Cooperative Property Rights and Development: Evidence from Land Reform in El Salvador*

Eduardo Montero†

12 January 2018
Most Recent Version Here

Abstract: In cooperative property rights systems, workers jointly own and manage production, whereas in outside ownership systems, an owner contracts laborers. Despite a rich theoretical literature on how the organization of property rights affects production, there is little causal evidence on the productivity implications of cooperative property rights. During a land reform in El Salvador in 1980, properties owned by individuals with cumulative landholdings over 500 hectares were reorganized into cooperatives to be managed by the former *hacienda* workers. Properties belonging to individuals with less than 500 hectares remained as privately-owned *haciendas*. Using the discontinuous probability of a property becoming a cooperative and regression discontinuity design, I present causal evidence on the effects of cooperative property rights relative to outside ownership on agricultural productivity and economic development. The reform cooperatives are (i) less likely to produce cash crops and more likely to produce staple crops; (ii) less productive when producing cash crops; but (iii) more productive when producing staple crops. Additionally, cooperative workers have more equitable worker income distributions and higher incomes relative to *hacienda* workers. The results are consistent with an incomplete contracting model that compares cooperatives and *haciendas*.

Keywords: Property rights, cooperatives, land reform, agricultural productivity, Latin America.

*I thank Richard Hornbeck, Nathan Nunn, James A. Robinson, and Andrei Shleifer for their guidance and support. I thank Emily Breza, Melissa Dell, Raissa Fabregas, James Feigenbaum, Siddharth George, Claudia Goldin, Oliver Hart, Sara Lowes, Michael Kremer, Edgar Marroquín Mena, Gautam Rao, Raul Sanchez de la Sierra, Nihar Shah, Edoardo Teso, Peter Tu, Jack Willis and participants at the Harvard Development Lunch and the Harvard Economic History Lunch for excellent comments and suggestions. I thank Sandra Diaz, Veronica Melgar, Jose Luis Orellana, Elias Preza, and Xenia Zuniga for their invaluable help. I thank Carlos Schmidt-Padilla and Maria Micaela Sviatschi for generously sharing data. I am grateful for the financial support from the Danielien Travel Research Grant, IQSS, and the Economic History Association.

†Harvard University, Department of Economics, 1805 Cambridge Street, Cambridge, MA, 02138. Email: `emontero@fas.harvard.edu`. Website: http://scholar.harvard.edu/emontero.

1. Introduction

Across the world and throughout history, we observe many types of ownership structures (Otsuka et al., 1992; Hansmann, 1996). Although economists tend to focus on single ownership, societies have often used cooperative ownership, where workers jointly own and manage production on a one-member one-vote basis. This is a particularly prevalent ownership arrangement in Latin America, where over half of Latin American countries attempted land reforms to create agricultural cooperatives (see Figure 1). However, cooperatives exist in other settings as well, such as U.S. law firm partnerships, timber production in the pacific northwest in the U.S., and the *kibbutz* system in Israel (Pencavel, ed, 2013).

A key benefit to giving workers ownership stakes and decision making rights, as is found in cooperative property rights systems, is that such arrangements may have beneficial incentive effects (Kandel and Lazear, 1992). Economic theory suggests that cooperative property rights may increase effort and efficiency under certain conditions (e.g. Sen, 1966; Bonin et al., 1993). However, profit sharing between workers may also lead to free riding problems within a firm, possibly negating the incentive effects from cooperative ownership (e.g. Holmstrom, 1982). Despite this rich theoretical literature on the possible implications of cooperative property rights for productivity, equity, and earnings, there is little causal evidence on these impacts.

The main empirical challenge when studying the impacts of cooperative property rights relative to outside ownership is that property rights arrangements are not randomly assigned. The choice of property right system may reflect the underlying characteristics, such as geography, capital requirements, or cultural practices. These characteristics may also affect outcomes such as productivity. This means that one cannot compare all cooperatives to non-cooperatives to identify the impacts of cooperative property rights. This empirical challenge has left a considerable gap in the research on the implications of cooperative ownership relative to outside ownership (Putterman, 1991; Bonin et al., 1993; Pencavel, ed, 2013).

This paper exploits unique features of a land reform program from El Salvador in 1980 to study the causal impacts of cooperative property rights on agricultural productivity, crop choices, and economic development. Prior to the land reform, almost all of El Salvador's agricultural production was organized in the form of *haciendas*, where the land owner contracts laborers. During the land reform, properties belonging to individuals with cumulative landholdings over 500 hectares (ha) were expropriated by the military; the military then redistributed the properties to the former workers on the properties in the form of cooperatives. However, properties belonging to individuals with cumulative land holdings under 500 hectares remained as privately-owned *haciendas*.

The El Salvador land reform had two important features that provide discontinuous variation in the probability of cooperative formation that I use to identify the causal impacts of cooperative property rights on economic outcomes. First, the cumulative ownership threshold of 500 ha creates a set of similar properties, some of which happen to be owned by someone with more than 500 ha in total holdings and were therefore expropriated, and some which were owned by someone with cumulative holdings just below the threshold and therefore were not expropriated. Importantly, since the ownership rule was defined by cumulative holdings and not by characteristics of each individual property, I am not comparing large properties to small properties, but rather properties of similar sizes. The second key feature of the land reform is that the military executed the reform swiftly and took multiple steps to ensure its secrecy prior to its implementation. This prevented large landholders from being able to selectively adjust their cumulative landholdings to avoid expropriation prior to the implementation of the reform.

I use the 500 ha threshold rule from El Salvador's land reform law and a regression discontinuity (RD) design to compare properties that were expropriated and converted to cooperatives to those that were not expropriated but were similar prior to the reform to estimate the economic impacts of cooperative property rights relative to the private ownership system (*haciendas*). In line with the RD identifying assumptions, I find no evidence that landholders selectively sorted around the threshold to avoid expropriation, and I show that properties near the cumulative landholding threshold of 500 ha are similar in terms of geographic characteristics. I test whether the government enforced the threshold rule using historical government records on the reform. I find most properties above the threshold were successfully reorganized as agricultural cooperatives.

To guide the empirical analysis, I present a model comparing cooperative property rights to *haciendas* that offers predictions on how property right structure impacts agricultural choices, agricultural productivities, and worker incomes. The model has two key features. First, employment contracts are incomplete, and individuals cannot perfectly observe and contract on effort. This means that both cooperatives and *haciendas* face a moral hazard problem in production. Under cooperative property rights, cooperatives make decisions on issues not specified in contracts through majority voting (as in Hart and Moore, 1998, and Kremer, 1997). In contrast, in *haciendas*, the owner makes decisions to maximize profits.

Second, I assume crops differ in their production opacity, i.e. in how easy it is for others to observe or verify output. Specifically, I assume that the production of staple crops – such as maize and beans – cannot be contracted on because these crops are produced individually and can be consumed directly by workers. However, the output from cash crops – such as sugar cane and coffee – can be contracted on. This is because cash crops differ from staple crops in two keys ways. First, the production of cash crops involves multiple workers because cash crops require capital investment and processing to be valuable. Second, cash crops cannot be directly consumed by an individual worker. These two features make cash crop production observable. The key implication is that cooperatives and *haciendas* can contract on cash crop production but not on staple crop production.

The model highlights that neither ownership structure necessarily reaches the most efficient outcome. However, the source of inefficiency varies by property rights regime. In *haciendas*, profit maximization by the owner leads to production inefficiencies: the owner will offer sharecropping contracts where the owner (i) provides less than optimal incentives (because higher worker incentives reduces the owner's profits) and (ii) devotes a large share of production to cash crops (because staple crop production will not benefit the owner because it can be consumed directly by workers if taxed). In contrast, in cooperatives, worker heterogeneity and the voting mechanism for decision making may lead to production inefficiency: when the median member has less than average ability, cooperatives will tend to (i) vote to redistribute cash crop earnings, undermining effort incentives and (ii) vote for a larger share of cash crop production than would be efficient.

This model offers a specific set of predictions under certain conditions (in particular, when the median member ability differs enough from the mean ability member) that I test in the data. First, relative to *haciendas*, cooperatives will be less productive at cash crops because members tend to vote to redistribute cash crop earnings. This reduces production incentives but increases equality of income within the cooperative. However, cooperatives will be more productive at staple crops, because cooperative members get to keep their staple crop earnings. Second, cooperatives devote less land to cash crops and more land to staple crops. Finally, relative to *hacienda* workers, cooperative workers are more likely to have more compressed incomes because they vote to redistribute cash crop earnings.

Using data from El Salvador's 2007 census of agriculture, I find that, relative to *haciendas*, cooperatives are more likely to specialize in staple crop production instead of cash crops. Specifically, cooperatives devote less land to cash crop production and are less productive at cash crops. However, cooperatives devote more land to produce staple crops and are more productive at these crops. I find no evidence that cooperatives are on aggregate less productive than haciendas, measured by revenues and profits per hectare. These results are consistent with the property rights model of agricultural cooperatives, in which cooperative voters choose to redistribute cash crop earnings and therefore reduce productivity in the production of cash crops. However, in the model and in focus group discussions with cooperative members, because workers can consume staple crops directly if their output is taxed, staple crops are not subject to this redistribution. As a result, cooperatives are more likely to focus on staple crop production and are more efficient than *haciendas* at producing staple crops.

I then examine the impacts of cooperative property rights on worker incomes and inequality at the worker level to understand the equity implications of cooperative property rights. I use household survey data to identify individuals working in the reform cooperatives and those working on *haciendas*. Consistent with the model, the income distributions for cooperative members are more equitable and have higher means compared to the income distributions of workers on *haciendas*. This suggests that while the cooperative property rights have important additional impacts on equity and worker incomes.

The paper contributes to several literatures. First, the paper contributes to the literature on the costs and benefits of cooperative ownership structures, often known as *labor-managed firms* (see Bonin et al., 1993; Pencavel, ed, 2013, for reviews).[1] Motivated by the existence of cooperatives in agriculture, these models similarly studied cooperative members' labor allocation between collective and private production (Sen, 1966; Domar, 1958; Bonin, 1977; Israelseni, 1980; Putterman, 1980, 1981). A common assumption in these models is that effort could be costlessly observed. Motivated by advances in the incomplete contract literature, subsequent models have examined labor effort choices where effort is unobservable and contracts are incomplete (Hart and

[1]The first analysis of cooperative production was provided by Ward (1958), who noted that cooperatives' objective functions differ from capitalist firms due to profit sharing.

Moore, 1996; Kremer, 1997).[2] However, most of these papers do not compare how cooperatives perform relative to other property right systems (Putterman, 1991). In this paper, I contribute to this literature by providing a model comparing cooperative ownership and outside ownership in a setting where effort is unobservable that highlights that neither ownership structure necessarily reaches the most efficient outcome.

Despite this large theoretical literature modeling the effects of different property right systems, few studies provide empirical evidence on the predictions of these models. An exception are Craig and Pencavel (1992) and Pencavel and Craig (1994), who compare worker cooperatives versus private firms in the plywood industry in the pacific northwest in the U.S. They focusing on how cooperatives relative to conventional firms in the plywood industry respond to shocks. They find that cooperatives are more likely to adjust pay rather than employment during shocks. Burdín and Dean (2009) study a panel of firms in Uruguay and provide evidence consistent with these adjustment mechanisms in cooperatives. Relatedly, Lang and Gordon (1995) study law firm partnerships and Gaynor and Gertler (1995) study medical group partnerships to examine the impacts of profit sharing on productivity. Finally, Burdín (2016) uses administrative data from Uruguay to compare labor-manged firms to outside-owned firms to compare differences in their compensation structures and quit rates, and finds that labor-managed firms have more equitable compensation structures but higher quit rates for high ability members.[3] However, these studies do not address the endogeneity of property rights, where omitted variables that may affect outcomes of interest also affect the choice of ownership structure.

In comparing the benefits and costs of cooperative property rights, this paper is most related to work by Abramitzky (2008) who examines the impacts of redistribution and outside options on the stability of the Israeli *kibbutz* system. Abramitzky models *kibbutzism* as risk-sharing groups that are subject to three incentive constraints: participation constraints, an adverse selection constraint, and an incentive compatibility constraint to limit shirking. He uses temporal variation in financial shocks to empirically demonstrate that exit rates are decreasing in *kibbutz* wealth - which increases the cost of exiting - and that members with higher outside options tend to be

[2] Additionally, Levin and Tadelis (2005) analyzed how profit sharing could affect the selection of workers in a firm, and find that cooperatives are likely to hire more productive workers. Other work has focused on cases where monitoring can be used to observe effort and study these monitoring choices in cooperatives (Putterman and Skillman, 1988; Bonin and Putterman, 1993; Ireland and Law, 1988).

[3] Additionally, there is an extensive literature on agricultural cooperatives in China, the transition from cooperatives to privately owned individual plots, and the debate on whether this transition increased productivity (see Putterman, 1987; Kung, 1993, 1994; Kung and Putternman, 1997).

more likely to exit. This paper builds on this work by comparing across property rights regimes, instead of focusing within cooperatives. Note that the main equity-efficiency trade-offs modeled in Abramitzky (2008) will still apply. Additionally, I am able to present causal estimates of the effects of cooperative property rights relative to outside ownership because of particular features of the El Salvador land reform.

Second, the paper is related to the literature that attempts to understand the lasting impacts of property right reforms. Besley and Burgess (2000) examine the case of land reforms in India and find that tenancy reforms are associated with subsequent reductions in rural poverty. Similarly, Banerjee et al. (2002) examine tenancy reform in West Bengal and find large impacts of tenancy reforms on agricultural productivity.[4] This paper contributes to this literature by examining the impact of the specific form of cooperative property rights that was frequently implemented during land reforms in Latin America. Figure 1 is a map of Latin America that illustrates which countries have implemented a land reform to create agricultural cooperatives. The majority of countries in Latin America underwent or attempted such land reforms.

This paper differs from other work on land reforms in that it focuses on the longer-run consequences of property right reforms instead of focusing on short-term impacts. Land reforms can often be disruptive, implemented in times of civil conflict, and may also impact views on the security of differing property right reforms. Thus, studying the longer-run consequences allows me to better isolate the differences due to property right changes.[5]

Finally, the paper is related to a growing literature on the sources of differences in agricultural productivity in developing countries. Evidence suggests that the gap between labor productivity in agriculture relative to non-agricultural production in developing countries is much larger than the gap in developed countries (Gollin et al., 2002; Restuccia et al., 2008; Adamopoulos and Restuccia, 2014). Additionally, developing countries allocate a much larger share of employment to agriculture than in developed countries (Restuccia, 2016). Recent work has begun to focus on how specific land institutions may account for some of this difference (Adamopoulos and

[4]These tenancy reforms increased bargaining power of workers; cooperative property rights can be thought of an maximal form of worker power.

[5]A large theoretical and empirical literature in development suggests that private and secure property rights are a pre-requisite for the process of economic growth (North, 1981; Besley, 1995; Hornbeck, 2010). The empirical literature has mostly focused on the *security* of property rights and how this affects economic development (Field, 2007; Goldstein and Udry, 2008; Galiani and Schargrodsky, 2010). (An exception to this is recent work by Burchardi et al. (2017), where the authors experimentally vary the amount of output kept by sharecroppers – their residual property rights – and study subsequent agricultural choices and investment.) In this paper, both cooperatives and *haciendas* today do not face differences in security; thus, differences in outcomes are likely due directly to differences in property right regimes.

Restuccia, 2014, 2015). This paper contributes to this literature by providing evidence on how specific property right structures that may be more common in developing countries can lead to agricultural productivity differences.

The paper is organized as follows. Section 2 provides background on the El Salvador land reform. Section 3 describes the institutional details of cooperatives in El Salvador and presents the theoretical framework. Section 4 describes the data, and Section 5 describes the empirical strategy, tests the main identifying assumptions, and demonstrates that the military successfully enforced the threshold. Section 6 analyzes differences in agricultural productivity and crop choices between the reform cooperatives and properties that were never expropriated. Section 7 examines the impacts of the land reform on worker wage distributions and canton-level economic outcomes. Section 8 concludes.

Figure 1: Land Reforms that Redistributed *haciendas* as Cooperatives

Notes: Constructed using de Janvry (1981) and Albertus (2015)

2. Background on the 1980 El Salvador Land Reform

The 1980 El Salvador land reform had several features that allow me to compare properties that were reorganized into cooperatives to those that were not reorganized into cooperatives. First, I explain the design and implementation of El Salvador's 1980 land reform law that defined a landholding threshold for expropriating properties and creating cooperatives. I then discuss the steps taken by the government to ensure that the land reform was unexpected for landholders and executed swiftly.

2.1. Decree 153

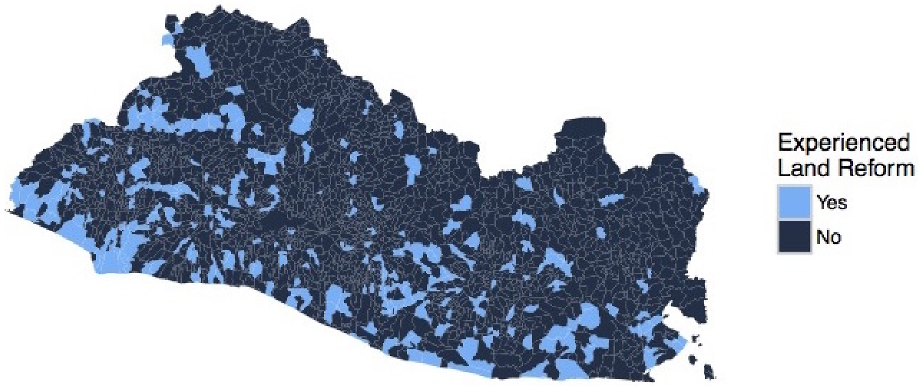
On March 5th, 1980, the military junta in power in El Salvador passed Decree 153 on land reform (Junta Revolucionaria de Gobierno, 1980). The reform specified a plan to reorganize large *haciendas* into agricultural cooperatives in two phases. Phase I called for the expropriation of all agricultural land owned by an individual with over 500 hectares in total landholdings. This land was to be distributed to the permanent laborers working on the land in the form of agricultural cooperatives. An undefined number of years after Phase I, Phase II of the land reform called for the expropriation of all agricultural land owned by an individual with over 100 hectares in total landholdings. However, Phase II was never carried out due to organized opposition following Phase I. The government officially called off Phase II in 1982 following a reorganization of the government leadership (Figueroa Aquino and Marroquín Mena, 1991).

Decree 153 outlined three official motivations for the land reform. First, the reform aimed to diminish land inequality and increase agricultural productivity. This goal was motivated by the military leadership's belief that large *hacienda* owners were absentee landholders and that they did not compensate workers enough. Second, the reform was intended to increase development and reduce poverty. Finally, the military government hoped that the land reform would reduce the power of the economic elite(Junta Revolucionaria de Gobierno, 1980).

Phase I was carried out immediately after the reform was announced and was enforced by the military. The morning after the publication of Decree 153, the Salvadoran Institute of Agrarian Transformation (ISTA) sent intervention teams of "agronomists, technicians, and military personnel to the country's largest farms to notify them" of expropriation (Marroquín Mena, 1988). Former owners were to be compensated by bonds paid out over 30 years. However, the value of these bonds was tied to the reported property values used in tax filings before the land reform, and thus, these bonds were extremely undervalued. Most of this debt was never paid off and was called off after the Civil War (González and Romano Martínez, 2000). Rather than providing individual title and possession to workers, ISTA organized former *hacienda* laborers into agricultural producer cooperatives where farmers would work the land in groups (Mennen, 2009). By the end of 1986, ISTA had expropriated 469 estates throughout the country (Marroquín Mena, 1988). Figure 2 shows cantons that experienced at least one expropriation.[6]

[6]Cantons are the smallest administrative unit in El Salvador, equivalent to approximately one village in rural areas. There are over 1,400 cantons in El Salvador.

Figure 2: Land Reform by Canton - El Salvador



Notes: Data are from MAG (1983). *Experienced Land Reform* is equal to *Yes* for a canton if at least one property was expropriated in that canton during Phase I of the 1980 land reform, and *No* otherwise.

Approximately 20% of all of El Salvador's farm land was expropriated during Phase I of the agrarian reform (Marroquín Mena, 1988). This expropriated land made up 14 percent of total coffee land, 31 percent of cotton land, and 24 percent of all sugarcane land in El Salvador (Seligson, 1994). Roughly 31,000 working families, or one-fifth of agricultural laborers, in El Salvador, benefited from the land reform (Mennen, 2009).

2.2. *Planning and Execution of the Land Reform*

Critically, the 1980 land reform program was unexpected for large landholders. According to accounts from the individuals responsible for its design and implementation, the land reform was "prepared under immense secrecy and executed at full velocity" in order to avoid strategic adjustments by the landholders (Velis Polío, 2012, pg. 117). The land reform was prompted by the unexpected addition to military junta leadership of a pro-land reform Colonel on March 3rd, 1980. Between March 4th and March 5th, the government took a number steps to keep the land reform secret. On March 4th, the military leadership called a fake "inter-agency coordination" seminar that gathered the critical personnel from ISTA and the Ministry of Agriculture to inform them of the junta's plans and provide them with national police escorts. The officials were given green key cards that meant that the military outside the hotel would bar them from leaving their hotels. On March 5th, after the "inter-agency coordination" seminar designed the reform and the government published Decree 153, the military transported the teams of agronomists, infantry, and technicians to the *haciendas* overnight (Velis Polío, 2012).

Additionally, the 500 ha threshold was chosen as a temporary threshold for implementation reasons (Velis Polío, 2012, pg. 110). Specifically, the government planners did not have enough agronomists and agricultural personnel to expropriate all landholdings over 100 ha and therefore settled on 500 ha as a temporary cut-off. As Velis Polío (2012) notes, the amount of personnel needed to execute Phase I was massive:

> The armed forces - on their own - temporarily deployed almost 10,000 members, among them officers, noncommissioned officers, and troops, all of this coordinated from the chiefs of staff, which additionally implied the utilization of transportation, fuel, food, military equipment, etc.; The same can be said of the Ministry of Agriculture and ISTA, which also made use of *all of their resources* [emphasis added] to provide the technical and social promotion personnel, vehicles, fuel and their weapons consisting of the paperwork to be used in the preparation of documents that would serve as a basis for the legalization of the takeover and possession of the affected properties (Velis Polío, 2012, pg. 112).

The secrecy of the planning and the swift execution of the reform made it unexpected to large landholders. As Velis Polío (2012, pg. 112) notes, the land expropriation on March 6th, 1980, caught *hacienda* owners by surprise: "The reform was an economic, political and social earthquake in the countryside... Landholders saw before their eyes something that they never imagined could possibly happen on the lands that they had always governed absolutely."

3. Theoretical Framework

To guide the empirical results, I present a model of cooperatives vs. outside ownership (*haciendas*) on agricultural choices, productivity, and worker incomes. Both cooperatives and *haciendas* are assumed to have identical production technologies and worker preferences. Thus, any differences in choices will be due to differences in economic organization.

The defining difference between cooperatives and *haciendas* in the model is how decisions get made. Under cooperative property rights, cooperatives make decisions on issues through majority voting on a one-member, one-vote basis, and each worker votes to maximize their own utility (as in Putterman, 1980, Hart and Moore, 1998, and Kremer, 1997). In contrast, in *haciendas*, the owner makes decisions to maximize profits.

The model has two main features. First, employment contracts are incomplete, meaning that individuals cannot perfectly observe and contract on worker effort. Thus, both cooperatives and *haciendas* face a moral hazard problem in production. Another important feature of the model is that I assume crops differ in their production opacity, i.e. in how easy it is for others to observe or verify output. I assume that individuals cannot contract on output levels for staple crops because these crops are produced individually and can be consumed directly by workers. Unlike staple crops, cash crops cannot be directly consumed by an individual worker because they require processing to be valuable. This feature of cash crops means that output per worker is observable. This assumption on how staple and cash crop production varies in opacity implies that cooperatives and *haciendas* can write contracts to remunerate workers based on their cash crop output but not on staple crop output.[7]

Three decisions occur in the model. First, the cooperative or *hacienda* decides how much land to allocate between cash crop production and staple crop production. In cooperatives, members vote on the share of land devoted to each crop. In *haciendas*, the owner sets the share of land devoted to each crop to maximize their profits. Second, the cooperative or the *hacienda* decides how to remunerate workers. For cash crop production in *haciendas*, the owner sets share contracts based on the total cash crop output of a worker because effort is unobservable. Thus, workers get to keep $(1 - \tau_h)$ of the cash crop output. Conversely, cooperatives vote over the share of each person's cash crop output, $(1 - \tau_c)$, that workers get to keep and the share of output, τ_c, that gets redistributed equally across members. Since I assume staple crop output cannot be observed, the *hacienda* owner will only be able to charge a fixed rent for staple crop production; likewise, cooperatives will not be able to redistribute staple crop output.[8] Finally, workers individually choose how much time and effort to allocate between work in cash crop production and their private staple crop production, taking the effort of all other workers as given. I summarize these features in Table 1.

Table 1: Ownership Type and Decision Making in Model

Ownership Type	Objective	Effort Choices	Remuneration & Crops
(1)	(2)	(3)	(4)
Cooperative: Worker-Owned Firm	Each member maximizes their utility	Determined by each worker individually	Set through majority voting (one vote per member basis)
Hacienda: Outside-Owner	Outside owner maximizes profits	Same as above	Set by the outside owner

Notes: *Crops* refers to share of land devoted to cash crops and staple crop, and *Remuneration* refers to (i) in the case of an *hacienda*: τ_h, the share of cash crop output kept by the *hacienda* owner, or (ii) in the case of a cooperative: τ_c, the share of cash crop output redistributed equally across members.

Table 2: Model Set-up Summary

	Hacienda	**Cooperative**
Players:	Owner (h) and Workers (i)	Workers (i)
	- Assumptions: Workers are heterogeneous, with ability shocks $A^i \sim [A^{min}, A^{max}]$ with $A^m < \bar{A}$	
Decisions:	**1)** Owner: Share of land allocated to cash crops (γ_h) **2)** Owner: Share of cash crop output kept by owner (τ_h) **3)** Owner: Rent for staple crop production (R^h) **4)** Workers: Effort between cash crops and staple crops (e^i)	**1)** Vote on share of land in to cash crops (γ_c) **2)** Vote on the share of cash crop output redistributed equally to all members (τ_c) **3)** Effort between cash crops and staple crops (e^i)
	- Assumptions: Cash crop output is observable, Staple crop output is not; Worker effort is unobservable; Workers are liquidity constrained; Cash crop production involves fixed capital costs	
Payoffs::	**Owner:** Share of cash crop output kept + staple crop rent; **Workers:** Share of cash crop output kept $(1 - \tau_h)$ + staple crop output - staple crop rent	**Workers:** Share of cash crop output kept $(1 - \tau_c)$ + share of cash crop output redistributed equally among members (τ_c) + staple crop output

3.1. Model Set-Up

Land and Crops: Consider an agricultural property with fixed land of size L with N workers.[9] The property can devote a share $\gamma \in [0,1]$ to cash crop production. This means that the cash crop production will use $\gamma L = L_c$. The land on the property not devoted to cash crops will be devoted to staple crop farming, $(1-\gamma)L = L_s$. To simplify, I assume that the land for cash crops and staple crops will be divided equally among the N workers for production, where each worker will devote $\frac{(1-\gamma)L}{N} = l_s$ to staple crops and $\frac{\gamma L}{N} = l_c$ to cash crops.

Because agricultural workers can choose to consume part of their own agricultural production when producing staple crops but not when producing cash crops, if a cooperatives or *hacienda* attempts to contract on staple crop output, workers will choose to consume part of their production before total output is tabulated.[10] To simplify, I assume staple crop output does not get shared in cooperatives.[11] For *haciendas*, owners will charge rent for the staple crop land with the knowledge that part of this output may be consumed.[12]

Workers: In both cooperatives and *haciendas*, workers individually choose to allocate effort between cash crop production, e_c, and staple crop production, e_s, taking the effort levels of all other worker as given.[13] Land and labor in cash crop production produces output of

---

[7]These assumptions on the technologies for production are common in the theoretical literature on cooperatives (see Putterman, 1986) and *haciendas* (see Sadoulet, 1992).

[8]This feature of how staple crops and cash crops are treated differently matches observations from focus group discussion with cooperatives in El Salvador. Cooperatives tend to redistribute cash crop output but do not do the same with staple crop output. Similarly, the way *haciendas* only charge rent for staple corp production but pay workers based on output for cash crop matches the set-up of *haciendas* (de Janvry, 1981).

[9]I assume the number of workers is fixed for cooperatives. This is a reasonable assumption for cooperatives as members do not generally leave the cooperative since (i) the cooperative land is often their largest asset and the cooperative requires a super-majority to sell, and (ii) cooperatives are slow in accepting new members as it dilutes the pool of voters.

[10]This feature of different crops, and difficulties in verifying output, and it's implications for sharecropping contracts has been previously modeled in the literature in work by De Janvry and Sadoulet (2007).

[11]This matches focus group evidence from cooperatives in El Salvador. Note that this does not mean that income does not get shared; this only means that staple crop output is not totaled and then shared centrally as a cooperative. However, cooperative members can still share income afterwards. For an example of a model with this latter feature, see Delpierre et al. (2016).

[12]This matches the historical structure of *haciendas* in Latin America, as *haciendas* often allowed their workers to have a small private plot for staple crop production for which the owner charged rent. See de Janvry (1981) for more details on this dualistic agrarian structure. Note that cooperatives will not charge rent in equilibrium – as the rent would be the same for all members and would then get redistributed equally. Thus, I abstract from cooperatives charging rent in the model.

[13]This is the Cournot-Nash assumption invoked by multiple papers on cooperative choices (see Putterman and Skillman, 1988; Ireland and Law, 1988; Bonin and Putterman, 1993).

value $G = \sum_i^N G(e_c^i, \gamma)$.[14] Staple crop production for each worker produces output of value $f^i = f(e_s^i, 1-\gamma)$. Workers choose effort subject to a time constraint, where $e_c^i + e_s^i \leq 1$.

The utility of a worker is assumed to be separable in income from cash crops and income from staple crops of the following form: $U^i = y_c + y_i$, where y_c equals the earnings from cash crop production and y_i equals the earnings from staple crop production f^i.[15] Additionally, each worker receives an unobserved shock to their productivity equal to A_i for their cash crop production, making their effective cash crop output equal to $G(e_c^i, \gamma) + A^i \gamma L$. This shock captures natural risks that are out of an individual's control that affect their productivity (such as health, liquidity, or plot-specific environmental shocks on their staple crop plot). The shock is larger the larger the amount of land devoted to cash crops, γ. This realized shock for a worker has support $\left[A^{min}, A^{max}\right]$, where the mean of A, $\bar{A}$, is equal to one. I assume that the median of A, A^m, is less than mean of A, $\bar{A}$. This assumption will be essential to the argument below because I assume that cooperatives make decisions through voting.

Finally, I assume that workers face limited liability constraints. Specifically, I assume that $U^i > \bar{u}$, where $\bar{u}$ denotes subsistence level of utility. This means that the *hacienda* owner or the cooperative members cannot write contracts with large penalties for low realizations of output. This assumption is important for the *hacienda* workers because it implies that they cannot directly purchase land from the *hacienda* owner. It also implies that the rent the owner charges for staple crop production is constrained by the lowest ability member.

Decision Making: In *haciendas*, choices regarding crop shares γ and remuneration are decided by the owner to maximize profits. In cooperatives, decisions are made through majority voting, as in Putterman (1980), Kremer (1997), and Hart and Moore (1998), on a one member, one vote basis.

Choices and Timing: The model for cooperatives and *haciendas* has the following general timing structure:

1. Each worker receives shocks to their ability, A^i.

[14] I assume that: $G(0,\gamma) = 0$, $G'(e,\gamma) > 0$, and $G''(e,\gamma) < 0$.

[15] The utility function of workers is simplified considerably. Alternatively, one could assume that the utility of workers includes leisure so that a worker has utility that is separable in income and leisure in the following form: $U^i = y_c + y_i + u_i(T - e_c - e_s)$, where y_c equal the earnings from the cash crop production, y_i equals the earnings from staple crop productions, and $u_i()$ measures a worker's valuation of leisure (similarly, the cost of effort) with $u' > 0$ and $u'' < 0$ and workers differ in their value of leisure as in Putterman (1980). However, the main predictions of the model hold with this alternative form of utility.

2. The cooperative or *hacienda* decides on the share of land to devote to cash crop production, γ_c or γ_h respectively. If γ is chosen to be greater than zero, the property pays a fixed capital cost k. I assume this capital cost is too large for an individual farmer to pay but that both the cooperative (when pooling capital) and *hacienda* can afford this cost.

3. The cooperative or *hacienda* then decides on a linear wage schedule as a function of output to remunerate cash crop production. In cooperatives, members vote on the share of cash crop output that will be redistributed equally to all members (τ_c). In *haciendas*, the owner decides on the share of cash crop output kept by owner (τ_h) and the rent charged for staple crop production (R^h).

4. Each worker chooses effort levels (e^i) and produces output.

3.2. *Objective Functions and Worker Effort in Cooperatives and Haciendas*

Cooperative: Given γ_c and τ_c, a cooperative member indexed by i chooses effort to maximize:

$$\max_{e_c^i} \underbrace{(1-\tau_c)(G(e_c^i,\gamma_c)+A_i\gamma_c L)}_{\substack{\text{Cash crop output that is not}\\ \text{redistributed by cooperative}}} + \underbrace{\tau_c(\sum_i^N \frac{(G(e_c^i,\gamma_c)+A_i\gamma_c L)}{N})}_{\substack{\text{Cash crop output that is}\\ \text{redistributed by cooperative}}} + \underbrace{f(e_s^i,1-\gamma_c)}_{\substack{\text{Staple crop}\\ \text{output}}} \tag{1}$$

$$\text{subject to: } \underset{e_c^j}{\text{argmax}} \quad (1-\tau_c)(G(e_c^j,\gamma_c)+A_j\gamma_c L) + \tau_c(\sum_i^N \frac{(G(e_c^i,\gamma_c)+A_i\gamma_c L)}{N}) + f(e_s^j,1-\gamma_c)\ \forall\, j \quad \textbf{(IC)}$$

$$(1-\tau_c)(G(e_c^i,\gamma_c)+A^i\gamma) + \tau_c(\sum_i^N \frac{(G(e_c^i,\gamma_c)+A_i\gamma_c L)}{N}) + f(1-e_c^i,1-\gamma) \geq \bar{u}\ \forall\, i \quad \textbf{(PC)}$$

where (1-τ_c) denotes the share of cash crop output kept by each worker and $\bar{u}$ denotes workers' outside option value. Each worker maximizes utility by solving for their optimal effort levels, e_c^i and $e_s^i = 1 - e_c^i$, taking other workers' choices as given. The first-order condition assuming N is large:

$$(1-\tau_c)G'(e_c,\gamma_c) = f'(1-e_c,1-\gamma_c).$$

This implies that workers under-supply effort to cash crops when $\tau_c > 0$ relative to the first-best effort level, which occurs when workers set $G'(e_c^i, \gamma) = f'(1 - e_c^i, 1 - \gamma)$.[16]

Hacienda: An *hacienda* owner solves:

$$\max_{\tau_h, \gamma_h, R^h} \sum_i^N [\underbrace{\tau_h (G(e_c^i, \gamma_h) + A^i \gamma_h)}_{\substack{\text{Cash crop output kept} \\ \text{by hacienda owner}}} + \underbrace{(1-\tau_h)(G(e_c^{min}, \gamma_h) + A^{min}\gamma_h) + f(e_s^{min}, \gamma_h) - \bar{U}}_{\substack{\text{Rent charged by hacienda owner} \\ \text{for staple crop output, } R^h}}] \quad (2)$$

$$\text{subject to: } \underset{e_c^i}{\text{argmax}} \quad (1 - \tau_h)(G(e_c^i, \gamma_h) + A^i \gamma_h) + f(1 - e_c^i, 1 - \gamma) - R^h \; \forall \, i \; \textbf{(IC)}$$

$$(1 - \tau_h)(G(e_c^i, \gamma_h) + A^i \gamma_h) + f(1 - e_c^i, 1 - \gamma_h) - R^h \geq \bar{u} \; \forall \, i \; \textbf{(PC)}$$

τ_h denotes the share of worker output kept by the owner. [17] Note that the maximization problem faced by individual workers when choosing effort levels is the exact same problem faced by cooperative workers. The first-order condition for workers in an *hacienda* is:

$$(1 - \tau_h) G'(e_c, \gamma_h) = f'(1 - e_c, 1 - \gamma_h).$$

This implies that *hacienda* workers under-supply effort when $\tau_h > 0$.

3.3. *Worker Wages and Crop Choices in Cooperatives and Haciendas*

In this section, I derive the wage rates for cooperatives and *haciendas*, τ_c and τ_h, and the crop choices, γ_c and γ_h. Subsequently, to capture the main intuition of the model and simplify the comparison of the effort levels and crop choices of cooperatives and *haciendas*, I make a few simplifying assumptions on the production functions.

Wage Rates in Cooperatives: Workers will maximize their utility, equation (1), when voting over their preferred wage rate, τ_c. Assuming preferences are single-peaked to that the median voter

[16] Note that if $\tau_c = 0$, then the cooperative does achieve optimal effort. This mirrors the results from other papers on the theory of cooperatives (see Sen, 1966, Putterman, 1981, Ireland and Law, 1981), in which cooperatives with labor-proportionate schemes are not always less productive. Additionally, note that in this formulation, as in Kremer (1997), all workers will set the same effort levels regardless of their ability realization. This is done to simplify the derivations but is not essential to the arguments made in the model.

[17] The participation constraints of the workers and the assumption that workers are liquidity constraints means that the rent that the owner will charge, R^h, is set at the expected income of the lowest ability member minus their outside option. Additionally, the following conditions must hold: $0 \leq \gamma \leq 1$, $e_s \geq 0$ and $e_c \geq 0$.

theorem applies, the median voter will determine the wage rate (Kremer, 1997).[18] This means that a worker with the median ability shock, A^m, prefers τ_c that maximizes:

$$\max_{\tau_c,\gamma_c} \; [(1-\tau_c)A^m\gamma_c L + \tau_c\bar{A}\gamma_c L] + G(e(\tau_c),\gamma_c) + f(1-e(\tau_c),1-\gamma_c)$$

$$\text{subject to: } \underset{e_c^j}{\text{argmax}} \; [(1-\tau_c)A^m\gamma_c L + \tau_c\bar{A}\gamma_c L] + G(e(\tau_c),\gamma_c) + f(1-e(\tau_c),1-\gamma_c) \; \forall j \; \textbf{(IC)}$$

$$[(1-\tau_c)A^m\gamma_c L + \tau_c\bar{A}\gamma_c L] + G(e(\tau_c),\gamma_c) + f(1-e(\tau_c),1-\gamma_c) \geq \bar{u} \; \forall i \; \textbf{(PC)}$$

Thus, the median voter will set:

$$(\bar{A} - A^m)\gamma_c L = e'(\tau_c)(f'(1-e(\tau_c),1-\gamma_c) - G'(e(\tau_c),\gamma_c),$$

where the left-hand side of this first order condition represents the extra income accruing to the median voter with ability shock, A_m, from raising the redistribution rate, τ_c, holding effort of all members constant. Conversely, the right-hand side denotes the reduction in effort caused by raising the tax rate, multiplied by the welfare cost of this reduction in effort.[19] The tax rate chosen by the cooperative, τ_c, is increasing in the difference between the mean and median ability shock, $\bar{A} - A^m$.

Wage Rates in *Haciendas*: The owner will maximize their profits as denoted in equation (2). Thus, the owner will set τ_h such that:

$$G(e_c^i,\gamma_h) - G(e_c^{min},\gamma_h) + \bar{A} - A^{min} = e'(\tau_h)[\tau_h G'(e_c^i,\gamma_h) + (1-\tau_h)G'(e_c^{min},\gamma_h) - f'(1-e_c^{min},\gamma_h)],$$

where the left-hand side of the owner's first order conditions denotes the extra income accruing to the owner from raising the tax rate holding worker effort constant. In contrast, the right-hand side represents the reduction in worker effort caused by raising the tax rate, multiplied by the welfare cost to the owner of this reduction in effort.[20]

Crop Choices in Cooperatives: When voting over γ_c, workers know that they will subsequently vote on τ_c and then individually choose effort and produce output.[21] The first order condition for

[18] I the next sub-section I assume that $f(0,1-\gamma)=0$, $f'(e_s,1-\gamma)>0$ and $f''(e_s,1-\gamma)=0$. These assumptions ensure that preferences over the wage rate are single peaked and that we can apply the median voter theorem to examine voting outcomes (Roberts, 1977).

[19] We can solve for the general form of τ_c, where the cooperative will set: $\tau_c = \frac{(\bar{A}-A^m)(G''-f'')-G'(f'-G')}{(\bar{A}-A^m)G''}$.

[20] Solving for the general form of τ_h implies that $\tau_h = \frac{G(G''-f'')}{G''G-G'^2}$.

[21] I assumed the voting occurs sequentially to avoid voting cycles.

γ for the worker with median ability is:

$$(\tau_c \bar{A} + (1-\tau_c)A^m)L = e'(\gamma)(f'(e,l_s) - G'(e,\gamma L)) + f_\gamma(e,l_s)\frac{L}{N} - G(e,\gamma L)L$$

Thus, the median ability worker prefers γ_c that is more than the optimal amount of land to devote to cash crops (i.e. the amount that equalizes the marginal product of cash crop land to the marginal product of staple crop land). This difference between the optimal amount of γ_c is increasing in τ_c and in the distance of A^m from $\bar{A}$.

Crop Choices in *Haciendas*: The *hacienda* owner will set γ_h to maximize their earnings from cash crop production and the rent from staple crop production. The owner will set γ such that:

$$\tau_h G_\gamma(e_c, \gamma L)L = A^{min}L + f_\gamma(e_s^{min}, l_s)\frac{L}{N},$$

meaning that the owner will set the marginal product of the cash crop land equal to the marginal product on the lowest productivity private plot (i.e. the rental rate). Thus, the amount of land devoted to cash crops is a function of how much the owner can extract in rent from the staple crop output of the lowest ability worker. This will differ from optimal crop choice, which would set the marginal product of the cash crop land equal to the marginal product on the average staple crop plot, because the owner will be constrained to charge the same rental rate to liquidity constrained workers.[22]

Cooperative and *Hacienda* Choices Relative to the First Best: An important initial result from the model is that neither cooperatives nor *haciendas* necessarily induce the most efficient outcome – relative to the first best – in terms of effort and crop choices. In the model, inefficiency in effort choices in cooperatives and *haciendas* is increasing in τ_c and τ_h, respectively. Interestingly, these inefficiencies occur for different reasons.

In cooperatives, heterogeneity in workers and the voting process for decisions (on a one member, one vote basis) induces distortions due to incentives to redistribute earnings: if the median ability member has less ability than the average ability member, the cooperative members will (i) vote to set $\tau_c > 0$ to redistribute cash crop earnings and (ii) vote for a larger share of

[22]This prediction differs slightly from Sadoulet (1992), where the owner in that model can set individual-specific rental rates and thus can extract surplus from all workers (and all workers earn $\bar{w}$). However, I assumed that this is not possible because, in practice, most *haciendas* do not set different rental rates across workers.

cash crop production than is optimal ($\gamma_c > \gamma*$) to increase the amount of redistributed cash crop earnings.

In contrast, in *haciendas*, profit maximization and limited liability constraints for workers induces distortions as the owner faces a motivation-rent extraction trade-off when making decisions. This means that the owner will (i) set a high share of cash crops for himself to maximize profits at the expense of lower worker effort incentives ($\tau_h > 0$), and (ii) devotes a large share of land to cash crops ($\gamma_c > \gamma*$) to ensure workers devote more time to (verifiable) cash crop production.

Comparing Cooperatives and *Haciendas*: To compare the choices of cooperatives and *haciendas* on τ_c and τ_h and crop choices, I make two simplifying assumptions on the productions functions.[23] Specifically, I let cash crop output, $G(e_c,\gamma)$, be equal to $\sqrt{e_c \gamma} + A_i \gamma$, and I let staple crop output, $f(e_s,l_s)$, be equal to $e_s(1-\gamma)$.[24]

In this case, the cooperative members will set: $\tau_c = 2(1-\gamma_c)(\bar{A} - A^m)$. Conversely, the *hacienda* owner will set: $\tau_h = 2(1-\gamma_h)(\bar{A} - A^{min})$. If $2(1-\gamma_c)(\bar{A} - A^m) > 2(1-\gamma_h)(\bar{A} - A^{min})$, the cooperative workers will undersupply effort at cash crops more than workers in an *hacienda*. Conversely, if $2(1-\gamma_c)(\bar{A} - A^m) < 2(1-\gamma_h)(\bar{A} - A^{min})$, the opposite would hold: the *hacienda* workers will undersupply effort in cash crops more than workers in the cooperative. Thus, the question of which ownership structure is more productive is *ex-ante* unclear and depends on the distribution of ability shocks and the amount of land devoted to cash crop production (and the production function assumptions).[25] Thus, it is important to solve for crop allocations in order to compare productivities. Using the same production functions, we next solve for the specific crop choices, γ_h and γ_c. The cooperative members will set: $\gamma_c = \frac{4(\bar{A}-A^m)^2 - \sqrt{4(\bar{A}-A^m)^2+1}+1}{4(\bar{A}-A^m)^2}$, and the *hacienda* owner will set: $\gamma_h = \frac{4(\bar{A}-A^{min})^2 - \sqrt{4(\bar{A}-A^{min})^2+1}+1}{4(\bar{A}-A^{min})^2}$. In this case, γ_h will be larger than γ_c, meaning the cooperative will specialize less in cash crops and more in staple crops. These crop allocations also imply that the cooperative will set $\tau_c > \tau_h$, meaning that cooperative workers will devote less effort to cash crops and more effort to staple crops. The reason for this

[23] These assumptions also ensure that we can apply the median voter theorem to voting outcomes in cooperatives.

[24] In other words, cash crop production is assumed to be Cobb-Douglas production, a standard assumption in the literature on misallocation in agriculture (Restuccia, 2016).

[25] For example, let the ability shock distribution be distributed as lognormal, $A \sim Log\mathcal{N}(\mu = 0, \sigma^2 = 1)$ with $A^{min} = \frac{1}{10}$ (i.e. truncated lognormal), a standard right-skewed distribution for modeling ability differences in workers. In this case, if $\gamma_h = 0.85 > \gamma_c = 0.5$, then $\tau_c > \tau_h$.

is that cooperatives will redistribute earnings from cash crops but not staple crops, as workers can consume staple crops but not cash crops. This means that workers will get to keep more of their output for staple crops, but share cash crop output, reducing incentives to supply effort to cash crop production over staple crop staple crop production. Thus, the cooperative workers will be more productive at staple crops. The opposite incentives occur in the outside ownership system, where the owner will be constrained by the fact that, if producing staple crops, workers can consuming their output; thus, the owner will choose to produce more cash crops (where the owner can verify output) and will need to give people strong incentives to work on the cash crop land (over working on their own staple crop plots). Therefore, in sum, the cooperative both (i) devotes less land to cash crops and (ii) is also less productive (in terms of worker effort) at cash crops over staple crops compared to the *hacienda*.

3.4. Discussion of the Model

An important result of the model is that neither cooperatives nor *haciendas* necessarily induce the most efficient outcome in terms of effort and crop choices. These inefficiencies occur for different reasons. In cooperatives, worker heterogeneity and the voting process for decisions (on a one member, one vote basis) may lead to incentives to redistribute earnings. This redistribution dampens worker incentives to provide higher levels of effort. In particular, if the median ability member has less ability than the average ability member, the cooperative members will choose to redistribute cash crop earnings and choose to devote a larger share of cash crop production than is optimal to redistribute more cash crop earnings.

In contrast, in *haciendas*, the owner faces a motivation-rent extraction trade-off. In order to increase effort, the owner would need to allow workers to keep a larger share of their earnings; however, this would reduce his profits. Thus, the desire to maximize profits, and limited liability constraints for workers, means that the owner will decide to keep a higher than optimal share of cash crop output for himself at the expense of lower worker effort incentives. Additionally, the owner will devotes a large share of land to cash crops than optimal to ensure workers devote more time to (verifiable) cash crop production instead of (unverifiable) staple crop production.

When comparing the decisions of cooperatives and *haciendas*, the framework offers four important predictions summarized in Table 4 under the assumptions discussed in the previous section. First, relative to *haciendas*, cooperatives will devote less land to cash crops and more land to staple crops. Second, for cash crops, cooperatives are less productive than *haciendas*. Third, for staple crops, cooperatives are more productive than *haciendas*. These three predictions highlight that cooperatives are more likely to specialize in staple crop production while *haciendas* will specialize more in the production of cash crops. The reason for this is that cash crop earnings are redistributed in cooperatives, dampening effort incentives, but not staple crop earnings; this means that the cooperative will be more productive at staple crops over cash crops. Conversely, in *haciendas*, the owner is able to extract more from workers cash crops (since the owner can verify output) and will give people strong incentives to work on the cash crop land (over working on their own staple crop plots). Finally, cooperative members will likely have more compressed incomes as they will redistribute earnings from cash crop production. Column 3 of Table 3 links each of these predictions to how these predictions are tested empirically.

Table 3: Summary of Model Predictions and Corresponding Empirical Tests

	Prediction:	*Empirics:*
1) Crop Allocation:	$\gamma^h > \gamma^c$	% of land devoted to cash crops vs. staple crops
2) Cash Crop Production:	$e^h > e^c$	Yields for cash crops
3) Staple Crop Production:	$e_s^h < e_s^c$	Yields for staple crops
4) Worker Incomes:	$\sigma(y^h) < \sigma(y^c)$	Inter-quartile range of incomes for workers
	Assumption: $A^i \sim [A^{min}>0, A^{max}]$ with $A^m<\bar{A}$	

This framework abstracts from three important aspects of cooperatives and *haciendas*. First, the model abstracts from differences in monitoring by organizational structure.[27] Second, the model does not address the threat of exit for cooperatives studied by Abramitzky (2008) and considers a static problem.[28] Finally, the model abstracts from macro-risk considerations. Other

[27]The literature on whether cooperatives will choose to monitor their workers more or less than outside owner firms is unclear. For example, Alchian and Demsetz (1972) argued that the optimal level of monitoring is more likely chosen if the monitor is given the residual income of the firm. This implies that the monitoring choice by an outside owner will be more efficient than the choice of monitoring under profit sharing in cooperatives, because all benefits of monitoring accrue to the owner in the former, whereas the benefits of monitoring are potentially diluted among the members of cooperative due to profit sharing (Putterman and Skillman, 1988). However, cooperative members might have incentives to monitor each other in a way that traditional firms may not (Kandel and Lazear, 1992).

[28]For papers that study cooperatives in a repeated game setting, see MacLeod (1993).

Table 4: Summary of Decisions by Ownership Type

	Cooperative	***Hacienda***	Comparison
	(1)	(2)	(3)
Worker Effort: Amount of effort, e_c, in cash crop production	Workers individually choose effort such that marginal product of effort on cash crops (taking into account τ_c) is equal to marginal product of staple crop production, $(1-\tau_c)G' = f'$.	Similarly, workers individually choose effort such that marginal product of effort on cash crops (taking into account τ_h) is equal to marginal product of staple crop production, $(1-\tau_h)G' = f'$.	Differences in worker effort depend on the differences between τ_c and τ_h. If $\tau_c > \tau_h$, cooperative workers will be less productive at cash crops than *hacienda* workers.[26]
Wage Rates: Share of cash crop output, τ, kept by workers	If the member with a median ability shock has less than mean ability shock, the cooperative will vote for $\tau_c > 0$, setting $(\bar{A} - A^m)\gamma_c L = e'(\tau_c)(f_e - G_e)$.	The *hacienda* owner will set $\tau_h > 0$ to maximize his/her profits, where increasing τ_h increases the share kept by the owner at the expense of lower cash crop incentives for his/her workers but higher staple crop rental rates, $e'(\tau_h)(\tau_h G_e + (1-\tau_h)G_e^{min} - f_e^{min}) = G - G^{min} + \bar{A} - A^{min}$.	The difference between is *ex-ante* unclear and depends on the distribution of ability shocks. Both τ_c and τ_h are decreasing the amount of land devoted to cash crops, γ.
Crop Choices: Share of land, γ, devoted to cash crops over staple crops	Median voter equalizes marginal product of cash crop with the marginal product of their staple plot, $G_L = A^m f_L$.	Owner will set the marginal product of cash crop output equal to the marginal product of the staple crop plot of the lowest productivity member, $G_L = f_L^{min}$.	Cooperative will devote less land to staple crop production than the *hacienda* owner.
Worker Earnings: Total worker earnings	Each cooperative worker will receive an equal share τ_c of cash crop output. Additionally, they will keep $(1-\tau_c)$ of their cash crop output and all their staple crop earnings.	Workers will received $(1-\tau_h)$ of their cash crop output and a portion of their staple crop earnings (the surplus above the lowest productivity member).	Cooperative workers will have more compressed incomes because they redistribute a share of cash corp output equally. Whether cooperative members have higher incomes than *hacienda* workers is not clear *ex-ante*.

Notes: G denotes the production of cash crop, $G = \sum_i^N G(e_c^i, \gamma L) + A^i$. f denotes the production of staple crops individually, $f = f'(e_s^i, \frac{(1-\gamma)L}{N})$. R^h denotes the rent charged by the hacienda, $R^h = (1-\tau_h)(G^{min} + A^{min}) + f^{min} - \bar{U}$. $\bar{U}$ denotes the outside wage for workers. $G^{min} = e_c^{min}, \gamma L)$ and $f^{min} = (e_s^{min}, \frac{(1-\gamma)L}{N})$. For more details, see Section 3.1.

work has motivated the existence of cooperatives as a way of coping with idiosyncratic risks (see, for example, Bonin (1977); Carter (1987); Parliament et al. (1989); Delpierre et al. (2016)). In this model, I do not explicitly study heterogeneity in risk aversion. Including heterogeneity amongst cooperative members in their risk aversion and/or the degree of idiosyncratic risk across individuals in a cooperative would strengthen the incentives to redistribute earnings as a form of insurance. However, some crops may involve greater price or production risk than others, which would symmetrically affect all workers in a cooperative. If members are risk averse and face credit constraints while *hacienda* owners do not face credit constraints, this could explain differences in crop choices. I examine this last alternative story in the empirical section by examining differences in credit access by ownership type in Section 6.6.[29]

4. Data

4.1. Data Sources on Land Reform in El Salvador

I gathered government records on reform expropriation, cooperative formation, and pre-reform landholdings to identify properties above the expropriation threshold that became cooperatives and those below that remained as privately owned *haciendas*. Data on the reform expropriations comes from the El Salvador Ministry of Agriculture (MAG) and the El Salvador Institute for Agrarian Transformation (ISTA). The Ministerio de Agricultura y Ganadería (1983) report on Phase I of the 1980 land reform contains the list of all the properties expropriated; the canton, municipality and department of the properties; and the name and number of members in the cooperative created in each property. I received the ISTA records for the name of the former owner of each expropriated property from ISTA's offices in San Salvador.[30]

Data on pre-reform landholdings comes from the Property Registry of El Salvador from 1980. There was no single source with the universe of landholdings before the reform for all of El Salvador. However, ISTA provided records on the total landholdings in 1980 for owners of expropriated properties, and Figueroa Aquino and Marroquín Mena (1991) provide records on the

[29]However, the setting of agricultural production allows me to abstract from one proposed explanation for why there might be differences in access to capital between cooperative ownership and outside ownership in other contexts. In particular, scholars have highlighted that cooperatives in other sectors are less likely to raise funds through equity, as selling shares dilutes the voting power of worker-members (Hart and Moore, 1996). This means that they may be more credit constrained as they do not have as many ways to access capital. However, as argued in Putterman (1986), this argument is less relevant for agricultural cooperatives, as agricultural producers do not sell equity.

[30]See Data Appendix for more details on these sources.

total landholdings for all landholders with above 100 ha in cumulative landholdings in 1980 that were not expropriated by ISTA. Thus, these two sources together provide pre-reform landholdings from 1980 and contain the size in hectares, the canton, and the former owner for each property.[31]

4.2. *Data from the El Salvador Census of Agriculture*

The analysis comparing cooperatives to *haciendas* uses data from the IV Census of Agriculture in El Salvador. The census was conducted in 2007 and 2008 by the Ministry of Agriculture and the Ministry of the Economy. It surveyed 94,168 distinct agricultural producers and reports detailed information on types of crops produced, area cultivated, amount produced, workers employed, total size, and investment choices.

The census also collected the name of each property and information on the geographic location for agricultural producers. The agricultural census from the MAG collected the municipality and department of each property. This allows me to match the properties in Section 4.1 to the corresponding property today using the name, municipality, department and the size of the property in ha.[32] Across the threshold, I am able to match approximately 70% of the pre-reform landholdings to a modern-day agricultural producer from the census. Importantly, there is no difference in the probability of finding a match based on whether the property was owned by an owner over the cumulative landholding threshold: there is no discontinuity at the threshold in this probability of a match, and the slopes on both signs of the discontinuity are effectively zero. See Figure A3 for the RD plot of the probability of existing today.

4.3. *Data Sources for Development Outcomes*

To examine differences in worker outcomes for cooperatives and *haciendas*, I use household survey data – the *Encuesta de Hogares de Propósitos Multiples* – from El Salvador from 2002-2013. These household surveys provide detailed information on household incomes, wages, and consumption

[31]Using two separate data sources for the 1980 landholdings is not ideal because there could be differences in reporting across these two sources (even though this is very unlikely since both sources use data from the property registry of El Salvador). Colindres (1977) provides a similar list of properties owned by landholders with over 100 ha in cumulative landholdings for 1971 for eight of the eighteen districts of El Salvador. Therefore, I use data from Colindres (1977) as a check on the pre-reform landholding distribution to ensure that the 1980 landholding data is reliable.

[32]The census includes an indicator variable for whether a property is a cooperative and (often) the name for each cooperative. However, the name for the *hacienda* is usually not included because many *haciendas* do not have a formal name. I use these variables to separate cooperatives from *haciendas* and to match the reform cooperatives to their corresponding name when available. This matching process is similar to the work done in World Bank (2012) to study the reform cooperatives.

levels for individuals in El Salvador. The household surveys include detailed questions on the geographic location for each individual – the canton, municipality, and department of each individual. For individuals in agriculture, the surveys includes questions on whether a person works in agriculture as a cooperative member or as an *hacienda* laborer, and the total number of other employees for the property where they work. I use these questions in the household surveys to match individuals to cooperatives and *haciendas*. Since the household surveys do not include the name of the property in every year, I limit this matching to cantons with only one cooperative/large *hacienda*, meaning that I have a smaller sample of the properties in this sample of workers. I check the accuracy of this matching process by using using the 2008-2010 household surveys for which I received access to the property/cooperative name for agriculture workers.[33]

To examine outcomes in cantons that had differing shares of properties converted to cooperatives as a result of the reform, I use the 2007 population census of El Salvador (*Censo de Población y Vivienda 2007*). While the census does not include questions on incomes or consumption for individuals, it provides information on demographics and occupational sector of all individuals in El Salvador. The census includes very detailed geographic information on the current residence of all individuals in El Salvador. Along with canton, municipality, and department, the census reports the *segmento censal* for each individual (roughly equivalent to neighborhoods).[34] I use these geographic variables from the census and ISTA maps on the location of expropriated properties to construct finer measures of the characteristics of the *segmentos censales* that are likely part of a cooperative.[35] The census includes a module on migration and whether individuals still reside in their same canton of birth that I use to compare migration patterns across cantons with differing exposure to the 1980 land reform.[36]

5. Empirical Strategy

5.1. *Specification*

To identify the impacts of cooperative property rights on plot-level outcomes, I exploit the 500 ha threshold rule defined in Decree 153 of the El Salvador land reform to implement a regression

[33]In this sample, I find that I assign individuals to the correct property 91% of the time.

[34]I thank Carlos Schmidt-Padilla and Micaela Sviatschi for generously sharing this data.

[35]I am only able to do this for the cooperatives and not the *haciendas* as there is no equivalent map of the locations of *haciendas*.

[36]The census does not provide information on the specific canton of birth for individuals.

discontinuity (RD) design. The intuition for this empirical design is that, at the time of the reform, properties just above and below the 500 ha cumulative individual ownership threshold were likely very similar except that properties above the threshold were subject to expropriation and organized as agricultural cooperatives while those below were not. Thus, properties just below the threshold serve as a reasonable counterfactual to those above it that became cooperatives.

The empirical specification used is as follows:

$$y_{po} = \alpha + \gamma Above500_o + f(holdings_o) + \epsilon_{po} \;\; for \;\; o \in RS \tag{3}$$

where y_{po} is the outcome of interest for plot p owned by owner o before the reform and $Above500_o$ is an indicator variable for whether owner o had over 500 ha in total landholdings before the reform. $f(holdings_o)$ is the RD polynomial which controls for a smooth function of total landholdings by owners. Following Calonico et al. (2014a,b), the baseline specification for equation (3) uses a local linear specification estimated separately on each side of cut-off. The coefficient of interest is γ, the causal difference in outcomes between properties subject to expropriation and reorganized into cooperatives and those that were not susceptible to expropriation and remained as privately owned *haciendas*. Since former landholder o may have owned multiple plots and the threshold depends on total holdings for o, standard errors are clustered at the former land holder level. RS defines the "risk set" of former owners who had cumulative landholdings within a bandwidth near 500 ha; the baseline bandwidth is the optimal bandwidth that minimizes the mean squared error of the point estimator developed by Calonico et al. (2014b, 2017). Appendix E provides robustness tests using different RD polynomials and using various sample bandwidths to address concerns that the estimation results are specific to the choice of RD polynomial or bandwidth.

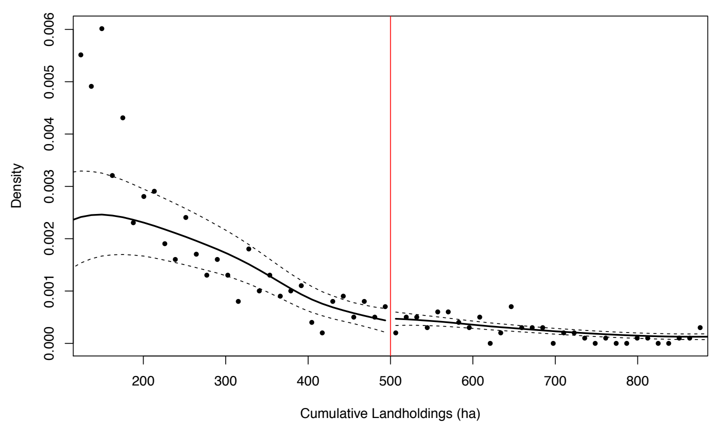
Equation (3) has two important identifying assumptions. First, former landowners must not have selectively sorted around the cut-off based on their characteristics. Second, all relevant factors other than treatment must vary smoothly at the 500 ha threshold. Below, I examine these two assumptions in more detail and provide evidence that they are likely satisfied.

5.2. *No Evidence of Sorting Along the 500 ha Cut-off*

Equation (3) requires the absence of selective sorting around the 500 ha cumulative landholding threshold. This would be violated, for instance, if landholders were able to selectively alter their cumulative landholdings amount at the time the reform was announced to avoid expropriation.

To test whether there was sorting around the threshold, I implement the McCrary test (McCrary, 2008) by collapsing the data into landholding-amount-bins and using the number of observations in each bin as the dependent variable in equation (3). Figure 3 illustrates that there is not a discontinuous change in the number of observations in each bin around the threshold. This suggests that landholders were unable to change their landholdings to avoid expropriation. This is consistent with the details of the reform implementation presented in Section 2.1, which describes how the land reform was executed swiftly and that there was a large effort by the military to keep key planning details secret from large landowners.

Figure 3: McCrary Sorting Test



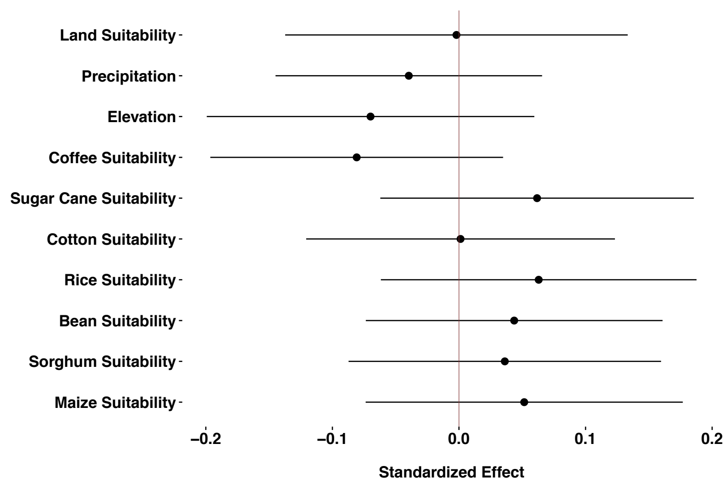
Notes: The figure implements the sorting test suggested by McCrary (2008) and plots the number of observations in each cumulative landholding bins. The plotted regressions use the number of observations in each bin as the dependent variable on each side of the cut-off to test if there is a discontinuity in the density of landholdings at the expropriation cut-off. See Data Appendix for more information on data sources and variable definitions.

5.3. *Balance on Geographic Characteristics*

The second RD identification assumption is that all relevant factors aside from treatment vary smoothly at the 500 ha threshold. This assumption is important to ensure that properties just below the ownership threshold serve as an appropriate counterfactual for those above the threshold. This assumption would not hold if, for example, properties with an owner over the 500 ha threshold differ systematically in their characteristics (such as land suitability or geographic location) from properties with an owner just below the threshold.

To assess the plausibility of this assumption, I examine whether key geographic characteristics are balanced across the 500 ha threshold. In particular, I estimate equation (3) for different geographic characteristics for each property and present the estimated coefficient of interest, γ, for each of these variables in Figure 4. The geographic characteristics used are land suitability, precipitation, elevation, suitability for the three main cash crops at the time (sugar cane, coffee and cotton), and suitability for the three main staple crops of El Salvador (maize, rice, sorghum and beans).[37] For each of these key geographic variables, there is no evidence of a discontinuity at the threshold. This provides evidence that the assumption that relevant factors vary smoothly at the 500 ha threshold is reasonable.[38]

Figure 4: Estimates for Differences in Geography



Notes: Figure plots standardized (beta) regression discontinuity coefficients. Regressions use local linear polynomials and the MSE optimal bandwidth from Calonico et al. (2017). See Appendix A for details on the data sources and variable construction for the geographic variables.

5.4. *First-Stage: Holdings Above Ownership Threshold Were Expropriated*

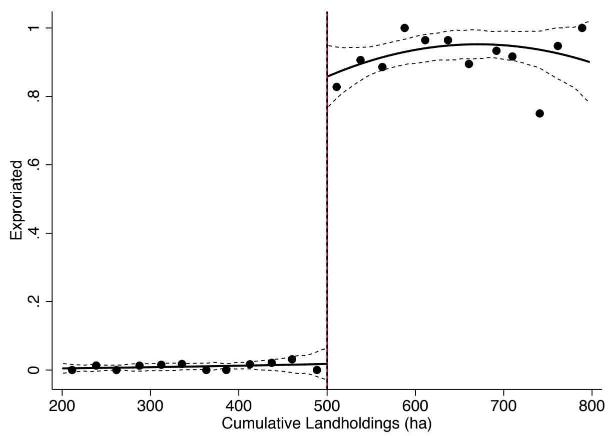
This section examines whether the land reform did in fact follow the details of Decree 153. In particular, I confirm whether properties owned by landholders with cumulative landholdings over 500 ha were expropriated. Figure 5 graphically examines the relationship between cumula-

[37] See Data Appendix for more details on these variables.

[38] Figure 2 presents a map of cantons in El Salvador that did and did not experience an expropriation and illustrates that the reform properties were not concentrated in one single geographic location of the country but were instead spread out across the country.

tive landholdings and expropriation.[39] Each point in the figure represents average expropriation rates in cumulative landholdings bins. The solid line plots predicted values from a regression of expropriation on a quadratic polynomial in the total landholdings of the former owner, estimated separately on either side of the 500 ha threshold. The dashed lines present the 95 percent confidence intervals for the regressions. The regressions are estimated on properties within 300 ha of the cumulative ownership threshold. Figure 5 shows that there is a discontinuous change

Figure 5: Phase I Expropriation RD Plot



Notes: The figure presents the estimated regression discontinuity plot on an indicator variable equal to 1 if a property was expropriated. The points represent the average value of the outcome variable in bins of width of 25 ha. The regressions are estimated using local quadratic polynomials in the total landholdings of the former owner estimated separately on each side of the reform threshold on the sample within a fixed bandwidth of 300 ha and use an uniform kernel. Standard errors are clustered at the former owner level. 95% confidence intervals around the estimated lines are shown in dashed lines. See Data Appendix for data sources and variable definitions.

in the probability of being expropriated above the 500 ha threshold. Specifically, properties with an owner owning over 500 ha in cumulative landholdings are approximately 75% more likely to have been expropriated after the 1980 land reform was announced. Interestingly, compliance with the reform rules was not perfect. Not all properties above the threshold were expropriated.[40] Additionally, a few properties below the threshold were expropriated even though they should

[39] In the figure, *Expropriation* is defined as an indicator variable equal to one if the property is reported as an expropriated property in the 1983 MAG report.

[40] About 20% of these properties remained as privately owned *haciendas*. This is in contrast to the accounts presented by the executioners of the reform, that suggested that all properties that should have been expropriated according to Decree 153 were indeed expropriated (Velis Polío, 2012).

not have been expropriated according to the reform details.[41] Overall, the 1980 land reform was successful in expropriating most properties above the threshold and redistributing these properties to the former *hacienda* workers in the form of agricultural cooperatives.

6. Results: Cooperative Property Rights and Agriculture Outcomes

In this section, I compare differences in crop choices, crop-specific productivities, and aggregate productivity between cooperatives and *haciendas* using the 2007 agricultural census of El Salvador. I then discuss whether the results are consistent with the theoretical framework.

6.1. Agricultural Choices and Crop Productivity

To understand differences in crop choice and productivity, I utilize the crop-specific measures of production and yields collected in the agricultural census of El Salvador. The agricultural census reports quantity produced, amount of land used, and yields for the major crops for each property. The major crops reported are sugar cane, coffee, maize, and beans.[42] Guided by the theoretical framework in Section 3, I present the results for the major cash crops in El Salvador – sugar cane and coffee – and then for the main staple crops – maize and beans.[43]

For cash crops, I estimate a version of equation (3) where the dependent variable is an indicator variable equal to one if a property produces a positive amount of that crop and zero otherwise. Then, for each cash crop, I estimate equation (3) where I vary the dependent to be (i) an indicator equal to one if a property produces a positive amount of that crop and zero otherwise, (ii) the share of land in a property devoted to that crop, and (iii) the reported yield for that crop. I report the estimates in Table 5, and I plot the estimated coefficients for production indicators and yields in Figure 6. I present the RD plots for the share of land devoted to cash crops in Figure A2.

I find that cooperatives devote less land to cash crops and are less likely to produce sugar cane and coffee relative to *haciendas*. Cooperatives devote 62% less of their land to cash crops, 18%

[41] Approximately 3% of properties below the threshold were expropriated. Since compliance with the reform threshold was imperfect, the empirical results will also present scaled instrumental variable estimates - i.e. "fuzzy" regression discontinuity approach - under the exclusion restriction that outcomes of interest are only affected through the change in expropriation probability at the threshold.

[42] The agricultural census contains an additional "horticulture" module that reports production for minor crops such as coconuts and cassava.

[43] Historically, cotton was a major cash crop in El Salvador leading up to Civil War. However, following the Civil War, cotton was no longer produced Marroquín Mena (1988). *Haciendas* prior to the reform were cash crop producers (Colindres, 1976).

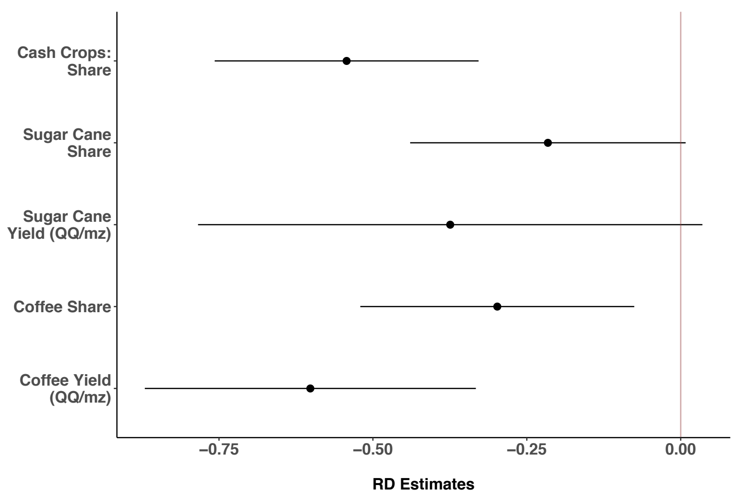
less land to sugar cane, and 31% less land to coffee production. Conditional on producing these crops, cooperatives also have lower yields for these cash crops. Yields for sugar cane are 15.6 *quintales* per *manzanas* (QQ/mz) lower in cooperatives than in *haciendas* and yields for coffee are 18.3 QQ/mz lower in cooperatives than in *haciendas*.[44]

Table 5: Agricultural Choices and Productivity: Cash Crops

	Cash Crops	Sugar Cane			Coffee		
	Share	Producer	Share	Yield	Producer	Share	Yield
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Above500	-0.628***	-0.236**	-0.186*	-15.60*	-0.340***	-0.311***	-18.30***
	(0.127)	(0.119)	(0.0985)	(8.375)	(0.115)	(0.119)	(4.173)
Observations	168	232	213	62	275	214	78
Clusters	103	142	132	48	166	132	39
Mean Dep. Var.	0.550	0.263	0.191	69.90	0.356	0.268	11.72
Bandwidth	92.56	122	121.5	122.6	133.8	115	125.2

Notes: Standard errors clustered at the former owner level reported in parenthesis. *Share* for *Cash Crops* measures the share of land in a property devoted to cash crop farming (coffee or sugar cane). *Producer* is an indicator variable equal to 1 if the any positive amount of the crop was reported as produced. *Share* measures the share of land in a property devoted to a given crop. *Yield* is measured as total produced, in tons per area in manzanas for sugar cane, and in quintiles (QQ) per area in manzanas (mz) for coffee. *Above500* is an indicator variable equal to 1 if the former owner of the property had over 500 ha. in cumulative landholdings in 1980. All regressions include a local linear polynomial in the total landholdings of the former owner estimated separately on each side of the reform threshold. Bandwidths are chosen using the MSE optimal procedure suggested by Calonico et al. (2017) and are reported in ha. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Figure 6: Agricultural Choices and Productivity: Cash Crops Coefficient Estimates



Notes: Figure plots standardized (beta) regression discontinuity coefficients. Regressions use local linear polynomials and the MSE optimal bandwidth from Calonico et al. (2017). *QQ* represents quintals, where 1 quintal is equal to 100 kg. *mz* represents *Manzanas*, where 1 *mz* equals 1.72 acres.

[44] *Quintales* is the unit of quantity used in El Salvador and is equivalent to 101.4 pounds or 46 kg. *Manzanas* are the unit for land areas in El Salvador and are equivalent to 1.72 acres or 0.70 hectares. More information on the variables used and their definitions is provided in Appendix A.

For staple crops, I follow the format for the cash crops results and first estimate the main specification using the share of land in property devoted to staple crops as the dependent variable. Then, for each main staple crop, I estimate the main specification where I vary the dependent variable to be (i) indicator equal to one if a property produces a positive amount of that crop and zero otherwise, (ii) the share of land in a property devoted to that crop, and (iii) the reported yield for that crop. I report the estimates in Table 6, and I plot the estimated coefficients for yields and production in Figure 7. Additionally, I present the RD plots for the share of land devoted to staple crops in Figure A2.

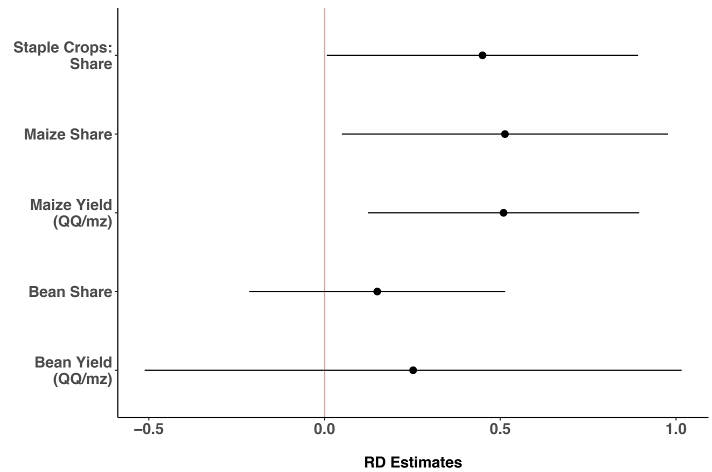
I find that cooperatives are more likely to produce staple crops than *haciendas*. Cooperatives devote 48% more of their land to staple crop production relative to *haciendas*. Specifically, cooperatives devote 43% more land to produce maize and are 36% more likely to produce beans (though there is no statistically significant difference in the share of land devoted to beans). Conditional on producing these crops however, cooperatives have higher yields for these staple crops. Yields for maize are 18 QQ/mz higher in cooperatives than in *haciendas*.

Table 6: Agricultural Choices and Productivity: Staple Crops

	Staple Crops	**Maize**			**Beans**		
	Share	Producer	Share	Yield	Producer	Share	Yield
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Above500	0.482**	0.547***	0.431**	18.44***	0.362**	0.0556	3.857
	(0.242)	(0.193)	(0.199)	(7.127)	(0.173)	(0.0689)	(4.676)
Observations	295	223	278	71	278	284	51
Clusters	185	136	173	54	176	175	46
Mean Dep. Var.	0.227	0.387	0.186	47.60	0.141	0.0399	15.15
Bandwidth	150.1	116.1	142.9	101.1	133.3	144.8	180

Notes: Standard errors clustered at the former owner level reported in parenthesis. *Share* for *Staple Crops* measures the share of land in a property devoted to staple crop farming (maize or beans). *Producer* is an indicator variable equal to 1 if the any positive amount of the crop was reported as produced. *Share* measures the share of land in a property devoted to a given crop. *Yield* is measured as total produced in quintales (QQ) per area in manzanas (mz). *Above500* is an indicator variable equal to 1 if the former owner of the property had over 500 ha. in cumulative landholdings in 1980. All regressions include a local linear polynomial in the total landholdings of the former owner estimated separately on each side of the reform threshold. Bandwidths are chosen using the MSE optimal procedure suggested by Calonico et al. (2017) and are reported in ha. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Figure 7: Agricultural Choices and Productivity: Staple Crops Coefficient Estimates



Notes: Figure plots standardized (beta) regression discontinuity coefficients. Regressions use local linear polynomials and the MSE optimal bandwidth from Calonico et al. (2017).

These results on crop choices and yields demonstrate that cooperatives are less likely to produce cash crops and more likely to produce staple crops relative to properties that were never expropriated; however, cooperatives are more productive when producing staple crops. I discuss these results and their implications in more detail in 6.7 after examining the robustness of these results and performing various extensions of this analysis.

6.2. *Aggregate Agricultural Productivity Differences*

To examine whether cooperative property rights lead to lower overall agricultural productivity compared to *haciendas*, I construct two measures for agricultural productivity. The first is revenues per hectare, the aggregate equivalent to crop yields. The second measure is productivity per hectare, which takes into account costs for each crop.

Formally, the first measure is :

$$Revenue\,per\,Hectare_p = ln(\frac{\sum_i p_i q_i}{l_p}), \tag{4}$$

where q_i is the total quantity produced for each crop i and p_i the price of each crop i in 2007 reported in Ministerio de Agricultura y Ganadería (2007a). I then normalize each measure by the property size in hectares (l_p).

Similarly, to capture production net of costs, the second measure is:

$$Land\ Productivity_p = ln(\frac{\sum_i p_i q_i - c_i}{l_p}), \quad (5)$$

where c_i is the costs of producing for each crop i. The 2007 agricultural census for El Salvador does not report these crop-specific costs for each property.[45] However, the Ministry of Agriculture reports the production cost for each crop in 2007 in Ministerio de Agricultura y Ganadería (2007b). Thus, to construct a proxy for profits per hectare for each crop i, I take the costs for each reported in Ministerio de Agricultura y Ganadería (2007b) (measured in $ per mz) and multiply this cost per the amount of land devoted to each crop (in mz). I then normalize each measure by the property size in hectares (l_p). Finally, I take logs of the revenue and productivity measures because these measures are naturally right-skewed.

Table 7 presents the regression discontinuity estimates from equation (3). Columns (1) and (2) report the estimates using revenue per hectare as the measure of productivity, while columns (3) and (4) report the estimates using land productivity. Columns (1) and (3) report reduced form estimates using an indicator variable for whether a property was owned in 1980 by an owner with over 500 ha in cumulative landholdings, while columns (2) and (4) report second-stage estimates (i.e. fuzzy rd estimates). As highlighted in Section 5.4, not all properties above the ownership threshold were expropriated. Thus, columns (2) and (4) use the indicator variable equal to one if a property was above the threshold as an instrument for an indicator equal to one if a property got expropriated and became a cooperative, and then estimates the second-stage regression using the latter indicator as the independent variable. The estimates suggest that there is not strong evidence that cooperatives are less productive per hectare. The coefficient estimates across both measures of productivity are consistently negative but not statistically significant.[46]

Interestingly, the magnitude of the estimated differences in revenues per ha and profits per ha are consistently small and close to zero across multiple RD specifications. Figures A18 and A20 plot the standardized (beta) coefficients for revenues per ha and profits per ha, respectively, across a variety of RD specifications and show that the standardized effect is consistently between 0.0 and -0.15, suggesting a small effect size (Cohen, 1988). Figures A18 and A20 plot the standardized (beta) coefficients for revenues per ha and profits per ha, respectively, across different bandwidths

[45] The census reports indicator variables for the use of some agricultural inputs. Interestingly, there are no differences in the probability of using a given input between cooperatives and *haciendas* – see Figure A15 – suggesting that using the same production costs for a given crop is not an extreme assumption.

[46] I present the RD plots for these variables in Appendix B.1 in Figure A1.

and also show that the estimated effect is consistently small. This suggests that even if the coefficient is negative, evidence suggests that any effect size is small; in fact, standardized effect sizes greater than -0.40 are rejected across most of these alternative specifications.[47] Thus, even though the reform cooperatives in El Salvador differ considerably from *haciendas* in terms of their crop choices and yields for cash crops and staple crops as highlighted in Section 6.1, the evidence presented in this section suggests that they are not less efficient in aggregate as measured by revenues or profits per hectares. These consistent and small differences in efficiency presented in this section are consistent with evidence from other settings and industries comparing cooperatives to outside-owned firms (see Craig and Pencavel, 1995; Pencavel, 2013).

Table 7: Cooperative Property Rights and Aggregate Agricultural Productivity

	Revenue Per Hectare *ln($/ha)*		**Profits per Hectare** *ln($/ha)*	
	(1)	(2)	(3)	(4)
Above 500	-0.313	-0.322	-0.317	-0.330
	(0.363)	(0.372)	(0.439)	(0.455)
Fuzzy RD	N	Y	N	Y
Observations	141	141	149	149
Clusters	90	90	99	99
Mean Dep. Var.	7.222	7.222	6.919	6.919
Bandwidth	100.6	100.6	108	108

Notes: Standard errors clustered at the former owner level reported in parenthesis. *Revenue Per Hectare* is measured as total value in 2007 dollars of all crops produced divided by area in hectares. *Profits per Hectare* is measured as total value in 2007 dollars of all crops produced minus the costs of production of each crop from MAG production reports divided by area in hectares. *Above 500* is an indicator variable equal to 1 if the former owner of the property had over 500 ha. in cumulative landholdings in 1980. All regressions include a local linear polynomial in the total landholdings of the former owner estimated separately on each side of the reform threshold. Bandwidths are chosen using the MSE optimal procedure suggested by Calonico et al. (2017) and are reported in ha. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

6.3. *Temporal External Validity Exercise*

The measures of productivity presented in Section 6.2 have a few important limitations. Aggregate measures of productivity may obscure important crop-specific differences in production choices and productivity. Additionally, because crop prices are volatile and the measures are weighted by prices in 2007, a particularly high (low) price of a crop in 2007 will give much more

[47] Additionally, due to power concerns with RD designs, I present the RD power calculations developed by Cattaneo et al. (2017) in Figure A16. The calculations suggest that the RD in this setting is not under-powered for studying standardized effect sizes of 0.50.

(less) weight to this crop in the productivity measures.[48] Price shocks could potentially make some producers seem more productive, even without underlying productivity differences. For these reasons, I perform an exercise in which I calculate both measures of productivity using all crop prices from 2005-2015, holding constant quantities and crop choices. I then plot the estimated productivity differences to examine whether the differences in productivity examined in Section 6.2 are sensitive to the use of other crop prices from other years. This exercise has the additional benefit of examining whether there is evidence of the temporal external validity of the results as suggested by Rosenzweig and Udry (2016).

To perform this exercise, I use crop prices and production costs from the El Salvador Ministry of Agriculture (MAG) from 2005 to 2015. The MAG price data is provided in Ministerio de Agricultura y Ganadería (2005-2015b) while the production costs data is provided by Ministerio de Agricultura y Ganadería (2005-2015a). The MAG reports domestic crop prices for El Salvador. This is important because staple crops are not always traded on international markets; therefore, world prices for these crops may differ considerably from domestic prices. The MAG does not report sugar cane prices, only processed sugar markets, so I use FAO data on sugar cane prices for El Salvador.

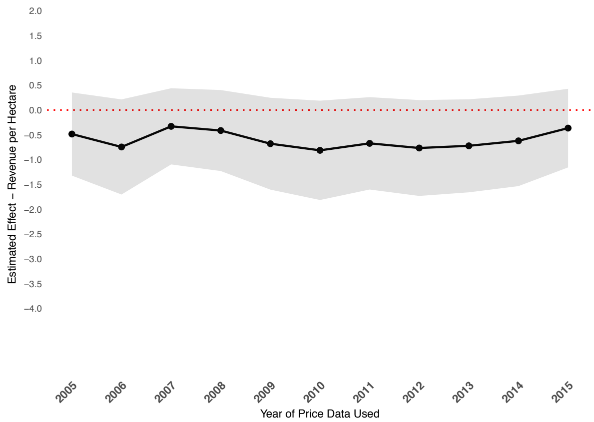
Using these crop prices and costs, I calculate the two measures of agricultural productivity, revenues per hectare and land productivity, by property for each year, holding the crop mix and quantities produced constant at their 2007 level from the agricultural census. I then estimate equation (3) for each year and plot the coefficient on a property being owned by an owner in 1980 with over 500 ha in cumulative landholdings in Figure 8. The results suggest that the estimates presented in Section 6.2 are not particularly sensitive to the specific prices and costs from the census year.

6.4. Robustness Checks

In this section, I describe additional robustness checks to regression discontinuity results presented above. In Appendix E, I present the main results using alternative RD polynomials (constant, linear and quadratic, estimated separately on each side of the threshold), using additional

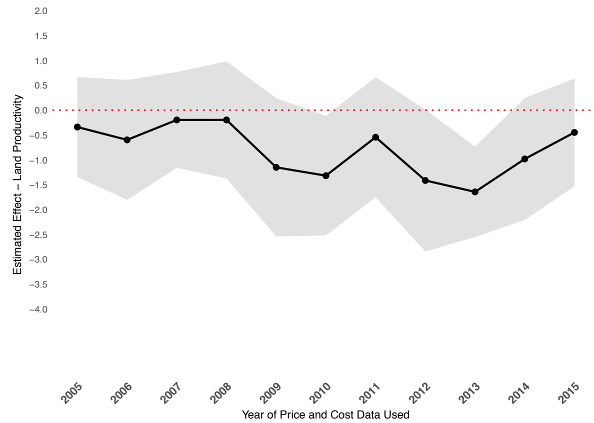
[48]For example, sugar cane prices in 2007 were particularly high worldwide (see Figure A6), and sugar cane is one of the main cash crops of El Salvador.

Figure 8: Temporal External Validity Exercise - Agricultural Productivity



(a) Revenue per Hectare

Notes: The figure presents the estimated regression discontinuity coefficients (*Above500*) on revenue per hectare using crop prices from 2005 to 2015 provided by the MAG while holding the crop mix and quantities produced constant at their 2007 level from the agricultural census. Gray areas represent the 95% confidence intervals



(b) Land Productivity

Notes: The figure presents the estimated regression discontinuity coefficients (*Above500*) on aggregate land productivity using crop prices and production costs from 2005 to 2015 provided by the MAG while holding the crop mix, labor amounts, and quantities produced constant at their 2007 level from the agricultural census. Gray areas represent the 95% confidence intervals.

bandwidth options suggested by Calonico et al. (2017), and varying the kernel choice to the RD results. I present the results employing local randomization methods suggested by Cattaneo et al. (2015) in Appendix D.

6.5. Similarities between RD and Full-Sample Estimates

I next examine whether the RD estimates from Sections 6.2 and 6.1 – estimated limiting the sample to observations close to the reform threshold – differ from estimates using the entire sample of *haciendas* and cooperatives in the agricultural census for which I have 1980 landholdings information. I do this for two reasons. One concern with RD estimates is that since they are estimated with a small sample of observations near the threshold, they may not generalize to other observations away from the threshold. For instance, it may be the case that the observed differences in choices between cooperatives and *haciendas* are only present for the type of properties I am examining in this paper - properties usually in the hundreds of hectares. Additionally, if the RD estimates differ considerably from the OLS estimates, it may be informative of the direction of omitted variable bias when comparing cooperatives to *haciendas* in other contexts.

Table 8: Cooperatives and Productivity - OLS Estimates

	Revenues per Hectare *ln($/ha)*	Land Productivity *ln($/ha)*
	(1)	(2)
Reform Cooperative	-0.635***	-0.775***
	(0.104)	(0.128)
Observations	654	635
Clusters	468	456
Mean Dep. Var.	7.242	6.887

Notes: Standard errors clustered at the former owner level reported in parenthesis. *Revenue Per Hectare* is measured as total value in 2007 dollars of all crops produced divided by area in hectares. *Land Productivity* is measured as total value in 2007 dollars of all crops produced minus the costs of production of each crop from MAG production reports divided by the total number of workers. *Reform Cooperative* is an indicator variable equal to 1 if the property became a cooperative following the 1980 land reform. Regressions examine all properties that have information on the total landholdings of the former owner. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table 9: Agricultural Choices and Productivity: Cash Crops - OLS Estimates

	Cash Crops	**Sugar Cane**			**Coffee**		
	Share	Producer	Share	Yield	Producer	Share	Yield
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Reform Cooperative	-0.459***	-0.179***	-0.142***	-2.791	-0.303***	-0.291***	-11.19***
	(0.037)	(0.029)	(0.022)	(3.126)	(0.033)	(0.027)	(0.487)
Observations	849	849	772	185	849	849	287
Clusters	584	584	543	153	584	584	207
Mean Dep. Var.	0.544	0.219	0.165	70.19	0.337	0.304	10.64

Notes: Standard errors clustered at the former owner level reported in parenthesis. *Share* for *Cash Crops* measures the share of land in a property devoted to cash crop farming (coffee or sugar cane). *Producer* is an indicator variable equal to 1 if the any positive amount of the crop was reported as produced. *Share* measures the share of land in a property devoted to a given crop. *Yield* is measured as total produced, in tons per area in manzanas for sugar cane, and in quintales (QQ) per area in manzanas (mz) for coffee. *Reform Cooperative* is an indicator variable equal to 1 if the property became a cooperative following the 1980 land reform. Regressions examine all properties that have information on the total landholdings of the former owner. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table 10: Agricultural Choices and Productivity: Staple Crops - OLS Estimates

	Staple Crops	**Maize**			**Beans**		
	Share	Producer	Share	Yield	Producer	Share	Yield
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Reform Cooperative	0.311***	0.589***	0.467***	-1.966	0.348***	0.154***	-1.098
	(0.0269)	(0.0415)	(0.0394)	(2.269)	(0.0493)	(0.0267)	(1.228)
Observations	772	849	772	275	849	772	98
Clusters	543	584	543	237	584	543	91
Mean Dep. Var.	0.120	0.324	0.204	47.21	0.115	0.0357	14.96

Notes: Standard errors clustered at the former owner level reported in parenthesis. *Share* for *Staple Crops* measures the share of land in a property devoted to staple crop farming (maize or beans). *Producer* is an indicator variable equal to 1 if the any positive amount of the crop was reported as produced. *Share* measures the share of land in a property devoted to a given crop. *Yield* is measured as total produced in quintales (QQ) per area in manzanas (mz). *Reform Cooperative* is an indicator variable equal to 1 if the property became a cooperative following the 1980 land reform. Regressions examine all properties that have information on the total landholdings of the former owner. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

The analysis from Sections 6.1 and 6.2 are replicated with the full sample in Tables 8, 9, and 10. The estimated OLS coefficient on *Reform Cooperative* tends to be of the same sign and similar magnitude as the RD estimate for *Above500*. Specifically, the OLS differences in productivity and in the share of land devoted to different crops are similar to the RD estimates. Additionally, the OLS estimates for differences in yields for cash crops in Table 9 has the same sign as the estimates in Table 5 but are generally smaller. However, the OLS estimates for differences in yields for staple crops in Table 10 differ from the RD estimates in Table 6: the magnitudes are much smaller and have the opposite sign.

Overall, while the estimates on shares of land devoted to different crops and aggregate productivity levels are similar, the OLS estimates for yield differences by crop are not consistently similar. One reason for this could be that yield estimates for very large properties tend to be very different than yield estimates for smaller properties due to the inverse farm size-productivity relationship often found in agriculture (Carter, 1984; Prosterman and Riedinger, 1987; Foster and Rosenzweig, 2017). By not limiting the estimates to properties that were similar before the reform, we are including many very large properties in the OLS estimates. This could have the effect of biasing downwards any differences in yields between cooperatives and *haciendas* for other contexts, in particular for settings where the size of properties under each ownership structure differ considerably.

6.6. Alternative Stories: Credit Access and Crop Risk

In this section, I analyze two alternative stories for why cooperatives may choose to specialize in staple crop production while *haciendas* specialize in cash crop production unrelated to the agency mechanisms highlighted in Section 3. One potential alternative explanation for the differences in crop choices between cooperatives and *haciendas* is that cooperatives may have less access to credit than *haciendas*. Cash crop production and processing is capital intensive. Thus, if cooperatives are more credit constrained than *haciendas*, this may explain their crop choices. The agricultural census provides questions on whether properties applied for credit, whether the credit was approved (and approved in a timely manner), and the sources for this credit. Table 11 presents the estimates from estimating equation (3) for these outcome variables, except for whether the credit was approved as every property in the sample reports that their credit application approved.

Cooperatives are not less likely to have applied for credit and receive credit from similar sources as *haciendas*, suggesting that credit access differences explain differences in crop choices.

Table 11: Credit Access and Sources - RD Estimates

	Applied for Loan	Credit Approval Timely	Credit Source			
			State Bank	Private Bank	Credit Coop	NGO
	(1)	(2)	(3)	(4)	(5)	(6)
Above500	0.185	0.0328	0.629*	-0.305	-0.227	-0.0390
	(0.212)	(0.0377)	(0.340)	(0.444)	(0.189)	(0.0540)
Observations	297	32	27	39	75	28
Clusters	187	32	23	34	61	21
Mean Dep. Var.	0.309	0.975	0.276	0.465	0.107	0.0714
Bandwidth	140.2	76.81	60.43	79.40	127.7	75.20

Notes: Standard errors clustered at the former owner level reported in parenthesis. *Applied for Credit* is an indicator variable equal to 1 if the property reported applying for a credit. *Credit Approval Timely* is an indicator variable equal to 1 if the property reported that the credit approval was timely. In the sample, all properties that applied for credit report being approved for the credit. *Credit Source* variables are an indicator variable equal to 1 if the credit used by the property comes from a state bank, private bank, credit cooperative, and NGO, respectively. *Above500* is an indicator variable equal to 1 if the former owner of the property had over 500 ha. in cumulative landholdings in 1980. All regressions include a local linear polynomial in the total landholdings of the former owner estimated separately on each side of the reform threshold. Bandwidths are chosen using the MSE optimal procedure suggested by Calonico et al. (2017) and are reported in ha. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

A second potential difference between cash crops and staple crops is that cash crops might be subject to more price risk As discussed in Section 3.4, this type of risk cannot be managed through the redistribution of earnings amongst cooperative members. Thus, if cash crops have more price volatility and cooperatives are more risk averse than *haciendas*, this could explain differences in crop choices. Using monthly crop price data from Ministerio de Agricultura y Ganadería (2005-2015b), I examine whether cash crop prices are more volatile than staple crop prices in a number of ways. First, I calculate the 6-month rolling standard deviation of prices for a portfolio made up of the main staple crops (equal parts maize and beans) to a portfolio consisting of the main cash crops (sugar cane and coffee) and plot the results in Figure A7. Staple crop prices seem to be just as volatile by this measure. To examine whether this result is driven by a particular crop, Figure A8 plots the 6-month rolling standard deviation for these four crops separately and shows that the results are not driven by a particular crop. Next, instead of examining rolling standard deviations, I construct the return (log price return) for each crop over different time periods. Specifically, I examine what return a crop would have if purchased at the start of a period and held until the end to examine whether the returns to cash crops are more volatile than staple crop returns. I plot these crop returns for the four main crops – maize, beans, sugar cane and coffee – for periods of 1 year, 6 months, or 1 month in Figures A9, A10, and A11, respectively. There is little evidence that the returns on cash crops are more volatile than the returns to staple crops.[49]

6.7. *Discussion*

The results presented in this section reveal an important difference between agricultural cooperatives and *haciendas*. Relative to *haciendas*, cooperatives are less likely to specialize in cash crops and more likely to specialize in staple crops. Specifically, cooperatives devote a larger share of their land to the production of staple crops instead of cash crops compared to *haciendas*. As well, relative to *haciendas*, cooperatives are less productive for cash crops but more productive for staple crops. Additionally, there is no strong evidence that cooperatives are less productive on aggregate compared to *haciendas*.

These findings are broadly consistent with the predictions from Section 3. First, the theory predicts that cooperatives will be less likely to choose cash crops relative to *haciendas*. Cooperative voting by workers leads to voters deciding to devote more land to produce (private) staple crops instead of cash crops (where the earnings will be redistributed and thus have worse work incentives compared to staple crops) while *haciendas* devote a larger share of land to cash crops to maximize profits for the owner.[50] However, cooperatives still choose to invest in producing cash crops due to median voters benefiting from some redistribution. Second, the theory predicts that cooperatives will be more productive than *haciendas* when producing staple crops and not cash crops. This is because cooperatives will redistributive earnings for cash crops, reducing work incentives. However, since cooperatives are constrained by the fact that members can choose to consume some of their staple crop production, earnings for staple crops will be private, inducing higher incentives for work on these crops. The results provide evidence on the causal impacts on agricultural productivity and choices of cooperative property rights relative to outside ownership, and highlight how cooperative property rights induce different specialization choices compared to outside ownership.

[49] Fafchamps (1992) provides a model where small-scale farmers may be more likely to produce staple crops rather than cash crops due to self-sufficiency concerns (i.e. staple crops can be produced in bad states) and missing rural markets. However, not that in this setting, the cooperatives are large, have similar levels of access to credit to potentially smooth these price shocks, and produce large amounts of staple crops (i.e. likely more than the amount of staple crops needed solely for self-consumption). Thus, this explanation is unlikely to drive the differences in crop choices in this context.

[50] Interestingly, these results are consistent with Gafaro (2015), who examines differences between cooperatives and individual small-holder producers in Peru. While the counterfactual property rights regime is different in her setting, she also finds that cooperatives are less likely to produce cash crops.

7. Results: Cooperatives, Equity, and Development Results

This section examines the impacts of cooperative property rights on inequality and development for individuals that work in cooperatives and *haciendas*, and then examines the broader impacts of the reform for canton-level outcomes by comparing cantons that had a higher share of land reorganized into cooperatives relative to those that had a lower share.

7.1. Household Survey Results: Income and Income Distribution

Using data from household surveys for El Salvador from 2002-2013, I examine whether cooperative members have higher incomes and more compressed income distributions compared to workers in *haciendas*. Table 12 presents the estimated differences in income levels and income distributions. Columns (1) and (2) report the results for household income per capita in dollars per month for cooperative and *hacienda* workers. All regressions include survey round fixed effects. Column (1) reports the results limiting the sample to properties within 300 ha of the reform threshold while column (2) limits the sample of properties to those within 150 ha of the reform threshold. Cooperative workers report having approximately $55 per month more in household income compared to *hacienda* workers, suggesting that members of reform cooperatives earn higher incomes per month than *hacienda* workers.

Second, the theoretical framework presented in Section 3 suggests that there may be incentives to redistribute earnings in cooperatives. Therefore, I use the household survey data to examine whether cooperatives members have more equal income distributions relative to the income distributions for current employees of *haciendas*. To construct measures of the income distributions to examine (i), I limit the sample to cooperatives and *haciendas* for which there are at least five members represented in the household surveys. To measure inequality, I examine the inter-quartile range in the income distributions. Columns (3) and (4) of Table 12 show that the inter-quartile range of cooperatives is approximately $37 per month lower than the inter-quartile range of worker incomes for *hacienda* workers, consistent with cooperatives have more equitable income distributions.

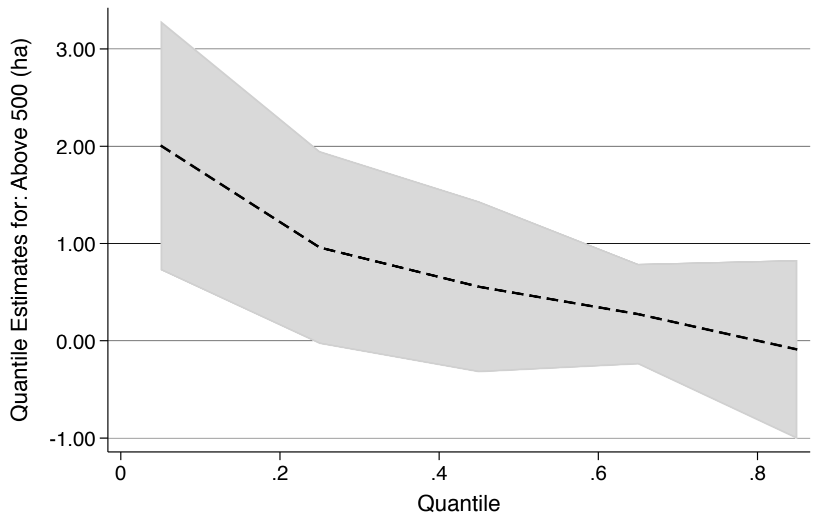
Finally, I use quantile regressions to study how the income premium discussed above for cooperative workers varies across the worker income distribution. If cooperatives redistribute earnings as argued in Section 3, then we might expect that the magnitude of the income earning differential for working in a cooperative to be greater at the bottom of the wage distribution. To perform this analysis, I estimate quantile regressions to estimate the income earnings difference for being a worker in a cooperative at each 10 percent quantile $q \ in \ [0.1, 0.9]$ of the distribution of log monthly incomes for workers. I present the quantile coefficient estimates in Figure 9. The figure shows that the income premium associated with being a worker in a property owned by a landholder in 1980 with over 500 ha in cumulative landholdings declines along the income distribution, and is positive at the lowest quintiles. This suggests that the earnings policies within reform cooperatives seem to help workers at the bottom of the income distribution. These findings that cooperative workers have higher wages and more equitable income distributions are consistent with recent evidence from Burdín (2016), who compares labor-managed firms to outside-owned firms in Uruguay. Burdín (2016) also finds that there is a wage premium associated with working in a labor-managed firm and that labor-managed firms have more equitable wage distributions. This growing evidence suggests that cooperative ownership has important equity implications for worker outcomes.

Table 12: Incomes and Income Distribution

	HH Income per capita			
	Levels		*Inter-Quartile Range*	
	(1)	(2)	(3)	(4)
Above 500	55.06**	53.73	-37.06*	-53.06**
	(25.26)	(36.41)	(19.20)	(22.73)
Observations	6,314	2,273	389	147
Properties	389	145	389	147
Clusters	80	28	80	28
Mean Dep. Var.	92.0	96.25	46.19	47.99
Bandwidth	300	150	300	150

Notes: Standard errors clustered at the former owner level reported in parenthesis. *HH Income per capita* measures a household's monthly income per capita in dollars of agricultural workers in the El Salvador Household Surveys (EHPM). *Inter-Quartile Range* measures the difference between the 75th and 25th percentile in reported household income per capita. *Above 500* is an indicator variable equal to 1 if the former owner of the property had over 500 ha. in cumulative landholdings in 1980. All regressions include survey fixed effects. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Figure 9: Quantile Estimates - Worker Income Levels



Notes: The figure presents the estimated quantile regression discontinuity coefficients where *Above500*, an indicator variable equal to one if the property was owned by a landholder with over 500 ha in cumulative landholdings in 1980, is the independent variable of interest and the log of worker incomes (in dollars per month) from the El Salvador household surveys (EHPM) as the dependent variable. Gray areas represent the 95% confidence intervals. The regressions include survey fixed effects, and control for the age, age squared and sex of each worker. The regressions include linear polynomials for the cumulative landholding amount of a properties owner in 1980 estimated separately on each side of the 500 ha threshold within a bandwidth of 150 ha from the reform threshold. Standard errors are clustered at the former owner level.

7.2. *Broader Rural Outcomes: Incomes and Sectoral Employment*

Between 1930 and 1980, the majority of countries in Latin America underwent large land reform programs that sought to reorganize landholdings from large *hacienda* owners to agricultural cooperatives (de Janvry, 1981; Albertus, 2015). There is a large debate on the long run effects of the reforms on industrialization, structural transformation, and whether property right systems implemented by governments may have hindered broader economic growth (Kay, 2002). I utilize the cross-sectional variation in the intensity of the land reform across cantons (shown in Figure A4) to examine the effects of the land reform on canton-level income distributions and sectoral employment.

7.2.1. *Empirical Strategy for Canton-Level Outcomes*

I continue to utilize the discontinuous nature of the reform but modify the empirical strategy from Section 5 so that it can be estimated for outcomes that are measured at the canton-level rather than at the plot-level. Cantons are the lowest administrative unit in El Salvador, equivalent to approximately one village in rural areas. There are over 1,500 cantons in El Salvador.

The intuition for the modified design is that, *conditional* on having at least some large properties (owned by an individual near the cumulative ownership threshold), cantons that happen to have relatively more properties owned by owners with over 500 ha in cumulative landholdings are unlikely to be systematically different from cantons that happen to have relatively fewer properties owned by owners below the reform threshold. Thus, for any given canton, I use the share of properties in a canton that were above the reform threshold rule of 500 ha in cumulative landholdings as a source of variation in the extent of a canton's exposure to the land reform. The empirical specification for canton-level outcomes is as follows:

$$y_{ct} = \alpha + \beta ShareAbove500_c + X_{ct}\Gamma + \epsilon_{ct} \tag{6}$$

where y_{iv} is the outcome of interest for canton c at time t, X_{ct} is a vector of controls, and $ShareAbove500_c$ is the total size in ha of properties in 1980 where the owner had over 500 ha in landholding, conditional on the canton c having at least one large property (i.e. a property of size greater than 100 ha). The coefficient of interest is β, the effect on development outcomes comparing cantons that happen to have more properties above the reform threshold to those cantons that had a fewer share of properties above the reform threshold. Figure A4 plots the variable $ShareAbove500_c$ across El Salvador to highlight the spatial distribution of this variable. Note that, unlike equation (3), equation (6) does not provide causal estimates of the reform but instead provides exploratory conditional correlations.

7.2.2. *Sectoral Employment*

Using the 2007 population census of El Salvador, I first examine differences in employment in agriculture and manufacturing in cantons that had differing shares of properties converted to cooperatives as a result of the reform. Table 13 presents the estimates from estimating equation (6) using the share of the population in a canton employed in agriculture, manufacturing, or services as the dependent variable. The results show that cantons that had a larger share of properties above the ownership threshold and subsequently reorganized as cooperatives have a higher share of their population employed in agriculture and a lower share of their population employed in manufacturing.

Table 13: Land Reform and Sectoral Employment

	% in Agriculture	% in Manufacturing	% in Services
	(1)	(2)	(3)
ShareAbove500	0.044*	−0.006***	0.001
	(0.024)	(0.002)	(0.001)
Mean Dep. Var.	0.41	0.03	0.006
Observations	645	645	645

Notes: Data is from the 2007 Population and Household Census of El Salvador. *% in Agriculture* is the share of the canton's population that reports that their main sector of employment is in agriculture. *% in Manufacturing* is the share of the canton's population that reports that their main sector of employment is in manufacturing. *% in Services* is the share of the canton's population that reports that their main sector of employment is in services. *ShareAbove500* represents the share of land in properties in 1980 where the owner owned over 500 ha. in total landholdings, restricted to ownership amounts within the reported bandwidth around 500. Robust standard errors in parenthesis. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

7.2.3. Incomes and Income Inequality at the Canton Level

I next examine differences in incomes and income distributions comparing cantons that had a higher share of properties above the ownership threshold to cantons with a lower share of properties above the ownership threshold. The 2007 population census does not include measures of income for individuals. For this reason, I construct a canton-level measure of household income per capita in the last month using the household survey data from El Salvador. Table 14 presents the estimates from estimating equation (6) using the average income per capita (in dollars in the last month) in cantons as the dependent variable in column (1) and using the inter-quartile range of household incomes per capita in cantons as the dependent variable in column (2). Cantons with more exposure to the land reform have a more equitable distribution of income (and perhaps lower incomes, though this difference is not statistically significant). These canton-level results are consistent with the property-level estimates, which also suggested that the reorganization of *haciendas* into cooperatives leads to more equitable income distributions, without providing strong evidence that the cooperatives reduce aggregate incomes. The results provide important evidence of the long-run impacts of land reforms on incomes and income distributions.

Table 14: Land Reform and Incomes

	HH Income Per Capita	IQR of Income
	(1)	(2)
ShareAbove500	-11.560	-14.566^{*}
	(8.859)	(7.817)
Survey-Year FEs	Y	Y
Mean Dep. Var.	144.8	111.0
Observations	1,402	1,402

Note: Data is from the 2005 Population and Household Census of El Salvador. *% in Agriculture* is the share of the canton's population that reports that their main sector of employment is in agriculture. *% in Manufacturing* is the share of the canton's population that reports that their main sector of employment is in manufacturing. *% in Services* is the share of the canton's population that reports that their main sector of employment is in services. *ShareAbove500* represents the share of land in properties in 1980 where the owner owned over 500 ha. in total landholdings, restricted to ownership amounts within the reported bandwidth around 500. Robust standard errors in parenthesis. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

8. Conclusion

Property right institutions are of central importance to understanding economic development (Alchian and Demsetz, 1972), particularly because there is considerable heterogeneity in ownership structures across the world (Hansmann, 1996). Economists have developed a rich theoretical literature on the impacts of differences in ownership structure on firm choices. Yet, because of the endogenous nature of choice of property rights, there is limited causal empirical evidence on the impacts of different property rights systems.

This paper address this gap in the literature by presenting causal evidence on the effects of cooperative property rights on agricultural productivity and economic development in the context of the El Salvador land reform program of 1980. I find that the reorganization of properties above the 500 ha cumulative landholding threshold from outside ownership (*haciendas*) into cooperatives following the land reform had two important impacts. First, the reform led to a shift in type of agriculture practiced. Compared to properties that remained as *haciendas*, cooperatives tend to specialize in staple crop production instead of cash crop production. Additionally, relative to *haciendas*, cooperatives are less productive when producing cash crops but more productive when producing staple crops. Second, cooperative property rights have led to higher incomes and more equitable wage distributions for current cooperative members relative to workers on the *haciendas*.

These results suggest that cooperative property rights have changed the patterns of production in agriculture in El Salvador and have increased equity among workers and that there is little evidence of a loss in efficiency. This evidence highlights that it is not the case that one ownership structure clearly dominates the other and demonstrates that ownership structures have important implications for equity and efficiency across industries.

The paper presented in this paper also serves as a starting point to understand the under-studied consequences of similar land reforms that were implemented across Latin America. Many countries in Latin America reorganized *haciendas* into cooperatives and the impacts of these land reforms may be important for understanding Latin America's comparative economic development. The results in this paper also speak to a modern policy question in Central America today, where there has been renewed interest in exploring "cooperative development" in the last few years. In fact, the UN declared the year 2012 as the "International Year of Cooperatives".[51] Thus, understanding the long-run impacts of land reforms that reorganized firms from outside ownership towards cooperatives can provide important evidence on the implications of cooperative property rights on economic development.

[51] For more information on the UN "International Year of Cooperatives", see: http://www.un.org/en/events/coopsyear/

References

Abramitzky, Ran, "The Limits of Equality: Insights from the Israeli Kibbutz," *The Quarterly Journal of Economics*, 2008, *123* (3), 1111–1159.

Adamopoulos, Tasso and Diego Restuccia, "The Size Distribution of Farms and International Productivity Differences," *American Economic Review*, 2014, *104* (6), 1667–1697.

_ **and** _ , "Land Reform and Productivity: A Quantitative Analysis with Micro Data," 2015. University of Toronto Working Paper.

Albertus, Michael, *Autocracy and Redistribution: The Politics of Land Reform*, New York, United States: Cambridge University Press, 2015.

Alchian, Armen A. and Harold Demsetz, "Production, Information Costs, and Economic Organization," *American Economic Review*, 1972, *62* (5), 777–795.

Banerjee, Abhijit V., Paul J. Gertler, and Maitreesh Ghatak, "Empowerment and Efficiency: Tenancy Reform in West Bengal," *Journal of Political Economy*, 2002, *110* (2), 239–280.

Besley, Timothy, "Property Rights and Investment Incentives: Theory and Evidence from Ghana," *The Journal of Political Economy*, 1995, *103* (5), 903–937.

_ **and Robin Burgess**, "Land Reform, Poverty Reduction, and Growth: Evidence from India," *The Quarterly Journal of Economics*, 2000, *115* (2), 389–430.

Bonin, John P., "Work Incentives and Uncertainty on a Collective Farm," *Journal of Comparative Economics*, 1977, *1* (1), 77–97.

_ **and Louis Putterman**, "Incentives and Monitoring in Cooperatives with Labor-Proportionate Sharing Schemes," *Journal of Comparative Economics*, 1993, *17* (1), 663–686.

_ **, Derek Jones, and Louis Putterman**, "Theoretical and Empirical Studies of Producer Cooperatives: Will Ever the Twain Meet?," *Journal of Economic Literature*, 1993, *31* (3), 1290–1320.

Burchardi, Konrad, Selim Gulesci, Benedetta Lerva, and Munshi Sulaiman, "Moral Hazard: Experimental Evidence from Tenancy Contracts," 2017. Working Paper, http://didattica.unibocconi.it/mypage/upload/144315_20170816_115459_MORALHAZARDPAPER.PDF.

Burdín, Gabriel, "Equality Under Threat by the Talented: Evidence from Worker-Managed Firms," *Economic Journal*, 2016, *126* (594), 1372–1403.

_ **and Andrés Dean**, "New Evidence on Wages and Employment in Worker Cooperatives Compared with Capitalist Firms," *Journal of Comparative Economics*, 2009, *37* (4), 517–533.

Calonico, Sebastian, Matias D. Cattaneo, and Rocío Titiunik, "Robust Data-Driven Inference in the Regression-Discontinuity Design," *Stata Journal*, 2014, *14* (4), 909–946.

_ **,** _ **, and** _ , "Robust Nonparametric Confidence Intervals for Regression-Discontinuity Designs," *Econometrica*, 2014, *82* (6), 2295–2326.

_ **,** _ **, Max H. Farell, and Rocío Titiunik**, "rdrobust: Software for Regression Discontinuity Designs," 2017. Working Paper, forthcoming *Stata Journal*.

Carter, Michael, "Identification of the Inverse Relationship between Farm Size and Productivity," *Oxford Economic Papers*, 1984, *36*, 131–145.

Carter, Michael R., "Risk Sharing and Incentives in the Decollectivization of Agriculture," *Oxford Economic Papers*, 1987, *39*, 577–595.

Cattaneo, Matias D., Brigham R. Frandsen, and Rocío Titiunik, "Randomization Inference in the Regression Discontinuity Design: An Application to Party Advantages in the U.S. Senate," *Journal of Causal Inference*, 2015, *3* (1), 1–24.

_ , Rocío Titiunik, and Gonzalo Vasquez-Bare, "Power Calculations for Regression Discontinuity Designs," 2017. Working Paper.

Cohen, Jacob, *Statistical Power Analysis for the Behavioral Sciences*, Saint Louis, US: Elsevier Science, 1988.

Colindres, Eduardo, "La Tenencia de la Tierra en El Salvador," *ECA*, 1976, *31* (335), 465–472.

_ , *Fundamentos Económicos de la Burguesía Salvadoreña*, San Salvador, El Salvador: UCA Editores, 1977.

Craig, Ben and John Pencavel, "The Behavior of Worker Cooperatives: The Plywood Companies of the Pacific Northwest," *American Economic Review*, 1992, *82* (5), 1083–1105.

_ and _ , "Participation and Productivity: A Comparison of Worker Cooperatives and Conventional Firms in the Plywood Industry," *Brookings Papers on Economic Activity: Microeconomics*, 1995, *1* (1), 121–174.

de Janvry, Alain, *The Agrarian Question and Reformism in Latin America*, Baltimore, United States: The Johns Hopkins University Press, 1981.

De Janvry, Alain and Elizabeth Sadoulet, "Optimal Share Contracts with Moral Hazard on Effort and in Output Reporting: Managing the Double Laffer Curve Effect," *Oxford Economic Papers*, 2007, *59*, 253–274.

Delpierre, Matthieu, Catherine Guirkinger, and Jean-Philippe Platteau, "Risk as Impediment to Privatization? The Role of Collective Fields in Extended Agricultural Households," 2016. University of Namur Working Paper.

Domar, Evsey, "The Soviet Collective Farm as a Producer Cooperative," *American Economic Review*, 1958, *56* (4), 734–757.

Fafchamps, Marcel, "Cash Crop Production, Food Price Volatility, and Rural Market Integration in the Third World," *American Journal of Agricultural Economics*, 1992, *74* (1), 90–99.

Field, Erica, "Entitled to Work: Urban Property Rights and Labor Supply in Peru," *The Quarterly Journal of Economics*, 2007, *122* (4), 1561–1602.

Figueroa Aquino, Ana Gloria and Edgar Marroquín Mena, "La Fase II de la Reforma Agraria y la Estructura Oligepólica en el Agro Salvadoreño," 1991. Tesis, Universidad de El Salvador.

Foster, Andrew D. and Mark R. Rosenzweig, "Are There Too Many Farms in the World? Labor-Market Transaction Costs, Machine Capacities and Optimal Farm Size," 2017. NBER Working Paper #23909.

Gafaro, Margarita, "Collective Property Rights and Agriculture," 2015. Working Paper.

Galiani, Sebastian and Ernesto Schargrodsky, "Property Rights for the Poor: Effects of Land Titling," *Journal of Public Economics*, 2010, *94* (9), 700–729.

Gaynor, Martin and Paul Gertler, "Moral Hazard and Risk Spreading in Partnerships," *The RAND Journal of Economics*, 1995, *26* (4), 591–613.

Goldstein, Markus and Christopher Udry, "The Profits of Power: Land Rights and Agricultural Investment in Ghana," *The Journal of Political Economy*, 2008, *116* (6), 981–1022.

Gollin, Douglas, Stephen Parente, and Richard Rogerson, "The Role of Agriculture in Development," *American Economic Review: Papers and Proceedings*, 2002, *92* (2), 160–164.

González, Luis Armando and Luis Ernesto Romano Martínez, "Reforma Agraria y Cooperativismo en El Salvador: Antecedentes y Perspectivas (1970-1996)," *Realidad*, 2000, *68*, 175–206.

Hansmann, Henry, *The Ownership of Enterprise*, Cambridge, US: Harvard University Press, 1996.

Hart, Oliver and John Moore, "The Governance of Exchanges: Members' Cooperative vs. Outside Ownership," *Oxford Review of Economic Policy*, 1996, *12* (4), 53–69.

— **and** — , "Cooperatives vs. Outside Ownership," 1998. NBER Working Paper No. 6421.

Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones, and A. Jarvis, "Very High Resolution Interpolated Climate Surfaces for Global Land Areas," *International Journal of Climatology*, 2005, *25*, 1965–1978.

Holmstrom, Bengt, "Moral Hazard in Teams," *The Bell Journal of Economics*, 1982, *13* (2), 324–340.

Hornbeck, Richard, "Barbed Wire: Property Rights and Agricultural Development," *The Quarterly Journal of Economics*, 2010, *125* (2), 767–810.

Ireland, Norman J. and Peter J. Law, "Efficiency, Incentives, and Individual Labor Supply in the Labor-Managed Firm," *Journal of Comparative Economics*, 1981, *5* (1), 1–23.

— **and** — , "Management Design under Labor Management," *Journal of Comparative Economics*, 1988, *12* (1), 1–23.

Israelseni, L. Dwight, "Collectives, Communes, and Incentives," *Journal of Comparative Economics*, 1980, *4* (2), 99–124.

Junta Revolucionaria de Gobierno, *Ley Basica de la Reforma Agraria*, San Salvador, El Salvador: Publicaciones del Ministerio del Interior, 1980.

Kandel, Eugene and Edward P. Lazear, "Performance Pay and Productivity," *Journal of Political Economy*, 1992, *100* (4), 801–817.

Kay, Cristóbal, "Why East Asia Overtook Latin America: Agrarian Reform, Industrialisation and Development," *Third World Quarterly*, 2002, *23*, 1073–1102.

Kremer, Michael, "Why are Worker Cooperatives So Rare?," 1997. NBER Working Paper No. 6118.

Kung, James Kai-sing, "Transaction Costs and Peasants' Choice of Institutions: Did the Right to Exit Really Solve the Free Rider Problem in Chinese Collective Agriculture?," *Journal of Comparative Economics*, 1993, *17* (1), 485–503.

— , "Egalitarianism, Subsistence Provision, and Work Incentives in China's Agricultural Collectives," *World Development*, 1994, *22* (2), 175–187.

— **and Louis Putternman**, "China's Collectivization Puzzle: A New Resolution," *The Journal of Development Studies*, 1997, *33* (6), 741–763.

Lang, Kevin and Peter-John Gordon, "Partnerships as Insurance Devices: Theory and Evidence," *The RAND Journal of Economics*, 1995, *26* (4), 614–629.

Lehner, Bernhard and Gunther Grill, "Global River Hydrography and Network Routing: Baseline Data and New Approaches to Study the World?s Large River Systems," *Hydrological Processes*, 2013, *27* (15), 2171–2186.

Levin, Jonathan and Steven Tadelis, "Profit Sharing and the Role of Professional Partnerships," *The Quarterly Journal of Economics*, 2005, *120* (1), 131–171.

MacLeod, W. Bentley, "The Role of Exit Costs in the Theory of Cooperative Teams: A Theoretical Perspective," *Journal of Comparative Economics*, 1993, *17* (2), 521–529.

Marroquín Mena, Edgar, *Evaluación Sobre la Reforma Agraria en El Salvador (1980-1987)*, San Salvador, El Salvador: Ciudad Universitaria, 1988.

McCrary, Justin, "Manipulation of the Running Variable in the Regression Discontinuity Design: A Density Test," *Journal of Econometrics*, 2008, *142* (2), 698–714.

Mennen, Tiernan, "Land Reform Revisited: Can Latin America Get It Right and Should It Even Try?," *International Affairs Review: Elliot School of International Affairs at George Washington University*, 2009.

Michalopoulos, Stelios, "The Origins of Ethnolinguistic Diversity," *American Economic Review*, 2012, *102* (4), 1508–39.

Ministerio de Agricultura y Ganadería, *Tercera Evaluación del Proceso de la Reforma Agraria*, San Salvador, El Salvador: Universidad Centroamericana José Simón Cañas, 1983.

— , *Informe Annual Sobre Costos de Producción de Cultivos Agrícolas*, San Salvador, El Salvador: Ministerio de Agricultura y Ganadería, 2005-2015. http://www.mag.gob.sv/direccion-general-de-economia-agropecuaria/estadisticas-agropecuarias/informe-anual-sobre-costos-de-produccion-de-cultivos-agricolas/.

— , *Retrospectiva Mensual de Precios de Productos Agropecuarios*, San Salvador, El Salvador: Ministerio de Agricultura y Ganadería, 2005-2015.

— , *Anuario de Estadísticas Agropecuarias - 2006-2007*, San Salvador, El Salvador: Ministerio de Agricultura y Ganadería, 2007.

— , *Informe Annual Sobre Costos de Producción de Cultivos Agrícolas*, San Salvador, El Salvador: Ministerio de Agricultura y Ganadería, 2007. http://www.mag.gob.sv/direccion-general-de-economia-agropecuaria/estadisticas-agropecuarias/informe-anual-sobre-costos-de-produccion-de-cultivos-agricolas/.

North, Douglass, *Structure and Change in Economic Growth*, New York, United States: W. W. Norton & Company, 1981.

Otsuka, Keijiro, Hiroyuki Chuma, and Yujiro Hayami, "Land and Labor Contracts in Agrarian Economies: Theories and Facts," *Journal of Economic Literature*, 1992, *30* (4), 1965–2018.

Parliament, Claudia, Yacov Tsur, and David Zilberman, "Cooperative Labor Allocation under Uncertainty," *Journal of Comparative Economics*, 1989, *13* (1), 539–552.

Pencavel, John, "Worker Cooperatives and Democratic Governance," in Anna Grandori, ed., *Handbook of Economic Organization*, Northampton, US: Edward Elgar, 2013, pp. 462–480.

_ **and Ben Craig**, "The Empirical Performance of Orthodox Models of the Firm: Conventional Firms and Worker Cooperatives," *Journal of Political Economy*, 1994, *102* (4), 718–744.

_ **, ed.**, *The Economics of Worker Cooperatives*, Northampton, USA: Edward Elgar, 2013.

Prosterman, Roy L. and Jefferey M. Riedinger, *Land Reform and Democratic Development*, Baltimore, USA: John Hopkins University Press, 1987.

Putterman, Louis, "Voluntary Collectivization: A Model of Producers' Institutional Choice," *Journal of Comparative Economics*, 1980, *4* (1), 125–157.

_ , "On Optimality in Collective Institutional Choice," *Journal of Comparative Economics*, 1981, *5* (1), 392–403.

_ , *Peasants, Collectives, and Choice: Economic Thoery and Tanzania's Villages*, Greenwich, US: JAI Press, 1986.

_ , "The Incentive Problem and the Demise of Team Farming in China," *Journal of Development Economics*, 1987, *26* (1), 103–127.

_ , "Agricultural Producer Co-operatives," in Pranab K. Bardhan, ed., *The Economic Theory of Agrarian Institutions*, Oxford, UK: Oxford University Press, 1991, pp. 319–339.

_ **and Gil Skillman**, "The Incentive Effects of Monitoring Under Alternative Compensation Schemes," *International Journal of Industrial Organization*, 1988, *6* (1), 109–119.

Ramankutty, Navin, Jonathan A. Foley, John Norman, and Kevin McSweeney, "The Global Distribution of Cultivable Lands: Current Patterns and Sensitivity to Possible Climate Change," *Global Ecology and Biogeography*, 2002, *11*, 377–392.

Restuccia, Diego, "Resource Allocation and Productivity in Agriculture," 2016. University of Toronto Working Paper.

_ **, Dennis Tao Yang, and Xiaodong Zhu**, "Agriculture and Aggregate Productivity: A Quantitative Cross-country Analysis," *Journal of Monetary Economics*, 2008, *55* (2), 234–250.

Roberts, Kevin W.S., "Voting Over Income Tax Schedules," *Journal of Public Economics*, 1977, *8* (3), 329–340.

Rosenzweig, Mark R. and Christopher Udry, "External Validity in a Stochastic World: Evidence from Low-Income Countries," 2016. Working Paper.

Sadoulet, Elizabeth, "Labor-Service Tenancy Contracts in a Latin American Context," *American Economic Review*, 1992, *82*, 1031–1042.

Seligson, Mitchell A., *Thirty Years of Transformation in the Agrarian Structure of El Salvador'*, San Salvador, El Salvador: Fundacion Dr. Guillermo Manuel Ungo, 1994.

Sen, Amartya K., "Labour Allocation in a Cooperative Enterprise," *The Review of Economic Studies*, 1966, *33* (4), 361–371.

Velis Polío, Rolando Antonio, "La Reforma Agraria de 1980 en El Salvador: Lucha Política, Diseño y Ejecución," *Revista de Humanidades y Ciencias Sociales*, 2012, *3*, 95–120.

Ward, Benjamin, "The Firm in Illyria: Market Syndicalism," *American Economic Review*, 1958, *48* (4), 566–589.

Wise, Michael L., "Agrarian Reform in El Salvador: Process and Progress," 1985. USAID/El Salvador Report No. PNABE547.

World Bank, "El Salvador Country Land Assessment," 2012. World Bank Report Number: 82312-SV.

Appendix for

Cooperative Property Rights and Agricultural Development: Evidence from Land Reform in El Salvador

Eduardo Montero

Harvard University

12 January 2018

Contents

Appendix A. Data Sources and Variable Definitions

A.1. Geographic Data and Variables

- **Elevation:** The elevation data is provided by Lehner and Grill (2013) and available at WWW.HYDROSHEDS.ORG. This data provides elevation information in meters at the 30 arc-second resolution (approximately at the 1 km^2 level near the equator). The elevation measure is constructed using NASAs SRTM satellite images (http://www2.jpl.nasa.gov/srtm/). In this paper, I calculate elevation for each canton as the mean elevation for canton in El Salvador in meters.

- **Precipitation:** Precipitation data is provided by the Global Climate Database created by Hijmans et al. (2005) and available at http://www.worldclim.org/. This data provides monthly average rainfall in millimeters. We calculate the average rainfall for each month for each 20 km by 20 km grid cell and average this over the twelve months to obtain our yearly precipitation measure in millimeters of rainfall per year.

- **Soil Suitability:** Soil suitability is the soil component of the land quality index created by the Atlas of the Biosphere available at http://www.sage.wisc.edu/iamdata/ used in Michalopoulos (2012) and Ramankutty et al. (2002). This data uses soil characteristics (namely soil carbon density and the acidity or alkalinity of soil) and combines them using the best functional form to match known actual cropland area and interpolates this measure to be available for most of the world at the 0.5 degree in latitude by longitude level. (The online appendix in Michalopoulos (2012) provides a detailed description of the functional forms used to create this dataset.) This measure is normalized to be between 0 and 1, where higher values indicate higher soil suitability for agriculture. The Soil Suitability variable used in the paper measures the average soil suitability in each canton in El Salvador to provide a measure of soil suitability that also ranges between 0 and 1, with higher values indicate higher soil suitability for agriculture.

- **Crop Suitability:** Crop suitability refers to the average suitability for rain-fed, low-input crops provided by the FAO's Global Ecological Zones website: http://www.iiasa.ac.at/Research/LUC/GAEZ/index.htm. FAO crop suitability model uses data on elevation, precipitation, soil and slope constraints to construct estimates of crop suitability at the 1 km^2 level for different crops. This measure is normalized to be between 0 and 1, where higher values indicate higher crop suitability and is reported for grid-cells across the world of 5 arc-minutes by 5 arc-minutes (approximately 56 km by 56 km). This paper utilizes the crop suitability measures for coffee, sugar cane, cotton, rice, beans (phaselous beans), and sorghum. I calculate the average value of the suitability for each crop for each canton in El Salvador.

A.2. Census of Agriculture Data and Variables

- **Sugar Cane Yield:** Sugar cane yield is taken from section S07, question S07P24 (*rendimiento*), from the agricultural census and is measured as total amount of sugar cane produced by each producer, in tons, per total land used for sugar cane cultivation, in *manzanas* (mz).

- **Sugar Cane Producer:** Sugar cane producer is taken from section S07, question S07P01, from the agricultural census and is an indicator variable equal to 1 if the any positive amount of the crop was reported as produced in the last year.

- **Sugar Cane Share:** Sugar cane share takes the amount of land in mz used for sugar cane cultivation from section S07, question S07P21, and divides this amount by the total land in the property, question S02P05 in section S02.

- **Coffee Yield:** Coffee yield is taken from section S09, question S09C225MDSC, from the agricultural census and is measured as total amount of coffee produced by each producer, in *quintales* (QQ), per total land used for coffee cultivation, in *manzanas* (mz).

- **Coffee Producer:** Coffee producer is taken from section S09, question S09P01, from the agricultural census and is an indicator variable equal to 1 if the any positive amount of the crop was reported as produced in the last year.

- **Coffee Share:** Coffee share takes the amount of land in mz used for coffee cultivation from section S07, questions S09C225, S09C226, and S09C227, (coffee cultivation at different altitudes) and divides this amount by the total land in the property, question S02P05 in section S02.

- **Maize Yield:** Maize yield is taken from section S03, questions S03P03 and S03P07, from the agricultural census and is measured as total amount of maize produced by each producer, in *quintales*, per total land used for maize cultivation, in *manzanas* (mz).

- **Maize Producer:** Maize producer is taken from section S03, question S03C44, from the agricultural census and is an indicator variable equal to 1 if the any positive amount of the crop was reported as produced in the last year.

- **Maize Share:** Maize share takes the amount of land in mz used for maize cultivation from section S03, question S03P03, and divides this amount by the total land in the property, question S02P05 in section S02.

- **Bean Yield:** Bean yield is taken from section S03, questions S03P19 and S03P20, from the agricultural census and is measured as total amount of bean produced by each producer, in *quintales*, per total land used for bean cultivation, in *manzanas* (mz).

- **Bean Producer:** Bean producer is taken from section S03, question S03C46, from the agricultural census and is an indicator variable equal to 1 if the any positive amount of the crop was reported as produced in the last year.

- **Bean Share:** Maize share takes the amount of land in mz used for bean cultivation from section S03, question S03P19, and divides this amount by the total land in the property, question S02P05 in section S02.

A.3. Land Reform Data and Variables

- **Expropriation and Cooperative Formation:** Data on the reform expropriations comes from the El Salvador Ministry of Agriculture (MAG) and the El Salvador Institute for Agrarian Transformation (ISTA). The Ministerio de Agricultura y Ganadería (1983) report on Phase I of the 1980 land reform contains the list of all the properties expropriated; the canton, municipality and department of the properties; and the name and number of members for the cooperative created in each property. In the analysis in the paper, *Expropriation* is defined as an indicator variable equal to one if the property is reported as an expropriated property in the 1983 MAG report.

- **Landholding in 1980 for Properties Over 100 ha:** There was no single source with the universe of landholdings before the reform for all of El Salvador. However, ISTA provided me with records on the total landholdings in 1980 for owners of expropriated properties, and Figueroa Aquino and Marroquín Mena (1991) provide records on the total landholdings in 1980 for all properties that were owned by landholders with above 100 ha in cumulative landholdings in 1980 that were not expropriated by ISTA.[52] Both these data sets include geographic information on the location of the property (at the canton level), the name of the owner, and, if available, the name of the property.

  Since there could be a concern that the use of two separate sources for the 1980 landholdings may not be ideal as there could be differences in reporting (though this is unlikely since both sources use data originating from the property registry of El Salvador), Colindres (1977) provides a similar list of properties owned by landholders with over 100 ha in cumulative landholdings for 1971 for a subset of districts in El Salvador. In particular, he provides this list for eight of the eighteen districts of El Salvador. I use this data from Colindres (1977) as a check on the pre-reform landholding distribution to ensure that the 1980 landholding data is reliable.

A.4. Household Surveys Data and Variables

- **Household Income per Capita:** This variable measures the household income for a household in the last month in U.S. dollars divided by the number of household members. The variable name is *INGPE* in the *Encuestas de Hogares de Própositos Múltiples* for El Salvador.

- **Household Consumption per Capita:** This variable measures the household consumption for a household in the last month in U.S. dollars divided by the number of household members. The variable name is *GASPER* in the *Encuestas de Hogares de Própositos Múltiples* for El Salvador.

- **Cooperative or Hacienda Member:** I construct measures of whether an individual belongs to a cooperative or hacienda by using variable *R503A* in the *Encuestas de Hogares de Própositos Múltiples* for El Salvador. A cooperative member reports a value equal to 4 for this question, while an hacienda laborer (*colono*) reports a value of 3 for this question. The size of the establishment in terms of number of other workers is taken from question *R420* and the geographic location of an individual is the canton (*R004*), municipality (*R005*), and the department (*R006*) for each individual.[53]

- **Demographic Variables:** For each individual, the household surveys includes a person's age (*R106*), gender (*R104*), literacy status (*R202A*), years of education (*APROBA1*), and educational attainment (*NIVAPROB*) from the *Encuestas de Hogares de Própositos Múltiples* for El Salvador.

[52]ISTA also provided the list of all *derechos de reservas*/reserve rights that were granted to former owners. Former owners were allowed to negotiate with ISTA to keep up to 100 or 150 ha of their land as a "reserve right" depending on the class of land (Class I-IV and Class V-VII land respectively). Owners had to apply within 12 months of the land reform passage to ISTA, who were given final authority to arbitrate and grant reserve rights. Reserve rights could be increased by twenty percent if the owner could show that they had properly maintained the property since the passage of the reform or otherwise improved the property, a move intended to discourage decapitalization (Wise, 1985). Approximately half of the owners applied for reserve rights, and ISTA granted these rights to 156 former owners and subtracted the value from the bond payments. Owners who did not apply received the full value of the bonds (Wise, 1985).

[53]I use the name of the establishment, question *R418-R419*, to confirm my matching to cooperatives and haciendas in household surveys for which these questions were included in the dataset.

A.5. Population Census Data and Variables

- **Geographic Variables:** The Population Census of El Salvador (2007) reports the geographic location of an individual. Specifically, it reports the canton (*CANID*), municipality (*MUNID*), and the department (*DEPID*) for each individual. Additionally, the census reports the census neighborhood (*Segmento Censal*, *SEGID*) for each individual.[54]

- **Basic Demographic Variables:** The Population Census of El Salvador (2007) includes a person's age (*S06P03A*), gender (*S06P02*), ethnicity (*S06P06A*), literacy status (*S06P09*), years of education (*S06P11A*), and educational attainment (*S06P11B*) for each individual.

- **Occupation Variables:** The Population Census of El Salvador (2007) includes a person's main occupation sector (*S06P20*) and occupation work type (*S06P21*) for each individual that reports employment in El Salvador.

- **Migration Variables:** The Population Census of El Salvador (2007) reports an indicator variable equal to 1 if a person lives in the same canton as his/her birth canton (*S06P07A*) and, if not, the municipality (*S06P07B2*) and department (*S06P07B3*) of birth for individuals who have moved since their birth and were born in El Salvador.[55]

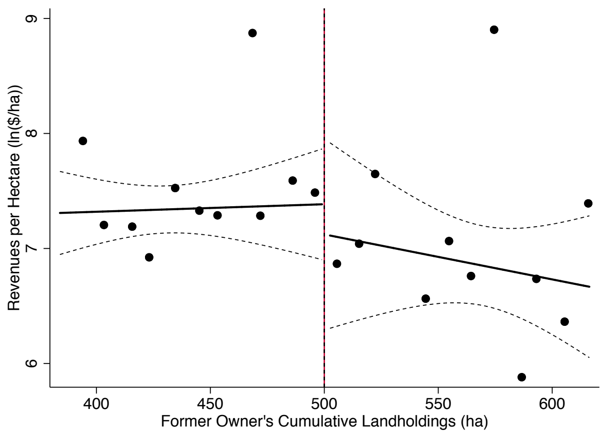
Appendix B. Additional Figures

B.1. RD Plots

[54] I thank Carlos Schmidt-Padilla for generously sharing the shapefiles of the census neighborhoods of El Salvador.

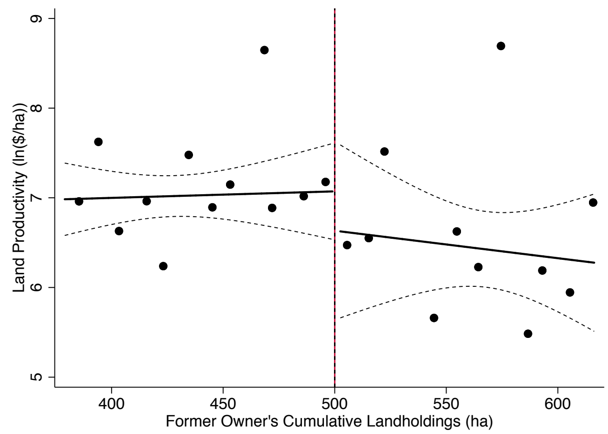
[55] The census data does not include the canton of birth for individuals. This question was asked in the census but the responses were not digitized due to incompleteness and recall problems during enumeration. I thank Carlos Schmidt-Padilla for detailing this issue.

Figure A1: RD Plots - Agricultural Productivity



(a) Revenues per Hectare - ln($/ha)

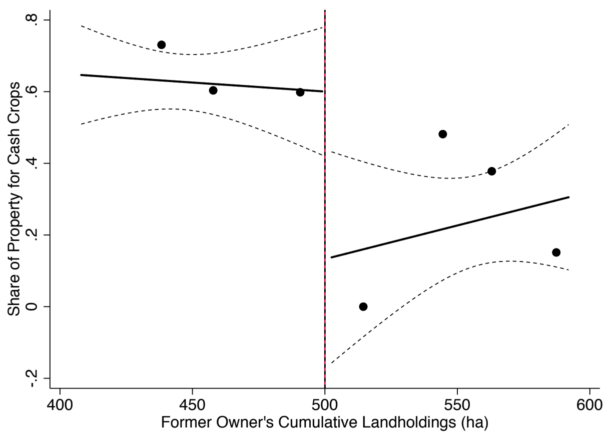
Notes: The figure presents the estimated regression discontinuity plot on aggregate revenues per hectare using the 2007 agricultural census of El Salvador. The points represents the average value of the outcome variable in bins of width of 10 ha. The regressions are estimated using local linear polynomials in the total landholdings of the former owner estimated separately on each side of the reform threshold on the sample within the optimal single-sided MSE bandwidth from Calonico et al. (2017) and use an uniform kernel. Standard errors are clustered at the former owner level. The figure presents the 95% confidence intervals around the estimated plot in dashed lines.



(b) Land Productivity - ln($/Worker)

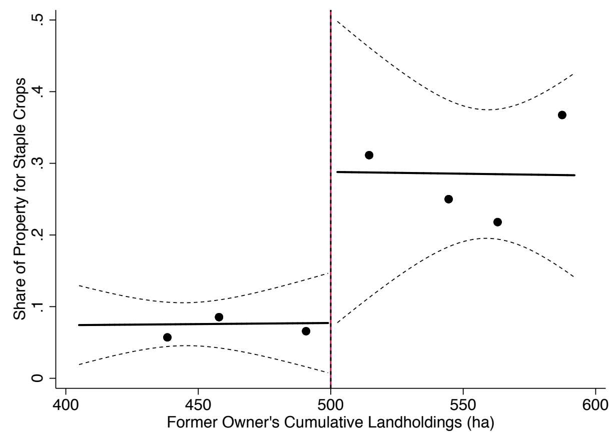
Notes: The figure presents the estimated regression discontinuity plots on aggregate land productivity (revenue net of costs per ha) using the 2007 agricultural census of El Salvador. The points represents the average value of the outcome variable in bins of width of 10 ha. The regressions are estimated using local linear polynomials in the total landholdings of the former owner estimated separately on each side of the reform threshold on the sample within the optimal single-sided MSE bandwidth from Calonico et al. (2017) and use an uniform kernel. Standard errors are clustered at the former owner level. The figure presents the 95% confidence intervals around the estimated plot in dashed lines.

Figure A2: RD Plots - Crop Choices



(a) Share of Property Devoted to Cash Crops

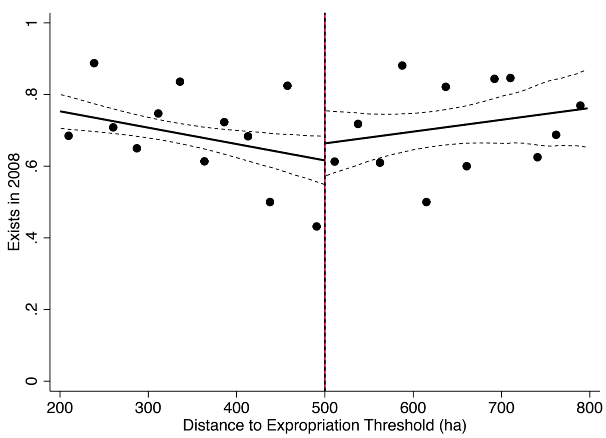
Notes: The figure presents the estimated regression discontinuity plot on the share of land in a property devoted to cash crop production (coffee or sugar cane) using the 2007 agricultural census of El Salvador. The points represents the average value of the outcome variable in bins of width of 25 ha. The regressions are estimated using local linear polynomials in the total landholdings of the former owner estimated separately on each side of the reform threshold on the sample within the optimal single-sided MSE bandwidth from Calonico et al. (2017) and use an uniform kernel. Standard errors are clustered at the former owner level. The figure presents the 95% confidence intervals around the estimated plot in dashed lines.



(b) Share of Property Devoted to Staple Crops

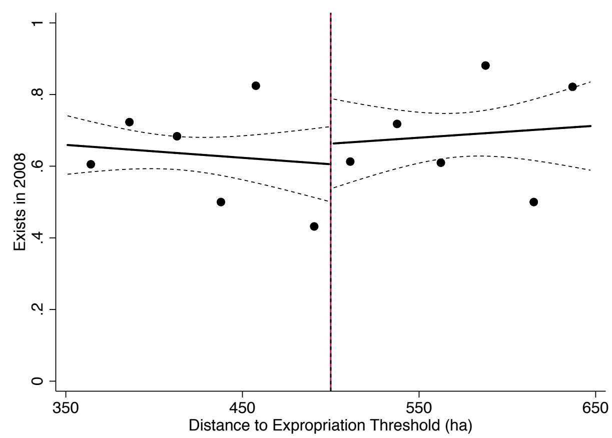
Notes: The figure presents the estimated regression discontinuity plots on the share of land in a property devoted to staple crop production (maize and/or beans) using the 2007 agricultural census of El Salvador. The points represents the average value of the outcome variable in bins of width of 25 ha. The regressions are estimated using local linear polynomials in the total landholdings of the former owner estimated separately on each side of the reform threshold on the sample within the optimal single-sided MSE bandwidth from Calonico et al. (2017) and use an uniform kernel. Standard errors are clustered at the former owner level. The figure presents the 95% confidence intervals around the estimated plot in dashed lines.

Figure A3: RD Plots - Existence in 2007



(a) Exists in 2007 Census

Notes: The figure presents the estimated regression discontinuity plot on an indicator variable equal to 1 if the 1980 property exists in the 2007 census of agriculture of El Salvador. The points represents the average value of the outcome variable in bins of width of 25 ha. The regressions are estimated using local linear polynomials in the total landholdings of the former owner estimated separately on each side of the reform threshold on the sample within a fixed bandwidth of 300 ha and use an uniform kernel. Standard errors are clustered at the former owner level. The figure presents the 95% confidence intervals around the estimated plot in dashed lines.

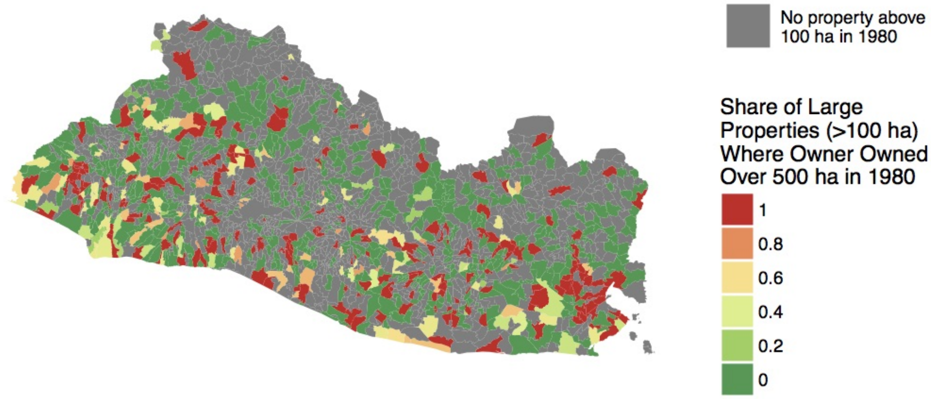


(b) Exists in 2007 Census

Notes: The figure presents the estimated regression discontinuity plot on an indicator variable equal to 1 if the 1980 property exists in the 2007 census of agriculture of El Salvador. The points represents the average value of the outcome variable in bins of width of 25 ha. The regressions are estimated using local linear polynomials in the total landholdings of the former owner estimated separately on each side of the reform threshold on the sample within a fixed bandwidth of 150 ha and use an uniform kernel. Standard errors are clustered at the former owner level. The figure presents the 95% confidence intervals around the estimated plot in dashed lines.

B.2. Additional Maps

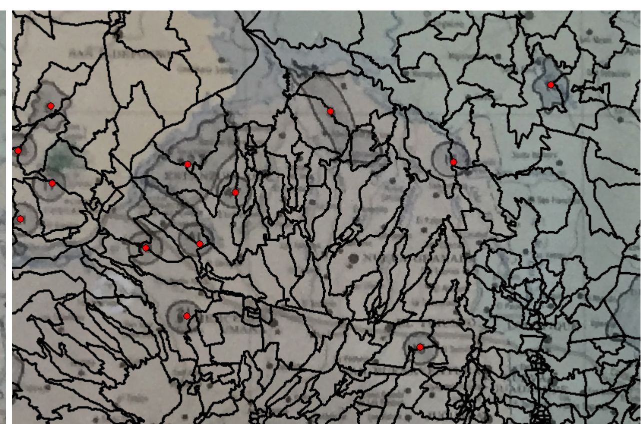
Figure A4: Share of Properties Above Threshold by Canton - El Salvador



Notes: The figure presents the share of large properties (over 100 ha) in a canton that were owned by an owner with over 500 ha in cumulative landholdings in 1980 for cantons in El Salvador.

Figure A5: Measuring Heterogeneity in Cooperatives

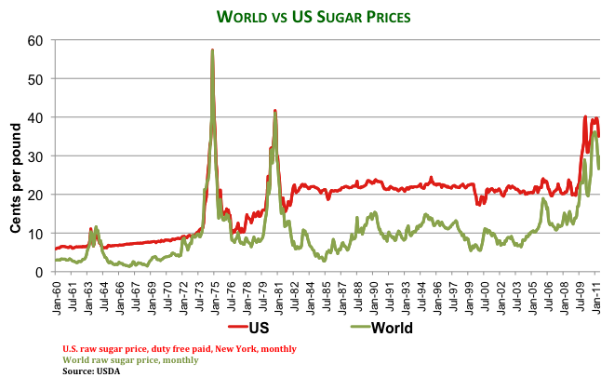
(a) ISTA Map of Reform Properties



(b) Overlaying Census Neighborhoods on ISTA Map of Reform Properties

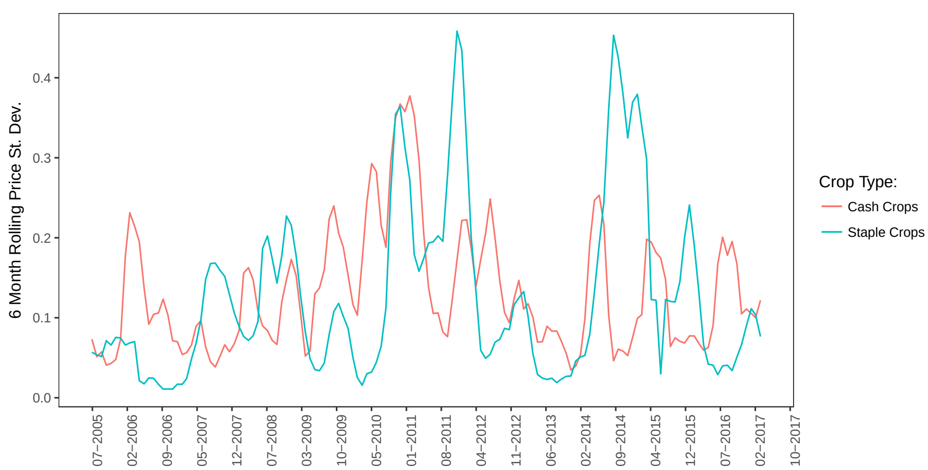
B.3. Crop Price Variation

Figure A6: World Sugar Cane Price by Year



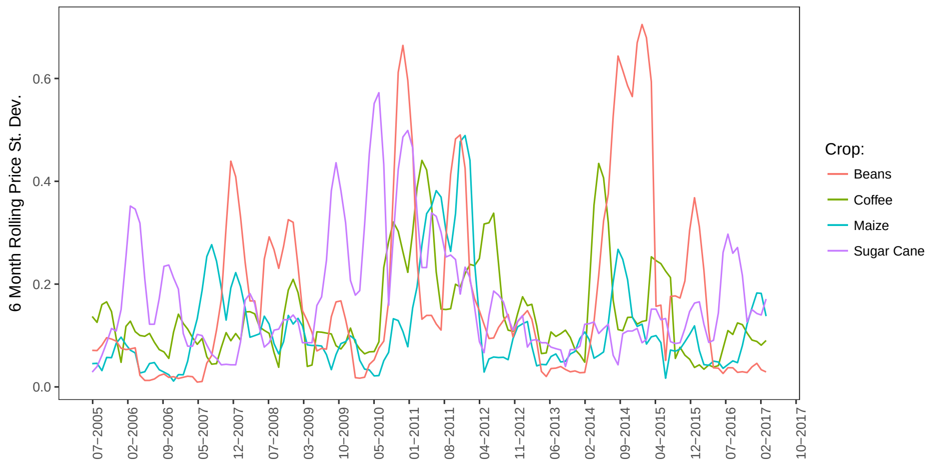
Notes: The figure presents world sugar prices from 1980 to 2016 from the USDA. Source: http://sugarcane.org/internal/images/world-vs-us-sugar-prices/view

Figure A7: 6-Month Rolling Standard Deviation of Prices for Cash Crops and Staple Crops in El Salvador



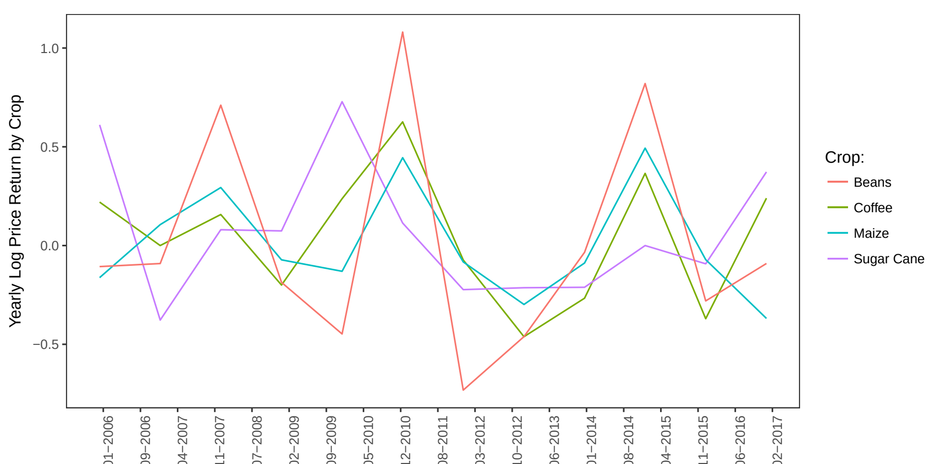
Notes: The figure presents the 6-month rolling standard deviation for cash crop prices (sugar cane and coffee) and staple crop prices (maize and beans) from 2005 to 2015 in El Salvador. The prices are normalized to be equal to 1 at the start of the period (January, 2005) and each portfolio weighs crops equally when calculating the rolling standard deviation. Source for monthly prices in El Salvador: Ministerio de Agricultura y Ganadería (2005-2015b)

Figure A8: 6-Month Rolling Standard Deviation of Crop Prices in El Salvador



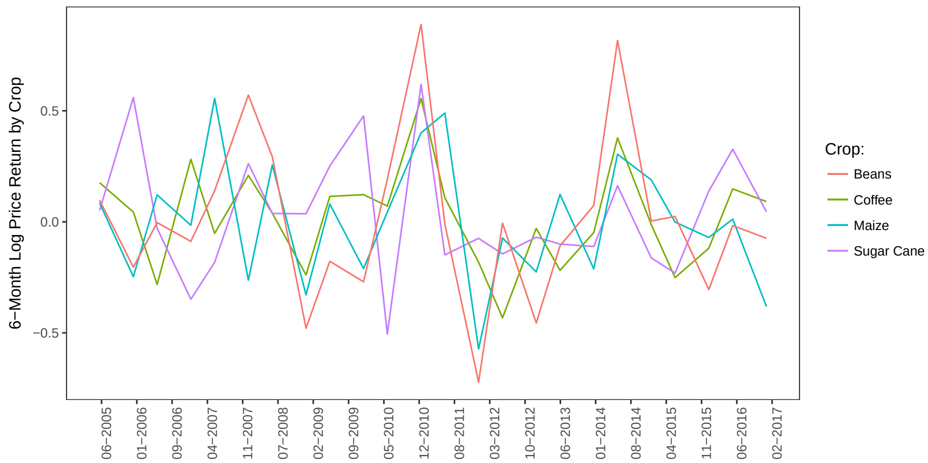
Notes: The figure presents the 6-month rolling standard deviation for sugar cane, coffee, maize, and bean prices from 2005 to 2015 in El Salvador. The prices are normalized to be equal to 1 at the start of the period (January, 2005). Source for monthly prices in El Salvador: Ministerio de Agricultura y Ganadería (2005-2015b)

Figure A9: Yearly Log-Price Return of Crops in El Salvador



Notes: The figure presents the yearly crop return (log price return) for sugar cane, coffee, maize, and bean prices from 2005 to 2015 in El Salvador. Source for monthly prices in El Salvador: Ministerio de Agricultura y Ganadería (2005-2015b)

Figure A10: 6-Month Log-Price Return of Crops in El Salvador



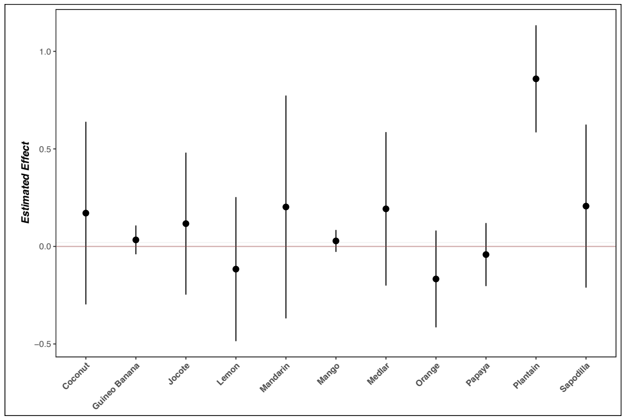
Notes: The figure presents the 6-month crop return (log price return) for sugar cane, coffee, maize, and bean prices from 2005 to 2015 in El Salvador. Source for monthly prices in El Salvador: Ministerio de Agricultura y Ganadería (2005-2015b)

Figure A11: Monthly Log-Price Return of Crops in El Salvador

Notes: The figure presents the monthly crop return (log price return) for sugar cane, coffee, maize, and bean prices from 2005 to 2015 in El Salvador. Source for monthly prices in El Salvador: Ministerio de Agricultura y Ganadería (2005-2015b)

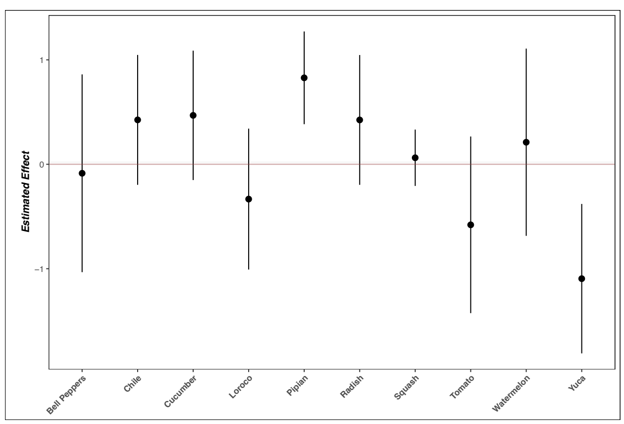
B.4. Additional Plots

Figure A12: Production of Minor Crops - Fruits



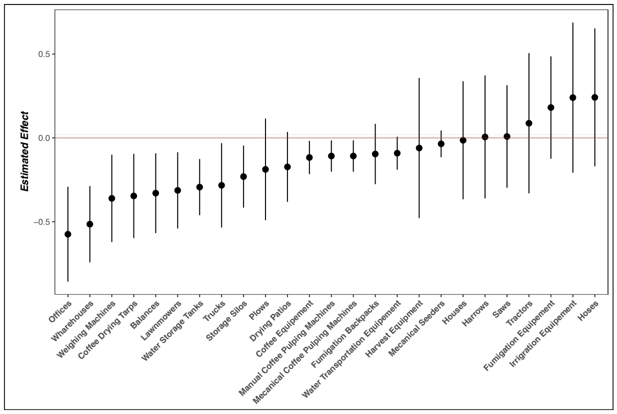
Notes: The figure plots the estimated RD coefficient for a property being owned in 1980 by an owner above the ownership threshold on the probability of using each minor fruit reported in the 2007 Census of Agriculture of El Salvador. The dependent variables are indicator variables equal to 1 if the property produced a positive amount of a given minor fruit.

Figure A13: Production of Minor Crops - Vegetables



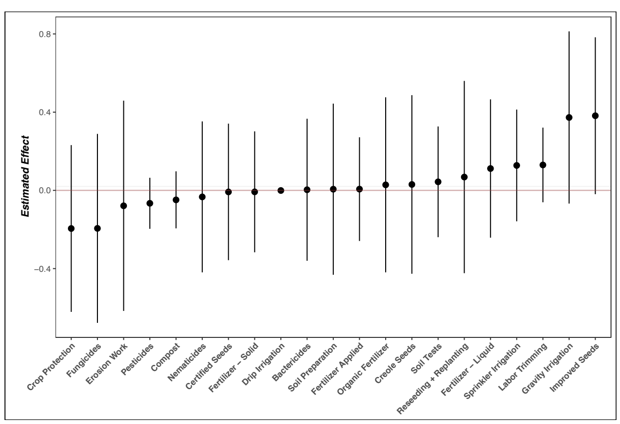
Notes: The figure plots the estimated RD coefficient for a property being owned in 1980 by an owner above the ownership threshold on the probability of using each minor vegetable reported in the 2007 Census of Agriculture of El Salvador. The dependent variables are indicator variables equal to 1 if the property produced a positive amount of a given minor vegetable.

Figure A14: Capital Ownership



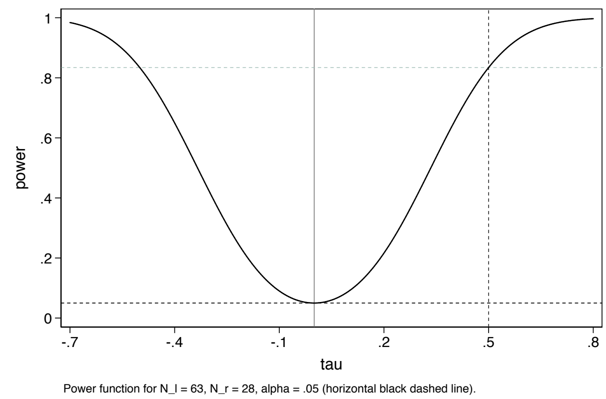
Notes: The figure plots the estimated RD coefficient for a property being owned in 1980 by an owner above the ownership threshold on the probability of owning each type of capital owned included in the 2007 Census of Agriculture of El Salvador. The dependent variables are indicator variables equal to 1 if the property owns a positive amount of each capital type. The census only reports indicators for ownerships but not the quantity owned of each capital type.

Figure A15: Input Use



Notes: The figure plots the estimated RD coefficient for a property being owned in 1980 by an owner above the ownership threshold on the probability of using each type of agricultural input included in the 2007 Census of Agriculture of El Salvador. The dependent variables are indicator variables equal to 1 if the property used a given input type. The census only reports indicators for input use but not the quantity used of each input type.

Figure A16: RD Power Calculations - Revenues per Hectare



Notes: The figure plots the power function for the RD using standardized values of revenues per hectare in the 2007 Census of Agriculture of El Salvador on a property being owned in 1980 by an owner above the ownership threshold. *tau* represents the standardized treatment effect. See Cattaneo et al. (2017) for more details.

B.5. Model Plots

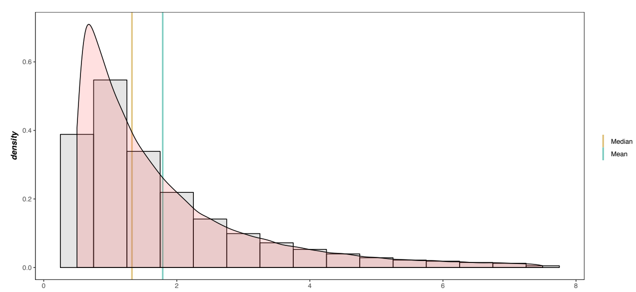
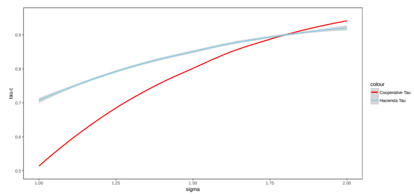


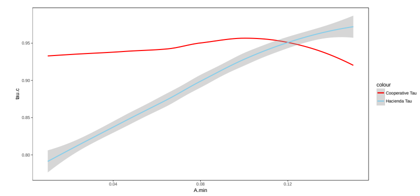
Figure A17: Example of a Skewed Ability Shock Distribution, A

$A \sim Log\mathcal{N}(\mu = 0, \sigma^2 = 1)$ with $A^{min} = \frac{1}{10}$ (i.e. truncated lognormal), meaning $A^m < \bar{A}$.

- **Example**: if $A \sim Log\mathcal{N}(\mu = 0, \sigma^2)$ with $A^{min} > 0$ (i.e. truncated lognormal):
- Difference in wage rates depends on difference between mean and median, σ^2, and amount owner can extract from staple crop production, A^{min}.



Effect of σ on τ_c and τ_h



Effect of A^{min} on τ_c and τ_h

Appendix C. Institutional Details of Cooperative in El Salvador

In this section, I summarize the main institutional details of cooperatives in El Salvador. In particular, I explain the regulations governing the selling of cooperative land, and the main laws passed by the government since the 1980 land reform that may have affected the governance of cooperatives.

Land Transactions in Cooperatives: Initially, the land reform cooperatives were not allowed to sell or rent their land. However, these restrictions were eased in the mid 1990s through the changes to the regulation of cooperatives (*Programa Promoci'on de la Reactivación Econ'omica y Social*). The selling of cooperative land (to non-members) became possible but only through a non-judicial public auction process requiring approved by two thirds of the cooperative members. The auctions require the participation of representatives of the Attorney General and the Ministry of Agriculture, and the sale price cannot be lower than the a reference price as evaluated by a local expert. Finally, the auction has to be open to the public at large through specific notice requirement. The notice of the auction needs to be approved by ISTA, the Ministry of Agriculture, the Attorney General, and unanimously by the cooperative's board. The notice can then to be published in two of the main newspapers at least 7 days before the auction (World Bank, 2012).

Given these regulations and this process, the sale of land non-members is relatively rare. World Bank (2012) reports that there have 78 public auctions between 1997 and 2006 (and two between 2006 and 2012, when the World Bank report was published). The average size of plots successfully auctioned was 68 hectares and the average sale price per hectare was US$8,459 (in 2005 dollars). The majority of the auctions only had one bidder and the sale price in the auction was often much lower than the average sale price for equivalent properties in the municipality (World Bank, 2012).

Government Laws related to Cooperatives: In the mid 1990s, the government passed a series of law aimed at improving the governance of cooperatives through the *Programa Promoci'on de la Reactivación Econ'omica y Social*. In particular, the government felt that the cooperatives struggled with organizational matters (World Bank, 2012). The government provided some assistance to the cooperatives after the reform in the 1980s in the form of technical assistance. However, after the end of the civil war and the change in government, technical assistance to the cooperatives stopped in the early 1990s. Due to the struggles of some cooperatives, in 1996, the government passed some reforms aimed at reducing cooperative debt and eliminating some of the restrictions on land sales (as detailed above). First, the government passed Decree 747 where members of cooperatives could decide if they wanted to retain the cooperative model orto parcel out lots to its members for housing and production (full parcelization as modeled in Section 3). The law also allowed members to sell land through the auction process detailed above (though at first this option was limited in that cooperative land could only be sold, or rented only to landless individuals for a total land area of up to 7 hectares per individual). Second, in 1998, the Government condoned 85% of the debt accrued by land reform beneficiaries (World Bank, 2012).

Appendix D. Robustness Tables: Randomization Inference Approach

Table A1: Robustness to Alternative RD Method - Randomization Inference Approach - Crop Choices Productivity

	Cash Crop Share			Staple Crop Share		
	(1)	(2)	(3)	(4)	(5)	(6)
Randomization Estimate	-0.527	-0.539	-0.523	0.451	0.431	0.401
Randomization P-Value	0.001	0.001	0.001	0.001	0.001	0.001
Observations	89	89	89	89	89	89
Mean Dep. Var.	0.540	0.540	0.540	0.199	0.199	0.199
Right Window	60.20	60.20	60.20	60.20	60.20	60.20
Left Window	-60.20	-60.20	-60.20	-60.20	-60.20	-60.20
Polynomial Degree	0	0	0	0	0	0
Kernel	Uniform	Triangular	Epanechnikov	Uniform	Triangular	Epanechnikov

Notes: Standard errors clustered at the former owner level. *Cash Crop Share* is the share of land in a property devoted to cash crop production (coffee or sugar cane). *Staple Crop Share* is the share of land in a property devoted to staple crop production (maize or beans). *Randomization Estimate* reports the local randomization estimate on *Above 500*, an indicator variable equal to 1 if the former owner of the property had over 500 ha in cumulative landholdings in 1980. Bandwidth window chosen by procedure suggested by Cattaneo et al. (2015) using land suitability as the balance covariate to choose the optimal local randomization inference window. Columns vary the kernel choice for the local randomization estimate. Windows are reported in ha. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table A2: Robustness to Alternative RD Method - Randomization Inference Approach - Land Productivity

	Revenue Per Hectare (ln($/ha))			Land Productivity (ln($/ha))		
	(1)	(2)	(3)	(4)	(5)	(6)
Estimate	-0.338	-0.332	-0.320	-0.523	-0.403	-0.414
Randomization P-Value	0.255	0.376	0.371	0.116	0.361	0.331
Observations	89	89	89	89	89	89
Mean Dep. Var.	7.242	7.242	7.242	6.887	6.887	6.887
Right Window	60.20	60.20	60.20	60.20	60.20	60.20
Left Window	-60.20	-60.20	-60.20	-60.20	-60.20	-60.20
Polynomial Degree	0	0	0	0	0	0
Kernel	Uniform	Triangular	Epanechnikov	Uniform	Triangular	Epanechnikov

Notes: Standard errors clustered at the former owner level. *Revenue per Hectare* is measured as total value in 2007 dollars of all crops produced divided by area in hectares. *Land Productivity* is measured as total value in 2007 dollars of all crops produced net of production costs for each crop divided by area in hectares. *Randomization Estimate* reports the local randomization estimate on *Above 500*, an indicator variable equal to 1 if the former owner of the property had over 500 ha in cumulative landholdings in 1980. Bandwidth window chosen by procedure suggested by Cattaneo et al. (2015) using land suitability as the balance covariate to choose the optimal local randomization inference window. Columns vary the kernel choice for the local randomization estimate. Windows are reported in ha. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Appendix E. Robustness Tables: Varying RD Parameters

Table A3: Robustness to Alternative RD Specifications - Share of Land Devoted to Cash Crops

	Cash Crop Share											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Panel A: Local Polynomial Order 0											
Above 500	-0.538***	-0.381***	-0.576***	-0.358***	-0.364***	-0.336***	-0.538***	-0.381***	-0.576***	-0.358***	-0.364***	-0.336***
	(0.0971)	(0.133)	(0.0932)	(0.0932)	(0.0888)	(0.0945)	(0.0971)	(0.133)	(0.0932)	(0.0932)	(0.0888)	(0.0945)
Bandwidth Type	mserd	mserd	mserd	msetwo	msetwo	msetwo	cerrd	cerrd	cerrd	certwo	certwo	certwo
Kernel	Triangular	Uniform	Epanechnikov	Triangular	Uniform	Epanechnikov	Triangular	Uniform	Epanechnikov	Triangular	Uniform	Epanechnikov
Observations	57	53	38	136	114	120	57	53	38	136	114	120
Clusters	37	34	30	160	123	136	37	34	30	160	123	136
Mean Dep. Var.	0.496	0.477	0.448	0.616	0.596	0.598	0.496	0.477	0.448	0.616	0.596	0.598
Bandwidth	47.38	45.29	40.12	63.41	51.10	56.08	47.38	45.29	40.12	63.41	51.10	56.08
	Panel B: Local Polynomial Order 1											
Above 500	-0.628***	-0.468***	-0.640***	-0.393***	-0.343***	-0.380***	-0.651***	-0.589***	-0.636***	-0.403***	-0.379***	-0.385***
	(0.127)	(0.148)	(0.128)	(0.131)	(0.126)	(0.130)	(0.146)	(0.150)	(0.146)	(0.148)	(0.145)	(0.147)
Bandwidth Type	mserd	mserd	mserd	msetwo	msetwo	msetwo	cerrd	cerrd	cerrd	certwo	certwo	certwo
Kernel	Triangular	Uniform	Epanechnikov	Triangular	Uniform	Epanechnikov	Triangular	Uniform	Epanechnikov	Triangular	Uniform	Epanechnikov
Observations	57	53	38	136	114	120	57	53	38	136	114	120
Clusters	103	103	96	532	530	531	65	65	59	311	314	301
Mean Dep. Var.	0.550	0.550	0.556	0.578	0.579	0.579	0.567	0.567	0.575	0.598	0.600	0.597
Bandwidth	92.56	93.56	88.35	131.4	123.9	133.8	67.19	67.91	64.13	95.39	89.90	97.13
	Panel C: Local Polynomial Order 2											
Above 500	-0.712***	-0.672***	-0.705***	-0.437***	-0.443***	-0.430***	-0.742***	-0.798***	-0.665***	-0.415**	-0.394**	-0.410**
	(0.159)	(0.199)	(0.166)	(0.160)	(0.166)	(0.161)	(0.198)	(0.246)	(0.215)	(0.184)	(0.197)	(0.184)
Bandwidth Type	mserd	mserd	mserd	msetwo	msetwo	msetwo	cerrd	cerrd	cerrd	certwo	certwo	certwo
Kernel	Triangular	Uniform	Epanechnikov	Triangular	Uniform	Epanechnikov	Triangular	Uniform	Epanechnikov	Triangular	Uniform	Epanechnikov
Observations	276	182	237	402	314	402	168	113	155	260	212	257
Clusters	167	111	146	542	536	542	103	70	92	531	523	530
Mean Dep. Var.	0.563	0.535	0.547	0.573	0.576	0.573	0.550	0.572	0.562	0.578	0.583	0.579
Bandwidth	134.6	101.5	124.9	170.5	135.5	171	93.34	70.35	86.57	118.2	93.97	118.5

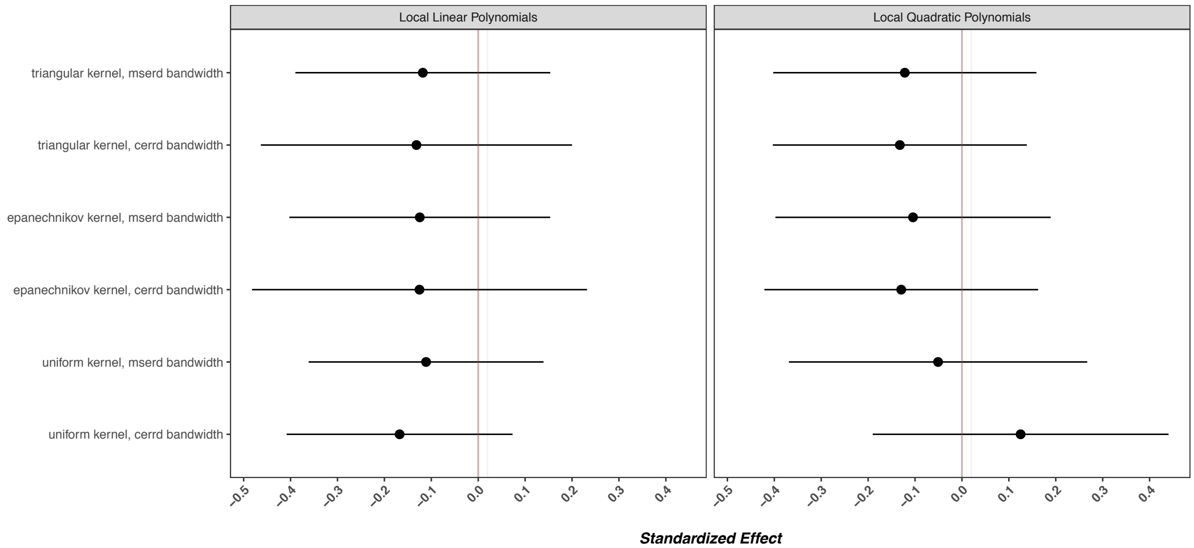
Notes: Standard errors clustered at the former owner level reported in parenthesis. *Cash Crop Share* is the share of land in a property devoted to cash crop production (coffee or sugar cane). *Above 500* is an indicator variable equal to 1 if the former owner of the property had over 500 ha in cumulative landholdings in 1980. Panels vary the local RD polynomial in the total landholdings of the former owner estimated separately on each side of the reform threshold. Bandwidth Type represents the optimal bandwidth selection procedure used for each regression: *mserd* choses one common MSE-optimal bandwidth; *msetwo* choses two different MSE-optimal bandwidths (below and above the cutoff); *cerrd* choses one common CER-optimal bandwidth; and *certwo* twodifferent CER-optimal bandwidths (below and above the cutoff). See Calonico et al. (2017) for more details. Bandwidths are reported in ha. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table A4: Robustness to Alternative RD Specifications - Share of Land Devoted to Staple Crops

	Staple Crop Share											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: Local Polynomial Order 0												
Above 500	0.237***	0.204**	0.237**	0.214***	0.221***	0.210***	0.237***	0.204**	0.237**	0.214***	0.221***	0.210***
	(0.0894)	(0.0861)	(0.0924)	(0.0460)	(0.0417)	(0.0449)	(0.0894)	(0.0861)	(0.0924)	(0.0460)	(0.0417)	(0.0449)
Bandwidth Type	mserd	mserd	mserd	msetwo	msetwo	msetwo	cerrd	cerrd	cerrd	certwo	certwo	certwo
Kernel	Triangular	Uniform	Epanechnikov	Triangular	Uniform	Epanechnikov	Triangular	Uniform	Epanechnikov	Triangular	Uniform	Epanechnikov
Observations	104	90	97	155	132	148	104	90	97	155	132	148
Clusters	66	53	60	304	265	265	66	53	60	304	265	265
Mean Dep. Var.	0.113	0.118	0.116	0.0942	0.0937	0.0952	0.113	0.118	0.116	0.0942	0.0937	0.0952
Bandwidth	74.79	63.73	67.77	77.22	54.96	75.72	74.79	63.73	67.77	77.22	54.96	75.72
Panel B: Local Polynomial Order 1												
Above 500 0.241**	0.211	0.220*	0.203***	0.197***	0.196***	0.289**	0.324**	0.274*	0.211**	0.217***	0.214**	
	(0.121)	(0.147)	(0.122)	(0.0725)	(0.0704)	(0.0710)	(0.139)	(0.147)	(0.142)	(0.0834)	(0.0788)	(0.0833)
Bandwidth Type	mserd	mserd	mserd	msetwo	msetwo	msetwo	cerrd	cerrd	cerrd	certwo	certwo	certwo
Kernel	Triangular	Uniform	Epanechnikov	Triangular	Uniform	Epanechnikov	Triangular	Uniform	Epanechnikov	Triangular	Uniform	Epanechnikov
Observations	295	155	281	315	202	331	180	102	172	215	155	228
Clusters	185	97	174	498	486	499	113	64	107	487	475	488
Mean Dep. Var.	0.114	0.120	0.113	0.0969	0.0921	0.0968	0.133	0.115	0.130	0.0931	0.0875	0.0936
Bandwidth	150.1	96.73	143.4	145.8	95.24	155.4	109.4	70.47	104.5	106.2	69.39	113.2
Panel C: Local Polynomial Order 2												
Above 500	0.372**	0.352**	0.364**	0.213**	0.238**	0.206**	0.476***	0.428**	0.453***	0.216*	0.211*	0.215*
	(0.156)	(0.164)	(0.161)	(0.0957)	(0.0971)	(0.0979)	(0.151)	(0.170)	(0.160)	(0.115)	(0.114)	(0.116)
Bandwidth Type	mserd	mserd	mserd	msetwo	msetwo	msetwo	cerrd	cerrd	cerrd	certwo	certwo	certwo
Kernel	Triangular	Uniform	Epanechnikov	Triangular	Uniform	Epanechnikov	Triangular	Uniform	Epanechnikov	Triangular	Uniform	Epanechnikov
Observations	284	224	270	380	300	384	164	144	155	246	201	252
Clusters	175	139	167	501	494	501	101	88	97	491	486	491
Mean Dep. Var.	0.112	0.122	0.112	0.0985	0.0962	0.0985	0.127	0.109	0.120	0.0952	0.0921	0.0952
Bandwidth	144.8	126.8	139.5	172.6	137.3	176.6	100.8	88.27	97.14	120.2	95.58	123

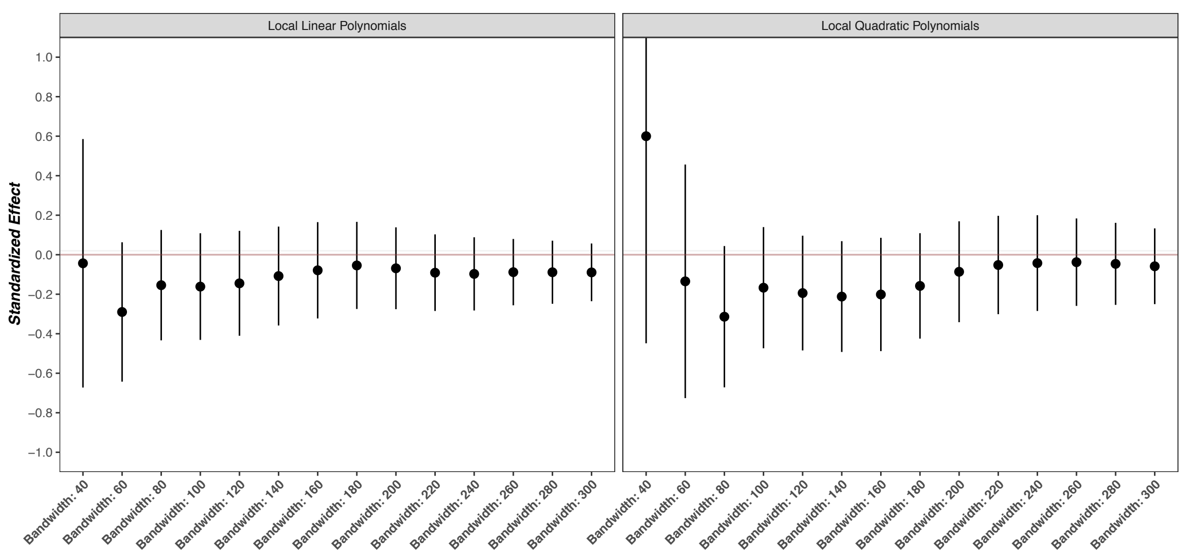
Notes: Standard errors clustered at the former owner level reported in parenthesis. *Staple Crop Share* is the share of land in a property devoted to staple crop production (maize or beans). *Above 500* is an indicator variable equal to 1 if the former owner of the property had over 500 ha in cumulative landholdings in 1980. Panels vary the local RD polynomial in the total landholdings of the former owner estimated separately on each side of the reform threshold. Bandwidth Type represents the optimal bandwidth selection procedure used for each regression: *mserd* choses one common MSE-optimal bandwidth; *msetwo* choses two different MSE-optimal bandwidths (below and above the cutoff); *cerrd* choses one common CER-optimal bandwidth; and *certwo* twodifferent CER-optimal bandwidths (below and above the cutoff). See Calonico et al. (2017) for more details. Bandwidths are reported in ha. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Figure A18: Robustness to Alternative RD Specifications - Revenue per Hectare



Notes: The figure plots the standardized effect size (beta coefficients) and 95% confidence intervals on *Above500* for alternative RD specifications. *Revenue per Hectare* is measured as total value in 2007 dollars of all crops produced divided by area in hectares. *Above 500* is an indicator variable equal to 1 if the former owner of the property had over 500 ha in cumulative landholdings in 1980. Standard errors are clustered at the pre-reform land owner level. Bandwidth Type represents the optimal bandwidth selection procedure used for each regression: *mserd* choses one common MSE-optimal bandwidth; *msetwo* choses two different MSE-optimal bandwidths (below and above the cutoff); *cerrd* choses one common CER-optimal bandwidth; and *certwo* twodifferent CER-optimal bandwidths (below and above the cutoff). See Calonico et al. (2017) for more details.

Figure A19: Robustness to Alternative RD Bandwidths - Revenue per Hectare



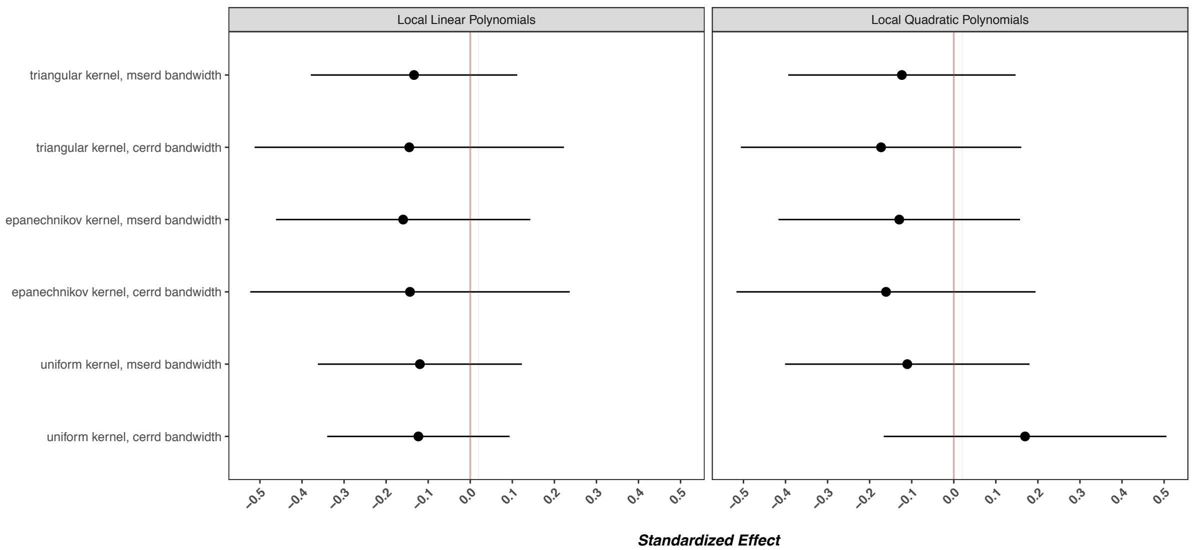
Notes: The figure plots the standardized effect size (beta coefficients) and 95% confidence intervals on *Above500* for alternative RD bandwidths. *Revenue per Hectare* is measured as total value in 2007 dollars of all crops produced divided by area in hectares. *Above 500* is an indicator variable equal to 1 if the former owner of the property had over 500 ha in cumulative landholdings in 1980. Standard errors are clustered at the pre-reform land owner level. Bandwidths are presented on the x-axis in hectares (ha) in increments of 20 ha.

Table A5: Robustness to Alternative RD Specifications - Revenue per Hectare

	Land Productivity *ln($/ha)*											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Panel A: Local Polynomial Order 0											
Above 500	-0.373*	-0.256	-0.390*	-0.490**	-0.546**	-0.514**	-0.373*	-0.256	-0.390*	-0.490**	-0.546**	-0.514**
	(0.223)	(0.263)	(0.211)	(0.209)	(0.222)	(0.210)	(0.223)	(0.263)	(0.211)	(0.209)	(0.222)	(0.210)
Bandwidth Type	mserd	mserd	mserd	msetwo	msetwo	msetwo	cerrd	cerrd	cerrd	certwo	certwo	certwo
Kernel	Triangular	Unifrom	Epanechnikov	Triangular	Unifrom	Epanechnikov	Triangular	Unifrom	Epanechnikov	Triangular	Unifrom	Epanechnikov
Observations	85	42	88	137	99	128	85	42	88	137	99	128
Clusters	54	27	56	122	94	131	54	27	56	122	94	131
Mean Dep. Var.	7.269	7.356	7.282	7.352	7.341	7.356	7.269	7.356	7.282	7.352	7.341	7.356
Bandwidth	68.52	48.72	69.35	86.23	62.73	83.36	68.52	48.72	69.35	86.23	62.73	83.36
	Panel B: Local Polynomial Order 1											
Above 500	-0.313	-0.259	-0.292	-0.439	-0.360	-0.452	-0.303	-0.185	-0.273	-0.486	-0.388	-0.476
	(0.363)	(0.343)	(0.374)	(0.326)	(0.291)	(0.339)	(0.379)	(0.415)	(0.402)	(0.359)	(0.334)	(0.389)
Bandwidth Type	mserd	mserd	mserd	msetwo	msetwo	msetwo	cerrd	cerrd	cerrd	certwo	certwo	certwo
Kernel	Triangular	Unifrom	Epanechnikov	Triangular	Unifrom	Epanechnikov	Triangular	Unifrom	Epanechnikov	Triangular	Unifrom	Epanechnikov
Observations	141	186	141	214	282	206	89	125	89	161	197	149
Clusters	90	119	90	410	399	408	57	79	57	246	250	284
Mean Dep. Var.	7.222	7.263	7.222	7.318	7.329	7.320	7.281	7.235	7.281	7.353	7.339	7.353
Bandwidth	100.6	121.5	100.3	124.6	157.3	115.1	73.89	89.26	73.68	91.52	115.6	84.60
	Panel C: Local Polynomial Order 2											
Above 500	-0.361	-0.240	-0.199	-0.410	-0.481	-0.446	-0.437	0.339	-0.479	-0.483	-0.538	-0.480
	(0.419)	(0.490)	(0.434)	(0.367)	(0.393)	(0.367)	(0.398)	(0.605)	(0.432)	(0.393)	(0.435)	(0.415)
Bandwidth Type	mserd	mserd	mserd	msetwo	msetwo	msetwo	cerrd	cerrd	cerrd	certwo	certwo	certwo
Kernel	Triangular	Unifrom	Epanechnikov	Triangular	Unifrom	Epanechnikov	Triangular	Unifrom	Epanechnikov	Triangular	Unifrom	Epanechnikov
Observations	220	179	266	368	293	371	132	105	161	256	194	257
Clusters	138	116	171	425	417	424	84	69	105	414	409	414
Mean Dep. Var.	7.295	7.249	7.302	7.308	7.316	7.310	7.247	7.305	7.242	7.318	7.316	7.315
Bandwidth	134	117.9	158.8	198	156.5	197.1	94.22	82.91	111.6	139.2	110	138.6

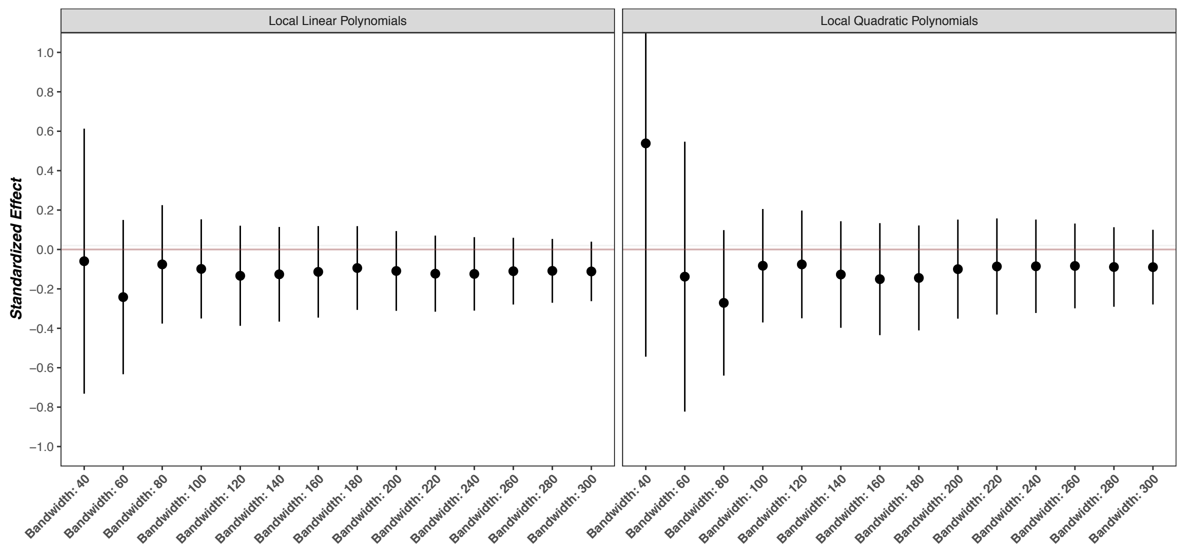
Notes: Standard errors clustered at the former owner level reported in parenthesis. *Land Productivity* is measured as total value in 2007 dollars of all crops produced net of production costs for each crop divided by area in hectares. *Above 500* is an indicator variable equal to 1 if the former owner of the property had over 500 ha in cumulative landholdings in 1980. Panels vary the local RD polynomial in the total landholdings of the former owner estimated separately on each side of the reform threshold. Bandwidth Type represents the optimal bandwidth selection procedure used for each regression: *mserd* choses one common MSE-optimal bandwidth; *msetwo* choses two different MSE-optimal bandwidths (below and above the cutoff); *cerrd* choses one common CER-optimal bandwidth; and *certwo* twodifferent CER-optimal bandwidths (below and above the cutoff). See Calonico et al. (2017) for more details. Bandwidths are reported in ha. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Figure A20: Robustness to Alternative RD Specifications - Land Productivity



Notes: The figure plots the standardized effect size (beta coefficients) and 95% confidence intervals on *Above500* for alternative RD specifications. The dependent variable is *Land Productivity*, measured as the total value in 2007 dollars of all crops produced net of production costs for each crop divided by area in hectares. *Above 500* is an indicator variable equal to 1 if the former owner of the property had over 500 ha in cumulative landholdings in 1980. Standard errors are clustered at the pre-reform land owner level. Bandwidth Type represents the optimal bandwidth selection procedure used for each regression: *mserd* choses one common MSE-optimal bandwidth; *msetwo* choses two different MSE-optimal bandwidths (below and above the cutoff); *cerrd* choses one common CER-optimal bandwidth; and *certwo* twodifferent CER-optimal bandwidths (below and above the cutoff). See Calonico et al. (2017) for more details.

Figure A21: Robustness to Alternative RD Specifications - Land Productivity



Notes: The figure plots the standardized effect size (beta coefficients) and 95% confidence intervals on *Above500* for alternative RD bandwidths. The dependent variable is *Land Productivity*, measured as the total value in 2007 dollars of all crops produced net of production costs for each crop divided by area in hectares. *Above 500* is an indicator variable equal to 1 if the former owner of the property had over 500 ha in cumulative landholdings in 1980. Standard errors are clustered at the pre-reform land owner level. Bandwidths are presented on the x-axis in hectares (ha) in increments of 20 ha.

Table A6: Robustness to Alternative RD Specifications - Land Productivity

	Land Productivity *ln($/ha)*											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Panel A: Local Polynomial Order 0											
Above 500	-0.505*	-0.576*	-0.505*	-0.557**	-0.664**	-0.599**	-0.505*	-0.576*	-0.505*	-0.557**	-0.664**	-0.599**
	(0.280)	(0.350)	(0.282)	(0.259)	(0.259)	(0.261)	(0.280)	(0.350)	(0.282)	(0.259)	(0.259)	(0.261)
Bandwidth Type	mserd	mserd	mserd	msetwo	msetwo	msetwo	cerrd	cerrd	cerrd	certwo	certwo	certwo
Kernel	Triangular	Unifrom	Epanechnikov	Triangular	Unifrom	Epanechnikov	Triangular	Unifrom	Epanechnikov	Triangular	Unifrom	Epanechnikov
Observations	86	55	82	113	94	104	86	55	82	113	94	104
Clusters	56	32	53	75	107	77	56	32	53	75	107	77
Mean Dep. Var.	6.963	7.032	6.949	7.030	7.065	7.033	6.963	7.032	6.949	7.030	7.065	7.033
Bandwidth	70.28	50.16	66.86	84.39	59.54	80.48	70.28	50.16	66.86	84.39	59.54	80.48
	Panel B: Local Polynomial Order 1											
Above 500	-0.317	-0.228	-0.338	-0.581	-0.598	-0.610	-0.248	-0.158	-0.330	-0.482	-0.645	-0.582
	(0.441)	(0.468)	(0.424)	(0.379)	(0.371)	(0.381)	(0.480)	(0.516)	(0.489)	(0.437)	(0.440)	(0.445)
Bandwidth Type	mserd	mserd	mserd	msetwo	msetwo	msetwo	cerrd	cerrd	cerrd	certwo	certwo	certwo
Kernel	Triangular	Unifrom	Epanechnikov	Triangular	Unifrom	Epanechnikov	Triangular	Unifrom	Epanechnikov	Triangular	Unifrom	Epanechnikov
Observations	144	128	172	237	221	238	95	86	114	154	150	162
Clusters	95	84	113	276	320	345	63	56	72	184	200	220
Mean Dep. Var.	6.910	6.965	6.928	7.010	6.986	6.996	6.997	6.963	7.005	7.018	7.030	7.031
Bandwidth	106.8	97.81	117.4	137.5	129.1	137.2	78.58	71.97	86.41	101.2	94.97	101
	Panel C: Local Polynomial Order 2											
Above 500	-0.264	-0.357	-0.226	-0.552	-0.623	-0.589	-0.170	0.588	-0.262	-0.353	-0.434	-0.486
	(0.527)	(0.592)	(0.547)	(0.457)	(0.483)	(0.479)	(0.538)	(0.775)	(0.559)	(0.503)	(0.550)	(0.518)
Bandwidth Type	mserd	mserd	mserd	msetwo	msetwo	msetwo	cerrd	cerrd	cerrd	certwo	certwo	certwo
Kernel	Triangular	Unifrom	Epanechnikov	Triangular	Unifrom	Epanechnikov	Triangular	Unifrom	Epanechnikov	Triangular	Unifrom	Epanechnikov
Observations	181	164	222	335	284	315	116	97	128	232	189	205
Clusters	118	108	141	410	409	409	74	65	84	283	398	400
Mean Dep. Var.	6.932	6.924	6.965	6.983	6.982	6.982	6.986	7.014	6.965	7.010	6.988	6.988
Bandwidth	124.1	114.2	138.1	192.5	159.6	177.7	87.40	80.42	97.24	135.6	112.4	125.2

Notes: Standard errors clustered at the former owner level reported in parenthesis. *Land Productivity* is measured as total value in 2007 dollars of all crops produced net of production costs for each crop divided by area in hectares. *Above 500* is an indicator variable equal to 1 if the former owner of the property had over 500 ha in cumulative landholdings in 1980. Panels vary the local RD polynomial in the total landholdings of the former owner estimated separately on each side of the reform threshold. Bandwidth Type represents the optimal bandwidth selection procedure used for each regression: *mserd* choses one common MSE-optimal bandwidth; *msetwo* choses two different MSE-optimal bandwidths (below and above the cutoff); *cerrd* choses one common CER-optimal bandwidth; and *certwo* twodifferent CER-optimal bandwidths (below and above the cutoff). See Calonico et al. (2017) for more details. Bandwidths are reported in ha. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$