The intuition is as follows. First, the supply of effective stocks of land is distorted by RDLP. Consequently, the agricultural TFP and the total agricultural output in the restricted economy are both lower than the ones of the efficient level. Since the representative household must secure the subsistence consumption, it has to allocate a significant share of its members into agriculture to compensate for the loss in the total agricultural output stemming from land use misallocation.[11] From Proposition 2, liberating RLDP will raise the agricultural output by improvement in TFP_A, thus, reducing the burden of subsistence consumption requirement. Hence, it follows that a number of farmers will be released to the non-agricultural sector as RLDP restrictions being lifted.

[11] Please refer to Restuccia et al. (2008) for a discussion on this topic. The authors also provide a simple but intuitive setting in which misallocation in agriculture can lower the share of non-agricultural labor to satisfy the subsistence consumption.

To facilitate the discussion, let us relax the assumption of fixed labor allocation in the example given in Proposition 2. The output and input prices are still being held constant, hence, abstracting from the offsetting price effects. We proceed to express the right hand equality of equation (17) as $\beta Y_M = (1-\beta)\big[Y_A - \chi\big]$. Then, the non-agricultural output gain can be expressed as follows,

$$\frac{Y_M^*}{Y_M} = \frac{Y_A^* - \chi}{Y_A - \chi} = 1 + \frac{Y_A^* - Y_A}{Y_A - \chi} \tag{25}$$

where Y_M^* is the non-agricultural output at the efficient level. Equation (25) states two important points. First, as the total agricultural output increases ($Y_A^* > Y_A$), the total non-agricultural output must also increase ($Y_M^* > Y_M$). Second, the higher the level of subsistence consumption requirement, the larger the effect of misallocation. In other words, the term $[Y_A - \chi] < Y_A$ captures the amplified output gain/loss in the non-agricultural sector caused by misallocation in the agricultural sector. For example, the smaller the value of $Y_A - \chi$, the higher the value of $(Y_A^* - Y_A)/(Y_A - \chi)$.

From equation (6), i.e. $Y_M = \int_{i \in N_M} z_i di$, it is clear that $Y_M^* > Y_M$ is driven by additional workers moving to the non-agricultural sector, not the other way around. Therefore, our model suggests that the gain/loss in the agricultural productivity also reflects the increase/decrease in the supply of workers in the non-agricultural sector.

Let us denote by N_S and $\bar{z}_S$ the total number and the average ability of those switching occupation after moving to the efficient level. As the assumption of fixed labor allocation is relaxed, the expression in equation (22) suggests the gain in agricultural output as follows,

$$\frac{Y_A^*}{Y_A} = \frac{TFP_A^*}{TFP_A} \left(\frac{N_A - N_S}{N_A}\right)^{1-\alpha} = \left(\frac{\bar{E}^*}{\bar{E}}\right)^{\alpha} \left(\frac{N_A \bar{z}_A - N_S \bar{z}_S}{N_A \bar{z}_A}\right)^{1-\alpha} \tag{26}$$

where the term $(N_A\bar{z}_A - N_S\bar{z}_S)/(N_A - N_S)$ is the average farmer ability, and the term $N_A - N_S$ is the total number of farmers at the efficient level. The common terms $N_A - N_S$ and L are both canceled out, thus, reducing to the last expression of equation (26). The equation suggests that the gain in agricultural output is a geometric weighted mean of a change in the effective stock of land and a change in farmer ability stock. Next, the non-agricultural output gain can be expressed as follows,

$$\frac{Y_M^*}{Y_M} = \frac{N_M \bar{z}_M + N_S \bar{z}_S}{N_M \bar{z}_M} \tag{27}$$

Here, N_M and $\bar{z}_M$ are the total number and the average ability of the existing workers. The derivation is quite simple. The term $N_M\bar{z}_M = \int_{i\in N_M} z_i di$ is the current level of the non-agricultural output, and the term $N_M\bar{z}_M + N_S\bar{z}_S = \int_{i\in N_{M,S}} z_i di$ expresses the non-agricultural output at the efficient level. Dividing the later by former yields the equality (27). This equation states that the gain in non-agricultural output is affected by a change in the stock of worker ability.

- **Proposition 4** *Liberating RLDP raises both the average farm size and the agricultural TFP. However, it reduces the average ability of both farmers and workers through the reallocation of labor across sectors. Such reductions offset the gain in agricultural TFP and decrease non-agricultural labor productivity.*

We continue with our example in Proposition 3. Since liberating RLDP leads to a decrease in the number of farmers, it certainly induces an increase in the average farm size. From the second equality of equation (26), we decompose the gain in agricultural TFP as follows,

$$\frac{TFP_A^*}{TFP_A} = \left(\frac{\bar{E}^*}{\bar{E}}\right)^{\alpha} \left(1 + \frac{N_S(\bar{z}_A - \bar{z}_S)}{N_A\bar{z}_A - N_S\bar{z}_A}\right)^{1-\alpha} \tag{28}$$

Here, we can see that the change in agricultural TFP is driven by changes in both labor and land characteristics. As we discussed in Proposition 2, lifting RLDP leads to an increase in the average effective stock of land, thus, contributing to the gain in agricultural TFP. This gain can be reduced or amplified depending on the relationship between $\bar{z}_A$ and $\bar{z}_S$. For example, if $\bar{z}_A < \bar{z}_S$, the reallocation of labor out of agriculture will offset the gain in agricultural TFP coming from land reallocation. Analogously, from equation (27), the change in non-agricultural labor productivity is given by,

$$\frac{Y_M^*}{N_M + N_S}\frac{N_M}{Y_M} = \frac{N_M\bar{z}_M + N_S\bar{z}_S}{N_M\bar{z}_M + N_S\bar{z}_M} = 1 + \frac{N_S(\bar{z}_S - \bar{z}_M)}{N_M\bar{z}_M + N_S\bar{z}_M} \tag{29}$$

Note that labor productivity in non-agriculture is obtained by dividing output by the total number of workers. Since the representative firm requires only effective labor to produce, non-agricultural labor productivity is also non-agricultural TFP. From equation (29), it is clear that the change in non-agricultural labor productivity is also influenced by the average ability of those moving out of agriculture. For example, if $\bar{z}_S < \bar{z}_M$, the non-agricultural labor productivity will decrease, and vice versa.

With reasonable parameter values in line with the calibration (labor productivity in non-agriculture is much higher than in agriculture), the mobility cost τ is negatively correlated with individual ability z. We denote by $\bar{\tau}^*$ an efficient threshold characterizing occupational choice. From the discussion of equation (8), it follows that individuals with $\tau_i \geq \bar{\tau}^*$ will remain in agriculture. Since liberating RLDP will reduce the number of farmers, the inequality $\bar{\tau}^* > \bar{\tau}$ must be satisfied. Therefore, the average ability of those moving out of agriculture (those endowed with $\bar{\tau}^* > \tau_i > \bar{\tau}$) will be lower than the average ability of the existing workers, but higher than the one of the remaining farmers, i.e. $\bar{z}_A < \bar{z}_S < \bar{z}_M$. This movement suggests a reduction in the average ability of both farmers and workers. Therefore, equation (28) suggests that the reduction in average farmer ability offset the gain in agricultural TFP stemming from the improvement of effective stock of land. From equation (29), the average ability of the new workers is relatively lower than the existing ones, which unambiguously translates to lower labor productivity in the non-agricultural sector at the efficient level. This implication coincides with the contribution of Garcia-Santana and Pijoan-Mas (2014) in which the reassignment of individuals between sectors can dampen the gain in TFP after moving to the efficient level.

5 Connecting Model and Data

Our strategy is to calibrate the model parameters in a benchmark economy to the restricted economy where RLDP is prevalent. We proceed in two steps. In Section 5.1, we first describe our assumptions on the functional forms of the distributions of individual characteristics $H(z, \tau)$ and land characteristics $F(e_R, e_O, \delta)$. In Section 5.2, given the assumed distributions, we calibrate the model parameters to match relevant data targets, such that the model equations constitute an equilibrium.

5.1 Functional Forms

Individual Characteristics - We need the joint cdf $H(z, \tau)$ to closely reproduce farm value-added distribution and labor productivity difference across the two sectors. Instead of directly parameterizing $H(z, \tau)$, we follow an approach of Garcia-Santana and Pijoan-Mas (2014) in parameterizing the conditional distribution $H(z|\tau)$. To do so, we first assume that the idiosyncratic distortions τ is drawn from a uniform distribution in the range of $[0, 1]$.

Then, the ability distribution is assumed to be conditionally log-normal taking the form of,

$$\log z_i = \gamma_0 + \gamma_1 \log \tau_i + \epsilon_i \tag{30}$$

where ϵ_i is a random variable drawn from a normal distribution with a variance of σ_ϵ^2. Here, the parameter γ_0 serves as a scale. The two parameters γ_1 and σ_ϵ together governs the distribution of ability. More importantly, the value of γ_1 regulates the correlation between ability and distortions, thus, allowing us to reproduce the sectoral difference in labor productivity. A negative value of γ_1 implies a negative correlation between ability z and distortion τ. Consequently, low ability individuals tend to face high mobility barrier creating an incentive for them to stay in agriculture. This characterization allows us to precisely match the large gap in labor productivity across the two sectors.

Land Characteristics - For the distribution of crop-specific productivity and restriction status, we want the cdf $F(e_R, e_O, \delta)$ to reproduce the empirical distribution of plot values and restrictions. We assume that the joint distribution of the two-dimensional productivity $\{e_R, e_O\}$ follows a bivariate log-normal distribution with zero means and covariance matrix,[12]

$$\Sigma = \begin{Bmatrix} \sigma_R^2 & \sigma_{RO} \\ \sigma_{RO} & \sigma_O^2 \end{Bmatrix} \tag{31}$$

where σ_{RO}, σ_R^2, and σ_O^2 are the covariance and variance of rice and non-rice productivity (in log form). The value of $\sigma_{RO}/(\sigma_R \sigma_O)$ is the correlation coefficient for productivities across crops. Given the joint distribution of the two-dimensional productivity, plots face a probability of being restricted to RLDP according to the Bernoulli conditional distribution. We assume the following functional form of restriction probability across plots,

$$\mathrm{P}(\delta_j = 1 | e_{Rj}, e_{Oj}) = \eta_0 + \eta_1 \log e_{Rj} + \eta_2 \log e_{Oj} \tag{32}$$

where $\mathrm{P}(\delta_j = 1 | e_{Rj}, e_{Oj})$ denotes the probability of plot j being restricted, conditional on its two-dimensional productivity. As discussed previously, the restriction status δ_j takes a value of one if the plot j is subject to RLDP, and zero otherwise. The three associated parameters $\{\eta_0, \eta_1, \eta_2\}$ together regulate the share of restricted plots, the correlation between

[12] The means will be scaled by crop prices in our model. Therefore, we can set them to zero for simplicity without affecting the results.

restrictions and rice productivity, and the correlation between restrictions and non-rice productivity. Intuitively, negative values of η_1 and η_2 suggest that relatively low productivity plots in cultivating rice and non-rice are more likely to face RLDP-restrictions. To sum up, the distribution of land characteristic $F(e_R, e_O, \delta)$ can be described by a set of six model parameters $\{\sigma_R, \sigma_O, \sigma_{RO}, \eta_0, \eta_1, \eta_2\}$.

5.2 Calibration Choices

We are now ready to discuss our calibration choices. The restricted economy is characterized by 16 model parameters. We take two of them from previous literature and normalize one parameter to unity $\{\alpha, \zeta, p_R\}$. The other seven parameters need to be calibrated within the model $\{\gamma_0, \gamma_1, \sigma_\epsilon, L/N, \phi, \beta, \psi/N\}$. The remaining six parameters are estimated directly from the joint population distribution of land characteristics $\{\sigma_R, \sigma_O, \sigma_{RO}, \eta_0, \eta_1, \eta_2\}$.

Price, Technology, Substitutability $\{p_R, \alpha, \zeta\}$ - Since what matters in the model is the relative price, we start by normalizing p_R to one. Then, the technology parameter α regulating the income share of land is set at 0.35. This choice of value is in a reasonable range of previous studies on developing economies. For example, Haley (1991) reports a land share of 0.34 for Asian countries, Restuccia and Santaeulalia-Llopis (2017) document a share of 0.39 for Malawi, and Adamopoulos et al. (2017) estimate a land income share of 0.36 for China. Our choice of value is slightly below the average so as to be conservative in estimating the effects of land misallocation. The parameter ζ, which regulates the substitutability across agricultural goods, is set to 2.63. This choice reflects the midpoint between a value of 2.44 to 2.80 in Sotelo (2015) and a value of 2.82 in Costinot et al. (2016).

Table 1: Parameterization 1 - Targets and Results

Parameter	Value	Target
p_R	1	Normalization
α	0.35	Land to labor income share
ζ	2.63	Elasticity of substitution

Labor Characteristics $\{\gamma_0, \gamma_1, \sigma_\epsilon, L/N\}$ - As discussed at the end of Section 3.3, we want our model distribution of ability to reproduce the distribution of farm value-added. Thus, we utilize the Vietnam Access to Resources Household Survey (VARHS) dataset, which is an unbalanced panel survey of six waves over 2002 - 2012. The sample of this dataset reflects the samples of the population census and the representative Vietnam Household

Living Standards Survey. Therefore, this dataset is likely to be nationally representative and comparable with the aggregate statistics. We proceed to exclude households not involved in agriculture production. Then, farm value-added is computed by subtracting costs of intermediate inputs from total values of output produced.[13] We also trim 1% tails to rule out potential measurement errors. We thus obtain a dispersion of log value-added of 0.96.

Another important statistics is the labor productivity ratio between the agricultural and non-agricultural sector. From World Bank collection of development indicators 2002 - 2012, we obtain an average of employment share in agriculture of 52.92% an average of agricultural value added share of 20.1%. These statistics translate to a relative labor productivity ratio between the two sectors of approximately 4.47.[14]

For the conditional distribution of ability, we proceed to set the parameter γ_0 at 7.36, such that the average farm value-added is 632 US dollars as in VARHS (2003 constant price). We then proceed to estimate the other two parameters $\{\gamma_1, \sigma_\epsilon\}$. Particularly, we want the model to generate a relative labor productivity ratio between the two sectors of 4.47 in the equilibrium. This target implies a value of $\gamma_1 = -0.68$. Then we use σ_ϵ to reproduce the dispersion of log value-added of 0.96. This require a parameter value of $\sigma_\epsilon = 0.96$. For the aggregate endowment of labor and land, we set the ratio of L/N to 0.45 implying an average farm size of 0.86 hectares as observed in VARHS over 2002 - 2012.

Table 2: Parameterization 2 - Targets and Results

Parameter	Value	Target
γ_0	7.36	Average farm value-added ($632)
γ_1	-0.68	Sectoral relative labor productivity (4.47)
σ_ϵ	0.96	Farm value-added dispersion(0.96)
L/N	0.45	Average farm size of 0.86 hectares
ϕ	0.25	Share rice land in agriculture (54%)
β	0.002	Long-run agricultural employment (5%)
ψ/N	147.2	Current agricultural employment (52.9%)

Preferences and Endowment $\{\phi, \beta, \psi/N\}$ - Next, we target the share of land dedicated to rice production in calibrating the preference for rice ϕ. Given the distributions of individual

[13] The costs of intermediate inputs include seeds, saplings, fertilizers, pesticides, herbicides, non-durable tools, energy, fuel, maintenance, irrigation fees, transportation, and other minor costs.

[14] Agricultural labor productivity is $\frac{0.201}{0.5292} \times \frac{GDP}{Labor}$. Non-agricultural labor productivity is $\frac{0.799}{0.4708} \times \frac{GDP}{Labor}$. We then divide the later by the former to obtain a labor productivity ratio of 4.47.

and land characteristics, we set $\phi = 0.25$ such that the model yields the share of total rice land in agriculture of 54%, as reported by the General Statistics Office over the period of 2002 - 2012. We then follow the literature in setting β and ψ, such as the work of Restuccia et al. (2008), Lagakos and Waugh (2013), and Chen (2017). Here, the value of β determines the long-run share of agriculture employment of 5% where the subsistence constraint is not binding ($\psi = 0$). Then, the value of ψ characterizes the current share of agriculture employment of 52.92%. These targets imply the values of $\beta = 0.002$ and $\psi/N = 147.2$. Prior studies, e.g. Gollin et al. (2002, 2007) and Restuccia et al. (2008), suggest a lower long-run share of agriculture employment requiring a smaller value of β. As shown in Section 6.2, moving the value of β closer to zero would imply slightly stronger misallocation effects.

Land Characteristics $\{\sigma_R, \sigma_O, \sigma_{RO}, \eta_0, \eta_1, \eta_2\}$ - The set of six model parameters regulating the distribution of land characteristic $F(e_R, e_O, \delta)$ is acquired directly from the population moments being estimated as follows. We first obtain a precise measure of the specialized land for rice production from the Local Land Use Atlas 2007 (LLUA) provided by the Ministry of Agriculture and Rural Development.[15] We then digitize the maps using ArcGIS. Our process of transformation is done by requiring the coordinate grids of the maps and the shapefile to exactly match. As a result, we obtain full information on which area is for agriculture production and which agricultural area is subject to RLDP.

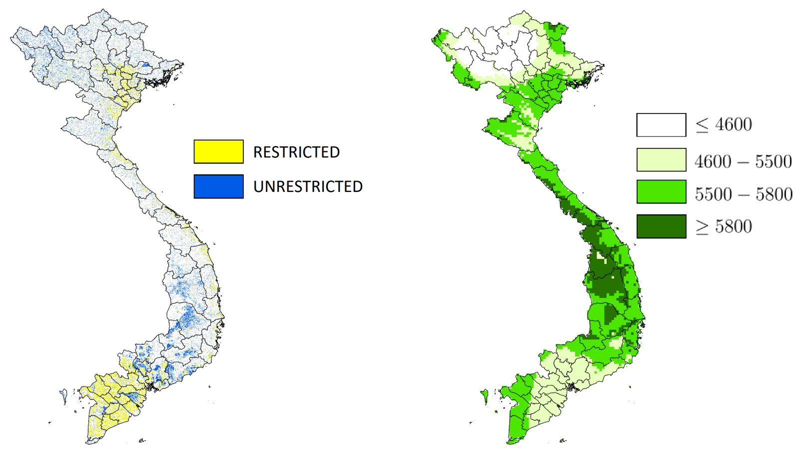
In Figure 1a, we present the spatial distribution of land use. Here, agriculture land consists of yellow and blue areas. The areas in yellow are those reserved for rice production only. The areas in blue are where farmers can cultivate other types of crop. We proceed to sample 100,000 equal size plots (spatial data points) on the agricultural land (yellow and blue areas). These plots represent the *'empirical plots'* guiding our parameter choices in calibration. Each of these plots contains information on restriction status, i.e. whether it is located in the yellow or blue areas. As reported in Resolution 29/2004/QH11, the share of the restricted area is around 44.69%, which is close to the share of restricted plots of 0.448 in our constructed dataset. Hence, the plots drawn from the digitized atlas are reasonably representative.

Next, we employ the Global Agro-Ecological Zones (GAEZ) database which provides the potential yields (in tons/ha/year) for different crops across micro-geographical units. The

[15] There is a total of 63 maps corresponding to 63 provinces/cities. These maps are conducted by the district/commune land offices throughout the country and reported to the General Department of Land Administration. It is worth noting that the National Assembly 2011 established RLDP restriction quotas for each province in the next ten years based on the detail information of LLUA.

potential yields here depend on purely exogenous agro-climatic conditions. Each unit (cell) is about 10 km^2 (5 arc-minute to be specific). Moreover, the potential yields are reported for different alternatives depending on water sources (irrigated and rain-fed) and agricultural practices (high, low, and intermediate inputs intensity).[16] We choose the yields associated with irrigated water sources and intermediate input intensity, which closely describe agricultural practices in Vietnam.[17]

Figure 1: Spatial Distributions of Restrictions and Rice Yields



(a) Land Use Distribution **(b)** Potential Yields for Rice

From GAEZ database, we have information on potential yields for wetland rice and other 17 major crops for each cell.[18] In Figure 1b, we illustrate the spatial distribution of potential yields for rice across the country. Combining with the spatial distributions of restrictions discussed previously, we have full information on restriction statuses and potential yields across 18 crops for our 100,000 representative plots. Next, we employ three waves of Vietnam Household Living Standards Surveys (VHLSS) conducted in even years from 2010 to 2014 to obtain a farm-gate price for each crop. For each crop-by-farm, a unit value is computed by dividing output values by physical quantity. A common set of prices is thus constructed as sample-wide averages for each crop in each province.

[16] Low inputs represent labor intensive practice without the use of fertilizer, pesticides, and chemicals (FPC for short). Intermediate inputs represent medium labor intensity practice with hand tools, some mechanization, and some FPC. High inputs represent low labor intensity with full mechanization, full utilization of FPC, and other advanced techniques. See www.gaez.fao.org and Adamopoulos and Restuccia (2018) for details.

[17] Note that management techniques (irrigation and intermediate input intensity) are common across cells and crops. This construction from GAEZ is consistent with our model in the sense that farm value-added is the same across land and crop for a given ability.

[18] Since dryland rice comprises a very small fraction of the total rice area, we focus on the wetland rice here.

Our last step is to value each of these plots across crop choices (rice or non-rice). In a manner analogous to equation (12) and (13), plot j's value in cultivating crop k is captured by $\{p_k^{1/\alpha} e_{kj}\}$. Thus, the value of plot j in producing rice is given by $p_R^{1/\alpha} e_{Rj}$, where e_{Rj} is the potential rice yield of the plot and p_R is the price of rice. On the other hand, plot j's value in producing other crops is obtained by taking the average of plot values in producing the other crops. In summary, we construct 100,000 plots carrying the spatial properties of the population distribution in plot by crop choice values and restrictions. This dataset provides us a set of population moments regarding land characteristics.

Table 3: Parameterization 3 - Targets and Results

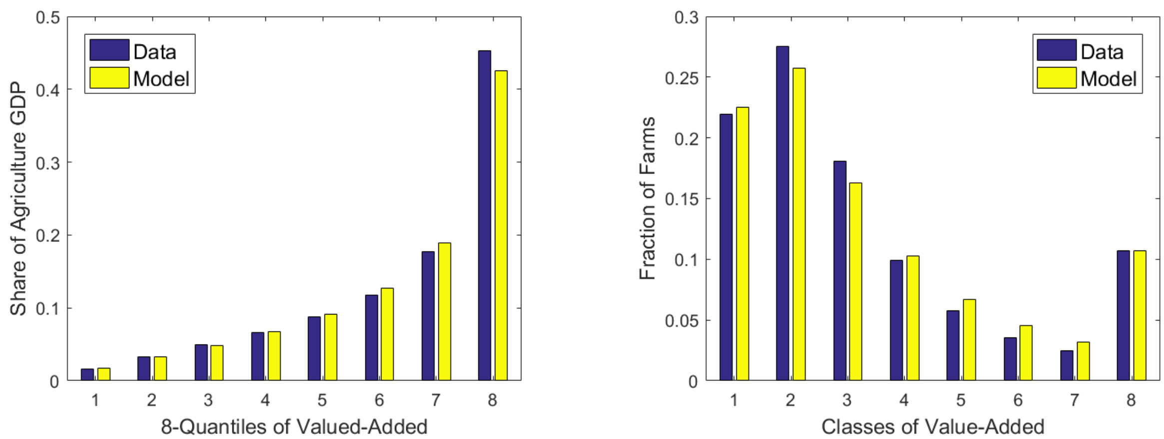
Parameter	Value	Target
σ_R	0.42	Plot value dispersion in producing rice
σ_O	1.37	Plot value dispersion in producing non-rice
σ_{RO}	0.14	Plot value correlation across crop choices
η_0	0.44	Share of restricted area
η_1	-0.19	Plot value partial correlation in rice and restriction
η_2	-0.02	Plot value partial correlation in non-rice and restriction

In the model, the price of each crop is common across farms. Thus, the empirical dispersion and covariance of log plot value conditional on producing rice and non-rice equal to the model dispersion and covariance of log plot productivity in rice and non-rice production, i.e. $\sigma_R = 0.42$, $\sigma_O = 1.37$, and $\sigma_{RO} = 0.14$. Next, the share of RLDP-restricted area is 44%, which translates to a value of $\eta_0 = 0.44$. Finally, we choose $\eta_1 = -0.19$ and $\eta_2 = -0.02$ to match the coefficient estimates from regressing RLDP-restriction status on log plot value in rice and non-rice production.

Table 1, 2 and 3 summarizes the values of all 16 model parameters. Recall that the first three parameters $\{p_R, \alpha, \zeta\}$ are either normalized or assigned directly based on previous literature. The remaining 13 parameters are determined by requiring the model to exactly reproduce relevant data targets. We refer to this calibrated economy as the benchmark economy. Given these parameter values, Figure 2 and 3 show how well the calibrated model matches the data. In Figure 2a, we sort farms into octiles according to their value-added and plot the share of agricultural GDP by farms of each octile. Figure 2b shows the fraction of farms falling into different value-added classes, ranging from 0-30%, 30-60%, ..., 180-210%, and above 210% of the average. Analogous to Figure 2, we plot the share of total plot value by plots of each octile in Figure 3a, and the fraction of plots falling into different value classes in Figure 3b.

We also plot the share of total plot value by plots of each octile for RLDP and non-RLDP plots separately (see Figure 3c and 3d). Overall, the calibrated model matches reasonably well the observed farm value-added, land value, and restriction distributions from the micro dataset, given our choices of the model parameters.

Figure 2: Calibrated Model versus Data at Farm Level



(a) Share of Agricultural GDP **(b)** Share of Farms

6 Quantitative Analysis

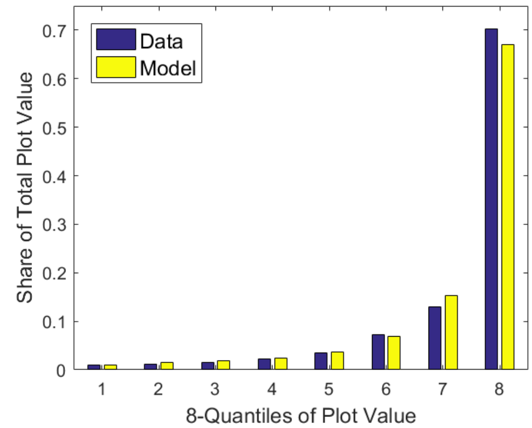
We are now ready to describe our quantitative results. From the benchmark economy, we conduct a set of counter-factual experiments to quantify the influence of RLDP on the allocation of resources. First, we investigate the impacts of solely liberating restricted land. Second, we perform sensitivity checks for several parameter values. Finally, we extend the model to capture 3% of the restricted plots not complying with RLDP. Then, we ask what happens to the aggregate outcomes if we force all farms to adhere to the policy.

6.1 Full Liberation and Main Results

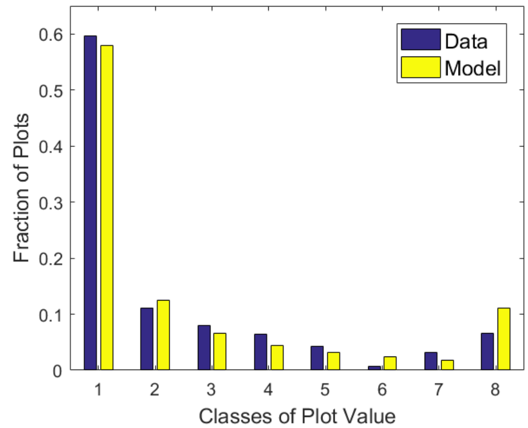
The baseline experiment concerns the effects of entirely liberating RLDP. To do so, we simply set $\delta_j = 0 \ \forall j \in J$, then re-solve the model with the calibrated set of parameters. The results of this experiment are summarized in Table 4. Here, we compare important statistics between the restricted economy (first column) and the efficient economy (second column). Then, the third column indicates the percentage changes as RLDP being lifted.

Before we start analyzing the results, it is important to note that all outputs in Table 4 are defined in terms of real GDP. Simply puts, all of the values are in 2003 US dollars, i.e. evaluated at the benchmark prices. The nominal GDP can be computed using the new

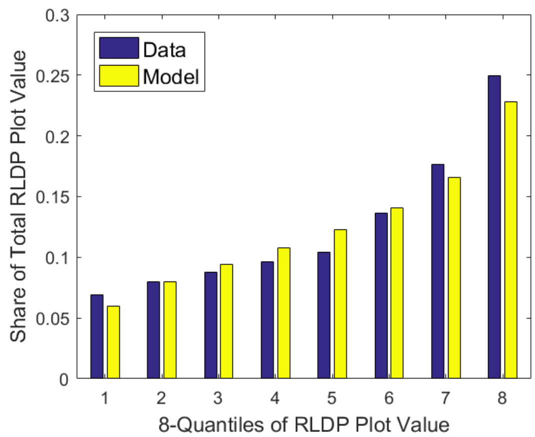
Figure 3: Calibrated Model versus Data at Plot Level



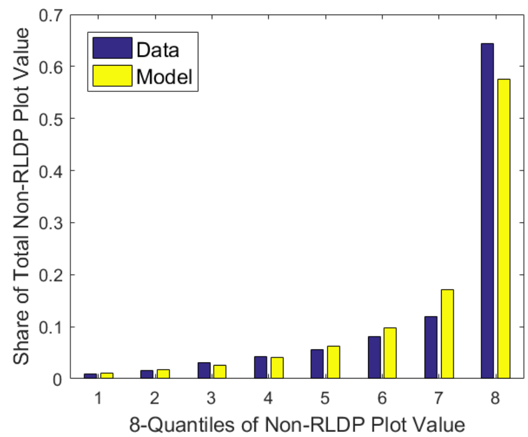
(a) Share of Total Plot Value



(b) Share of Plots



(c) Share of Total RLDP Plot Value



(d) Share of Total Non-RLDP Plot Value

set of prices, which can be important in welfare analysis. However, the main focus of the paper is misallocation and productivity; thus, nominal GDP is not relevant. In addition, we model farmers to be indifferent in crop choice leading to indeterminacy in labor allocation of rice and non-rice activity. What matters is the share of the total stock of farmer ability ($\int_{i \in N_A} z_i di$) devoting to each crop production, which is regulated by the distribution of land characteristics. Therefore, we only report results for labor allocation between agricultural and non-agricultural sectors in Table 4. Furthermore, Vietnam is not a big country, nor is it closed. Therefore, the price of goods might not be very sensitive to RLDP liberation (as reported in Table 4). To this end, we explore the impacts of RLDP with output prices being fixed instead of considering a closed economy. Table C1 of Appendix C shows that the misallocation effects are slightly larger compared to those in the main analysis below.

Agricultural Productivity - In the first row of Panel A in Table 4, we report the agricultural total factor productivity TFP_A. We find that eliminating RLDP raises the agricultural TFP by 10.6%. Another important concern is farmer average productivity Y_A/N_A. As shown in the second row of Panel A, farmer productivity experiences an increase of 16.4% from \$632 per farmer to \$736 per farmer (2003 USD). From equation (22), we decompose farmer productivity into the following,

$$\frac{Y_A}{N_A} = TFP_A \left(\frac{L}{N_A} \right)^{\alpha} \tag{33}$$

From this decomposition, the increase of 16.4% in farmer productivity is due to the increase in agricultural TFP of 10.6% and an increase in average farm size of 15.5%. These two gains together constitute the total gain in average farmer productivity through a multiplicative effect. For a graphical comparison between the restricted and unrestricted economy, please refer to Figure A1 in the Appendix A where the cumulative and density distributions of farm value-added are plotted.

Channels of Reallocation - Next, we focus on the channels of resource reallocation leading to the gain in productivity. The first channel, which we discussed in Proposition 2, is land use reallocation. This channel alone contributes to the gain in TFP by 1.14-fold (this gain, however, is offset by a factor of 0.97 from a reduction of average farmer ability). Such improvement is a result of agricultural land being optimally used highlighted by 22% of land being reallocated to the production of the other crops (see Panel C.2 and C.3). Consequently, the total amount of rice reduces dramatically by 37.2% as shown Panel B.1. We will explore this issue further at the end of this section.

The second channel, which is a combination of Proposition 3 and 4, is labor reallocation. The effects of this channel can be decomposed into two sources. First, a reduction in the total number of farmers raises the ratio of land to farmer. As reported in Panel D.1 and D.2, approximately 7% of working population moves to the non-agricultural sector reducing labor resource required to produce the agricultural goods. This switch also leads to an increase in the average farm size of 15.5% accordingly (Panel C.1). Second, the average ability of those moving out of agriculture is higher than the one of the remaining farmers, thus, reducing the average farmer ability by 4.05% (Panel D.3). This downward shift of average ability creates an offsetting effect lowering the gain in both farmer productivity and agricultural TFP.

Table 4: The Effects of Liberating RLDP

	Restricted (1)	Efficient (2)	Change (%) (3)
(A) Productivity			
1. Agricultural productivity TFP_A	668	739	+10.6%
2. Farmer productivity Y_A/N_A	632	736	+16.4%
3. Non-Ag. worker productivity $p_M Y_M/N_M$	2,824	2,582	-8.55%
4. GDP per capita $(Y_A + p_M Y_M)/N$	1,664	1,736	+4.36%
(B) Real Output per Capita			
1. Rice	32.1	20.1	-37.2%
2. Other crops	199	209	+4.77%
3. Non-agricultural good	5,436	5,720	+5.24%
(C) Land Allocation			
1. Average farm size	0.86	0.99	+15.5%
2. Share of rice land	0.54	0.32	-40.7%
3. Share of non-rice land	0.46	0.68	+47.1%
(D) Labor Allocation			
1. Share of farmers	0.53	0.46	-13.4%
2. Share of workers	0.47	0.54	+15.1%
3. Average farmer ability	3,176	3,047	-4.05%
4. Average worker ability	11,546	10,558	-8.55%
(E) Relative Prices			
1. Non-rice crops to Rice	1.52	1.25	-17.7%
2. Non-agriculture goods to Rice	0.24	0.29	+16.8%

Notes: In Panel A, we denote by $Y_A = p_R Y_R + p_O Y_O$ the agricultural GDP. All prices are evaluated at the benchmark level in calculating productivity gain.

Other Productivity Measures - Reported in Panel A.3, labor productivity in the non-agricultural sector decreases by 8.55%. From the discussion of Proposition 4, the reason is that the average ability of those moving out of agriculture is lower than the average ability of the existing workers. These individuals increase the number of workers by 15.1% (Panel D.2) while driving down the average ability by 8.55%, thus, reducing the non-agricultural labor productivity by an equal amount.

We are also interested in the economy-wide labor productivity. As shown in Panel A.4, we find that eliminating RLDP raises the economy-wide labor productivity by 4.36%. This is the combined effect of the changes in both agricultural and non-agricultural productivity. It is worth noting that the value of economy-wide labor productivity, which is also real GDP per working individual, is $1,664 at the benchmark level. This value is close to an average of \$1,665 over 2005 - 2010 reported by the General Statistics Office of Vietnam. Although this absolute value is not relevant to estimating the misallocation effects, it highlights the appropriateness of our constructed data.

Remaining Statistics - Lifting RLDP reduces the total amount of rice dramatically by 37.2% while increasing the output of other crops and non-agricultural good by 4.77% and 5.24% respectively (Panel B). We cautiously note that the gain in productivity costs a non-negligible loss in the total rice output. Since the novelty of RLDP is to ensure national food sources, it is important to assess the matter of self-sufficiency in rice production. From FAOSTAT database, we obtain a milled-equivalent total rice production of 29.4 million tons and total rice consumption of 13.2 million tons as of 2013. A reduction of 37.2% in rice output translates to a new total rice quantity of over 18.4 million tons (29.4×0.628), which is still well above the current level of consumption (13.2 mil. tons). Moreover, there is a declining trend in rice consumption over the year because of the increases in per capita income. For example, using household level survey, World Bank (2016) estimates that household rice expenditure decreases more than 30% from 2002 through 2012. Therefore, these observations together call for the need of liberating RLDP.

Overall, our baseline results suggest that eliminating RLDP leads to 10.6% increase in the agricultural TFP. This improvement is highlighted by 16.4% gain in agricultural labor productivity, 4.36% increase in economy-wide labor productivity, 13.4% reduction in agricultural employment, and 15.5% increase in average farm size. An important question to ask is whether these values together make sense. In a model calibrated to the U.S, Adamopoulos and Restuccia (2014b) document that reducing economy-wide productivity to the poor economy level increases the share of agricultural employment from 2.5% to 16.6%, decreases average farm size by 8.6-fold, depresses agricultural labor productivity by 11.2-fold, and generates a 7.6-fold reduction in aggregate labor productivity. Comparing to their results, ours are much smaller in magnitude because we focus exclusively on a particular case of resource misallocation. However, the pattern is the same regarding the channels through which agricultural misallocation manifest itself.

6.2 Issue of Robustness

Three parameter values are either assigned or taken from outside the model: land income share α, preference weight β, and elasticity of substitution across agricultural goods ζ. While our choices of values are consistent and somewhat conservative, it is still important to evaluate the sensitivity of our quantitative results. We do so by varying the values of these parameters and recalibrating the economy to the same targets as before. We report the results from sensitivity checks in Table 5, where the first row presents some of the baseline results including: (i) the gain in agricultural productivity [ΔTFP_A], (ii) the gain in GDP per capita [ΔGDP], and (iii) the reduction in the total number of farmers [Δ Farmer].

Thus far, we have chosen the land elasticity value of $\alpha = 0.35$. Now, we change the value of α to 0.3 and 0.4. As shown in the discussion of equation (24), the misallocation effects of RLDP is larger as land becomes more important, and vice versa. Indeed, the gain in agricultural TFP reduces to 9.15% when $\alpha = 0.3$, and increases to 12.2% when $\alpha = 0.4$. While the productivity gains change very little, we observe that the reduction in farmer share increases greatly in magnitude from -13.4% to -16.2% as we raise α to 0.4. This suggests that the channel of labor reallocation is quite sensitive. Since we set a conservative value of α, it is unlikely that the misallocation effects are overestimated in our main results.

Table 5: Results for Alternative Parameter Values

	ΔTFP_A (1)	ΔGDP (2)	Δ Farmers (3)
Main Results	+10.6%	+4.36%	-13.4%
Alternatives			
$\alpha = 0.3$	+9.15%	+3.62%	-11.0%
$\alpha = 0.4$	+12.2%	+5.12%	-16.2%
$\beta \approx 0$	+10.6%	+4.41%	-13.9%
$\beta = 0.01$	+10.9%	+4.19%	-12.1%
$\zeta = 1.5$	+8.95%	+3.74%	-11.5%
$\zeta = 3.5$	+11.3%	+4.59%	-14.3%

In the benchmark economy, our value of $\beta = 0.002$ is calibrated to the long-run employment share in agriculture of 5%. However, previous studies have assumed targets that are close or equal to zero, such as the works of Gollin et al. (2002, 2007) and Restuccia et al. (2008). Therefore, we want to examine how our gains response as β being moved close to zero or raised to 0.01. Note that a lower value of β means a higher level of subsistence requirement, thus, suggesting a more responsive employment share (see equation (25) and its associated discussion). Consistent with the prediction, we find that the misallocation effects are slightly enlarged as we move β toward zero, and slightly reduced as $\beta = 0.01$. However, these fluctuations are insignificant in magnitude.

For the elasticity of substitution across agricultural goods, we have set $\zeta = 2.63$ as a midpoint between values documented in prior studies. Here, we allow ζ to take a value of 1.5 and 3.5 for our sensitivity checks. This range of value is much broader than the range suggested by previous studies. However, we prefer a more extensive range because the preference for rice is declining rapidly, e.g. a reduction of 32% in rice share of household food expenditure over the period of 2002 - 2012 (World Bank 2016). In either case, we still observe substantial misallocation effects that are not much different from the primary results.

6.3 Issue of Compliance

As the Law on Land has become more and more refined over time, enforcing farmers upon following the"vision" is also an essential objective of the State. Therefore, the next experiment concerns the quantitative influence of law enforcement. We do so by introducing to our model a hypothetical cost c_f of violating the policy. Particularly, we assume that a farmer can pay a fee equaling to c_f, so that he/she can use a restricted plot j for non-rice crop production. Thus, conditional on being subject to RLDP, the price of a restricted plot j is given by,

$$\max \left\{ q_R e_{Rj},\ q_O e_{Oj} - c_f \right\}, \qquad \forall j \in J \text{ and } \delta_j = 1 \tag{34}$$

The derivation is analogous to the discussion of equation (12). Intuitively, if a farmer wants to use a restricted plot j to produce non-rice crops, he/she has to pay an extra fee of c_f. The expenditure for this plot is given by $q_O e_{Oj} + c_f$. Consequently, the maximum price the farmer is willing to pay for that plot is $q_O e_{Oj} - c_f$. Therefore, conditional on being restricted, plot j will deviate if the inequality $q_O e_{Oj} - c_f > q_R e_{Rj}$ satisfies.

Next, we are required to have some sense of the degree of enforcement. Using VARHS at the plot-level, we determine the compliance status by comparing plots' restricted status to their cultivated crop. A restricted plot that does not produce rice is considered as a non-compliant plot. According to this simple mapping, there are approximately 3% of the restricted plots, around 1.3% of the total plots, does not comply with RLDP in the micro-data. We recognize that farmers may inaccurately report which crops are actually cultivated on their plots. However, this statistic represents the best estimate of the RLDP compliance rate that is available to us. Nevertheless, we cautiously note that the results here can be driven by measurement errors or the method of defining compliance. Therefore, we do not wish to incorporate the compliance issue of this section into our main analysis.

Table 6: The Effects of Strengthening Law Enforcement

	3% Deviation (1)	0% Deviation (2)	Change (%) (3)
Agriculture Productivity TFP_A	693	668	-3.61%
GDP per capita	1,694	1,664	-1.77%
Share of farmers	0.50	0.53	+5.99%

According to the setup in equation (34), the top 3% of the restricted plots, in terms of $[q_O e_{Oj} - q_R e_{Rj}]$, will deviate. We proceed to set the restriction status $\delta_j = 0$ for these plots and reproduce the model.[19] Then, we compare an economy where the deviation rate is 3% to the benchmark economy where all plots comply. We report some important statistics from this exercise in Table 6. Our results indicate that policy deviations may promote allocative efficiency. Notably, moving to the deviation-free environment where all farms comply with the policy reduce agricultural productivity by 3.61% and GDP per capita by 1.77%. It also results in 5.99% increase in the total number of farmers.

7 Conclusion

Our primary objective is to answer a question of why less-developed countries devote a significant share of labor to agriculture despite its low productivity. To do so, we connect the misallocation and the institution-growth literature by investigating the distortionary consequences of a specific type of land institution. In particular, we study the impacts of Vietnam's Rice Land Designation Policy on resource allocation and productivity. Within a quantitative two-sector model, we quantify the effects using micro-geographical data and household survey over the period 2002 - 2012. In the theoretical framework, the restrictions on farmland not only lower agricultural productivity but also prevent a share of labor from moving out of agriculture.

The main counter-factual experiment suggests that eliminating all land use restrictions leads to 10.6% gain in agricultural total factor productivity (TFP). This improvement is highlighted by 16.4% gain in agricultural labor productivity, 4.36% increase in real GDP per capita, 13.4% reduction in agricultural employment, and 15.5% increase in average farm size. From a series of sensitivity checks, we find that our main results are unlikely to be driven by the

[19] Alternatively, we can calibrate the fixed cost c_f so that the model reproduces the estimated compliance rate. Then, we simply raise the fixed cost to the point where all farms comply with the policy. The results reported in Table 6 are unchanged regardless of the approach we take.

choices of parameter values. We further explore the channel in which policy deviations may promote allocative efficiency. In particular, moving to the deviation-free environment where all farms comply with the policy results in a decrease of 3.61% in agricultural TFP and 1.77% in GDP per capita. It also leads to an increase of 5.99% in the number of farmers.

While misallocation in agriculture has been studied extensively, our research highlights a novel source of misallocation that is prevalent in other countries such as China, Myanmar, Uzbekistan, among others. Nevertheless, we cautiously note that the gain in productivity costs a non-negligible loss in the total rice output. The novelty of RLDP is to ensure national food security to cope with unexpected circumstances. Indeed, rice has been the primary subsidy for people living below the national poverty line and those experiencing natural disasters. Therefore, making appropriate adjustments regarding RLDP may require both economic and political assessments.

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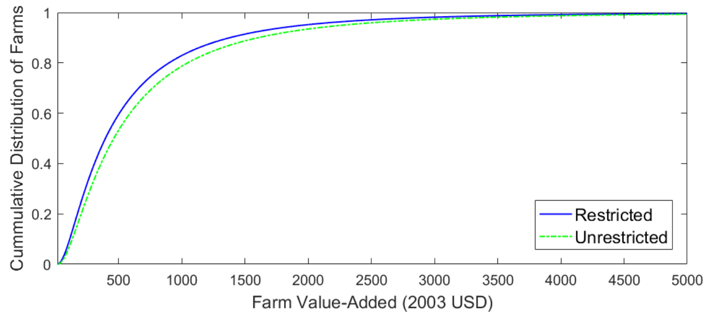
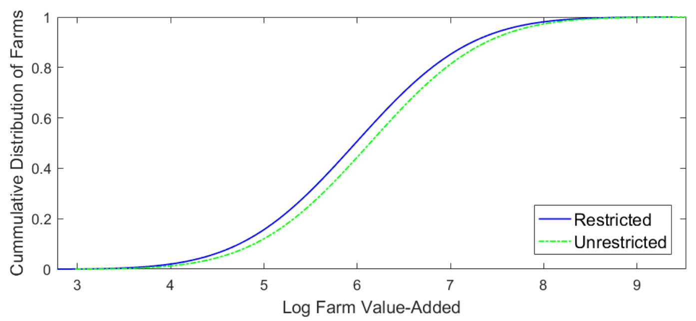
Appendix A

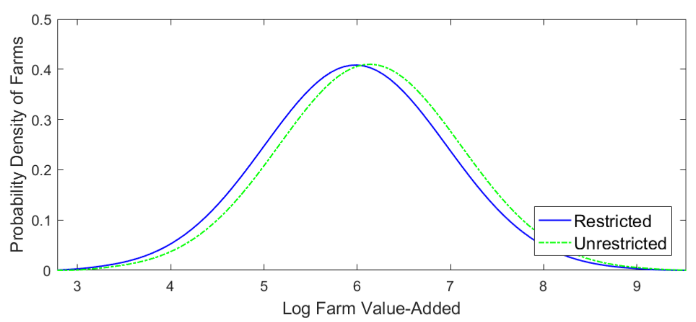
Figure A1: Farm Value-Added: Restricted vs. Unrestricted



(a) Distribution of Farms and Value-Added



(b) Distribution of Farms and Value-Added (log scale)



(c) Density Distribution of Farms and Value-Added (log scale)

Appendix B

In this Appendix, we show that our model is unaffected by: (i) subsidies given to rice growers (as discussed in Section 2.2), and (ii) the inclusion of sectoral technology. We consider a more extensive version of the model. Rice farmers receive subsidies in both output and input markets, denoted by $(1+\tau_R^y)$ and $(1-\tau_R^l)$ respectively. Meanwhile, farmers of the other crops are subject to both output and input taxes, denoted by $(1-\tau_O^y)$ and $(1+\tau_O^l)$ respectively.

Besides, there exists a crop-specific technology in producing rice (A_R) and non-rice (A_O). Farmer i profit maximization problems are given by,

$$\begin{cases} \pi_R(z_i) = \max\limits_{E_R} \left\{ (1+\tau_R^y)\tilde{p}_R \kappa A_R z_i^{1-\alpha} E_{Ri}^{\alpha} - (1-\tau_R^l) q_R E_{Ri} \right\} \\ \pi_O(z_i) = \max\limits_{E_O} \left\{ (1-\tau_O^y)\tilde{p}_O \kappa A_O z_i^{1-\alpha} E_{Oi}^{\alpha} - (1+\tau_O^l) q_O E_{Oi} \right\} \end{cases} \tag{B1}$$

where $\tilde{p}_R$ and $\tilde{p}_O$ are the *actual price* of rice and non-rice respectively. The *model price* of rice and non-rice $\{p_R, p_O\}$ can be expressed as $p_R = \frac{(1+\tau_R^y)\tilde{p}_R A_R}{(1-\tau_R^l)^\alpha}$ and $p_O = \frac{(1-\tau_O^y)\tilde{p}_O A_O}{(1+\tau_O^l)^\alpha}$. Therefore, we can rewrite the profit maximization problems in (B1) as follows,

$$\begin{cases} \pi_R(z_i) = \max\limits_{E_R} \left\{ p_R \kappa z_i^{1-\alpha} E_{Ri}^{\alpha} - q_R E_{Ri} \right\} \\ \pi_O(z_i) = \max\limits_{E_O} \left\{ p_O \kappa z_i^{1-\alpha} E_{Oi}^{\alpha} - q_O E_{Oi} \right\} \end{cases} \tag{B2}$$

The sets of maximization problems in (B1) and (B2) yield the same set of solutions, given by,

$$\begin{cases} \pi_R(z_i) = z_i \left(\frac{[(1+\tau_R^y)\tilde{p}_R A_R]^{1/\alpha}}{(1-\tau_R^l) q_R} \right)^{\frac{\alpha}{1-\alpha}} = z_i \left(\frac{p_R^{1/\alpha}}{q_R} \right)^{\frac{\alpha}{1-\alpha}} \\ \pi_O(z_i) = z_i \left(\frac{[(1-\tau_O^y)\tilde{p}_O A_O]^{1/\alpha}}{(1+\tau_O^l) q_O} \right)^{\frac{\alpha}{1-\alpha}} = z_i \left(\frac{p_O^{1/\alpha}}{q_O} \right)^{\frac{\alpha}{1-\alpha}} \end{cases} \tag{B3}$$

In our main model, both crop choice and occupational choice are governed by the relative price p_R/p_O (see Section 3.3 and 3.4). The relative price between rice and non-rice crop can be expressed as,

$$\frac{p_R}{p_O} = \frac{\tilde{p}_R}{\tilde{p}_O} \left[\frac{A_R}{A_O} \left(\frac{1+\tau_R^y}{1-\tau_O^y} \right) \left(\frac{1+\tau_O^l}{1-\tau_R^l} \right)^{\alpha} \right] = \frac{\tilde{p}_R}{\tilde{p}_O}\, \Omega \tag{B4}$$

where Ω is the value inside the square brackets. The experiments conducted in our study concerns only removing RLDP. In other words, the values of the parameters $\{A_R, A_O, \tau_R^y, \tau_R^l, \tau_O^y, \tau_O^l\}$ do not change; thus, Ω is constant. Any change in the relative price p_R/p_O reflects the change in the actual relative price $\tilde{p}_R/\tilde{p}_O$. The same logic applies for the non-agriculture sector. Thus, our results are unaffected by other taxes/subsidies and sectoral technologies.

Appendix C

Table C1: The Effects of Liberating RLDP as Prices Being Fixed

	Restricted (1)	Efficient (2)	Change (%) (3)
(A) Productivity			
1. Agricultural productivity TFP_A	668	740	+10.9%
2. Farmer productivity Y_A/N_A	632	741	+17.2%
3. Non-Ag. worker productivity $p_M Y_M/N_M$	2,824	2,559	-9.30%
4. GDP per capita $(Y_A + p_M Y_M)/N$	1,664	1,739	+4.56%
(B) Real Output per Capita			
1. Rice	32.1	8.30	-74.1%
2. Other crops	199	214	+7.83%
3. Non-agricultural good	5,436	5,747	+5.73%
(C) Land Allocation			
1. Average farm size	0.86	1.00	+17.2%
2. Share of rice land	0.54	0.19	-65.4%
3. Share of non-rice land	0.46	0.81	+75.6%
(D) Labor Allocation			
1. Share of farmers	0.53	0.45	-14.7%
2. Share of workers	0.47	0.55	+16.6%
3. Average farmer ability	3,176	3,036	-4.42%
4. Average worker ability	11,546	10,472	-9.30%
(E) Relative Prices			
1. Non-rice crops to Rice	1.52	1.52	0%
2. Non-agriculture goods to Rice	0.24	0.24	0%

Notes: In Panel A, we denote by $Y_A = p_R Y_R + p_O Y_O$ the agricultural GDP. As opposed to the main analysis (closed economy), all output prices are fixed in calculating productivity gain here. Overall, the misallocation effects are slightly larger without the offsetting effects caused by changes in prices.