Land-Market Restrictions and Agricultural Productivity under Market Power

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Abstract

I estimate how the imposition of municipality-specific restrictions on rural land markets impacts productivity, land concentration, and agricultural labor outcomes in Colombia. Using a newly built dataset and exploiting variation in land ownership ceilings across bordering municipalities, I find that municipalities with more stringent restrictions experienced a permanent reduction in agricultural revenue per hectare, accompanied by minimal reductions in overall land inequality. However, restrictions also increased agricultural workers' earnings and the share of workers employed in agriculture. I further show that the average negative effects on productivity are heterogeneous and depend on the degree of pre-reform land concentration in each municipality. These results are in line with a local economy where producers have market power in agricultural input markets, and where the implementation of sales restrictions curbs market power effects but also introduces other type of distortions. To formalize this intuition, I develop a general-equilibrium model of agricultural production in which large landholders exert market power in both land and labor markets, while the government imposes limits on land accumulation. The model's predictions are consistent with both the estimated effects and with the observed long-run patterns of persistent land concentration in the economy.

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1 Introduction

Governments often impose restrictions on the sale or transfer of assets being granted as part of redistributive policies. This practice is particularly prevalent in the distribution of agricultural land, where restrictions take varied forms such as use-contingent property rights or area limits on ownership. The imposition of these restrictions is usually justified as necessary to prevent unfettered market forces from undoing the redistributive efforts, yet a growing body of evidence shows that these constraints hinder productivity and labor mobility across sectors (de Janvry et al., 2015; Gottlieb and Grobovšek, 2019; Adamopoulos and Restuccia, 2020).

The fear of reconcentration can be understood, however, as relying on an argument based on the existence of market failures in rural land and labor markets. In particular, settings with high levels of land concentration might have a market structure such that large landholders exert market power and distort input prices, and where the resulting unrestricted equilibrium is of suboptimally large latifundia (Conning, 2003). If governments are politically constrained to directly implement perfect competition by breaking up large estates, and if the distortions produced by market power are larger than those introduced by restrictions, it could be argued that allowing land markets to operate unrestrained might not be desirable, and that the application of second-best policies like restricting some types of land sales could be warranted (Lipsey and Lancaster, 1956). While the practice of restricting land markets is prevalent and has been employed by many governments across the world (Allen, 1991), it is still uncertain if imperfect-competition arguments used as justification hold validity. Is the presence of market power a large enough concern to merit the imposition of land restrictions?

In this paper I investigate this question by studying how the imposition of land ceilings on rural landholdings impacts land and labor markets, land concentration, and agricultural productivity. I theoretically explore the effect of the introduction of land market restrictions by developing a stylized general-equilibrium model of a production economy where ownership limits are imposed on a fraction of the total land available and where, simultaneously, some agents exert market power in both land and labor input markets. The introduction of restrictions distorts the efficient allocation of inputs across producers, but also curtails the market power exerted by large agricultural firms, and their net effect on productivity and agricultural wages is ambiguous. At high enough levels of land concentration, market power distortions could become a larger source of inefficiency than market restrictions themselves, with the unrestricted equilibrium being less efficient than the restricted one.

I empirically test these predictions by investigating how the imposition of municipality-specific land market restrictions affected local rural economies in Colombia, a country where both high land inequality levels and ambitious land distribution policies have been longstanding. The Colombian case is particularly well-suited to study this question for two reasons. First, the enactment of a 1994 law imposed land ownership ceilings of varying height and on varying amounts of farmland in hundreds of municipalities throughout the country, leading to variation in the level of market restrictiveness across hundreds of otherwise comparable local economies. Second, the levels of pre-reform land concentration between Colombian municipalities varied widely, allowing for the study of any potentially heterogenous effects by initial concentration levels. Taking advantage of these features, I estimate the impact of the law on agricultural productivity, land inequality, and agricultural labor outcomes. To do so, I build a new dataset based on archival documents with information on crop-specific agricultural yields at the municipality-year level for the period 1988–2004, which I combine with several other sources of micro-level data on individual land sales, the distribution of farm sizes, and agricultural workers' earnings and employment.

To identify the causal effects of land market restrictions I rely on two features of the law: first, the ceiling restriction only applied for land originally owned by the state but that at some point was granted to an individual through a public-land distribution act. Second, the height of land ceilings was set to vary according to broad regional agroclimatic conditions. My identification strategy relies on the assumption that, across municipalities that share a border, the combination of disparities in ceiling height and the differences in the share of municipal farmland under restriction serve as a source of plausibly exogenous variation in the stringency of market constraints between otherwise comparable rural economies. My econometric strategy therefore follows a differences-in-differences approach that relies on this within-municipality-pair variation in the severity of market constraints to estimate how the law affected local economies.

I find that municipalities with more stringent restrictions had a permanent reduction in agricultural land productivity, and that restrictions led only to small reductions in overall land inequality. Regarding the magnitude of the effects I estimate that, during the ten years following the passing of the law, a municipality moving from the 25^{th} to the 75^{th} percentile of the restriction stringency measure would have suffered a persistent 25% reduction in revenue per hectare, with a concurrent decrease of roughly 7% in its land ownership gini index. Puzzlingly, I also find that despite the drop in productivity, restrictions led as well to a substantial increase in the earnings of agricultural wage workers, and to higher levels of agricultural employment. Going from the 25^{th} to the 75^{th} percentile of restriction stringency would entail an increase of 68% in agricultural workers' monthly earnings, and a 23% increase in the share of workers occupied in agriculture. Moreover, I find that the negative productivity effects are heterogeneous across municipalities and depend on the degree of pre-reform land concentration present in the local economy, with more initially-concentrated municipalities having lower productivity reductions due to the law. These results are at odds with a standard, perfectly competitive agricultural production model, but they instead seem consistent with an economy in which there is market power. Simulation results show that, within a context of imperfect competition, the effects on productivity and wages of land market restrictions ultimately depend on the initial level of land concentration.

These findings suggest that while the policy of restricting land transfers has been too blunt of a tool that has, on average, held back the efficiency of the Colombian agricultural sector, policymakers should nonetheless be aware of the potentially large negative distortions that market power can have on rural economies with high levels of land concentration. This paper shows that the imposition of restrictions does not always have the unambiguous effects presupposed in a perfectly-competitive framework, and that there are important distributive implications –in particular regarding the welfare of landless agricultural workers– related to the imposition (or the lifting) of restrictions in contexts where market power effects might be strong.

Conceptually, there are reasons to believe in the existence of market power in agricultural input markets. There is growing consensus that firms exert labor market power in many settings (see Card (2022) for a review), and even in markets thought to be very competitive Dube et al. (2020). In developing countries, and specifically in Latin America, Felix (2021), and Amodio and de Roux (2023) quantify the substantial degree of monopsony power held by firms. These estimates are based on mostly non-agricultural, urban jobs. Rural workers, who are subject to high mobility frictions between, and even within, labor markets (Imbert and Papp, 2020; Emerick et al., 2022), and particularly Latin American agricultural workers –a region with the highest levels of land concentration in the world (Eslava and Caicedo, 2023)– potentially face labor markets where imperfect competition of this sort is at least as prevalent. If the magnitude of market-power distortions are large enough, an unmitigated land market could actually lead to an equilibrium that is both less equitable *and* less efficient (Deininger, 2003; Carter and Zegarra, 2000).

This paper is related to the literature that investigates the causes of the large observed differences in agricultural productivity across countries (Restuccia et al., 2008; Gollin et al., 2014). A growing literature has shown that this productivity gap can be in part explained by the imposition of land-tenure institutions that impede the allocation of resources towards activities with higher returns (de Janvry et al., 2015; Gottlieb and Grobovšek, 2019; Adamopoulos and Restuccia, 2020; Adamopoulos et al., 2020; Chari et al., 2021; Adamopoulos et al., 2022). This paper contributes to this literature by providing evidence on the productivity impacts of a specific, previously unexplored, broad-ranging policy implementation effort. Moreover, while the bulk of evidence showing how market restrictions affect rural economies has focused on relatively land-egalitarian settings, we still don't know how these restrictions interact with potential distortions stemming from imperfect competition in environments of high land concentration. This paper adds to this literature by theoretically exploring the potential interactions of these policies with the distortionary effects stemming from a market structure with imperfect competition, and by contrasting the impact that policies of this kind have across contexts with varying levels of initial land concentration.

This paper is also related to the literature that studies the effects of agrarian and property-rights reform in developing economies (see, for example, Besley and Burgess (2000); Banerjee et al. (2002); Carter and Olinto (2003); Deininger et al. (2008); Besley et al. (2016); Montero (2022)). The bulk of this literature studies the effect of reforms that aimed to profoundly transform the distribution of property rights in the economy. I contribute to this literature by analyzing the effects of a relatively moderate policy reform that, while imposing limits on future land accumulation, did not push for the redistribution of current landholdings and did not impose any restrictions on the transfer of land so long as the resulting holdings remained below ceiling. Analyzing the effects of a closely-related but independent reform effort in Colombia, Galán (2018) estimates the micro-level intragenerational effects of increasing the access to land for rural workers. I contribute to this literature by estimating the joint general-equilibrium effects that land-market reform has on productivity, inequality, and agricultural workers' earnings.

This paper also contributes to the study of the causes of persistence in land concentration and land utilization patterns across time. Assunção (2008b) and Bardhan et al. (2014) show how even very ambitious land reform efforts may not lead to persistent reductions in land inequality, while Smith (2020) shows how initial land endowments have lasting effects long after any restrictions on land sales have been lifted. Studying the Colombian case, Faguet et al. (2020) document how initial land concentration levels are a major determinant of the effectiveness of public-land allocation policies in improving land distribution measures, while Deininger (1999), and Assunção (2008a) further show that this persistent-concentration puzzle is compounded by the very stark underutilization of the land being concentrated. Following a conceptual framework that stresses the potential impacts of market power in rural economies with high land concentration levels –laid out in Conning (2003) and further empirically explored in Martinelli (2014)– this paper provides empirical evidence supporting the importance of this imperfect-competition mechanism in explaining these observed patterns.

Finally, this paper makes a methodological contribution by presenting and making public the first comprehensive dataset on crop-specific yields for Colombian municipalities during the 1988–2004 period. This dataset, collected through archival work and assembled by digitizing hundreds of distinct government publications, contains detailed agricultural production and land use figures for a period during which, until now, no harmonized sources of municipal-level information were available. This dataset can be potentially helpful for researchers and policymakers in several different topics and will hopefully be useful in advancing our understanding of the dynamics of agricultural sectors in developing countries.

The rest of this paper is organized as follows. In Section 2 I describe the institutional details of public land distribution policies in Colombia and the enactment of the law that established restrictions on land markets. Section 3 then outlines the theoretical framework and presents the simulation results. Section 4 describes the different sources of data used to empirically estimate the impact of the law while Section 5 discusses the empirical strategy. Section 6 reports and discusses the empirical findings, and Section 7 concludes.

2 Institutional Background

The unequal distribution of land in Colombia has historically been argued to be a major obstacle for economic development as well as one of the main drivers of violent conflict in the country; efforts to give poor farmers access to land have been numerous (Berry, 2017). Throughout the twentieth century the Colombian government tried in several occasions to reform landholding patterns using redistributive policies —either through direct state expropriation of large estates or by market-assisted reform— yet all of these attempts were largely unsuccessful (Ibáñez and Muñoz, 2010; CNMH, 2016).

By contrast, the free allocation of public idle lands (*baldíos*) to private individuals has been an uninterrupted policy of the Colombian state since the beginning of the twentieth century and has become, by far, the most consequential 'land reform' policy instrument employed by the government. This allocation process has mostly consisted of a combination of frontier-settlement schemes where unused public lands are granted to poor smallholders, and of programs focused on the titling of state-owned lands that might have been previously informally occupied (Albertus, 2015). Since the enactment of the Social Agrarian Reform Act (Law 135) in 1961, the explicit objective of the policy has been that of reducing land inequality and giving land to landless farmers.

In terms of the number of beneficiaries and the amount of land allocated, the scale of the policy has been vast. Colombia has had "one of the Western Hemisphere's largest public land distribution programs during the last century" (Albertus, 2019), having granted (throughout the period 1901–2012) more than 500,000 land plots to private individuals in 1,031 of the

1,122 existing municipalities, amounting to roughly half of the currently privately-held land in the country (Sánchez and Villaveces, 2016). Despite its scale, the *baldío* allocation program did not fundamentally alter the country's severely concentrated land distribution (Faguet et al., 2020; Ibánez et al., 2012).

In contrast with other land distribution policies frequently imposed across the developing world (e.g. Adamopoulos et al. (2022)) receiving and maintaining the property rights of a *baldío* was not conditional on its direct use and cultivation, although recipients who sold their land were ineligible to receive any other state land for a 15-year period. Examining the effects of a parallel but independent land allocation program, Galán (2018) finds that ten years after receiving land, 30% of beneficiaries had sold the plot to a third party.[1]

Land ceilings - the *UAF*: Driven by the ineffectiveness of the public-land allocation policy to reduce land concentration during the previous three decades, the enactment of law 160 in 1994 established municipality-specific ceilings on the amount of land originally allocated by the government that any individual could purchase and own. The ceiling was notionally defined as the amount of land that a rural household would require to obtain a minimum basic level of income and became known as the Agricultural Family Unit (UAF). It was established that the height of this ceiling would vary geographically to account for varying agroecological conditions, and its magnitude was defined following the concept of 'relatively homogeneous zones', a novel geographical division that did not correspond to the traditional administrative divisions of *municipio* or *departamento*.

Importantly, the law established that the ceiling on landholdings only applied to land that at some point in the past had been part of the public land distribution program. Land plots not initially allocated by the government were excluded from the restriction and no constraints were placed on how much of this land could be owned by individuals.

In practice, the restriction banned any future land transactions which would have as a result an individual accumulating an amount of land above the stipulated ceiling. It did not, however, lead to any retroactive expropriation and redistribution of above-ceiling landholdings. At the same time, any transfer of land (either restricted or unrestricted) between individuals whose landholdings remained below the ceiling were also allowed.

The specific height of the land ceiling imposed in each municipality was formally published in resolution 041 of 1996 by the *Instituto Colombiano de la Reforma Agraria* (INCORA), the national land agency of the time. The amounts of land defined by these ceilings, as well as the restrictions on sales stipulated by law 160 are still currently in force. Additional legislation (law 902) passed in 2017 additionally established a complete ban on the sale of

[1]The *Sharecroppers and Tenants Program* studied by Galán (2018) did, in fact, impose a 10-year restriction on sales.

newly granted government plots for a period of seven years since the allocation takes place. A detailed exposition of the institutional context in which law 160 was enacted can be found in chapter 3 of CNMH (2016).

Finally, although the UAF restriction was only imposed on purchases, and no limits on land rental markets were imposed, Colombian land rental markets are characterized by being notoriously thin, with only 9% of farmers surveyed in a 2019 nationally-representative survey reporting to operate any rented land.[2] For this reason, in the model presented in the following section I abstract from rental markets and focus solely on land sales.

3 Theoretical Framework

This section develops a stylized general-equilibrium, agricultural production economy model that tries to capture the main institutional features of the Colombian land ceiling policy outlined in Section 2, and that highlights the potential tension between the distinct sources of inefficiency that policies seeking to regulate land markets might be confronted by. In the spirit of Conning (2003), the model allows for some firms in the economy to exert market power in both land and labor markets and shows how this leads to the existence of multiple equilibria depending on initial endowments. I then extend the model to allow for the imposition of a ceiling on land ownership on a fraction of the economy's farmland and analyze how this impacts input demand decisions, prices, and aggregate productivity.

3.1 Market power with no land ceiling:

Setup: Consider an agrarian production economy with population N and a fixed amount of land L, where all farmers produce an homogeneous, exogenously priced good which is the numeraire. Farmers are heterogeneous in terms of ability s which is drawn from a probability distribution $G(s)$. Each farmer is endowed with uniform amounts of labor n_i^0 and varying amounts of land l_i^0.

Suppose one of these producers (indexed by $i = b$) is aware that her input demand choices influence market prices.[3] This producer is endowed with $l_b^0 = \theta L$ units of land, where $\theta \in [0, 1]$ is a measure of the degree of initial concentration in land ownership. For simplicity I refer to farmer b as the *landlord* throughout the analysis, despite the fact that having

[2]National Agricultural Survey (ENA), carried out by the National Statistical Agency (DANE); 2019-1 bulletin.

[3]This producer can also be thought of as the share of firms in the economy who have market power and act as a perfectly collusive cartel.

market power is independent of the size of the firm, and that the model allows for this agent to have low or even no initial land endowments.

All farmers have access to the same technology:

$$y_i(l_i, n_i; s_i) = s_i^{1-\gamma}\left(l_i^{\alpha} n_i^{1-\alpha}\right)^{\gamma},$$

where $\gamma \in (0,1)$ is the span-of-control parameter, $\alpha \in (0,1)$ determines the profit share of land, and l_i and n_i are respectively the quantities of land and labor employed.

Given a land price r and a wage rate w, price-taking producers at the competitive fringe define their optimal demand for land and labor (l_i^*, n_i^*) simultaneously. Regardless of market structure, these producers choose input demands such that each firm's marginal productivity matches input prices: $y'_{l_i} = r$ and $y'_{n_i} = w$.

For their part, market clearing conditions require that

$$\sum_{i \neq b} l_i = L - l_b\,; \quad \sum_{i \neq b} n_i = N - n_b. \tag{1}$$

where l_b and n_b are, respectively, the amounts of land and labor demanded by the market-power aware firm.

Combining the two sets of equations above it is possible to express input prices in terms of the demand decisions of the landlord:

$$w = (1-\alpha)\gamma\left[\frac{(L-l_b)^{\alpha\gamma}}{(N-n_b)^{1-(1-\alpha)\gamma}}\right]\left(\sum_{j\neq b} s_j\right)^{1-\gamma}\,;\ r = \alpha\gamma\left[\frac{(N-n_b)^{(1-\alpha)\gamma}}{(L-l_b)^{1-\alpha\gamma}}\right]\left(\sum_{j\neq b} s_j\right)^{1-\gamma}, \tag{2}$$

which in turn chooses inputs that maximize the profit function:

$$\pi_b(l_b, n_b; s_b) = s_b^{1-\gamma}\left(l_b^{\alpha} n_b^{1-\alpha}\right)^{\gamma} - r(l_b - \theta L) - w n_b. \tag{3}$$

Where, for simplicity, I assume the landlord's endowment of labor (n_b^0) is zero.

Competitive Benchmark: Under perfect competition the optimality conditions of the landlord coincide with those of all other firms (i.e. $y'_{l_b} = r, y'_{n_b} = w$). Given market clearing conditions, the optimal operational scale of each firm is determined by its relative productivity:

$$l_b^{pc} = L \times \frac{s_b}{\sum_j s_j}\,; \quad l_i^{pc} = L \times \frac{s_i}{\sum_j s_j},\ \forall i.$$

In the perfectly competitive scenario input demands are independent of initial endowments and varying levels of initial land concentration have distributive implications but do not alter the (optimal) aggregate efficiency of the economy.

Market Power: Assume for simplicity that the landlord exerts market power only when deciding how much land (l_b) to demand but acts as a price taker regarding the amount of labor (n_b) hired.[4] This assumption implies that, analogous to firms in the competitive fringe, the landlord's marginal productivity of labor matches the market wage, $y'_{l_B} = w$. By contrast, when deciding on its optimal demand for land the firm with market power will take into account the indirect effects on input prices. In this scenario the first-order condition for land stemming from the profit function in equation (3) is:

$$y'_{l_b} = r\left(1 + \left(1 - \frac{\theta L}{l_b}\right)\varepsilon^{-1}_{l_b r}\right) + \frac{w n_b}{l_b}\varepsilon^{-1}_{l_b w}, \tag{4}$$

where $\varepsilon^{-1}_{l_b r} \equiv \frac{\partial ln(r)}{\partial ln(l_b)}$ and $\varepsilon^{-1}_{l_b w} \equiv \frac{\partial ln(w)}{\partial ln(l_b)}$ are, respectively, the inverse elasticity of land supply with respect to land prices and wages. Following the expression for input prices in equation (2), these elasticities are also a function of b's net demand for land:

$$\varepsilon^{-1}_{l_b r} = (1 - \alpha\gamma)\frac{l_b}{L - l_b} \geq 0\ , \quad \varepsilon^{-1}_{l_b w} = -\alpha\gamma\frac{l_b}{L - l_b} \leq 0.$$

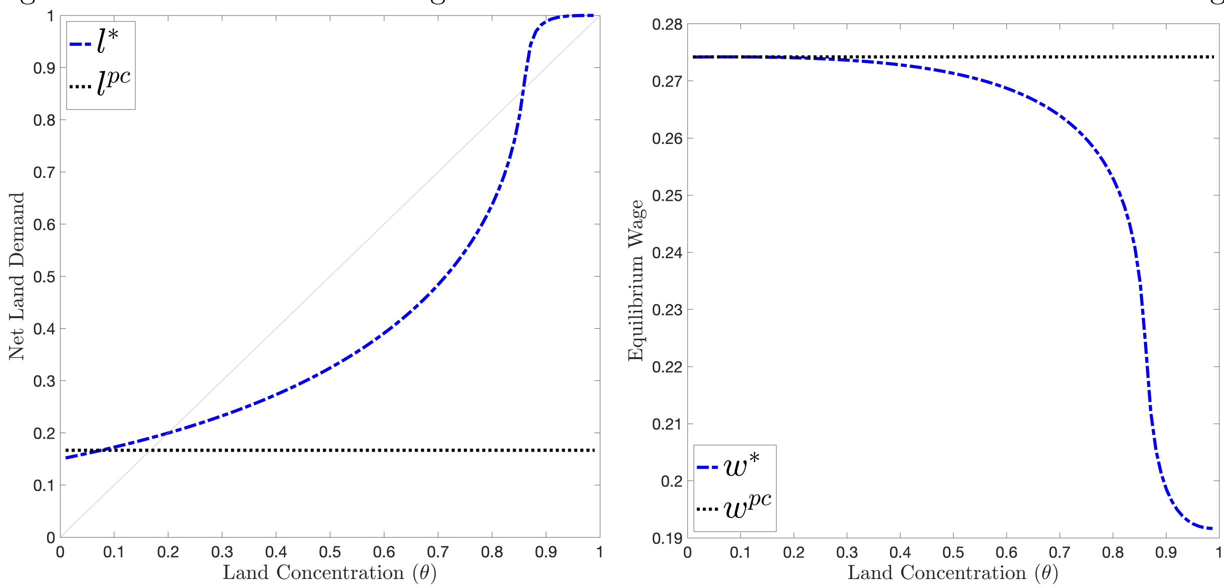
Equation (4) implicitly defines the optimal demand for land (l_b^*) by a firm with market power in both land and labor markets. It is possible to show using this expression that *i)* $l_b^*|_{\theta=0} < l_b^{pc}$, and *ii)* $\frac{\partial l_b^*}{\partial \theta} > 0$.[5] The first result mirrors a standard result in the literature studying monopsony in labor markets and states that, in order to mark-down wages, firms with market power but no land endowment will be smaller –employing less land and labor– than under perfect competition. Moreover, the higher the ability level of the landlord, the wider the gap between perfectly competitive labor demand and the one in the imperfect competition case. The second result states that the operational scale of the market-power aware firm is monotonically increasing in its initial land endowment. The fact that farm size is not independent of the pre-existing distribution of land implies that firms with market power will be in general inefficiently large (or small) with respect to the competitive scenario.

Equilibrium: While it is not possible to derive an analytical expression for the landlord's

[4] The assumption that market power is exerted in only one of the two input decision simplifies the analysis but is not necessary for the model's main results to hold. The same qualitative patterns are observed when allowing the farmer with market power to consider how her own input demands affect input prices for both land *and* labor decisions.

[5] Derivations for these results, and all expressions for prices, elasticities, and input demands are given in Appendix B.

Figure 1: Land Demand and Wage as a Function of Initial Concentration - No Land Ceilings



(a) Net Land Demand (b) Wage

Notes: Equilibrium values for the landlord's net land demand based on the numerical result to equation (4) (left panel) and for equilibrium market wages (right panel) across the domain of initial concentration values θ. Blue dashed line: equilibrium values for market power case. Black dotted lines: equilibrium values for the perfectly competitive benchmark case. Details on the parameter values chosen reported in Table 1.

demand for land, given parameter values $\{\theta, \gamma, \alpha\}$, and a vector of farmer abilities $\{s_b, \overrightarrow{s_i}\}$, starting from equation (4) it is possible to find a numerical solution. This solution in turn sequentially defines the landlord's optimal demand for labor, the input prices, and the input demand choices of the competitive fringe. The market equilibrium is then a tuple of input demands and prices $\{l_b^*, n_b^*, \overrightarrow{l_i^*}, \overrightarrow{n_i^*}, w, r\}$ such that all agents make optimal choices and the market clearing conditions in equation (1) hold.

Numerical solutions from a simulated economy for these equilibrium values as a function of the initial land concentration parameter are shown in Figure 1. The landlord's demand function for land at varying concentration levels (i.e. at varying amounts of her initial land endowment) gives rise to an S-shaped demand function that crosses the 45-degree line twice. This non-linearity arises due to the opposing incentives faced by a firm simultaneously exerting monopsony power in labor markets and monopoly power in land markets. At low levels of land concentration the monopsony incentives are stronger and (relative to the perfectly competitive case) the landlord operates a suboptimally small farm in order to mark-down wages. As concentration levels rise (i.e. as θ increases), the landlord's monopolist incentive to mark-up land prices by curtailing the amount of land supplied to markets becomes increasingly important. Consequently, the landlord's equilibrium farm size expands monotonically with land concentration levels. The landlord will continue to curtail the supply of land and operate an ever larger farm even beyond the point when it is utilizing all of her endowment. At high enough concentration levels the landlord's net demand for land becomes positive and she turns to *buy* land from firms in the competitive fringe. This 'reverse-tenancy' scenario described by Conning (2003) can be explained by the fact that, once the operational scale of the landlord exceeds a certain threshold, the monopsonist incentive to keep wages depressed once again overcomes the monopolist incentive to profit from high land prices. At sufficiently high levels of initial concentration the landlord finds it optimal to buy-out firms in the competitive fringe in order to suppress aggregate labor demand levels and keep wages low.

One implication of the model's results is that, in a dynamic framework, the economy's long-run equilibrium depends on the landlord's endowments. If initial land concentration exceeds a certain threshold the economy will gravitate towards a high-inequality equilibrium where the landlord operates a large and inefficient estate, and where any firms entering the economy get bought up in order to maintain aggregate labor demand depressed. This dynamic offers a possible explanation for the well-documented persistence of land inequality in Colombia despite the country's ambitious policy of smallholder land allocation (Sánchez and Villaveces, 2016; Faguet et al., 2020; Deininger, 1999). I return to this point in Section 6.6 where, using the data on individual sales of government-allocated land plots, I find suggestive evidence consistent with this hypothesis.

3.2 The imposition of land ceilings:

Suppose now that on a fraction $\psi \in (0,1)$ of land in the economy there is a restriction that impedes the accumulation of more than a fixed amount of land by any single farmer. Denote this land ceiling by $\bar{l}$.

The imposition of this restriction can be modelled as separating available farmland into two distinct, perfectly substitutable, production inputs: restricted (l_R) and unrestricted (l_U) land. Given this assumption, the production technology available to farmers becomes:

$$y_i(l_{Ui}, l_{Ri}, n_i; s_i) = s_i^{1-\gamma}\left((l_{Ui}+l_{Ri})^{\alpha} n_i^{1-\alpha}\right)^{\gamma},$$

and the individual problem of each firm can be written as:

$$\max_{\{n_i, l_{Ui}, l_{Ri}\}} y_i(l_{Ui}, l_{Ri}, n_i; s_i) - r_U(l_{Ui} - l_{Ui}^0) - r_R(l_{Ri} - l_{Ri}^0) - w(n_i - n_i^0), \qquad (5)$$

subject to the constraints:

$$l_{Ri} \leq \bar{l};$$
$$l_{Ri}, l_{Ui}, n_i \geq 0,$$

where, as before, l^0_{Ui}, l^0_{Ri}, and n^0_i are input endowments and l_{Ui}, l_{Ri}, and n_i are input demands.

Note first that, since restricted and unrestricted land act as perfect substitutes, if $r_R > r_U$ the aggregate demand for unrestricted land is zero and no equilibrium exists since land markets never clear at these prices. Market equilibrium then requires that $r_R \leq r_U$. Then, as shown in Appendix B, for any pair of input prices $\{r_R, r_U : r_R < r_U\}$, the ability level of each farmer determines whether some of the constraints above are binding in each individual solution of the firm's optimization problem. Depending on which constraints bind, each firm is placed in one of three distinct production regimes. There is first a set of fully unconstrained firms (denoted as firms $i \in S$) made up of farmers with low enough productivity levels that they do not find the ceiling on landholdings binding. There is a second set of mid-ability farmers who find the ceiling binding and would benefit from increasing their operational scale buying more land at price r_R but not at price r_U. The optimal choice for all farmers in this regime is thus to operate farms precisely at the ceiling ($\bar{l}$); denote this set of firms as $i \in C_1$. Finally, the set of highest-ability farmers operate the largest farms and for all the land demanded in excess of the mandated ceiling they pay the unrestricted-land price r_U. Denote this set of firms as $i \in C_2$. Figure 2 shows how farmers are sorted across these different regimes according to their innate ability level.

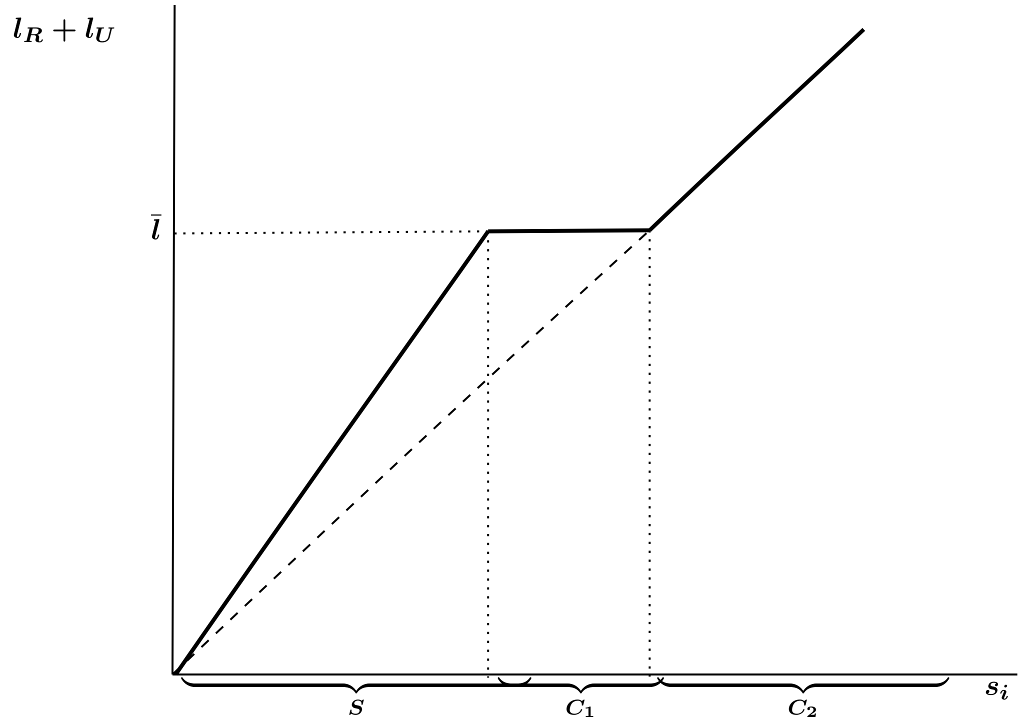
Define for convenience the auxiliary term $\rho = 1 - (1-\alpha)\gamma$. Input demand functions in terms of prices for the three different types of firms are as follows. For farmers of type S:

$$n^S_i = s_i \left(\gamma \left(\frac{\alpha}{r_R} \right)^{\alpha\gamma} \left(\frac{1-\alpha}{w} \right)^{1-\alpha\gamma} \right)^{\frac{1}{1-\gamma}}, l^S_{Ri} = s_i \left(\gamma \left(\frac{\alpha}{r_R} \right)^{\rho} \left(\frac{1-\alpha}{w} \right)^{1-\rho} \right)^{\frac{1}{1-\gamma}}, l^S_{Ui} = 0;$$

for farmers of type C_1:

$$n^{C_1}_i = s_i^{\frac{1-\gamma}{\rho}} \left(\frac{(1-\rho)\bar{l}^{\alpha\gamma}}{w} \right)^{\frac{1}{\rho}}, \quad l^{C_1}_{Ri} = \bar{l}, \quad l^{C_1}_{Ui} = 0;$$

Figure 2: Aggregate Land Demand as a Function of Individual Productivity



and for farmers of type C_2:

$$n_i^{C_2} = s_i \left(\gamma \left(\frac{\alpha}{r_U} \right)^{\alpha\gamma} \left(\frac{1-\alpha}{w} \right)^{1-\alpha\gamma} \right)^{\frac{1}{1-\gamma}},$$

$$l_{Ri}^{C_2} = \bar{l}, \quad l_{Ui}^{C_2} = s_i \left(\gamma \left(\frac{\alpha}{r_U} \right)^{\rho} \left(\frac{1-\alpha}{w} \right)^{1-\rho} \right)^{\frac{1}{1-\gamma}} - \bar{l}. \tag{6}$$

Recall as well that out of the total amount of land in the economy L, a fraction θ is initially owned by the firm with market power. By assumption this land is unrestricted. Out of the remaining $(1-\theta)L$ units of land, a fraction ψ is restricted and subject to the land ceiling limit. The total supply of unrestricted land is then $L_U = (1-\psi)(1-\theta)L + \theta L$ while the supply of restricted land is $L_R = \psi(1-\theta)L$. Combining these expressions with the set of input demand functions in equations (6) leads to the following set of market-clearing conditions:

for restricted land:

$$L_R = \psi(1-\theta)L = \sum_{i\in S} l_{Ri}^S + \sum_{i\in C_1} l_{Ri}^{C_1} + \sum_{i\in C_2} l_{Ri}^{C_2} + l_{Rb}$$
$$= \sum_{i\in S} s_i \left(\gamma \left(\frac{\alpha}{r_R}\right)^{\rho} \left(\frac{1-\alpha}{w}\right)^{1-\rho}\right)^{\frac{1}{1-\gamma}} + \mathcal{I}_{C_1} + \mathcal{I}_{C_2} + l_{Rb},$$

where $\mathcal{I}_{C_1} \equiv \sum_{i\in C_1} \bar{l}$, and $\mathcal{I}_{C_2} \equiv \sum_{i\in C_2} \bar{l}$;

for unrestricted land:

$$L_U = (1-\psi+\psi\theta)L = \sum_{i\in S} l_{Ui}^S + \sum_{i\in C_1} l_{Ui}^{C_1} + \sum_{i\in C_2} l_{Ui}^{C_2} + l_{Ub}$$
$$= \sum_{i\in C_2} s_i \left(\gamma \left(\frac{\alpha}{r_U}\right)^{\rho} \left(\frac{1-\alpha}{w}\right)^{1-\rho}\right)^{\frac{1}{1-\gamma}} - \mathcal{I}_{C_2} + l_{Ub};$$

and for labor:

$$N = \sum_{i\in S} n_i^S + \sum_{i\in C_1} n_i^{C_1} + \sum_{i\in C_2} n_i^{C_2} + n_b$$
$$= \left(\gamma\alpha^{\alpha\gamma}\left(\frac{1-\alpha}{w}\right)^{1-\alpha\gamma}\right)^{\frac{1}{1-\gamma}} \left(\frac{\sum_{i\in S} s_i}{r_R^{\frac{\alpha\gamma}{1-\gamma}}} + \frac{\sum_{i\in C_2} s_i}{r_U^{\frac{\alpha\gamma}{1-\gamma}}}\right) + \sum_{i\in C_1} s_i^{\frac{1-\gamma}{\rho}} \left(\frac{(1-\rho)\bar{l}^{\alpha\gamma}}{w}\right)^{\frac{1}{\rho}} + n_b. \quad (7)$$

The set of equations (7) makes it possible to compute an analytic expression for each input price that depends only on the landlord's choices and the share of firms across the different production regimes. Just as in the no-ceiling scenario described in section 3.1, these expressions further allow for the derivation of the inverse elasticity of the landlord's land supply with respect to prices: $\varepsilon^{-1}_{l_{Ub},r_U} \equiv \frac{\partial ln(r_U)}{\partial ln(l_{Ub})}$, $\varepsilon^{-1}_{l_{Ub},r_R} \equiv \frac{\partial ln(r_R)}{\partial ln(l_{Ub})}$, and $\varepsilon^{-1}_{l_{Ub},w} \equiv \frac{\partial ln(w)}{\partial ln(l_{Ub})}$. Maintaining the assumption that market power is only exerted in the decision for land (i.e., $y'_{n_b} = w$ always holds), these prices and inverse elasticities make it possible to derive an (implicit) expression for the landlord's demand for unrestricted land. In particular, this expression is obtained from the landlord's first-order condition for unrestricted land when solving the profit maximization problem described in equation (5):

$$y'_{l_{Ub}} = r_U \left(1 + \left(1 - \frac{\theta L}{l_{Ub}}\right) \varepsilon^{-1}_{l_{Ub},r_U}\right) + \frac{w n_b}{l_{Ub}} \varepsilon^{-1}_{l_{Ub},w} + \frac{\bar{l} r_R}{l_{Ub}} \varepsilon^{-1}_{l_{Ub},r_R}. \tag{8}$$

Equilibrium: I assume throughout, and parameterize the numerical simulations such that the productivity level of the landlord is high enough to ensure that she is always of type C_2, meaning that both the restriction $l_{Rb} \leq \bar{l}$ is binding and that her demand for unrestricted land is strictly positive. With this assumption in place equation (8) implicitly defines the optimal land demand of the landlord, from which it is possible to find a numerical solution given an initial concentration value. As before, this demand choice then sets the landlord's optimal demand for labor, pins down input prices, and defines the input demands from price-taking firms. The market equilibrium is a tuple of input demands and prices $\{l^*_{Ub}, l^*_{Rb}, n^*_b, \overrightarrow{l^*_{Ui}}, \overrightarrow{l^*_{Ri}}, \overrightarrow{n^*_i}, w, r_U, r_R\}$ such that all agents are solving their maximization problem and the market clearing conditions in equation (7) hold.

3.3 Numerical simulation:

Computation: Table 1 shows the details of the parameterization used to simulate the model. Note that all variables are defined in per capita terms so that the model is scale-invariant with respect to population size. One important issue regarding the numerical computation of the equilibrium values relates to the fact that, while all input prices and input demands (with the exception of the landlord's land demand) have analytical expressions, these expressions depend on the share of firms across the different production regimes S, C_1, C_2. This introduces a circular element in the definition of these objects given that the shares are ultimately defined by input prices themselves. In order to address this issue I compute the equilibrium values starting from an initial guess for the share of workers in each regime, obtain prices based on this guess, and iteratively update the shares until the difference in values across iterations approaches zero.[6]

The central goal of this numerical analysis is to formally illustrate how, at different levels of initial land concentration, the economy's outcomes vary across the possible combinations of market structure and land market regulations: *i)* perfect competition with no land ceiling, *ii)* market-power with no land ceiling, *iii)* perfect competition with land ceiling, and *iv)* market-power with land ceiling.

[6] In this sense, one additional implicit assumption of the model is that, when exerting market power, the landlord takes into account how her demand choices will affect input prices but not how those prices will further affect the composition of workers across different types.

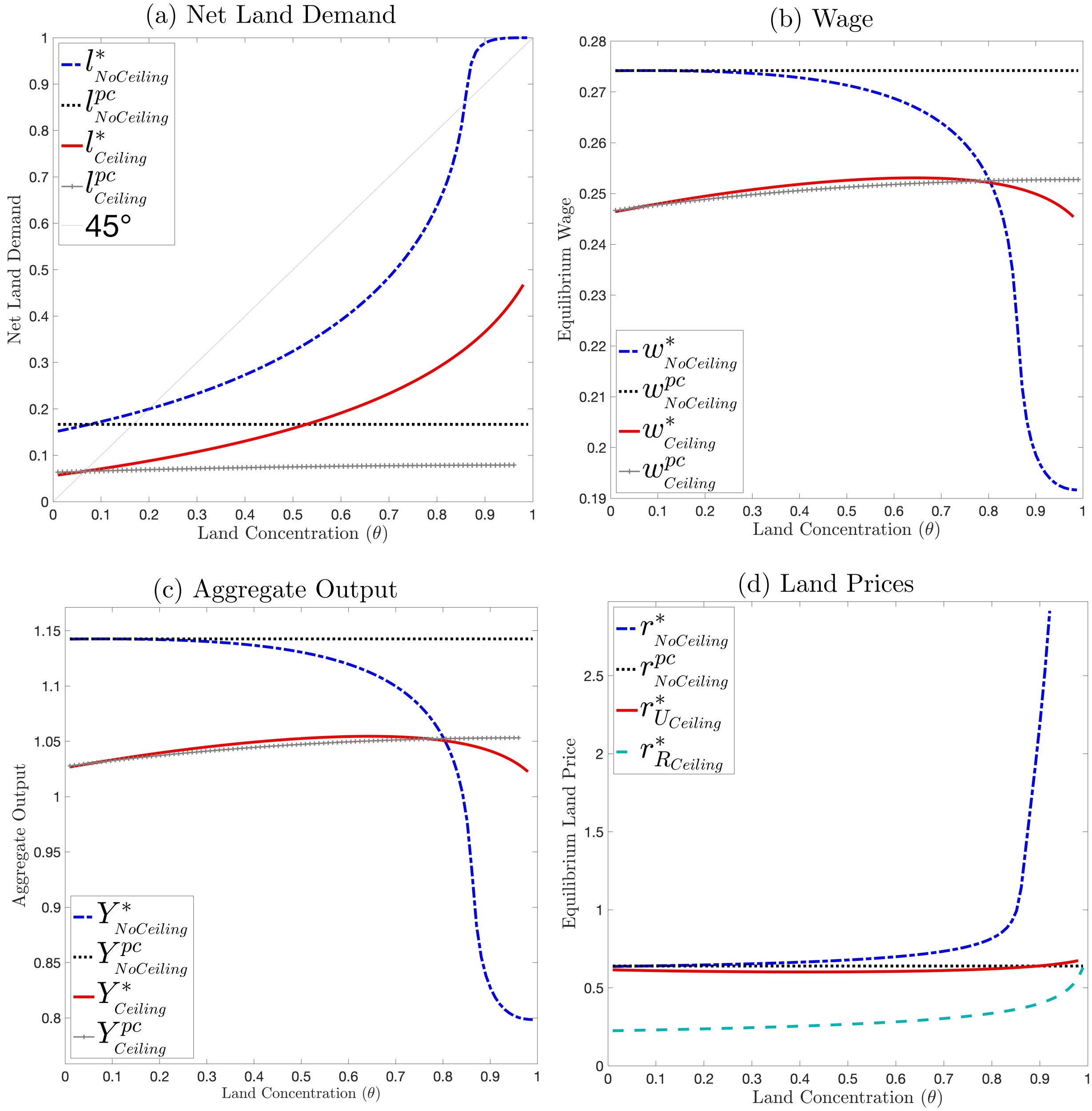
Table 1: Model Parameterization

Parameter	Value
Technology	
α: Land-share of profits	0.7
γ: span-of-control parameter	0.8
Skill distribution ($s_i \sim GPD(k, \sigma, \mu)$)	
k: Generalized Pareto dispersion parameter	0.1
σ: Generalized Pareto scale parameter	1
μ: Generalized Pareto location parameter	0
s_b: Landlord's skill level	$0.2 \times \sum_i s_i$
Land endowment ($l^0_{Ri}, l^0_{Ui} \sim log\mathcal{N}(\mu, \sigma)$)	
σ: log-normal variance	1
μ: log-normal mean	0
Land restrictions	
θ: Share of land as landlord's endowment	$\in [0, 1]$
ψ: Share of land restricted	0.6
$\bar{l}$: Land ceiling	$1.01 \times \frac{1}{N} \sum_i l^0_{Ri}$

Simulation Results: Equilibrium values for a simulated economy as a function of the initial land concentration parameter are shown in Figure 3. Intuitively, the introduction of a land ceiling has two countervailing effects on an economy's aggregate productivity level. On the one hand it introduces a direct distortion to the allocative efficiency of the economy by disallowing land trades that would make more productive farmers operate larger farms. In the context of the model, farmers in the production regime C_1 are the most notorious example of the misallocation produced by ceilings: farmers in this regime have varying productivity levels but the restriction on land markets leads all of them to operate equally-sized farms. Were land-market restrictions lifted, land sizes would then adjust and the marginal productivity of land would equate across all farmers in the competitive fringe. If, however, market-power distortions are also present in the economy, land-market restrictions preventing agents with market power from becoming excessively large can, potentially, increase aggregate productivity by hampering market-power effects.

As the upper-left panel of Figure 3 shows, the imposition of a ceiling on the amount of (restricted) land any farmer can own reduces the landlord's equilibrium farm size across the whole domain of initial concentration levels. When both land ceiling restrictions and market-power effects are at play the landlord's farm size still increases monotonically with her initial endowment, but the ceiling constraints her capacity to effectively reduce the amount of land available in the market. Given that she cannot purchase more than the maximum amount of restricted land determined by the ceiling, there is always a fraction of price-taking farms operating in the economy that the landlord is incapable of buying-off. The inability to fully

Figure 3: Equilibrium Outcomes as a Function of Initial Concentration - Ceiling vs. No ceiling



Notes: Equilibrium values across the domain of initial concentration values θ. Upper left panel: landlord's net land demand based on the numerical result to equation (8). Upper right panel: equilibrium wages. Lower left panel: Aggregate output across all types of firms (C_1, C_2, S). Lower right panel: Prices for restricted and unrestricted land. Blue dashed lines: equilibrium values for the case of market power without land ceilings. Red solid lines: equilibrium values for case of market power with land ceilings. Black dotted lines: equilibrium values for the perfectly competitive benchmark case without land ceilings. Gray lines: equilibrium values for the perfectly competitive benchmark case with land ceilings. Details on the parameter values chosen reported in Table 1.

fend-off other farms from operating –and by doing so to maintain the aggregate labor demand and market wages depressed– leads the landlord to operate a significantly smaller farm than in the no-ceiling scenario.

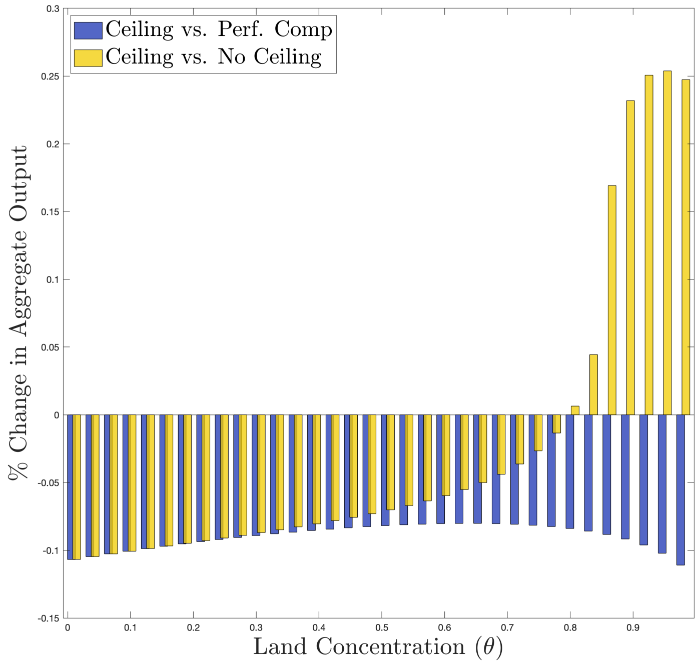
The reduction in the landlord's farm size caused by the imposition of ceilings has knock-on effects on input prices and aggregate productivity. Relative to the perfectly competitive case, the effect of land market ceilings on productivity is unambiguously negative across the whole the domain of possible concentration values. When market-power effects are present, however, both the magnitude and the sign of the change in productivity between the unrestricted and the restricted land market cases depend on the level of initial land concentration in the economy. At low concentration levels where market-power effects are less severe, the misallocation introduced by land ceilings has a net-negative effect on productivity and wages. By contrast, at higher concentration levels the reduction in market-power distortions brought about by ceilings more than offsets its own distortionary effects and productivity is in net terms *higher* than in the unrestricted land market case. The way in which productivity changes between the restricted and the unrestricted cases across concentration levels is illustrated in Figure 4. The model therefore predicts that, if there are underlying market-power effects in the economy, the negative productivity consequences of the imposition of land ceiling should be more severe in economies with lower initial inequality levels. I empirically test this prediction in Section 5.2 and find that the results are consistent with the model's predictions.

4 Data

The central empirical question of this paper is to estimate the effect that varying levels of land-market restrictions have on the agricultural sector of local economies. As I detail in Section 5, the main explanatory variable I use to address this question exploits the variation produced by the combination of differences in ceiling heights and the share of land in each municipality that was effectively subject to the restriction. I estimate how this change in restrictions affected *i)* the number and type of land transactions held, *ii)* inequality in land ownership, *iii)* aggregate agricultural productivity, and *iv)* labor market conditions in agriculture. This section describes each of the datasets used to construct these measures.

Share of municipal land restricted: To measure the fraction of land in each municipality subject to the ceiling restriction I use the dataset from the System of Information for Rural Development (SIDER), currently mantained by the National Land Agency (ANT), which contains information on the date, area, location (at the municipal level), and recipient

Figure 4: Change in Productivity Across Scenarios by Initial Concentration

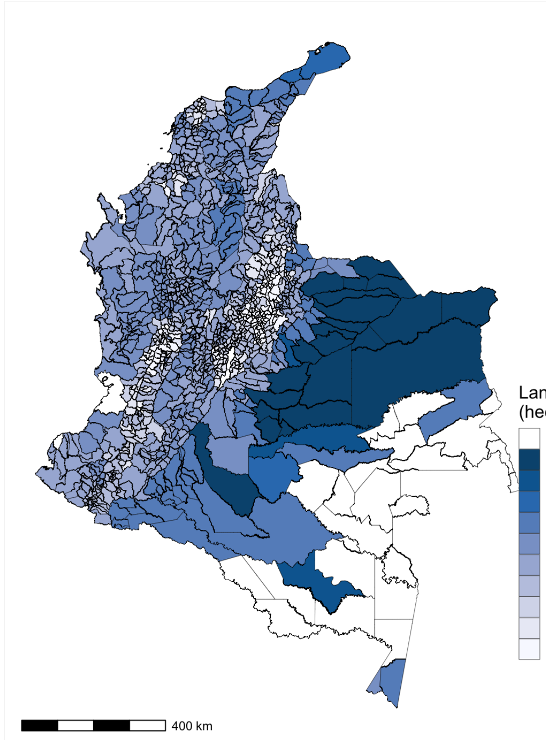


Notes: Log-difference in equilibrium aggregate output values between the simulated case of market power with land ceilings, and the simulated case of market power without land ceilings (red and blue lines in the bottom left panel of Figure 3 respectively)

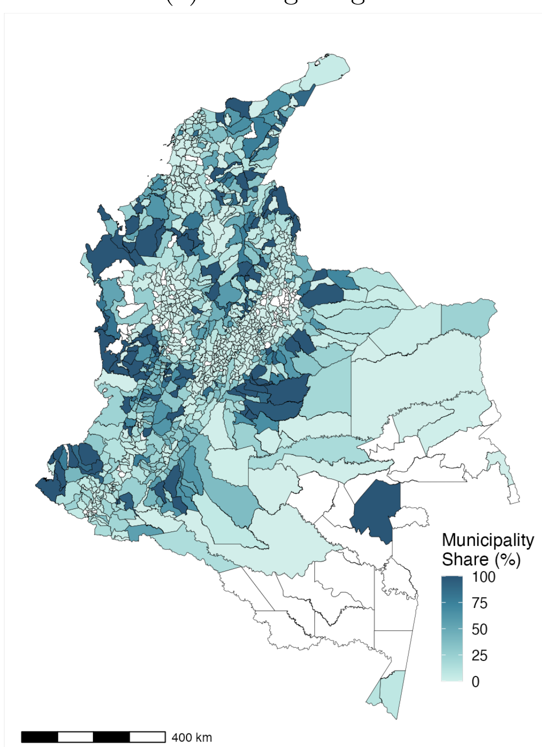
of every public land (*baldío*) allocation made by the Colombian government since 1900 until 2013. The dataset consists of 503,000 allocations made across 1,031 municipalities, and adding up to 19 million hectares of land; about 49% of all farmland held by private individuals in 2010. A growing number of studies (e.g. Albertus and Kaplan (2013); Albertus (2019); Faguet et al. (2020); López-Uribe (2022)) use this source of information to study the determinants of land allocation patterns across time. Figure 5 shows the geographical variation of both land-ceiling heights and of the share of land subject to restriction across colombian municipalities, while Figure A1 in Appendix A shows the temporal variation in number of allocations and the amount of land granted by the government throughout the 1940–2012 period.

Land sales: To measure if the imposition of land ceilings did in fact affect the prevalence and type of land sales in Colombian municipalities, I use data from the National Superintendency of Notaries (SNR), the national-level agency in charge of supervising and keeping record of property transfers. This dataset allows me to observe all formal sales for the universe of land plots initially registered as a governmental allocation, i.e. those plots subject to the ceiling restriction. The data allows me to distinguishing between full land transfers (when the totality of a plot is transferred to another individual), and partial transfers (when the original owner keeps a fraction of the plot). The data also records when two plots are merged and consolidated into a larger farm, in addition to dozens of other legal figures such

Figure 5: Measures of Land-Market Restrictions at the Municipal Level.



(a) Ceiling Height



(b) % of Government-Allocated Area in 1990

Notes. Geographical distribution of land-market restrictions. Left panel: Maximum UAF in hectares as defined by *INCORA* Resolution 041 of 1996. Right panel: Share of cumulative government-allocated land in 1990 as a fraction of total privately-owned farmland in the municipality according to the 2014 national agricultural census (CNA).

as mortgages, evictions, or inheritances. The information in this dataset amounts to roughly 1.5 million observable transactions for the period 1960–2012, which I aggregate to a yearly municipal-level panel.

While very rich, the SNR dataset is subject to some important caveats. First, the information available is only for those plots originally allocated by the government, and thus it consists on a sample of selected land plots (albeit specifically those plots subject to the restriction). Knowing if the restriction had an impact on the transaction frequency of unrestricted land plots is therefore not possible. Second, while being the recipient of a land allocation implied receiving a formal property title, the registration of this title in the SNR was not automatic. Plots from owners who did not pursue this process, and therefore never finalized the formalization process are not observed. Third, any informal sales –which, by definition, are not registered in a state agency– will not be observable in the data. Gauging the magnitude of the last two omissions is difficult but, as shown in Figure A2 in Appendix A the aggregate number of yearly plot registrations observed in the SNR dataset follows a broadly similar pattern to the number of allocations observed in the –completely independent– SIDER dataset, suggesting that the majority of government-allocated plots were indeed formally registered.

Land inequality: To assess changes in land inequality I use gini indices in agricultural land ownership and average farm sizes at the municipality level using information based on the national cadastre system for years 1985, 1993, and the period 2000–2005. This data consists of municipal-level aggregates of the national land registry maintained by the National Institute for Geographic Information (IGAC).[7] This registry is intended to be a census of rural property and aims to collect information on the location, size, and valuation of all plots in the country.[8] The dataset aggregates at the municipal level information from all privately-owned agricultural land plots across every municipality including both formally and informally owned plots, as well as government and non-government allocated ones. The cadastre system is meant to be continuously updating, and each municipality's rural-property registry should in theory be updated every five years at a minimum. In practice the frequency of cadastral updates varies significantly across municipalities, but Martínez (2023) shows that the updates are not driven by changes in municipality characteristics or local economic conditions like property booms. I exclude from the analysis information from municipalities where the number of registered properties in any given year is below the 99^{th} percentile of

[7]Aggregate municipal data for the period 2000–2005 was made available by (IGAC) for the construction of the *Atlas of Rural Property*, (Ibánez et al., 2012). I thank Fabio Sanchez at Universidad de los Andes for sharing his data for years 1993 and 1985.

[8]With the exception of the *departamento* of Antioquia, and the cities of Bogotá and Cali, who conduct independent land surveys.

the distribution. The final municipal-level panel contains information on nearly 40 million hectares of privately-owned farmland across 982 municipalities.

Agricultural productivity: In order to measure agricultural productivity at the municipal level before and after the enactment of law 160, I collected and digitized hundreds of volumes of the *Evaluaciones Agropecuarias Municipales*, a series of semestral publications made at least since 1980 at the bequest of the national government by each *departamento's* rural planning unit.[9] These volumes contain information on the area planted, area harvested and production data at the semester-crop-municipality level for a broad range of both perennial and non-perennial crops. The information was gathered by local authorities through a process called 'agricultural consensus', in which extension workers, producers, downstream supply chain participants and local officials were surveyed regarding each season's harvest. Throughout the period 1980–2000 these volumes were published independently by local state offices in at least 20 *departamentos* (with variations in publication frequency).While not as high-quality as an agricultural census, the methodology is the same as the one used in the modern version of the *Evaluaciones* which, since 2007, are carried out nationwide by the National Statistics Office (DANE). These publications are a rich source of information on Colombian agriculture and are potentially useful for a large number of research questions. As far as I am aware, however, these municipal productivity figures had not been digitized and harmonized until now.[10] This paper is the first to use a comprehensive dataset with municipality-level agricultural productivity measures for the 1988–2004 period. The dataset consists of more than 135,000 crop-semester-municipality observations organized in an (unbalanced) panel of 859 municipalities in 17 *departamentos* across 17 years. This comprises 69% of the country's total population and 76% of its rural population in 2005. To get a measure of municipal land productivity, I aggregate yields across crops using FAO's primary-crop producer prices, with which I compute yearly revenue-per-hectare values.[11]

Agricultural wages and employment: For municipal measures of employment in agriculture and of the share of population in rural areas I use the National Population Censuses of 1993

[9] Most often either the *Secretaría de Agricultura* or the *Unidad Regional de Planificación Agropecuaria* (URPA).

[10] The archival work to collect this data was carried out in (and I believe exhausted) the physical archives of the Ministry of Agriculture, the Colombian Agricultural Library (*Biblioteca Agropecuaria de Colombia*), the archive of the National Metereological Institute (IDEAM), and through several requests to *departamento*-level government offices of agriculture. I do not think, however, that the current dataset contains the totality of *Evaluaciones* published during the period, as many missing volumes are probably archived in state agricultural offices across the country. As such, this data collection effort is still very much a work in progress.

[11] FAO prices are available for Colombia starting only in 1990. To compute unit-value measures in previous years I set each crop's price at 1990 levels.

and 2005 carried out by the National Statistics Office (DANE). Given that the census does not collect information on income or wages, I use data on earnings by agricultural workers from the National Household Surveys (ENH), a set of repeated cross-section household surveys available for the period 1990–2004 also carried out by DANE. The surveys are representative at the national and *departamento* level and, while not representative for individual municipalities, do contain a large set of rural municipalities randomly selected on each survey wave.

Given that the focus of this paper is on measuring the effect of the law on wages rather than overall income, for the estimations I keep only wage laborers, aged 15 to 65, and employed in the agricultural sector, excluding self-employed individuals. For this subsample I use the survey's self-reported measure of monthly monetary income as a proxy for agricultural workers' earnings, as well as a self-reported measure of the average number of hours normally worked at the job. This results in a sample of 22,517 workers spanning 332 municipalities across the country.

Additional municipal characteristics: To measure if the enactment of land market restrictions ultimately affect rural-urban migration patterns, I compute the share of population living in the rural area of the municipality using the data available in the 'municipal panel' dataset maintained by CEDE at Universidad de los Andes, a large collection of municipal-level characteristics gathered from several administrative data sources.

As a measure of the intensity of high land concentration across municipalities during the pre-reform period, I use the 'latifundia intensity' measure reported in Lorente et al. (1985). This study conducted a land census in 1984 across the country and produced a measure on the extent of land concentration in each municipality. The measure is defined as the share of total farmland that made part of estates larger than 500 hectares.

Table 2 shows descriptive statistics for all of the variables used in the analysis. All monetary values are expressed in 2018 real Colombian pesos. The next section describes the empirical strategy to assess how these outcomes were affected by the introduction of the UAF ceiling across the country.

5 Empirical Strategy

5.1 The effect of land market restrictions

In general terms, the identification strategy of this paper uses cross-municipal variation in the stringency of land market restrictions due to differences in both ceiling height and the share of land restricted, to estimate a difference-in-difference regression model before

Table 2: Estimation Sample - Descriptive Statistics

	Observations	N. Years	Mean	Std. Dev.	Min	Max
Land ceiling (hectares)	1,088	1	66.4	201	5	2,269
Govt. allocated area in 1990 (%)	1,031	1	.218	.319	0	1
Total yearly land sales	64,818	18	21.7	37.8	0	853
Number of yearly full sales	64,818	18	15.6	28.8	0	825
Number of yearly fragmenting sales	64,818	18	5.13	12.4	0	255
Number of yearly consolidating sales	64,818	18	1.03	3.66	0	83
Average farm size (hectares)	37,186	8	31.2	106	.0631	2,790
Land ownership gini index	37,186	8	.635	.171	.0264	.972
Revenue per hectare (million COP)	41,510	17	12.1	15.2	.0131	243
Annual Corn Yield (tons/hectare)	27,772	17	2.65	2.43	.0533	110
Annual Coffee Yield (tons/hectare)	11,278	17	.968	.571	.0006	18.8
Annual Plantain Yield (tons/hectare)	16,410	17	6.82	22.5	.0085	1,130
Annual Rice Yield (tons/hectare)	4,748	17	7.63	4.63	.0437	25.6
Ag. worker monthly earnings (1000 COP)	109,459	15	779	1,232	8.03	67,159
Occupied in agriculture (%)	5,904	2	.475	.214	.0051	.913
Share of rural population (%)	5,904	2	.625	.226	.0136	.983
Latifundia Intensity in 1984 (%)	617	1	.125	.167	0	.988

Notes: Summary statistics for main dependent variables and outcomes. Column 1 indicates the number of municipality-pair observations. Column 2 indicates the number of years for which there is information available on the outcome variable. All monetary values are expressed in real 2018 Colombian pesos (COP).

and after the enactment of law 160. However, given that ceiling heights were not assigned randomly but defined according to regional agroclimatic conditions, the standard approach of estimating a two-way municipal and yearly fixed-effect model would not account for the fact that heterogeneity in restriction levels is potentially correlated with differential trends across regions in regulation enforcement, productivity growth, and other time-varying sources of omitted variable bias.

As an example, municipalities in the country's peripheral, more sparsely populated eastern region were assigned higher ceilings due to their perceived lower land quality. If underlying agricultural productivity growth rates during the period of study in this region were lower relative to the rest of the country (for example due to the intensifying armed conflict), the cross-region comparison produced by the standard two-way fixed-effect approach would estimate a positively-biased relationship between the stringency of land restrictions and agricultural productivity.

With this in mind, my preferred estimation approach uses variation in market restriction levels only between pairs of contiguous municipalities that straddle an 'homogeneous zone' border, across which ceiling heights vary by decree. By comparing outcomes only within pairs of municipalities at opposite sides of a border, which are arguably more similar to each other than any two pair of municipalities chosen at random, this specification addresses the heterogeneity in unobserved time-varying trends that could bias standard TWFE estimates. This estimation strategy follows the approach of studies that evaluate the effect of state-level policies in the U.S. by comparing outcomes in county pairs located across state boundary lines (e.g. Dube et al. (2010); Cortés et al. (2022)).

Formally, let m index municipalities, t years, and p neighboring municipality-pairs. Let $y_{m,p,t}$ denote the outcome for municipality m belonging to pair p, and let C_m denote municipal land ceiling height. Given that lower ceilings represent more restricted land markets, I define the restriction level variable as the reciprocal of ceiling height: $R_m \equiv 1/C_m$. Let the share of municipal agricultural land allocated by the government before the enactment of the law be denoted by S_{m,t^0}.[12] I then run the following OLS regression:

$$y_{m,p,t} = \beta\left(R_m \times S_{m,t^0} \times T\right) + \alpha_1\left(R_m \times T\right) + \alpha_2\left(S_{m,t^0} \times T\right) + \phi_m + \kappa_{p,t} + \varepsilon_{m,p,t} \tag{9}$$

where T is an indicator variable such that $T = \mathbf{1}(t \geq 1994)$, ϕ_m represents municipality fixed effects, and $\kappa_{p,t}$ represents neighboring municipality-pair×year fixed effects. The municipality fixed effect absorbs terms such as R_m or S_{m,t^0}, along with any other characteristics that do not vary within municipality, while the contiguous municipality-pair-by-year fixed effects control for any unobserved time-varying shocks that occur at a level broader than the municipality pair.[13] Within a municipality pair, the inclusion of coefficients α_1 and α_2 controls for heterogeneous post-treatment trends correlated respectively to ceiling height and share of land restricted. The coefficient of interest β is the effect of the market-restriction treatment jointly defined by ceiling height and fraction of farmland restricted, and is identified under the assumption that, conditional on the heterogeneous trends and on the set of fixed effects, the treatment variable is uncorrelated with any remaining unobserved shocks in the error term. An omitted variable confounding estimates obtained from equation (9) would have to vary across time and within municipality pairs, differentially affecting municipalities with more stringent market frictions.

In order to test whether the identification assumption is threatened by the existence of

[12] I compute this share as the amount of land allocated in each municipality over total farm land in the municipality according to the 2014 National Agricultural Census. I define the 'pre-reform' period to include all government allocations made up to the year 1990 (i.e., $t^0 = 1990$), but moving this cutoff one or two years either back or forward has very little impact on the estimation results.

[13] A mid-point between the standard time and municipality two-way fixed-effect approach and the neighboring municipality-pair estimation is to estimate a regression with municipality and *departamento*-year fixed effects that control for unobserved time-varying trends in municipalities across different *departamentos*. Results in Tables tables A2 to A5 in Appendix A show results for regressions with these sets of fixed effects as well as for the more standard time and municipality fixed-effect approach. In general, results across the three sets of fixed effects are similar, suggesting that the potential omitted variable bias from unobserved cross-region trends appears not to be large.

pretrends leading up to the enactment of the law, as well as to evaluate the persistency of the estimated treatment effects across time, I estimate an event study of the form:

$$y_{p,m,t} = \sum_{\substack{h=-j \\ h\neq -1}}^{J} \beta_h (R_m \times S_{m,t^0} \times \tau_h) + \alpha_1 (R_m \times T) + \alpha_2 (S_{m,t^0} \times T) + \phi_m + \kappa_{p,t} + \epsilon_{p,m,t}, \quad (10)$$

where τ_h is an indicator function such that $\tau_h = \mathbf{1}\{t - 1994 = h\}$.

Note that under the contiguous municipality-pair specification each municipality can have more than one adjacent neighbor across homogeneous zones, and can therefore be part of more than one municipality pair. This implies that in a single year a municipality might appear multiple times in the estimation sample. For this reason, all regressions are weighted by the inverse number of pairs to which each municipality belongs to. Conversely, municipalities that only share boundaries with other municipalities subject to the same ceiling height are not included in the sample since the estimation approach leaves no variation left to exploit from these observations. Figure A3 in Appendix A shows the geographical distribution of the resulting sample of municipalities on which the estimation is carried out.

Inference: Standard errors from equations (9) and (10) are potentially subject to bias due to serial correlation in municipal level outcomes, as well as to the fact that treatment is constant within an homogeneous zone.[14] Additionally, error terms are mechanically correlated across neighbor-pairs that share a common municipality given that, as discussed above, municipalities with more than one neighbor will appear repeatedly in the estimation sample.

In order to account for these potential sources of correlation, I define *departamento*-pair groupings as the set of all municipalities belonging to either one of the two *departamentos* to which a municipality-pair observation belongs to. I then set standard errors in all regressions to be separately clustered both at the *departamento* and at the *departamento*-pair level, where the first type of error clustering addresses autocorrelation and common treatment across units, and the second addresses correlation across neighbor-pairs that share a common municipality.

[14]The second-level administrative unit in Colombia, the *departamento*, is the equivalent of the U.S. state. *Departamentos* are composed of municipalities, which are analogous to U.S. counties. The homogeneous zones that define land ceiling height are collections of municipalities that do not straddle *departamento* boundaries. Homogeneous zones are not an administrative division, and were defined *ad-hoc* for the enactment of law 160.

5.2 Heterogeneity and the Persistence of Land Concentration

The theoretical framework outlined in Section 3 has two main predictions that can be tested in the data. First, when there is market power and relative to the unrestricted case, the net effect of imposing market restrictions on productivity depends on the economy's level of initial land concentration. At low concentration levels –where market-power distortions are minimal– the imposition of land-accumulation restrictions will simply introduce distortions that dislodge the efficient allocation of land and will unambiguously reduce aggregate output. By contrast, at high enough levels of initial concentration, while the imposition of restrictions still introduces harmful distortions, it also curtails the inefficiencies produced by imperfect competition. The model shows that in this case, if the market-power driven inefficiencies are large enough, introducing restrictions to prevent further concentration can actually increase the economy's aggregate output.

Second, when no restrictions on land purchases are in place and large landholders exert market power in land and labor, public-land allocations made in high-concentration environments will tend to become concentrated faster. Since the optimal response of a landholder in a highly concentrated economy entails having a net-positive demand for land, purchases of plots allocated in economies with more land concentration should be more prevalent and should happen sooner. Similarly, the evolution of concentration levels across time should be higher for land allocated in initially more concentrated municipalities.

In order to investigate the first prediction I estimate a modified version of equation (9) where I introduce an additional interaction term that measures if restrictions have heterogeneous effects on agricultural productivity between municipalities with high and low initial concentration levels. Formally, let I_{m,t^0} be an indicator function for high initial land concentration in municipality m at time $t^0 < T$. I estimate:

$$\begin{aligned} y_{p,m,t} = {} & \beta \left(R_m \times S_{m,t^0} \times T\right) + \gamma \left(R_m \times S_{m,t^0} \times I_{m,t^0} \times T\right) \\ & + \delta_1 \left(I_{m,t^0} \times S_{m,t^0} \times T\right) + \delta_2 \left(I_{m,t^0} \times R_m \times T\right) \\ & + \alpha_1 \left(R_m \times T\right) + \alpha_2 \left(S_{m,t^0} \times T\right) + \alpha_3 \left(I_{m,t^0} \times T\right) + \phi_m + \kappa_{pt} + \varepsilon_{p,m,t} \end{aligned} \tag{11}$$

Where the measure of initial land inequality comes from Lorente et al. (1985). This measure is defined as the share of total farmland in a municipality that was part of an estate larger than 500 hectares. The indicator variable I_{m,t^0} is equal to one if municipality m has a measure of latifundia above the national-level median.

The second testable prediction of the model is that, during the pre-reform period (i.e. when there were no restrictions in place against land accumulation), land plots allocated in municipalities with higher land concentration levels should get resold faster and more often, and that this should be accompanied by higher levels of land reconcentration across time.

Estimating the correlation between initial concentration and the prevalence of land sales for allocated plots can be done using the transaction-level data contained in the SNR dataset. However, the SNR transaction dataset lacks information on the area of each allocated plot, so testing if changes in concentration across time vary between high- and low-concentration municipalities requires merging the transaction-level dataset with the allocation-level SIDER dataset. In the absence of plot-level id's, the merging of these two datasets has to be based on characteristics such as the date and municipality where the allocation took place, and on the name (subject to spelling variations) under which each plot was registered. This challenge is close to the one faced by economic historians who seek to link the same individual in two different waves of a population census before the use of personal identification numbers became widespread. I therefore follow the approach proposed by Abramitzky et al. (2021), and tailor their ABE-JW algorithm to this context. At conservative parameter values (such that keeping a low probability of false-positive matches is prioritized), the algorithm produces a match rate between both datasets of 43%, yielding a sample of 213,001 allocations.

Focusing on the subsample of matched allocations that took place between 1984 and 1993, the year when the initial concentration measure was collected and the year before the enactment of law 160, respectively, I define a 'cohort' as all allocations made in a given municipality on a specific year. Within each cohort, I compute an owner-level farm size measure defined as the sum of the area of all land plots owned by the same individual in each cohort. I then track how changes in ownership across time make each cohort more or less concentrated relative to the original distribution of allocations. Following Roberts and Key (2008), I measure changes in concentration with as the percent change in the area-weighted median farm.[15]

To corroborate these patterns I run two sets of regressions that estimate the correlation between initial concentration and sale probability, and further concentration changes across time. I first run the following plot-level linear-probability regression:

$$s_{i,m,\Delta t} = \beta X_m + \delta_{d,t} + \epsilon_{i,m,t}, \tag{12}$$

where $s_{i,m,\Delta t}$ is a dummy variable indicating if plot i allocated in municipality m had been sold Δt years after its initial allocation: $s_{i,m,\Delta t} \equiv \mathbf{1}(Sold_{i,m,\Delta t} = 1)$, X_m is the continuous initial latifundia intensity measure from Lorente et al. (1985), and $\delta_{d,t}$ represents the inclusion

[15]The area-weighted median can be though of the size of a farm such that half of all of the stock of land is operated by smaller farms while the other half is operated by larger farms. Results using different concentration measures such as the area-weighted mean, or the Hirschman-Herfindhal Index yield very similar results.

of *departamento*-specific time trends.

I also run cohort-level regressions of the form:

$$\Delta A_{j,m,t} = \beta X_m + \delta_{d,t} + \eta_{j,m,t}, \tag{13}$$

where the outcome variable $\Delta A_{j,m,t}$ measures the change in land concentration observed within each allocation cohort j between allocation year t and time interval Δt. Standard errors in all regressions based on equations (12) and (13) are clustered at the municipality level.

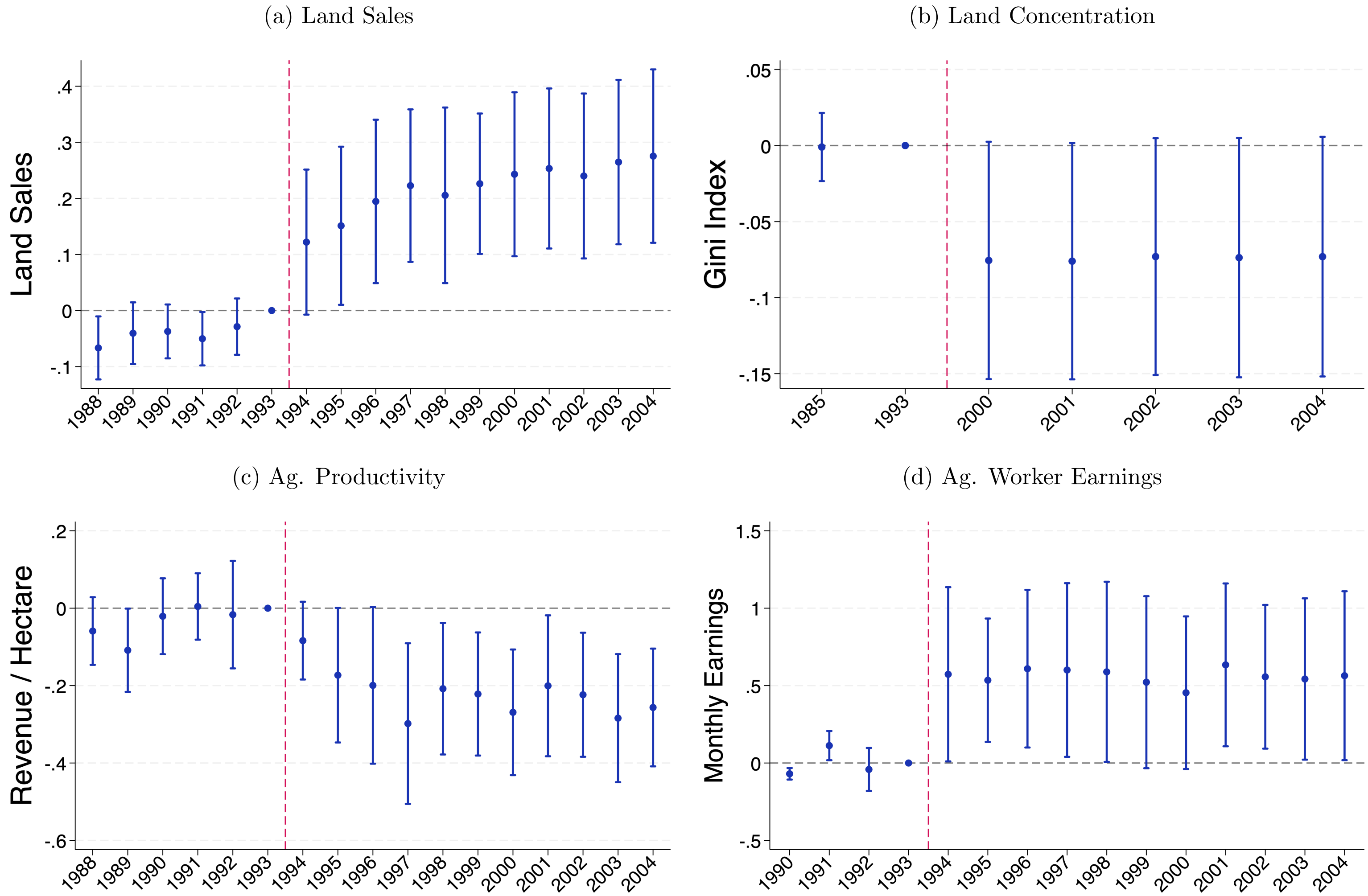
6 Results

This section examines the impact of law 160, which imposed municipality-specific limits on the amount of government-granted land any private entity is legally allowed to own. As described in section 5, the stringency of the restriction on a municipality's land market will jointly depend on the height of the imposed land ceiling and on the fraction of farmland in the municipality over which such restrictions apply.

The impact that land market restrictions had on land sales, land concentration, agricultural productivity, and agricultural workers' earnings is visible in the event-study graphs shown in Figure 6. The graphs show estimated coefficients from equation (10) before and after the imposition of law 160 in 1994. Supporting the identifying assumption of the difference-in-difference approach, the estimated coefficients in years before the enactment of the law are substantially smaller and almost always statistically insignificant, implying the absence of differential pre-treatment trends. The estimates show a consistent effect on all outcomes after the treatment year. The imposition of land market restrictions had persistent effects throughout (at least) the ten years following the passing of law 160, with gradual increases in the magnitude of the effect on land sales as well as on agricultural productivity. For its part, the estimated effect on workers' earnings remained consistently positive throughout the 1994–2004 period, albeit with somewhat wider confidence intervals.

Tables tables 3 to 6 shown in the subsections below report the difference-in-difference estimates based on equation (9) for all outcome variables evaluated in this paper; I now turn to discuss these results.

Figure 6: Event Study for Main Outcomes



Notes: OLS estimates of equation (10) for main outcome variables. All regressions weighted by the inverse number of pairs to which each municipality belongs to. Lines around the point estimates show 95% confidence intervals for two-way clustered standard errors at the *departamento*, and at the *departamento*-pair level in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

6.1 Land sales

I start by looking at whether the enactment of the law had an effect on the number of land sales held in a municipality using the SNR transaction data. Looking for changes in land sales after the imposition of the law can be thought as a first-stage result evaluating whether the law was actually enforced. Recall that this data consists of government-allocated land plots, and that the number of cumulative allocations increases with time. To avoid spurious correlations due to the fact that more sales will take place as the number of plots allocated increases, these regressions include as an additional control variable the logarithm of the cumulative number of land allocations made in the municipality up to that point of time.

Table 3 reports results of estimating equation (9) on the (log) number of yearly land sales in a municipality.[16] Column 1 shows the result for the total number of sales, and columns 2-4 disaggregate by the type of sale, i.e., whether the sale transferred the property of the entire plot, whether the sale fractioned a property into smaller plots, or whether it involved merging a plot into a larger landholding.[17] Surprisingly, the imposition of limits on private landholdings *increased* the number of land sales taking place in a municipality. The point estimate indicates that 10% increase in the composite restriction variable led on average to an increase of roughly 1.8% in the number of yearly land sales. To gauge the magnitude of this effect, consider that a municipality going from the 25^{th} to the 75^{th} percentile of restriction stringency would have 19.3% more sales every year, an increase of roughly 4.2 transactions per year at mean values.[18]

The positive effect in total sales was equally driven by increases in both full sales and 'partial' sales where the owner keeps a fraction of the original land plot. For their part, 'consolidation' transactions –where a plot is aggregated into a larger landholding– fell substantially: a municipality going from the 25^{th} to the 75^{th} percentile of restriction stringency would have 25.6% fewer consolidations every year after the passing of the law. I interpret these results as showing that *i)* the enactment of law 160 did have a tangible effect on land-market dynamics across Colombian municipalities, and *ii)* the simultaneous increases in fragmenting sales and decreases in consolidating sales suggest that this effect was concentrated in driving rural property towards smaller, more fragmented farms. While I cannot observe how the area of the plots transacted changed before and after the law,

[16] Alternatively, table A1 in Appendix A shows an analogous set of results where the measure of land sales is instead defined as the number of sales as a proportion to the cumulative number of allocations.

[17] Formally the legal figures are *Compraventa* for full sales, *Compraventa Parcial* and *División Material* for partial sales, and *Englobe* for consolidating transfers.

[18] The difference in the log value of the treatment variable between municipalities at the 25^{th} and the 75^{th} percentiles is of $|0.939 - 0.002| = 0.937$ log points. The $p25/p75$ effect on percentage of sales is then $e^{0.937\times0.188} - 1 = 0.193$.

Table 3: Land Market Restrictions and Land Sales

	Transaction Type			
	Total Sales	Full Property Transfer	Fragmenting Sales	Consolidating Sales
	(1)	(2)	(3)	(4)
$\hat{\beta}$: Restriction Level × Area restricted × T	0.188***	0.191***	0.204***	-0.244**
	(0.051)	(0.046)	(0.063)	(0.092)
Observations	64,818	64,818	64,818	64,818
R^2	.956	.951	.892	.795
Mean Dep. Var.	21.708	15.612	5.133	1.025

Notes: Data from the National Superintendency of Notaries (SNR) records. Column 1 shows the effect on the aggregate number of transactions, column 2 shows the effect on full sales, column 3 shows the effect on partial sales (when only a fraction of the plot is transferred), and column 4 shows consolidation transfers. All sales variables computed as the fraction of yearly sales in proportion to the number of cumulative government allocations at the time. All outcomes are in $\log(x + 1)$ transformation. All regressions include municipality and municipality-pair-by-year fixed effects. All regressions weighted by the inverse number of pairs to which each municipality belongs to. Two-way clustered standard errors at the at the *departamento*, and at the *departamento*-pair level in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

the results on number and type of transactions seem to suggest a substantial number of landholders responded to the new regulations by adjusting the size of their holdings and in that way fall within the prescribed area limits.

6.2 Land concentration

If the imposition of the law led a large enough number of owners to adjust –at least nominally– the size of their holdings in order to remain below ceiling, this reshuffling of property could produce aggregate changes in the overall farm size distribution in a municipality. Reducing land inequality and preventing land concentration were explicit goals of law 160 but, to my knowledge, no quantitative evaluation on the effect of the law has been carried out to this date. I investigate this question using data from the National Cadastre registry from IGAC, which has pre-treatment municipal-level information on average farm sizes and municipal land gini indices for 1985 and 1993, and post-treatment indices starting in the year 2000. Results for these outcomes are reported in Table 4. Column 1 shows the enactment of law 160 had no statistically discernible impact on average farm sizes, and a negative but small impact on land concentration. The point estimate in column 2 implies that the gini index in a municipality going from the 25^{th} to the 75^{th} percentile of restriction stringency would be reduced by 7%, or 0.045 points at the mean value. This decrease amounts only to a quarter of a standard deviation in the distribution of gini indices across municipalities.

The relatively small magnitude of this effect could be in part caused by the possibility that any reductions in concentration due to the law were offset by concurrent increases in the consolidation patterns of unrestricted properties. Recall that while the law only applied to plots originally granted by the government, the national land registry includes information on all privately-owned land plots, regardless of their origin. Assessing whether individuals

Table 4: Land Market Restrictions and Farm Size

	Average Farm Size (1)	Land Gini (2)
$\hat{\beta}$: Restriction Level × Area restricted × T	-0.040	-0.074*
	(0.084)	(0.039)
Observations	37,186	31,774
R^2	.99	.958
Mean Dep. Var.	31.17	.637

Notes: Data from the National Land Registry (*Catastro Nacional*) maintained by the National Geographical Office (IGAC). All outcome variables are in logarithms. All regressions include *departamento* and municipality-pair-by-year fixed effects. All regressions weighted by the inverse number of pairs to which each municipality belongs to. Two-way clustered standard errors at the *departamento*, and at the *departamento*-pair level in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

did in fact respond to the imposition of the law by substituting restricted for unrestricted land purchases would, however, require a more extensive dataset with information on land transactions for all types of plots. Regardless of the mechanism, these estimates show that law 160 appears to have been relatively ineffective in its goal of reducing land inequality in rural Colombia.[19]

6.3 Agricultural productivity

I now turn to assessing the impact of land market restrictions on agricultural land productivity. As described in section 4, for this outcome I use data from the *Evaluaciones Municipales* which contain information on crop-specific yields. I aggregate yields across crops using information on farm-gate prices reported by FAO, and compute a measure of average revenue per unit of land at the municipality-year level expressed in (log) real million Colombian pesos per hectare. I also compute yields at the individual crop level expressed in (log) tons per hectare for the four most common crops (in terms of area planted) in this dataset during the pre-reform period 1988–1993.

Table 5 reports the difference-in-difference estimates from equation (9) for the outcomes described above. The result in column 1 shows that, in aggregate, higher land market restriction levels led to a substantial decrease in the agricultural productivity of Colombian municipalities. On average, a municipality going from the 25^{th} to the 75^{th} percentile of restriction stringency would have a 24.6%, reduction in revenue per hectare. At mean values this amounts to 2.9 million Colombian pesos at 2018 prices ($\approx$ 980 U.S. dollars in 2018).

At the level of individual crop yields, the imposition of restrictions led to statistically

[19] The theoretical framework described in section 3 suggests that the imposition of restrictions on a fraction of available farmland would in fact lead more skilled farmers to operate larger farms through the purchase of relatively larger amounts of unrestricted land. The model in turn predicts restrictions would create a wedge between unrestricted and restricted land prices. Unfortunately, it is not possible to empirically verify this prediction given that data on rural land prices has never been systematically collected in the country.

Table 5: Land Market Restrictions and Agricultural Productivity

	Revenue per Hectare	Yield (Tons/Hectare)			
		Corn	Coffee	Plantain	Rice
	(1)	(2)	(3)	(4)	(5)
$\hat{\beta}$: Restriction Level × Area restricted × T	-0.235**	-0.160**	0.233***	0.202***	0.158
	(0.080)	(0.062)	(0.031)	(0.064)	(0.165)
Observations	41,510	27,772	11,278	16,410	4,748
R^2	.911	.911	.796	.857	.956
Mean Dep. Var.	12.113	2.652	.968	6.82	7.63

Notes: Data from the *Evaluaciones Agropecuarias Municipales.* Outcome in column 1 in log million Colombian pesos. Outcomes in columns 2-6 in log tons per hectare. All regressions include municipality and municipality-pair-by-year fixed effects. All regressions weighted by the inverse number of pairs to which each municipality belongs to. Two-way clustered standard errors at the *departamento*, and at the *departamento*-pair level in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

significant decreases in corn yields (the most common crop, in terms of area planted, in the country), but to increases in both coffee and plantain yields, two crops grown almost exclusively in smallholder farms with low capital-labor ratios. These effects appear consistent with the idea that market restrictions moved production towards smaller farms where crops better suited to profit from economies of scale are less productive.

Potentially, the observed effect on aggregate crop yields could be not because of changes in productivity per unit of land but due to changes in the crop composition of the municipality, and could be instead revealing adjustments in the area planted for each crop. Results reported in Table A6 in Appendix A show that land market restrictions had no statistically significant effect in the growth of area planted for any of the four crops examined. Moreover, the signs of the coefficients for corn and coffee are the same as the coefficients for yield estimates, implying that changes in the quantity produced of these crops must have been relatively larger –and in the same direction as yields– than any changes in area.

6.4 Agricultural labor

Finally, I look at the effect of land market restrictions on the earnings of agricultural workers (both wage laborers and self-employed), on the share of agricultural employment, and on the share of population living in the rural area of a municipality. Results for these estimations are reported in Table 6. The estimate in column 1 shows that higher land market restriction levels led to a increase in monthly earnings for workers in the agricultural sector. On average, a worker in a municipality going from the 25^{th} to the 75^{th} percentile of restriction stringency would have a 68% increase in monthly earnings. At mean values this amounts to 546 thousand Colombian pesos at 2018 prices ($\approx$ 185 U.S. dollars in 2018). Regarding employment rates, this same increase in restriction levels would cause a 23% increase in the share of workers employed in agriculture, a rise of roughly 10 percentage points at mean values. These results are consistent with the findings of Emran and Shilpi (2020), who evaluate the impact of a prohibition on land sales in Sri Lanka and show that this restriction increased agricultural employment and wages. These authors argue that land market restrictions (who in the context they study additionally entailed the imposition of bans on rentals and mortgages) curtailed the structural transformation process of more heavily restricted areas. The estimate reported in column 3, however, shows that for the Colombian context there is no evidence of restrictions having increased rural population growth. Table A7 in Appendix A shows that the increase in workers' monthly earnings is not driven by intensive-margin changes in the amount of weekly hours worked, and are not sensitive to alternative definitions of the earnings measure or to the definition of the population in the workforce.

Table 6: Land Market Restrictions and Labor Market Outcomes

	Ag. Worker Earnings	% Occupied in Ag.	% Pop in Rural Area
	(1)	(2)	(3)
$\hat{\beta}$: log Restriction Level × Area restricted × T	0.554**	0.223*	0.019
	(0.243)	(0.128)	(0.042)
Observations	102,123	5,904	5,904
R^2	.135	.93	.988
Mean Dep. Var.	802.595	.475	.625

Notes: Data from the National Population Census and the National Household Surveys carried out by the National Statistics Office (DANE). Outcome in column 1 in log thousand Colombian pesos. All regressions include municipality and municipality-pair-by-year fixed effects. All regressions weighted by the inverse number of pairs to which each municipality belongs to. Two-way clustered standard errors at the *departamento*, and at the *departamento*-pair level in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

The fact that market restrictions had simultaneous, persistent, and opposing effects on productivity and wages is puzzling since, from a perfectly competitive standpoint, wages should be ultimately linked to the productivity of agricultural firms. While it is intuitive to think that restricting land markets –and thus disallowing a more efficient input allocation– will lead to a reduction in aggregate productivity, it is not clear how this reduction could be accompanied by rising wages, especially given the results showing restrictions were accompanied by an increase in employment rates and no declines in rural population growth.

The effects observed are instead consistent with an economy where large landholders have the capacity to exert market power in both land and labor input markets. In particular, the observed increase in wages after the imposition of land market restrictions is consistent with the curtailment of monopsony power exerted by large agricultural employers in a rural economy where workers have limited outside options. While directly introducing distortions of their own, limits on the amount of land individual's can accumulate might prevent large landowners from fending-off competitors through the expansion of their holdings.

6.5 Treatment heterogeneity by initial land concentration

If restrictions allow for the entry of smaller agricultural firms that demand labor from the local economy, the upward pressure on wages might lead firms with market power to substantially reduce their operational scale, increase the supply of land available and, through the effect on input prices, further promote the growth of smaller competing firms. Within a framework that allows for market power effects, the impact of imposing restrictions on land markets for both productivity and wages becomes ambiguous and the direction of the effect will ultimately depend on the initial level of land concentration in the economy.

Table 7: Restrictions and Productivity - Heterogeneity by Initial Land Concentration

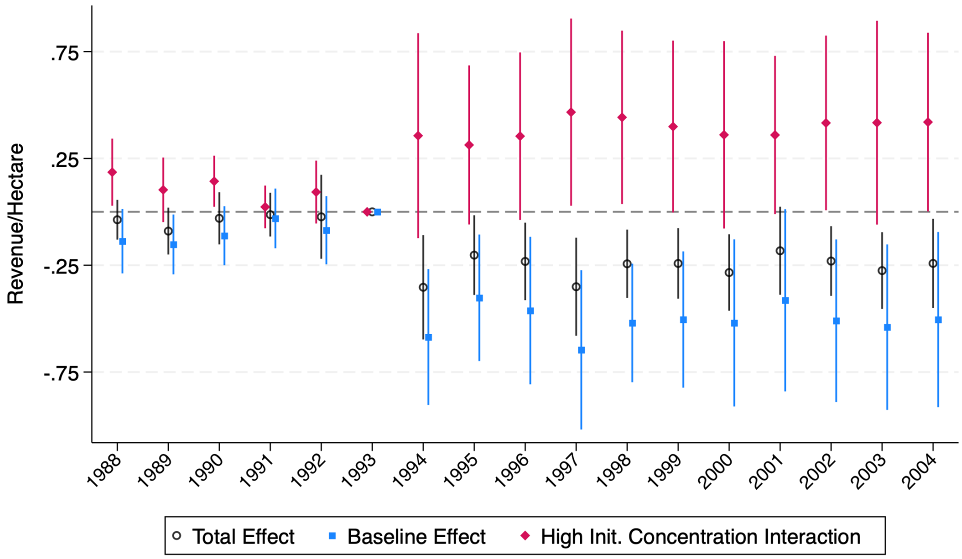
	Split Sample		Full Sample	
	Low	High		
	(1)	(2)	(3)	(4)
$\hat{\beta}$: Restriction Level × Share area restricted × T	-0.307	-0.201*	-0.217***	-0.420**
	(0.192)	(0.106)	(0.071)	(0.145)
$\hat{\gamma}$: Restriction Level × Share area restricted × T × High Init. Concentration				0.319*
				(0.170)
R^2	0.913	0.896	0.907	0.907
Observations	11,822	7,780	30,300	30,300

Notes: Productivity data from the *Evaluaciones Agropecuarias Municipales*. Initial land concentration levels from Lorente et al. (1985). Column 1 shows the estimated coefficient of running the regression specified in equation (9) only on the subsample of municipalities with below-median initial concentration measure. Column 2 shows the estimated coefficient of the same regression in the subsample of municipalities with above-median initial concentration. Revenue per hectare outcome in log million Colombian pesos. All regressions include municipality and municipality-pair-by-year fixed effects. All regressions weighted by the inverse number of pairs to which each municipality belongs to. Two-way clustered standard errors at the *departamento*, and at the *departamento*-pair level in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

I test if there is evidence for heterogeneous effects on productivity depending on the initial level of land concentration by running the regression in equation (11). Results for this regression are shown in Table 7, which also shows the results of running the regression in equation (9) after splitting the sample between municipalities above or below the median latifundia intensity value.[20] The estimated coefficients show that, on average, the impact of restrictions on municipalities with high inequality is less severe than in municipalities with low inequality. The interaction term in column 4 shows that while in municipalities with low concentration the effect of a 10% increase in restriction stringency lead to reduction in productivity of about 4.2%, this effect is attenuated by 3.2 percentage points in municipalities with high initial concentration levels. The heterogeneous impact of land market restrictions on productivity is also visible in the event-study graphs shown in the event-study version of

[20] The number of observations in columns 1 and 2 of Table 7 does not add up to the number of observations in columns 3 and 4 due to the fact that municipality-pair observations composed of one municipality with high inequality ($I_{m,t^0} = 1$), and one municipality with low inequality ($I_{m,t^0} = 0$) become excluded from the estimation in both subsamples.

Figure 7: Agricultural Revenue per Hectare - Heterogeneity by Initial Land Concentration



Notes: OLS estimates for $\hat{\beta}$ (blue) and $\hat{\gamma}$ (red) of the event-study version of equation (11). Estimates in black are OLS coefficients of regression (9) on the full sample of municipalities with data for the initial concentration measure. Productivity data from the *Evaluaciones Agropecuarias Municipales*. Initial land concentration levels from Lorente et al. (1985). Revenue per hectare outcome in log million Colombian pesos. All regressions include municipality and municipality-pair-by-year fixed effects. All regressions weighted by the inverse number of pairs to which each municipality belongs to. Lines around the point estimates show 95% confidence intervals for two-way clustered standard errors at the *departamento*, and at the *departamento*-pair level in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

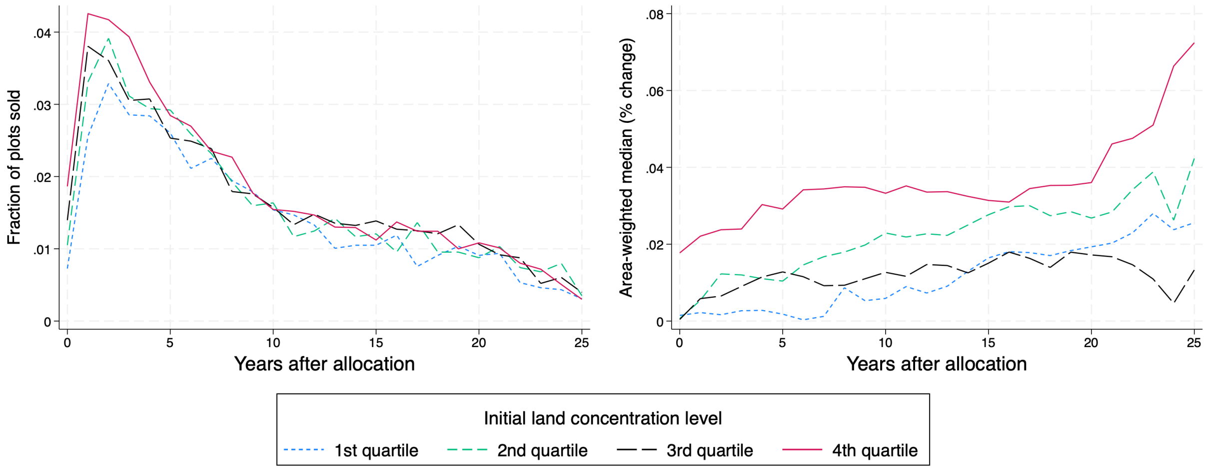
equation (11), shown in Figure 7.

6.6 Concentration persistence

Figure 8 shows how both sales frequency and the change in concentration evolve through time after splitting the sample by quartiles of the latifundia intensity measure as described in Section 5.2. Consistent with the model's predictions, land plots granted in municipalities situated in the highest quartile of initial concentration are more likely to be sold within the first five years of allocation than land granted in municipalities in the lowest initial concentration quartile. Moreover, concentration levels increase more rapidly and remain persistently higher within allocation cohorts in municipalities with the highest prevalence of latifundia than in municipalities in the lower initial concentration quartiles.

The estimates reported in Tables 8 and 9 –based, respectively, on equations (12) and (13)–, confirm the observed correlation between initial land concentration levels in a municipality and the higher prevalence of government-allocated land to be resold and reconcentrated across time. A 1 percentage-point increase in the latifundia index measure is related to a 1.3% percent increase in the probability of an allocated land plot being repurchased the same year of its allocation, with this probability increasing in time. Analogously, higher

Figure 8: Land Sales and Area-Weighted Median Farm Size by Initial Land Concentration



Notes: Data from the National Superintendency of Notaries (SNR) records and from from Lorente et al. (1985).

Table 8: Initial Concentration and Land Sales Across Time

	Land plot sold after allocation:				
	Same year	1 year later	2 years later	5 years later	10 years later
	(1)	(2)	(3)	(4)	(5)
Initial Land Concentration	0.013***	0.025*	0.024	0.030	0.041
	(0.005)	(0.014)	(0.016)	(0.024)	(0.031)
Observations	37,479	37,479	37,479	37,479	37,479
R^2	.0149	.0256	.0332	.0534	.0792

Notes: Data from the National Superintendency of Notaries (SNR) records and from from Lorente et al. (1985). Columns 1-5 show estimates of the regression described in (12) at varying intervals Δt. Estimation sample only includes allocations made between 1984 and 1993. Regressions include departamento-by-year fixed effects. Clustered standard errors at the municipality level in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

prevalence of latifundia in a municipality is correlated with the reconcentration of allocated land. Allocation cohorts in municipalities with initially higher latifundia levels tend to have faster growth in their area-weighted median farm size, with this measure of reconcentration increasing monotonically in time.

These results mirror the findings in Faguet et al. (2020), who show that land allocations did not reduce land inequality in rural economies where latifundia was initially prevalent. While the authors' explanation for this phenomenon relies in the motivation rural elites have to reconcentrate allocated land in order to retain political power, I have focused throughout this paper –following the ideas in Conning (2003)– on the possibility of an alternative explanation: imperfect competition in land and labor input markets can lead to persistently high (and inefficient) levels of land inequality. Either of these possibilities dispenses with traditionally assumed explanations for the persistence of land concentration that rely on the non-economic, cultural significance assigned to land by large landholders, or outright economic irrationality. Adjudicating between the different mechanisms that might drive the persistence of land concentration is an important question for future research.

Table 9: Initial Concentration and Change in Allocation Cohort's Concentration Level

	Change in area-weighted median farm size (%)				
	Same year	1 year later	2 years later	5 years later	10 years later
	(1)	(2)	(3)	(4)	(5)
Initial Land Concentration	0.056	0.067	0.063	0.076*	0.092**
	(0.041)	(0.047)	(0.047)	(0.044)	(0.047)
Observations	3,129	3,129	3,129	3,129	3,129
R^2	.0665	.0839	.0795	.0745	.0821

Notes: Data from the National Superintendency of Notaries (SNR) records and from from Lorente et al. (1985). Columns 1-5 show estimates of the regression described in (13) at varying intervals Δt. Estimation sample only includes allocations made between 1984 and 1993. Regressions include departamento-by-year fixed effects. Clustered standard errors at the municipality level in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

7 Conclusion

This paper estimates the effect that restrictions on land markets –imposed with the aim of reducing land inequality– have on agricultural productivity, agricultural labor outcomes, and land concentration levels. I find that market restrictions permanently reduce productivity and have very reduced impacts on land inequality. These restrictions, however, also raise the earnings of agricultural workers even while they also lead to increases in the fraction of workers in the economy employed in the agricultural sector. I offer an explanation for these results that relies on the potential existence of market power being exerted by large landholders in both land and labor markets.

Theoretically, if land concentration levels in a rural economy are sufficiently high, unrestricted land markets might lead to an equilibrium where the existence of suboptimally large landholdings and where depressed agricultural wages persist in time. The findings reported on this paper suggest, however, that the imposition of restrictions on sales are too blunt of a tool that has enduring negative impacts on productivity, ultimately hindering the development of the agricultural sector and of the broader rural economy.

This paper illustrates how, in highly heterogeneous settings, policymakers deciding on rural land regulations are likely to face a trade-off between distinct sources of misallocation. Additional political constraints –i.e. the infeasibility of directly breaking up inefficiently large latifundia– might place policy makers in a situation where only second-best alternatives are possible. Future research should focus on designing and estimating the impact of innovative regulatory policies (e.g. Posner and Weyl (2017)) that are flexible in allowing markets to play a role aggregating information and allocating resources but that are as well capable of addressing potential concerns regarding the effects of imperfect competition.

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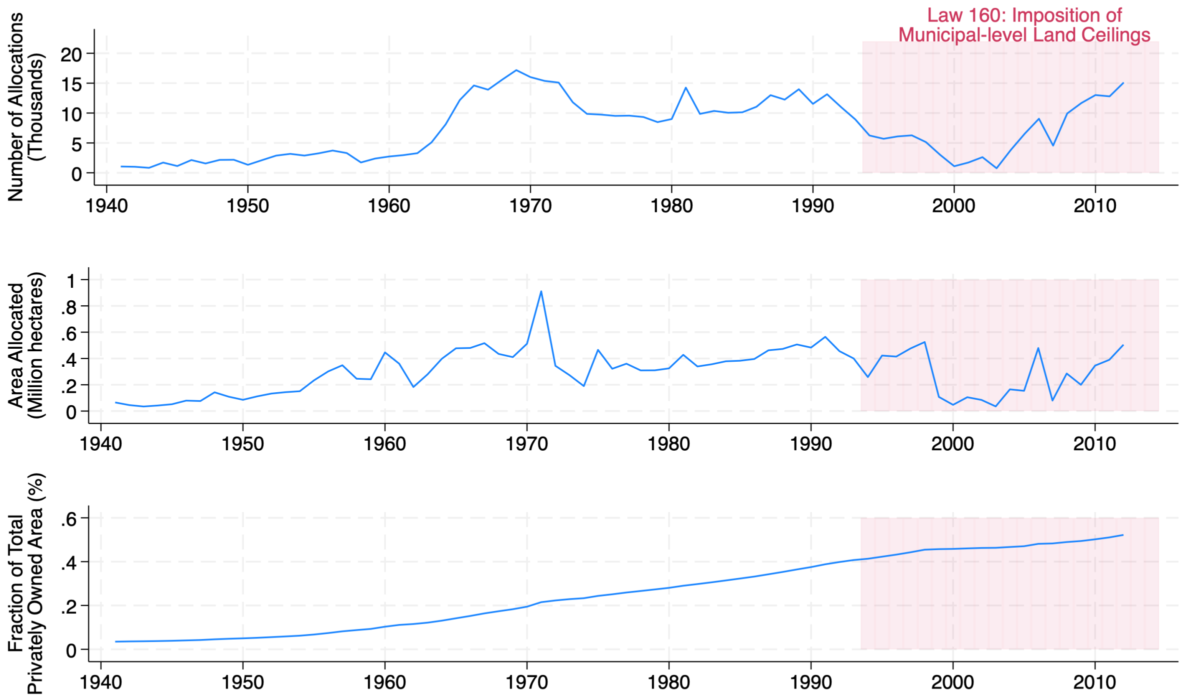
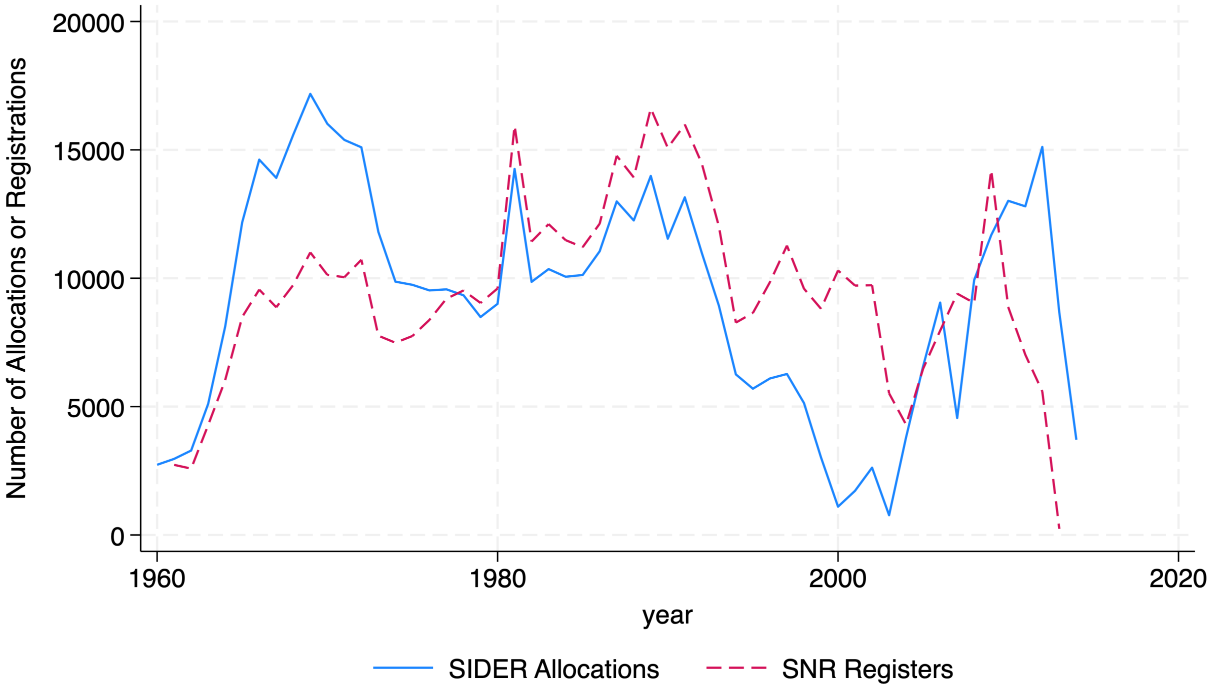
Appendix A Additional Tables and Figures

Figure A1: Number of Land Allocations and Total Area Allocated Across Time



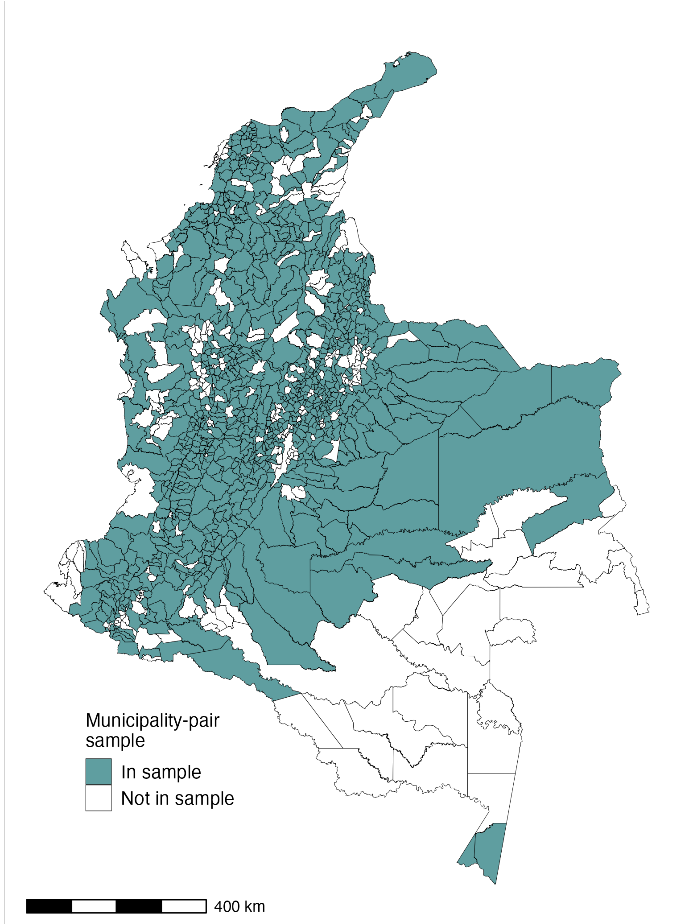
Notes: Data from the System of Information for Rural Development (SIDER)

Figure A2: Number of land plots allocated and number of land plots formally registered in a public notary office (1960–2010).



Notes: Data from the System of Information for Rural Development (SIDER) and from the National Superintendency of Notaries

Figure A3: Contiguous Municipality-Pair Sample



Notes. Ceiling height data from *INCORA* resolution 041 of 1996. Shaded municipalities have at least one neighboring municipality classified into a different 'homogeneous zone' and with a different ceiling height.

Table A1: Land Market Restrictions and Land Sales as Fraction of Cumulative Land Allocations

	Transaction Type			
	Total Sales (1)	Full Property Transfer (2)	Fragmenting Sales (3)	Consolidating Sales (4)
$\hat{\beta}$: Restriction Level × Area restricted × T	0.0075**	0.0054**	0.0028	-0.0007
	(0.0032)	(0.0025)	(0.0017)	(0.0005)
Observations	64,792	64,792	64,792	64,792
R^2	.685	.684	.658	.617
Mean Dep. Var.	.041	.03	.01	.001

Notes: Data from the National Superintendency of Notaries (SNR) records. Column 1 shows the effect on the aggregate number of transactions, column 2 shows the effect on full sales, column 3 shows the effect on partial sales (when only a fraction of the plot is transferred), and column 4 shows consolidation transfers. All sales variables computed as the fraction of yearly sales in proportion to the number of cumulative government allocations at the time. All outcomes are in $\log(x + 1)$ transformation. All regressions include municipality and municipality-pair-by-year fixed effects. All regressions weighted by the inverse number of pairs to which each municipality belongs to. Two-way clustered standard errors at the *departamento*, and at the *departamento*-pair level in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

Table A2: Market Restrictions and Land Sales - Varying Sets of Fixed Effects

	Number of Land Sales as Share of Allocations								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Total Sales									
$\hat{\beta}$: Restriction Level × Area restricted × T	0.164			0.137			0.188***		
	(0.109)			(0.108)			(0.051)		
$\hat{\alpha}_1$: Restriction Level × T	-0.099*	-0.048		-0.045	-0.010		-0.068**	-0.000	
	(0.049)	(0.033)		(0.074)	(0.056)		(0.030)	(0.021)	
$\hat{\alpha}_2$: Area restricted × T	0.157		-0.411***	0.142		-0.364***	0.425*		-0.272***
	(0.418)		(0.109)	(0.411)		(0.104)	(0.218)		(0.086)
R^2	0.864	0.862	0.863	0.880	0.879	0.879	0.956	0.956	0.956
Observations	24,029	24,029	24,029	23,994	23,994	23,994	64,818	64,818	64,818
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X						
Departamento × Year FE				X	X	X			
Municipality-pair × Year FE							X	X	X
Panel B: Full Property Sales									
$\hat{\beta}$: Restriction Level × Area restricted × T	0.277***			0.210**			0.161***		
	(0.088)			(0.080)			(0.053)		
$\hat{\alpha}_1$: Restriction Level × T	-0.121**	-0.050		-0.038	0.011		-0.043	0.017	
	(0.048)	(0.038)		(0.071)	(0.058)		(0.033)	(0.024)	
$\hat{\alpha}_2$: Area restricted × T	0.444*		-0.250***	0.337		-0.204***	0.360		-0.241**
	(0.240)		(0.061)	(0.208)		(0.060)	(0.217)		(0.091)
R^2	0.854	0.853	0.854	0.872	0.872	0.872	0.945	0.945	0.945
Observations	19,828	19,828	19,828	19,799	19,799	19,799	83,872	83,872	83,872
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X						
Departamento × Year FE				X	X	X			
Municipality-pair × Year FE							X	X	X
Panel C: Fragmenting Sales									
$\hat{\beta}$: Restriction Level × Area restricted × T	0.207			0.250***			0.169***		
	(0.126)			(0.083)			(0.061)		
$\hat{\alpha}_1$: Restriction Level × T	-0.064**	-0.003		-0.077*	-0.018		-0.016	0.053	
	(0.026)	(0.041)		(0.044)	(0.045)		(0.035)	(0.037)	
$\hat{\alpha}_2$: Area restricted × T	0.178		-0.573***	0.455		-0.469***	0.192		-0.446***
	(0.494)		(0.138)	(0.331)		(0.108)	(0.236)		(0.111)
R^2	0.719	0.716	0.719	0.755	0.754	0.755	0.889	0.888	0.889
Observations	19,828	19,828	19,828	19,799	19,799	19,799	83,872	83,872	83,872
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X						
Departamento × Year FE				X	X	X			
Municipality-pair × Year FE							X	X	X
Panel D: Consolidating Sales									
$\hat{\beta}$: Restriction Level × Area restricted × T	-0.151			-0.183***			-0.250***		
	(0.098)			(0.059)			(0.090)		
$\hat{\alpha}_1$: Restriction Level × T	-0.060*	-0.113*		-0.048	-0.101**		-0.009	-0.100*	
	(0.034)	(0.059)		(0.042)	(0.038)		(0.048)	(0.049)	
$\hat{\alpha}_2$: Area restricted × T	-0.254		0.331***	-0.423**		0.262***	-0.610*		0.338***
	(0.346)		(0.104)	(0.201)		(0.077)	(0.320)		(0.081)
R^2	0.510	0.506	0.506	0.593	0.589	0.591	0.780	0.778	0.779
Observations	19,828	19,828	19,828	19,799	19,799	19,799	83,872	83,872	83,872
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X						
Departamento × Year FE				X	X	X			
Municipality-pair × Year FE							X	X	X

Notes: OLS estimates of equation (9) for land transaction outcomes. Regressions in columns 1-6 show clustered standard errors at the *departamento* level in parentheses. Regressions in columns 7-9 show two-way clustered standard errors at the *departamento* and at the *departamento*-pair level in parentheses. Regressions in columns 7-9 are weighted by the inverse number of pairs to which each municipality belongs to. *** p<0.01, ** p<0.05, * p<0.10.

Table A3: Market Restrictions and Land Concentration - Varying Sets of Fixed Effects

	Average Farm Size								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Average Farm Size									
$\hat{\beta}$: Restriction Level × Area restricted × T	-0.062			-0.082			-0.040		
	(0.087)			(0.068)			(0.084)		
$\hat{\alpha}_1$: Restriction Level × T	0.102**	0.096***		0.049	0.033		0.054	0.043	
	(0.039)	(0.028)		(0.034)	(0.029)		(0.047)	(0.031)	
$\hat{\alpha}_2$: Area restricted × T	-0.323		-0.188**	-0.268		0.015	-0.151		-0.019
	(0.293)		(0.091)	(0.224)		(0.070)	(0.270)		(0.073)
R^2	0.975	0.975	0.975	0.981	0.981	0.981	0.990	0.990	0.990
Observations	12,217	12,217	12,217	12,215	12,215	12,215	37,186	37,186	37,186
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X						
Departamento × Year FE				X	X	X			
Municipality-pair × Year FE							X	X	X
Panel B: Land Ownership Gini Index									
$\hat{\beta}$: Restriction Level × Area restricted × T	-0.407***			-0.235***			-0.074*		
	(0.119)			(0.070)			(0.039)		
$\hat{\alpha}_1$: Restriction Level × T	0.275***	0.215***		0.166***	0.135***		0.096***	0.078***	
	(0.063)	(0.058)		(0.036)	(0.042)		(0.027)	(0.023)	
$\hat{\alpha}_2$: Area restricted × T	-1.853***		-0.587***	-1.124***		-0.328***	-0.331*		-0.090
	(0.498)		(0.207)	(0.324)		(0.115)	(0.175)		(0.053)
Observations	12,166	12,166	12,166	12,164	12,164	12,164	31,774	31,774	31,774
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X						
Departamento × Year FE				X	X	X			
Municipality-pair × Year FE							X	X	X

Notes: OLS estimates of equation (9) for farm size outcomes. Regressions in columns 1-6 show clustered standard errors at the *departamento* level in parentheses. Regressions in columns 7-9 show two-way clustered standard errors at the *departamento* and at the *departamento*-pair level in parentheses. Regressions in columns 7-9 are weighted by the inverse number of pairs to which each municipality belongs to. *** p<0.01, ** p<0.05, * p<0.10.

Table A4: Market Restrictions and Productivity - Varying Sets of Fixed Effects

	Agricultural Revenue per Hectare								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Revenue per Hectare									
$\hat{\beta}$: Restriction Level × Area restricted × T	-0.608***			-0.451***			-0.235**		
	(0.131)			(0.131)			(0.080)		
$\hat{\alpha_1}$: Restriction Level × T	0.177***	0.089		0.112***	0.055		0.021	-0.034	
	(0.043)	(0.058)		(0.037)	(0.048)		(0.046)	(0.050)	
$\hat{\alpha_2}$: Area restricted × T	-2.358***		-0.336	-1.705***		-0.147	-0.901**		-0.080
	(0.405)		(0.224)	(0.475)		(0.238)	(0.382)		(0.184)
R^2	0.729	0.726	0.725	0.769	0.768	0.768	0.911	0.911	0.911
Observations	8,281	8,281	8,281	8,281	8,281	8,281	41,510	41,510	41,510
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X						
Departamento × Year FE				X	X	X			
Municipality-pair × Year FE							X	X	X
Panel B: Corn Yield per Hectare									
$\hat{\beta}$: log Restriction Level × Area restricted × T	-0.208**			-0.138			-0.160**		
	(0.089)			(0.098)			(0.062)		
$\hat{\alpha_1}$: log Restriction Level × T	-0.006	-0.039		0.113*	0.094		0.067	0.033	
	(0.054)	(0.048)		(0.056)	(0.054)		(0.048)	(0.047)	
$\hat{\alpha_2}$: Area restricted × T	-0.800**		-0.070	-0.478		-0.032	-0.607**		-0.064
	(0.308)		(0.129)	(0.339)		(0.088)	(0.214)		(0.060)
R^2	0.714	0.713	0.713	0.775	0.775	0.773	0.911	0.911	0.911
Observations	6,396	6,396	6,396	6,396	6,396	6,396	27,772	27,772	27,772
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X						
Departamento × Year FE				X	X	X			
Municipality-pair × Year FE							X	X	X
Panel C: Coffee Yield per Hectare									
$\hat{\beta}$: log Restriction Level × Area restricted × T	-0.108			-0.081			0.233***		
	(0.076)			(0.065)			(0.031)		
$\hat{\alpha_1}$: log Restriction Level × T	-0.006	-0.022		0.084	0.048		-0.096**	-0.039	
	(0.044)	(0.037)		(0.050)	(0.041)		(0.036)	(0.034)	
$\hat{\alpha_2}$: Area restricted × T	-0.248		0.079	-0.061		0.187***	0.881***		0.136
	(0.228)		(0.094)	(0.169)		(0.055)	(0.114)		(0.096)
R^2	0.465	0.464	0.464	0.543	0.542	0.543	0.796	0.795	0.795
Observations	2,715	2,715	2,715	2,715	2,715	2,715	11,278	11,278	11,278
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X						
Departamento × Year FE				X	X	X			
Municipality-pair × Year FE							X	X	X
Panel D: Plantain Yield per Hectare									
$\hat{\beta}$: log Restriction Level × Area restricted × T	-0.104			0.004			0.202***		
	(0.155)			(0.123)			(0.064)		
$\hat{\alpha_1}$: log Restriction Level × T	0.117*	0.089*		-0.032	-0.032		-0.032	0.047	
	(0.065)	(0.044)		(0.060)	(0.058)		(0.044)	(0.048)	
$\hat{\alpha_2}$: Area restricted × T	-0.394		-0.036	0.044		0.035	0.727***		0.009
	(0.599)		(0.182)	(0.477)		(0.081)	(0.215)		(0.108)
R^2	0.516	0.516	0.514	0.689	0.689	0.689	0.857	0.857	0.856
Observations	4,049	4,049	4,049	4,048	4,048	4,048	16,410	16,410	16,410
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X						
Departamento × Year FE				X	X	X			
Municipality-pair × Year FE							X	X	X
Panel E: Rice Yield per Hectare									
$\hat{\beta}$: log Restriction Level × Area restricted × T	-0.036			-0.013			0.158		
	(0.171)			(0.097)			(0.165)		
$\hat{\alpha_1}$: log Restriction Level × T	-0.081	-0.091		0.000	-0.005		-0.132	-0.048	
	(0.108)	(0.060)		(0.039)	(0.008)		(0.105)	(0.035)	
$\hat{\alpha_2}$: Area restricted × T	-0.331		-0.172	-0.106		-0.053	0.626		0.001
	(0.696)		(0.216)	(0.434)		(0.166)	(0.671)		(0.135)
R^2	0.834	0.833	0.833	0.907	0.907	0.907	0.956	0.956	0.956
Observations	1,349	1,349	1,349	1,343	1,343	1,343	4,748	4,748	4,748
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X						
Departamento × Year FE				X	X	X			
Municipality-pair × Year FE							X	X	X

Notes: OLS estimates of equation (9) for land productivity outcomes. Regressions in columns 1-6 show clustered standard errors at the *departamento* level in parentheses. Regressions in columns 7-9 show two-way clustered standard errors at the *departamento* and at the *departamento*-pair level in parentheses. Regressions in columns 7-9 are weighted by the inverse number of pairs to which each municipality belongs to. *** $p<0.01$, ** $p<0.05$, * $p<0.10$.

Table A5: Market Restrictions and Agricultural Labor - Varying Sets of Fixed Effects

	Monthly Earnings for Agricultural Wage Workers								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Ag. Worker Earnings									
$\hat{\beta}$: log Restriction Level × Area restricted × T	0.232*			0.361**			0.554**		
	(0.120)			(0.132)			(0.243)		
$\hat{\alpha_1}$: log Restriction Level × T	-0.056	-0.007		-0.100	-0.092*		-0.271*	-0.069	
	(0.038)	(0.042)		(0.106)	(0.049)		(0.141)	(0.084)	
$\hat{\alpha_2}$: Area restricted × T	0.810**		0.014	1.245***		0.082	1.734**		-0.046
	(0.370)		(0.123)	(0.334)		(0.144)	(0.581)		(0.237)
R^2	0.105	0.106	0.106	0.127	0.125	0.127	0.135	0.135	0.135
Observations	14,022	13,083	13,083	13,083	14,022	13,083	102,123	102,123	102,123
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X						
Departamento × Year FE				X	X	X			
Municipality-pair × Year FE							X	X	X
Panel B: % Occupied in Ag.									
$\hat{\beta}$: log Restriction Level × Area restricted × T	0.016			0.190**			0.223*		
	(0.087)			(0.096)			(0.125)		
$\hat{\alpha_1}$: log Restriction Level × T	-0.019	-0.015		-0.061	-0.028		-0.080	-0.014	
	(0.035)	(0.027)		(0.050)	(0.042)		(0.062)	(0.046)	
$\hat{\alpha_2}$: Area restricted × T	0.029		-0.003	0.589**		0.102	0.842*		-0.007
	(0.230)		(0.063)	(0.255)		(0.081)	(0.464)		(0.152)
R^2	0.849	0.849	0.849	0.861	0.860	0.861	0.930	0.929	0.929
Observations	1,446	1,446	1,446	1,444	1,444	1,444	5,904	5,904	5,904
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X						
Departamento × Year FE				X	X	X			
Municipality-pair × Year FE							X	X	X
Panel C: % Pop. in Rural Area									
$\hat{\beta}$: log Restriction Level × Area restricted × T	0.037			0.067			0.019		
	(0.039)			(0.042)			(0.045)		
$\hat{\alpha_1}$: log Restriction Level × T	0.010	0.017**		-0.029**	-0.018		-0.018	-0.014	
	(0.009)	(0.007)		(0.013)	(0.012)		(0.017)	(0.014)	
$\hat{\alpha_2}$: Area restricted × T	0.134		-0.014	0.275*		0.033	0.116		0.044
	(0.136)		(0.035)	(0.154)		(0.036)	(0.162)		(0.040)
R^2	0.970	0.970	0.969	0.974	0.974	0.974	0.988	0.988	0.988
Observations	1,446	1,446	1,446	1,444	1,444	1,444	5,904	5,904	5,904
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X						
Departamento × Year FE				X	X	X			
Municipality-pair × Year FE							X	X	X

Notes: OLS estimates of equation (9) for agricultural labor outcomes. Regressions in columns 1-6 show clustered standard errors at the *departamento* level in parentheses. Regressions in columns 7-9 show two-way clustered standard errors at the *departamento* and at the *departamento*-pair level in parentheses. Regressions in columns 7-9 are weighted by the inverse number of pairs to which each municipality belongs to. *** p<0.01, ** p<0.05, * p<0.10.

Table A6: Market Restrictions and Area Planted - Varying Sets of Fixed Effects

	Agricultural Revenue per Hectare								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Corn Hectares Planted									
$\hat{\beta}$: log Restriction Level × Area restricted × T	0.324**			0.277**			-0.060		
	(0.133)			(0.116)			(0.139)		
$\hat{\alpha_1}$: log Restriction Level × T	-0.063	-0.026		-0.097	-0.072		0.054	0.024	
	(0.044)	(0.049)		(0.067)	(0.065)		(0.101)	(0.086)	
$\hat{\alpha_2}$: Area restricted × T	1.506***		0.416*	1.238***		0.298	0.172		0.370*
	(0.323)		(0.220)	(0.344)		(0.230)	(0.434)		(0.197)
R^2	0.771	0.770	0.771	0.787	0.786	0.786	0.907	0.907	0.907
Observations	6,406	6,406	6,406	6,406	6,406	6,406	27,846	27,846	27,846
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X						
Departamento × Year FE				X	X	X			
Municipality-pair × Year FE							X	X	X
Panel B: Coffee Hectares Planted									
$\hat{\beta}$: log Restriction Level × Area restricted × T	-0.004			-0.053			0.087		
	(0.230)			(0.302)			(0.108)		
$\hat{\alpha_1}$: log Restriction Level × T	-0.000	-0.006		0.049	0.047		-0.092	-0.063	
	(0.070)	(0.030)		(0.221)	(0.160)		(0.082)	(0.052)	
$\hat{\alpha_2}$: Area restricted × T	-0.069		-0.057	-0.336		-0.169	0.264		0.008
	(0.829)		(0.112)	(1.116)		(0.205)	(0.323)		(0.079)
R^2	0.922	0.922	0.922	0.942	0.942	0.942	0.979	0.979	0.979
Observations	2,729	2,729	2,729	2,729	2,729	2,729	11,320	11,320	11,320
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X						
Departamento × Year FE				X	X	X			
Municipality-pair × Year FE							X	X	X
Panel C: Plantain Hectares Planted									
$\hat{\beta}$: log Restriction Level × Area restricted × T	-0.103			-0.139			-0.175*		
	(0.095)			(0.084)			(0.098)		
$\hat{\alpha_1}$: log Restriction Level × T	-0.111	-0.139**		0.074	0.040		-0.049	-0.124**	
	(0.064)	(0.061)		(0.056)	(0.053)		(0.085)	(0.054)	
$\hat{\alpha_2}$: Area restricted × T	-0.169		0.200	-0.452		0.036	-0.539		0.107
	(0.365)		(0.152)	(0.372)		(0.105)	(0.347)		(0.144)
R^2	0.812	0.812	0.811	0.850	0.850	0.850	0.939	0.939	0.939
Observations	4,062	4,062	4,062	4,061	4,061	4,061	16,522	16,522	16,522
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X						
Departamento × Year FE				X	X	X			
Municipality-pair × Year FE							X	X	X
Panel D: Rice Hectares Planted									
$\hat{\beta}$: log Restriction Level × Area restricted × T	0.104			0.068			-0.163		
	(0.178)			(0.164)			(0.229)		
$\hat{\alpha_1}$: log Restriction Level × T	-0.025	0.018		0.026	0.050		0.172	0.085	
	(0.114)	(0.057)		(0.099)	(0.044)		(0.187)	(0.077)	
$\hat{\alpha_2}$: Area restricted × T	0.219		-0.185	0.063		-0.206	-0.624		0.020
	(0.635)		(0.230)	(0.643)		(0.290)	(0.946)		(0.261)
R^2	0.853	0.853	0.853	0.880	0.880	0.880	0.944	0.944	0.944
Observations	1,355	1,355	1,355	1,349	1,349	1,349	4,768	4,768	4,768
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X						
Departamento × Year FE				X	X	X			
Municipality-pair × Year FE							X	X	X

Notes: OLS estimates of equation (9) for area planted by crop. Regressions in columns 1-6 show clustered standard errors at the *departamento* level in parentheses. Regressions in columns 7-9 show two-way clustered standard errors at the *departamento* and at the *departamento*-pair level in parentheses. Regressions in columns 7-9 are weighted by the inverse number of pairs to which each municipality belongs to. *** p<0.01, ** p<0.05, * p<0.10.

Table A7: Effects on Agricultural Labor - Hours Worked and Alternative Measures of Earnings

	Ag. Workers' Earnings				Hours Worked	
	Monetary Income Ages 15-65	Monetary Income All ages	Total Income Ages 15-65	Total Income All ages	Hours Worked Ages 15-65	Hours Worked All ages
	(1)	(2)	(3)	(4)	(5)	(6)
$\hat{\beta}$: log Restriction Level × Area restricted × T	0.554**	0.408*	0.562**	0.495**	0.042	0.048
	(0.243)	(0.214)	(0.237)	(0.223)	(0.052)	(0.063)
Observations	102,123	109,459	104,903	112,686	103,896	111,651
R^2	.135	.133	.114	.111	.0537	.0507
Mean Dep. Var.	802.595	779.383	890.727	868.412	889.296	866.983

Notes: Data from the National Population Census and the National Household Surveys carried out by the National Statistics Office (DANE). Outcomes in columns 1-4 in log thousand Colombian pesos. Outcomes in columns 5-6 in log weekly hours. All regressions include municipality and municipality-pair-by-year fixed effects. Column 1 replicates the baseline result for agricultural workers' income in Table 6. All regressions weighted by the inverse number of pairs to which each municipality belongs to. Two-way clustered standard errors at the *departamento*, and at the *departamento*-pair level in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

Appendix B Supplementary Appendix

B.1 Market power with no land ceiling: expressions for prices, elasticities, and input demands

Define for convenience the auxiliary term $\rho = 1-(1-\alpha)\gamma$. Without land ceilings firms on the competitive fringe maximize the profit function:

$$\pi_i(l_i, n_i; s_i) = s_i^{1-\gamma}\left(l_i^{\alpha} n_i^{1-\alpha}\right)^{\gamma} - wn_i - rl_i.$$

First order conditions yield input demands in terms of prices:

$$l_i = s_i\left[\gamma\left(\frac{\alpha}{r}\right)^{\rho}\left(\frac{1-\alpha}{w}\right)^{1-\rho}\right]^{\frac{1}{1-\gamma}}, \quad n_i = s_i\left[\gamma\left(\frac{\alpha}{r}\right)^{\alpha\gamma}\left(\frac{1-\alpha}{w}\right)^{1-\alpha\gamma}\right]^{\frac{1}{1-\gamma}},$$

which, combined with market clearing conditions,

$$L = \sum_{i\neq b} l_i + l_b\,; \quad N = \sum_{i\neq b} n_i + n_b,$$

yield the expressions for input demands:

$$l_i = (L-l_b)\times\frac{s_i}{\sum\limits_{j\neq b} s_j}\,; \quad n_i = (N-n_b)\times\frac{s_i}{\sum\limits_{j\neq b} s_j}, \ \ \forall i,$$

and thus the expressions for prices and elasticities in terms of parameters and landlords' choices shown in equation (2):

$$w = (1-\rho)\left[\frac{(L-l_b)^{\alpha\gamma}}{(N-n_b)^{\rho}}\right]\left(\sum_{j\neq b} s_j\right)^{1-\gamma}, \quad r = \alpha\gamma\left[\frac{(N-n_b)^{(1-\rho)}}{(L-l_b)^{1-\alpha\gamma}}\right]\left(\sum_{j\neq b} s_j\right)^{1-\gamma},$$

$$\varepsilon_{l_b w}^{-1} \equiv \frac{\partial ln(w)}{\partial ln(l_b)} = -\alpha\gamma\frac{l_b}{L-l_b} \leq 0, \quad \varepsilon_{l_b r}^{-1} \equiv \frac{\partial ln(r)}{\partial ln(l_b)} = (1-\alpha\gamma)\frac{l_b}{L-l_b} \geq 0\,. \qquad \text{(A.1)}$$

Regarding the landlord's optimal input demands, this agent maximizes the profit function in equation (3):

$$\pi_b(l_b, n_b; s_b) = s_b^{1-\gamma}\left(l_b^{\alpha} n_b^{1-\alpha}\right)^{\gamma} - r(l_b - \theta L) - wn_b.$$

The assumption that market power is only exerted when deciding how much land to demand implies that $y'_{l_B} = w$, i.e.,

$$s_b^{1-\gamma} l_b^{\alpha\gamma} n_b^{-\rho} = \left[\frac{(L-l_b)^{\alpha\gamma}}{(N-n_b)^{\rho}}\right] \left(\sum_{j\neq b} s_j\right)^{1-\gamma},$$

yields b's reaction function for labor demand in terms of land demanded:

$$\frac{N-n_b}{n_b} = \left(\frac{L-l_b}{l_b}\right)^{\frac{\gamma\alpha}{\rho}} \left(\frac{s_b}{\sum_{j\neq b} s_j}\right)^{\frac{\gamma-1}{\rho}} \tag{A.2}$$

$$\implies n_b = N\left[1+\left(\frac{l_b}{L-l_b}\right)^{\frac{\alpha\gamma}{\rho}} \left(\frac{s_b}{\sum\limits_{j\neq b} s_j}\right)^{\frac{1-\gamma}{\rho}}\right]^{-1}.$$

By contrast, when deciding on its optimal land demand, the landlord takes into account how her demand impacts input prices. Hence, the first order condition of the profit function with respect to land implies that:

$$\alpha\gamma \underbrace{s_b^{1-\gamma} n_b^{(1-\alpha)\gamma} l_b^{\alpha\gamma-1}}_{=y/l_b} = \frac{\partial r}{\partial l_b} l_b + r - \frac{\partial r}{\partial l_b}\theta L + \frac{\partial w}{\partial l_b} n_b$$

$$\implies \alpha\gamma\frac{y}{l_b} = r\left(1+\left(1-\frac{\theta L}{l_b}\right)\varepsilon_{l_b r}^{-1}\right) + \underbrace{w n_b}_{=(1-\alpha)\gamma y} \varepsilon_{l_b w}^{-1}$$

$$\implies \alpha\gamma\frac{y}{l_b} = \alpha\gamma\frac{(N-n_b)^{1-\rho}}{(L-l_b)^{1-\alpha\gamma}}\left(\sum_{j\neq b} s_j\right)^{1-\gamma}\left(1+\left(1-\frac{\theta L}{l_b}\right)\varepsilon_{l_b r}^{-1}\right) + (1-\alpha)\gamma\frac{y}{l_b}\varepsilon_{l_b w}^{-1}$$

$$\implies \gamma\left(s_b^{1-\gamma} n_b^{(1-\alpha)\gamma} l_b^{\alpha\gamma}\right)\left(\alpha-(1-\alpha)\varepsilon_{l_b w}^{-1}\right) = \alpha\gamma\frac{(N-n_b)^{1-\rho}}{(L-l_b)^{1-\alpha\gamma}}\left(\sum_{j\neq b} s_j\right)^{1-\gamma}\left(1+\left(1-\frac{\theta L}{l_b}\right)\varepsilon_{l_b r}^{-1}\right) l_b$$

$$\implies \left[\frac{L-l_b}{l_b}\right]^{1-\alpha\gamma}\left(\alpha-(1-\alpha)\varepsilon_{l_b w}^{-1}\right) = \alpha\left(\frac{s_b}{\sum\limits_{j\neq b} s_j}\right)^{\gamma-1}\left(1+\left(1-\frac{\theta L}{l_b}\right)\varepsilon_{l_b r}^{-1}\right)\left[\frac{N-n_b}{n_b}\right]^{(1-\alpha)\gamma}$$

Replacing $(N-n_b)/n_b$ in the last line with the expression in equation (A.2) yields:

$$\left[\frac{L-l_b}{l_b}\right]\left(1-\frac{1-\alpha}{\alpha}\varepsilon_{l_b w}^{-1}\right)^{\frac{\rho}{1-\gamma}} = \left(\frac{\sum\limits_{j\neq b} s_j}{s_b}\right)\left[1+\left(1-\frac{\theta L}{l_b}\right)\varepsilon_{l_b r}^{-1}\right]^{\frac{\rho}{1-\gamma}}, \tag{A.3}$$

which implicitly defines the landlord's demand for land in terms of parameters only.

Proof that $\boldsymbol{l_b^*|_{\theta=0} < l_b^{pc}}$:

Note that under perfect competition the landlord's optimal demand for land implies that:

$$\begin{aligned} l_b^{pc} &= L \times \frac{s_b}{\sum\limits_j s_j} \\ \implies \frac{L}{l_b^{pc}} &= \frac{s_b + \sum\limits_{j\neq b} s_j}{s_b} \\ \implies \frac{L-l_b^{pc}}{l_b^{pc}} &= \frac{\sum\limits_{j\neq b} s_j}{s_b}. \end{aligned}$$

while the expression for the landlord's demand for land under market power shown in equation (A.3) when $\theta = 0$ is:

$$\left.\frac{L-l_b}{l_b}\right|_{\theta=0} = \left(\frac{\sum\limits_{j\neq b} s_j}{s_b}\right)\left[\frac{\alpha(1+\varepsilon_{l_b r}^{-1})}{\alpha-(1-\alpha)\varepsilon_{l_b w}^{-1}}\right]^{\frac{\rho}{1-\gamma}},$$

Note that, based on the expressions for elasticities in equations (A.1):

$$\begin{aligned} \left[\frac{\alpha(1+\varepsilon_{l_b r}^{-1})}{\alpha-(1-\alpha)\varepsilon_{l_b w}^{-1}}\right] > 1 &\iff \alpha(1-\alpha\gamma)\frac{l_b}{L-l_b} > (1-\alpha)\alpha\gamma\frac{l_b}{L-l_b} \\ &\iff 1 > \gamma. \end{aligned}$$

Which is always the case since $\gamma \in (0,1)$. The expressions for land demand above and the fact that $\left[\frac{\alpha(1+\varepsilon_{l_b r}^{-1})}{\alpha-(1-\alpha)\varepsilon_{l_b w}^{-1}}\right] > 1$ imply that:

$$\left.\frac{L-l_b}{l_b}\right|_{\theta=0} > \frac{L-l_b^{pc}}{l_b^{pc}} \implies l_b|_{\theta=0} < l_b^{pc}$$

■

Proof that $\frac{\partial l_b^*}{\partial \theta} > 0$:

From equation (A.3), define,

$$\Psi \equiv \left[\frac{L-l_b}{l_b}\right]^{\frac{1-\gamma}{\rho}} \left(1 - \frac{1-\alpha}{\alpha}\varepsilon_{l_b w}^{-1}\right) - \left(\frac{\sum_{j\neq b} s_j}{s_b}\right)^{\frac{1-\gamma}{\rho}} \left[1 + \left(1 - \frac{\theta L}{l_b}\right)\varepsilon_{l_b r}^{-1}\right] = 0.$$

By the implicit function theorem $\frac{\partial l_b^*}{\partial \theta} = -\frac{\partial \Psi/\partial \theta}{\partial \Psi/\partial l_b}$. Note that,

$$\frac{\partial \Psi}{\partial \theta} = \underbrace{\left(\frac{\sum_{j\neq b} s_j}{s_b}\right)^{\frac{1-\gamma}{\rho}}}_{(+)} \times \underbrace{\frac{\varepsilon_{l_b r}^{-1} L}{l_b}}_{(+)} > 0,$$

and so $\frac{\partial l_b^*}{\partial \theta} > 0 \iff \frac{\partial \Psi}{\partial l_b} < 0$.

To evaluate $\frac{\partial \Psi}{\partial l_b}$ it is convenient to define the term $\tilde{L} \equiv \left[\frac{L-l_b}{l_b}\right]^{\frac{1-\gamma}{\rho}}$, and to note that:

$$\frac{\partial \tilde{L}}{\partial l_b} \leq 0; \quad \frac{\partial \varepsilon_{l_b r}^{-1}}{\partial l_b} \geq 0; \quad \frac{\partial \varepsilon_{l_b w}^{-1}}{\partial l_b} \leq 0.$$

This derivative is then,

$$\frac{\partial \Psi}{\partial l_b} = \underbrace{\frac{\partial \tilde{L}}{\partial l_b}}_{(-)} \underbrace{\left(1 - \frac{1-\alpha}{\alpha}\varepsilon_{l_b w}^{-1}\right)}_{(+)} + \tilde{L} \underbrace{\left(\frac{1-\alpha}{\alpha}\frac{\partial \varepsilon_{l_b w}^{-1}}{\partial l_b}\right)}_{(-)} - \underbrace{\left(\frac{\sum_{j\neq b} s_j}{s_b}\right)^{\frac{1-\gamma}{\rho}}}_{(+)} \left[\underbrace{\frac{\theta L}{l_b^2}\varepsilon_{l_b r}^{-1}}_{(+)} + \left(1 - \frac{\theta L}{l_b}\right) \underbrace{\frac{\partial \varepsilon_{l_b r}^{-1}}{\partial l_b}}_{(+)}\right],$$

and thus when $\theta L < l_b$, it is always the case that $\frac{\partial \Psi}{\partial l_b} < 0$.

When $\theta L > l_b$, note that:

$$\begin{aligned} \frac{\partial \Psi}{\partial l_b} \leq 0 &\iff \frac{\theta L}{l_b^2}\varepsilon_{l_b r}^{-1} > \left(1 - \frac{\theta L}{l_b}\right)\frac{\partial \varepsilon_{l_b r}^{-1}}{\partial l_b} = \left(1 - \frac{\theta L}{l_b}\right)\frac{L}{(L-l_b)l_b}\varepsilon_{l_b r}^{-1} \\ &\iff \theta > \frac{l_b - \theta L}{L - l_b}, \end{aligned}$$

which always holds since $l_b - \theta L < 0$, $L - l_b \geq 0$, and $\theta \in (0, 1)$. ■

B.2 Market power with land ceilings: expressions for prices, elasticities, and input demands

The Lagrangian associated to the maximization problem in (5) is:

$$\mathcal{L} = s_i^{1-\gamma}[(l_{Ui} + l_{Ri})^{\alpha} n_i^{1-\alpha}]^{\gamma} - r_U(l_{Ui} - l_{Ui}^0) - r_R(l_{Ri} - l_{Ri}^0) - w(n_i - n_i^0) \\ + \lambda(l_{Ri} - \bar{l}) + \mu_1 l_{Ui} + \mu_2 l_{Ri} + \mu_3 n_i,$$

with first-order conditions:

$$\frac{\partial \mathcal{L}}{\partial l_{Ui}} = \alpha\gamma s_i^{1-\gamma} n_i^{(1-\alpha)\gamma}(l_{Ui} + l_{Ri})^{(\alpha\gamma-1)} - r_U + \mu_1 = 0 \tag{A.4}$$

$$\frac{\partial \mathcal{L}}{\partial l_{Ri}} = \alpha\gamma s_i^{1-\gamma} n_i^{(1-\alpha)\gamma}(l_{Ui} + l_{Ri})^{(\alpha\gamma-1)} - r_R + \mu_2 = 0 \tag{A.5}$$

$$\frac{\partial \mathcal{L}}{\partial n_i} = (1-\alpha\gamma) s_i^{1-\gamma} n_i^{(1-\alpha)\gamma-1}(l_{Ui} + l_{Ri})^{(\alpha\gamma)} - w + \mu_3 = 0, \tag{A.6}$$

and complementary slackness conditions:

$$\lambda(l_{Ri} - \bar{l}) = 0; \quad \mu_1 l_{Ui} = 0; \quad \mu_2 l_{Ri} = 0; \quad \mu_3 n_i = 0.$$

Case *i):* $\lambda = 0$ (Unconstrained agent, $i \in \mathcal{S}$).

In this case $\mu_1 \neq 0$ and also, since the production function is strongly monotonically increasing, $\mu_2, \mu_3 = 0$. Then, from (A.5) and (A.6):

$$n_i^S = s_i \left(\gamma \left(\frac{\alpha}{r_R}\right)^{\alpha\gamma} \left(\frac{1-\alpha}{w}\right)^{1-\alpha\gamma}\right)^{\frac{1}{1-\gamma}}, l_{Ri}^S = s_i \left(\gamma \left(\frac{\alpha}{r_R}\right)^{\rho} \left(\frac{1-\alpha}{w}\right)^{1-\rho}\right)^{\frac{1}{1-\gamma}}$$

and $l_{Ui}^S = 0$.

Case *ii):* $\lambda > 0$ and $\mu_1 > 0$ (Mid-ability constrained agent, $i \in \mathcal{C}_1$).

In this case both $l_{Ri}^{C_1} = \bar{l}$ and $l_{Ui}^{C_1} = 0$. Hence, from equation (A.6) the demand for labor for this type of agent is:

$$n_i^{C_1} = s_i^{\frac{1-\gamma}{\rho}} \left(\frac{(1-\rho)\bar{l}^{\alpha\gamma}}{w}\right)^{\frac{1}{\rho}}$$

Case *iii):* $\lambda > 0$ and $\mu_1 = 0$ (High-ability constrained agent, $i \in \mathcal{C}_2$).

In this case $l_{Ri}^{C_1} = \bar{l}$, and from (A.4) and (A.6):

$$n_i^{C_2} = s_i \left(\gamma \left(\frac{\alpha}{r_U} \right)^{\alpha\gamma} \left(\frac{1-\alpha}{w} \right)^{1-\alpha\gamma} \right)^{\frac{1}{1-\gamma}}, \quad l_{Ui}^{C_2} = s_i \left(\gamma \left(\frac{\alpha}{r_U} \right)^{\rho} \left(\frac{1-\alpha}{w} \right)^{1-\rho} \right)^{\frac{1}{1-\gamma}} - \bar{l}.$$

Now define for conveniency the following auxiliary terms:

$$\begin{aligned}
&\mathcal{I}_{C_1} \equiv \sum_{i \in C_1} \bar{l}; \quad \mathcal{I}_{C_2} \equiv \sum_{i \in C_2} \bar{l}; \quad \Sigma_{C_1} \equiv \sum_{i \in C_1} s_i; \quad \Sigma_{C_2} \equiv \sum_{i \in C_2} s_i; \quad \Sigma_S \equiv \sum_{i \in S} s_i \\
&\mathcal{L}_R \equiv \psi(1-\theta)L - \mathcal{I}_{C_1} - \mathcal{I}_{C_2} - \bar{l}; \quad \mathcal{L}_U \equiv (1 - \psi + \psi\theta)L - l_{Ub} + \mathcal{I}_{C_2}
\end{aligned}$$

Combining the individual input demand functions shown above with the market clearing conditions yields the following expressions:

$$\begin{aligned}
L_R = \psi(1-\theta)L &= \sum_{i \in S} l_{Ri}^S + \sum_{i \in C_1} l_{Ri}^{C_1} + \sum_{i \in C_2} l_{Ri}^{C_2} + l_{Rb} = \sum_{i \in S} l_{Ri}^S + \underbrace{\sum_{i \in C_1} \bar{l}}_{=\mathcal{I}_{C_1}} + \underbrace{\sum_{i \in C_2} \bar{l}}_{=\mathcal{I}_{C_2}} \\
\implies \mathcal{L}_R &= \sum_{i \in S} s_i \left(\gamma \left(\frac{\alpha}{r_R} \right)^{\rho} \left(\frac{1-\alpha}{w} \right)^{1-\rho} \right)^{\frac{1}{1-\gamma}},
\end{aligned} \tag{A.7}$$

$$\begin{aligned}
L_U = (1 - \psi + \psi\theta)L &= \sum_{i \in S} l_{Ui}^S + \sum_{i \in C_1} l_{Ui}^{C_1} + \sum_{i \in C_2} l_{Ui}^{C_2} + l_{Ub} \\
\implies \mathcal{L}_U &= \sum_{i \in C_2} s_i \left(\gamma \left(\frac{\alpha}{r_U} \right)^{\rho} \left(\frac{1-\alpha}{w} \right)^{1-\rho} \right)^{\frac{1}{1-\gamma}},
\end{aligned} \tag{A.8}$$

$$\begin{aligned}
N &= \sum_{i \in S} n_i^S + \sum_{i \in C_1} n_i^{C_1} + \sum_{i \in C_2} n_i^{C_2} + n_b \\
&= \left(\gamma \alpha^{\alpha\gamma} \left(\frac{1-\alpha}{w} \right)^{1-\alpha\gamma} \right)^{\frac{1}{1-\gamma}} \left(\frac{\sum_{i \in S} s_i}{r_R^{\frac{\alpha\gamma}{1-\gamma}}} + \frac{\sum_{i \in C_2} s_i}{r_U^{\frac{\alpha\gamma}{1-\gamma}}} \right) + \sum_{i \in C_1} s_i^{\frac{1-\gamma}{\rho}} \left(\frac{(1-\rho)\bar{l}^{\alpha\gamma}}{w} \right)^{\frac{1}{\rho}} + n_b.
\end{aligned} \tag{A.9}$$

Define the additional auxiliary term:

$$\Phi \equiv \left(\mathcal{L}_R^{\alpha\gamma} \Sigma_S^{1-\gamma} \right)^{\frac{1}{\rho}} + \bar{l}^{\frac{\alpha\gamma}{\rho}} \sum_{i \in C_1} s_i^{\frac{1-\gamma}{\rho}} + \left(\mathcal{L}_U^{\alpha\gamma} \Sigma_{C_2}^{1-\gamma} \right)^{\frac{1}{\rho}}, \tag{A.10}$$

combining equations (A.7), (A.8), and (A.9) yields an expression for the wage in terms of parameters and landlords' choices only:

$$w = \frac{(1-\alpha)\gamma}{(N-n_b)^\rho} \left[\left(\underbrace{\psi(1-\theta)L - \mathcal{I}_{C_1} - \mathcal{I}_{C_2} - \bar{l}}_{\equiv \mathcal{L}_R} \right)^{\frac{\alpha\gamma}{\rho}} \left(\underbrace{\sum_{i \in S} s_i}_{\equiv \Sigma_S} \right)^{\frac{1-\gamma}{\rho}} + \bar{l}^{\frac{\alpha\gamma}{\rho}} \sum_{i \in C_1} s_i^{\frac{1-\gamma}{\rho}} \right.$$

$$\left. + \left(\underbrace{(1-\psi+\psi\theta)L - l_{Ub} + \mathcal{I}_{C_2}}_{\equiv \mathcal{L}_U} \right)^{\frac{\gamma\alpha}{\rho}} \left(\underbrace{\sum_{i \in C_2} s_i}_{\equiv \Sigma_{C_2}} \right)^{\frac{1-\gamma}{\rho}} \right]^\rho = \frac{(1-\alpha)\gamma}{(N-n_b)^\rho} \Phi^\rho$$

and, analogously, for land prices:

$$r_U = \frac{\alpha\gamma(N-n_b)^{1-\rho}}{\Phi^{1-\rho}} \times \left(\frac{\Sigma_{C_2}}{\mathcal{L}_U} \right)^{\frac{1-\gamma}{\rho}}$$

$$r_R = \frac{\alpha\gamma(N-n_b)^{1-\rho}}{\Phi^{1-\rho}} \times \left(\frac{\Sigma_S}{\mathcal{L}_R} \right)^{\frac{1-\gamma}{\rho}} .$$

Finally, the corresponding inverse demand elasticities are then:

$$\varepsilon^{-1}_{l_b, r_U} \equiv \frac{\partial \ln r_U}{\partial \ln l_b} = \frac{(1-\rho)\alpha\gamma}{\rho} \times \frac{l_b}{\Phi} \left(\frac{\Sigma_{C_2}}{\mathcal{L}_U} \right)^{\frac{1-\gamma}{\rho}} + \frac{1-\gamma}{\rho} \left(\frac{l_b}{\mathcal{L}_U} \right)$$

$$\varepsilon^{-1}_{l_b, r_R} \equiv \frac{\partial \ln r_R}{\partial \ln l_b} = \frac{(1-\rho)\alpha\gamma}{\rho} \times \frac{l_b}{\Phi} \left(\frac{\Sigma_{C_2}}{\mathcal{L}_U} \right)^{\frac{1-\gamma}{\rho}}$$

$$\varepsilon^{-1}_{l_b, w} \equiv \frac{\partial \ln w}{\partial \ln l_b} = -\alpha\gamma \times l_b \left(\frac{\Sigma_{C_2}}{\mathcal{L}_U} \right)^{\frac{1-\gamma}{\rho}} .$$