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Land Reform and Productivity: A Quantitative Analysis with Micro Data

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Land Reform and Productivity: A Quantitative Analysis with Micro Data[†]

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Abstract

We assess the effects of a major land-policy change on farm size and agricultural productivity using a quantitative model and micro-level data. We study the 1988 land reform in the Philippines that imposed a ceiling on land holdings and severely restricted the transferability of the redistributed farm lands. We study this reform in the context of an industry model of agriculture with a non-degenerate distribution of farm sizes featuring an occupation decision and a technology choice of farm operators. In this model, a land reform reduces agricultural productivity not only by misallocating resources from large/high productivity farms to incumbent small/low productivity farms, but also by distorting farmers' occupation and technology adoption decisions. The model, calibrated to pre-reform farm-level data in the Philippines, implies that on impact the land reform reduces average farm size by 34% and agricultural productivity by 17%. The government assignment of land and the ban on its transfer are key for the magnitude of the results since a market allocation of the above-ceiling land produces only 1/3 of the size and productivity effects. These results emphasize the potential role of land market efficiency for misallocation and productivity in the agricultural sector.

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1 Introduction

A key challenge in the literature on misallocation and development is to measure quantitatively how specific institutions, frictions, and policies that generate establishment-level (idiosyncratic) distortions affect productivity at the industry level. For the very poor countries in particular understanding how farm-level distortions affect agricultural productivity is an especially pressing issue. This is because the poorest countries are: (a) particularly unproductive in agriculture and devote a lot of resources to it when compared to rich countries, e.g. Restuccia et al. (2008) and (b) on average undertake farming on a much smaller operational scale than rich countries, at least partly the result of farm-size distortions (Adamopoulos and Restuccia, 2014b).

In this paper, we quantify the aggregate effects of a major land policy change on farm size and agricultural productivity using a quantitative model and micro-level data before and after the reform. We study the 1988 land reform in the Philippines, known as the Comprehensive Agrarian Reform Program (CARP). CARP was an extensive land redistribution program that imposed a restrictive ceiling on existing land holdings, channeled a substantial portion of above-ceiling land to landless and smallholders, and severely restricted the transferability of the redistributed farm lands. The period after the reform shows substantial reallocation of farms and land to smaller farm sizes –reflected in a substantial reduction in average farm size of 30%– and a reduction of agricultural productivity of almost 12% between 1989 and 1993. We study this reform in the context of a quantitative model of farm-size in agriculture, featuring an occupation decision and a technology choice of farm operators. The model, calibrated to pre-reform farm data in the Philippines, implies that on impact the land reform reduces average farm size by 34% and agricultural productivity by 17%. The government ban on transfers and intervention in the redistribution of land is key for the magnitude of the results since a market allocation of the above-ceiling land produces only 1/3 of the size and productivity effects. This result emphasizes the potential role of land market efficiency for misallocation and productivity in the agricultural sector.

We combine two sources of micro data on the Philippines to study the size and productivity effects of the land reform: (a) Decennial Agricultural Census Data, which offer a complete enumeration of farms, land and labor inputs at the farm-level in two separate cross sections, before and after the reform; (b) Philippines Cash Cropping Project, a panel of household survey data, which tracks a much more limited number of rural households before and after the reform but offers a wealth of production information on all inputs and outputs at the parcel and farm level. The survey data allow us to construct precise measures of productivity at the farm level. By focusing on farm operators that are present before and after the reform we construct a balanced panel which allows us to assess farm-level changes controlling for farmer ability and location.

Given that the land reform affected the operational scales of large farms that were subjected to the land ceiling, but not those of small farms, as a first pass to studying the effect of the reform, we estimate the difference-in-differences impact of the reform on the affected farms relative to the unaffected farms whose changes are more indicative of sector-specific or economy-wide trends. Our estimates indicate that the land reform had a significant negative impact on the labor productivity and total factor productivity (TFP) of affected farms. These results constitute strong evidence of the negative impact of the land reform on farm-level productivity of affected farms. From a macroeconomic perspective we are also interested in understanding the allocation effects induced by the reform and their implications for aggregate productivity. Whereas in the typical productivity decomposition, reallocation has a substantial positive contribution to growth, we show using our panel data of farms that resource reallocation decreased aggregate productivity. In order to evaluate the aggregate impact of the land reform and separate its effect from other changes over time, we develop a model that allows us to construct counterfactual experiments and assess the importance of the reallocation of land, occupational and technology choice distortions, and land market barriers for aggregate agricultural productivity.

Our quantitative industry model of agriculture builds on Lucas (1978) and Adamopoulos and Restuccia (2014b). Agricultural goods are produced by farmers who are heterogeneous with respect to their ability in managing a farm. In this model, farm-level productivity is drawn from a known distribution. We assume that the productivity of the farmer remains constant over time. As in Lucas (1978), an individual can become a worker (hired labor) or enter the agricultural sector as a farm operator. We extend this theory to allow for a technology adoption choice for the farmer. The farmer chooses between two technologies, a "cash crop" technology and a "food crop" technology, with the key difference being that cash crops are produced on a larger scale. The motivation for this broad technology-choice specification is dictated by our farm survey data. We calibrate the model to the agricultural sector of the Philippine economy before the reform, matching in particular the farm, land, and productivity distributions from the survey data prior to the reform. We discipline the parameters of the technology choice on farm cropping patterns from the farm survey data.

We implement the land reform as a government-mandated land redistribution program, consistent with CARP in the Philippines. The key components of this redistribution program that we account for are: (1) a ceiling; (2) imperfect enforcement (probability ceiling not enforced); (3) redistribution of the farmlands above the effective ceiling to the landless and smallholders; and (4) a government ban on all transfers of the redistributed lands, effectively shutting down the land market. We show that this characterization of the reform resembles not only the spirit of the legislation but also the distributions of farms, land, and labor productivity after the reform. On impact this government-mandated land redistribution reduces average farm size by 34%, agricultural productivity by 17%, and the share of landless individuals in the economy by 20%. Moreover, we find that accounting for the post-reform share of farms above the ceiling implies a fairly weak enforcement of the reform. If the reform was enforced fully, the productivity drop in agriculture would double to 34%. We demonstrate that the land reform reduces agricultural productivity through two channels: (1) by reallocating resources from large high-productivity farms to existing small low-productivity farms–the incumbent reallocation effect, and (2) by altering how farmers sort across occupations and across technologies–the selection effect.

The mode of redistribution is key for the magnitude of the overall size and productivity drops. We compare the results of the Philippine government-mandated land redistribution program to a market-based alternative redistribution, where the market optimally allocates land to clear the land market subject to the ceiling and enforcement constraints. If the above-ceiling farmlands were allocated via a rental market for land, the distribution of farmers and land would be much more compressed mitigating the productivity impact of the reform. In particular, average farm size and aggregate agricultural productivity would drop by 9% and 5% respectively, less than 1/3 of the effects under the government-mandated redistribution. We also examine how farm size and productivity are affected when we combine the land reform with other changes occurring alongside the reform over the same period, such as overall productivity growth in the economy and the adoption of high-yield seed varieties in agriculture. We find that taking these changes into account can mask the negative effects of the land reform. This is especially important in evaluating land reforms since a key property of these reforms is that full implementation takes time.

Our paper is closely related to Adamopoulos and Restuccia (2014b) in integrating the literature on misallocation and productivity (e.g. Restuccia and Rogerson 2008; Restuccia and Rogerson 2013; Guner et al. 2008; and Hsieh and Klenow 2009) into the study of the agricultural productivity gap across countries (e.g. Gollin et al. 2004; Restuccia et al. 2008; Adamopoulos 2011; Lagakos and Waugh 2013; Herrendorf and Schoellman 2013; Gollin et al. 2014b, among many others). We differ from Adamopoulos and Restuccia (2014b) in that we study a specific farm-size distortion (land reform), in a particular context (Philippines), using micro-productivity data. Importantly, in Adamopoulos and Restuccia (2014b) conditional on any type of farm-size distortion, the market efficiently allocates resources, while in this paper the allocation of land is government-mandated. We also differ from Adamopoulos and Restuccia (2014b) in studying the distortionary impact in occupation and technology choices. Our approach uncovers a substantial negative productivity impact of land redistribution on the selection of individuals across occupation and technology choices. In utilizing micro data to motivate model features, calibrate the model, and assess the model's predictions, we relate to a recent literature on macro development using micro data (e.g. Hsieh and Klenow 2009; Udry 2012; Gollin et al. 2014a; Buera et al. 2014).

Land reforms have been a traditional theme in the development economics literature and have been prevalent in developing countries in the second half of the 20th century (see for example, De Janvry 1981; Binswanger-Mkhize et al. 2009). We study the most common type of land reform, a ceiling on land holdings, with redistribution of above-ceiling land. While the primary goal of land reforms is to improve the welfare of the rural poor (reduce poverty, promote equity, secure nutrition etc.) there has been a large literature in development economics arguing in favor of land reform programs also on efficiency grounds. This view is rooted in the ample empirical evidence documenting an inverse relationship between farm size and land productivity (see for example, Berry and Cline 1979; Carter 1984; Cornia 1985; and Banerjee 1999, for a review and discussion of this literature).

Despite the vast literature on land reforms and their prevalence in developing countries, the empirical work studying the effects of land reforms on agricultural productivity or other key variables has been limited. One of the challenges in assessing the impact of land reforms is to disentangle the effect of the reform from other concurrent economic or policy changes. To identify the impact of land reforms the empirical literature has tried to find an exogenous source of variation in policy. For this reason much of the existing empirical work has focused on India, exploiting the cross-state variation in the amount and timing of land reform legislation (Besley and Burgess 2000; Ghatak and Roy 2007), the cross-district variation in implementation of land reform legislation within states (Banerjee et al. 2002), as well as farm-level data across villages (Bardhan and Mookherjee 2007). Complementing this literature, our approach is to use a quantitative model and micro-level data to disentangle the effects of the land reform legislation per se, from: (a) the degree of implementation, (b) the functioning of the land market, and (c) other changes occurring in the economy in parallel to the implementation of the reform. Our approach also allows us to assess the different mechanisms through which reforms operate on key variables.

In terms of agricultural productivity, the empirical literature finds mixed results, partly due to the differences in the types of reforms studied. Ghatak and Roy (2007) show that land ceilings had a significant negative effect on agricultural productivity in India. Differently, tenancy reforms had a positive effect on productivity in West Bengal where reforms were implemented more rigorously (Ghatak and Roy 2007; Banerjee et al. 2002; Bardhan and Mookherjee 2007). Mendola and Simtowe (2014) find that decentralized market-assisted land redistribution raised agricultural yields in Malawi, while Lahiff and Li (2012) find no such evidence in South Africa. Consistent with Ghatak and Roy

(2007) but using instead farm-level data and a quantitative model, we find that ceiling reforms have a negative effect on agricultural productivity. A key insight of our analysis is that the functioning or restrictiveness of the land market is important for the magnitude of the effects of the ceiling on size and productivity. The idea that impediments to the functioning of land markets can raise the costs associated with implementing land reforms is echoed in Deininger and Feder (2001) and Lipton (2009).

Our focus is on the aggregate productivity effects of land reforms through distortions to the operational scale of farms rather than the land ownership distribution. While government-led land redistribution constitutes an intervention in the distribution of land ownership, when accompanied by restrictions in land markets, it is effectively an intervention in the operational size distribution. As a result our analysis is separate, but complementary to the literature that studies the effect of inequality in land ownership on long-run economic growth, through its effect on the institutions and policies adopted (Sokoloff and Engerman 2000; Adamopoulos 2008; Galor et al. 2009).

The paper proceeds as follows. The next section documents some land reforms and describes the details of the Philippine land reform. In Section 3 we present a set of facts and empirical estimates from the land reform in the Philippines both using aggregate Census and Industry data as well as micro panel data from a sample of farmers. Section 4 describes the model. In Section 5 we calibrate the model to the Philippines before the land reform and perform quantitative experiments of land reforms and other aggregate factors. We conclude in Section 6.

2 Land Reforms

In Table 1 we have compiled a set of land reforms capping farm size that have been implemented since the 1950s for countries for which we were able to obtain data. The middle column indicates the period of the land reform. The column to the right provides the explicit legislated ceiling imposed by the reform. This ceiling per se might not be a good description of how restrictive or binding the reform was, as these countries differ in their pre-reform average farm size. One way to measure the restrictiveness of the reform is to look at the ratio of the ceiling to the pre-reform average farm

Table 1: Some Land Reforms

Country	Change in AFS (%)	Land Reform Period	Ceiling on Land Size (Ha)
Bangladesh	-49.1	1984	8
Ethiopia	-44.1	1975	10
India	-25.8	by early 1970s	by province: 4-53
Korea	-21.5	1950	3
Pakistan	-11.5	1972, 1977	61, 40
Sri Lanka	-26.2	1972	10-20
Philippines	-29.6	1988	5

size. This restrictiveness ratio varies substantially across reforms: e.g. 1.75 in the Philippines, 9 in Bangladesh, 18 in Sri Lanka. It should be noted that these reforms can vary not only in the set of accompanying institutional changes (e.g., operation of factor markets), but also in the degree of enforcement. In the first column, we calculate the change in average farm size before and after the reform using census data from the World Census of Agriculture (and where such data are absent from the respective national agricultural censuses).[1] It is particularly striking that in all these cases average farm size dropped following the reform, since the tendency is for average farm size to increase over time as a country goes through the process of structural transformation and individuals move out of agriculture.[2]

Philippine Land Reform

It is difficult to draw general conclusions about the productivity effects of land reforms from the information in Table 1 given that such reforms differ in a variety of dimensions. Instead of examining a number of land reforms, our approach in this paper is to quantitatively assess the effects of a particular land reform by focusing on the institutional detail of that reform and using detailed micro data. We study the 1988 land reform in the Philippines, known as the Comprehensive Agrarian Reform Program (CARP). Its enabling law was the Comprehensive Agrarian Reform Law (CARL) or Republic

[1] *World Census of Agriculture*, Food and Agricultural Organization (FAO) of the United Nations. The World Census of Agriculture collects data on the number of agricultural holdings and land area in holdings classified by size in hectares.

[2] That average farm size increases over time is strongly supported by the data, for example by examining the trends in average farm size of today's developed economies: in the United States, average farm size increased almost 4-fold over 1880 - 1997 and in Canada more than 7-fold over 1871 - 2006.

Act (RA) 6657. The objective of the law was to give land to the tiller and deliver a more equitable distribution of land (DAR 2006). To achieve these objectives, the reform imposed a ceiling on all agricultural holdings and redistributed the land in excess of the ceiling. The retention limit was 5 hectares for any landowner with farm size above this limit. Landowners above the ceiling could award up to 3 hectares of land to a child as long as the child was at least 15 years of age at the time the law was enacted and was actually working the land. For a beneficiary of the land reform (recipient of land) the maximum permitted size was 3 hectares (Saulo-Adriano 1991). To qualify as a beneficiary a farmer had to be landless or a smallholder and be willing to cultivate the land.

In terms of its scope the reform was extensive and comprehensive. It targeted all agricultural lands, private and public, covered all crops, and all tenurial arrangements. This target involved 80% of the country's total farm land. The reform was to be completed within 10 years. However, for a number of reasons this was not possible and CARP's time frame was extended, and in fact is still being implemented today. However, about 80% of the targeted land had been redistributed by the mid 2000s. Land acquisition took place on a compulsory and voluntary basis (sale of excess land to government or beneficiary directly) at fair market value. The government heavily subsidized the reform by covering land transfer fees and titling costs, and by providing a credit subsidy to beneficiaries. A characteristic of this reform was that it restricted the transferability of the redistributed lands. In particular, the law precluded the sale, transfer, lease or donation of the redistributed land except to an heir or the government for the first 10 years after the land had been awarded to a beneficiary (failing to do so would lead the government to reclaim the land and disqualify the beneficiary from the reform). After the 10 years, the land could be transferred provided it had been fully paid off and the transferee did not own more than 5 hectares of agricultural land. But even then, the law provided that preference be given to those cultivating the land or the government (Section 27, RA 6657).

It is natural to ask, did the land reform completely eliminate farms, as operational units, above 5 hectares? The answer is no, for two reasons. First, because operational unit and owned land were not perfectly correlated. For example, if a large landowner had two children above the age of 15 working the farm, under CARP the landowner would have been able to retain 5 hectares and award his children 3 hectares each of ownership. If these lands were pooled together into one farm under single management in the agricultural census it would appear as an 11 hectare farm. If in addition, the spouse separately owned land, another 5 hectares could be added to the farm bringing the operational farm unit to 16 hectares. Second, while the law was strict in terms of the retention limits and the restrictions on the transferability of the land, in practice, enforceability was not perfect. In some cases landowners refused to accept the land valuation determined by the government and challenged it in court, delaying the awarding of the lands to beneficiaries. There are also accounts of reform evasion, whereby landowners voluntarily "sold" land to relatives, or awarded land to their children that were either minors at the time of the reform or were not working the land (Borras 2003). Further, the cost of CARP became so high that the government funds allocated to the reform run out a few times, which also delayed the full implementation of the reform.

There are a few reasons why we study the land reform in the Philippines. First, as mentioned above it was an extensive and comprehensive reform. Second, it was a "successful" reform, as the majority of the targeted lands had been redistributed in the first 15 years. Third, the reform was restrictive. From the countries that we were able to obtain data for in Table 1 it was the most restrictive, with a restrictiveness ratio of 1.75. Finally, it is a relatively recent reform, and as a result good data exists before and after the reform.

3 Data Analysis

To study the effects of the Philippine land reform on farm size and productivity we use aggregate and micro-level data. The aggregate sectoral data allow us to observe what has happened to farm size and agricultural productivity for Philippine agriculture as a whole. The micro-level data allow us to conduct a deeper investigation of the sources of the changes in farm size and productivity.

We use two sources of micro-level farm data for the Philippines: (a) the decennial agricultural censuses and (b) the Philippines Cash Cropping Project. The decennial agricultural censuses are undertaken by the National Statistics Office (NSO) of the Republic of the Philippines (we use the 1981 and 2002

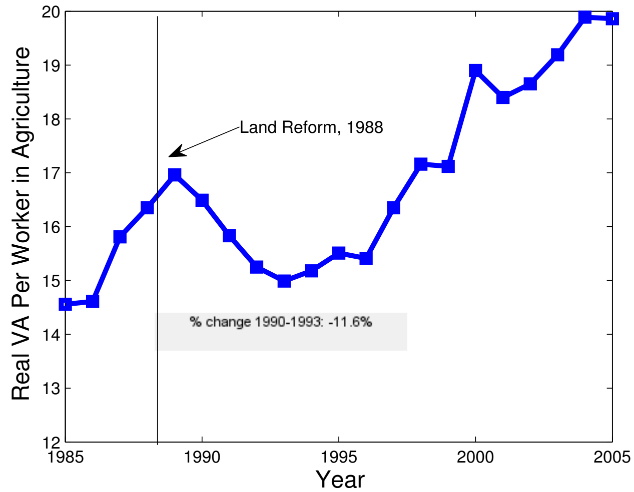

Figure 1: Agricultural Labor Productivity

Census of Agriculture) and provide a complete enumeration of farms covering the entire country. Even though the census data is comprehensive, it does not provide information on outputs or other inputs (besides land and hired labor) at the farm level. In order to calculate productivity with precision at the farm-level we use more detailed survey data. In particular, we use household survey data from the International Food Policy Research Institute (IFPRI), known as the Philippines Cash Cropping Project (PCCP) which was conducted in the Bukidnon province on the island of Mindanao.[3]

3.1 Agricultural Productivity in the Philippines

Since we are interested in studying the effect of the reform on productivity we first ask, how has overall agricultural labor productivity evolved in the Philippine agricultural sector in the periods before and after the reform? In Figure 1 we plot real agricultural labor productivity over 1985-2005. Agricultural labor productivity is calculated as gross value added in agriculture, fishery, forestry in 1985 constant prices (mil. pesos) over agricultural employment (persons).[4]

[3]Mindanao is the second largest island (after Luzon) in the Philippines, located in the south-east of the country. Bukidnon is the food basket of the island. Compared to Luzon, Mindanao has a more even distribution of rainfall throughout the year, is not on the path of typhoons, and has lower population density.

[4]Gross value added for the entire period, and employment in agriculture from 1990 on are from the Bureau of Agricultural Statistics, Philippines. For the period 1985-1989 employment data are linked using the trend from the ILO, Labor Force Survey, Table 2B.

We also indicate with a vertical line the timing of the legislation of the land reform. In the period following the reform agricultural productivity dropped by as much as 11.6% (over 1989-1993). This drop should be put into perspective as there are other changes that are occurring in the economy besides the land reform. For example, there is general growth: labor productivity in the non-agricultural sector increased 9.3% over 1988-2004 (Groningen Growth and Development Centre, 10-sector database, Philippines). Over a longer horizon, agricultural productivity increases by 17.1% over 1989-2005 and 36.4% over 1985-2005. Thus aggregate data over a longer horizon, may confound the effects of the land reform. Our goal in this paper is to use a quantitative model to disentangle the aggregate effects of the reform from other changes that may be occurring alongside the reform in the Philippines over time.

3.2 Changes in Farm Size — Census Data

In the census data a farm is an operational unit regardless of ownership or legal status. A farm may consist of more than one parcels as long as all are under the same management and use the same means of production. Throughout the paper we focus on the operational scale of farms and not on the ownership structure.

In the last decennial census before the reform (1981) average farm size was 2.85 hectares. By the 2002 census, average farm size had dropped to 2.01 hectares, a drop of 29.6%.[5] This drop in average scale of operation is also evident when examining the farm size distribution in Figure 2, which shows the share of farms within each size category for 1981 and 2002. There has been a noticeable shift in the mass of farms from larger scale farms (2+ hectares) to smaller scale farms (less that 1 hectare) over 1981-2002. The share of farms under 2 hectares increases from 50.9% in 1981 to 68.1% in 2002. This is due to the fact that farms under 1 hectare almost double over the two censuses (from 22.7% to 40.1%).

In Figure 3 we plot the share of farm land operated by farms within each farm size category. While

[5] There is a decennial census in 1991 but given that the land reform had largely not been implemented by that time we look at the next census.

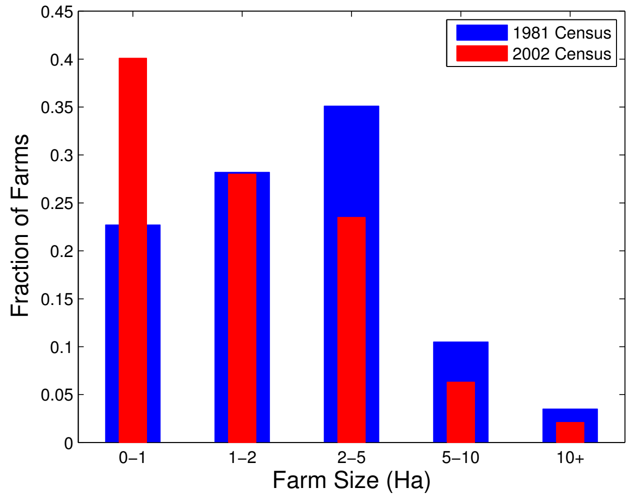

Figure 2: Changes in Farm Size Distribution - Census

it is still the case that large farms account for a disproportionate share of land, the graph indicates a shift in land mass from larger farms (2+ hectares) to smaller farms (0-2 hectares). In 2002 25.5% of land is concentrated in farms under 2 hectares, whereas in 1981 this share was 16%.

3.3 Survey Micro Data

In the PCCP survey data 448 households were interviewed in four rounds over 1984-85 (just before the reform). Then the original households and their children were interviewed again in five rounds (seasons) over 2003-04.[6] Although the number of farms is much more limited than in the census, it tracks the same set of households before and after the reform. The survey offers a wealth of information, with precise and detailed measurement of inputs and outputs at the parcel and farm level.[7]

There are important benefits of using this data for production-unit productivity calculations. First, in contrast to many establishment-level studies that have access only to information on sales and input expenditures by establishment, we observe quantities and prices of outputs and inputs separately at the parcel-level. This allows us to obtain more precise measures of real productivity without having

[6] Bouis and Haddad (1990) contains a detailed description of the project and an analysis of the 1984-85 data.

[7] This survey provides rich data not only on production, but also on consumption and nutrition patterns of households, as the primary purpose of the survey was to study the effect of agricultural commercialization on nutrition.

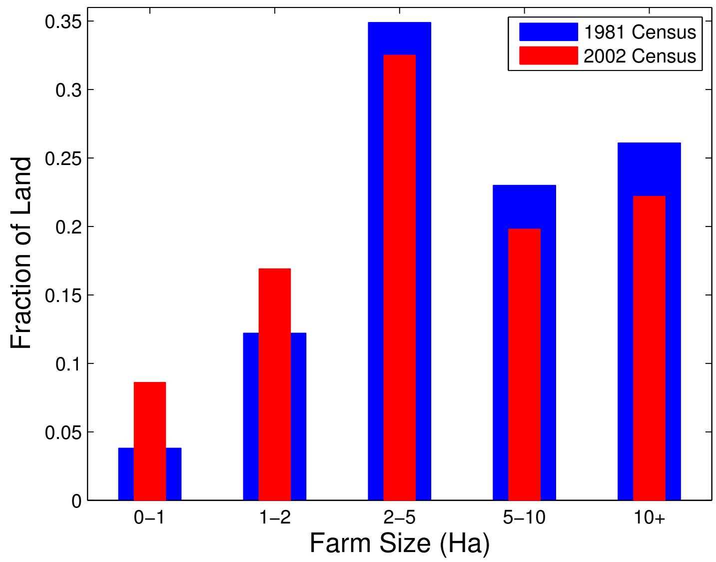

Figure 3: Changes in Land Share by Size - Census

to resort to using industry-level deflators. Second, the unit of observation is at the parcel level with information on which parcels are operated by which households. As a result, we are able to accurately aggregate productivity up to the farm-level. Third, because households are interviewed in four season rounds within a period of two years in 1984-85 and again in five rounds in 2003-04, our measures of output and hence productivity are less subject to seasonal and transitory weather shocks that are important in agriculture. Fourth, because the sample covers a specific region in the Philippines, differences in productivity across farmers are not likely driven by differences in land quality.[8] Moreover, since the data follow the same farmer-location, they inherently control for land quality characteristics of that production unit, when assessing changes in farm-level productivity over time.

In 1984-85, when the first rounds of the survey were conducted, the study area was primarily engaged in corn, rice, and sugarcane production plus some other crops such as bananas, cacao, rubber, coffee, pineapples, coconut. In order to potentially control for crop composition that differs in scale of production, we group crops into two categories based on the purpose of production: 1) Food crops, which include corn and rice, are produced on a semi-subsistence basis by farmers for their own consumption

[8]See also the discussion in Adamopoulos and Restuccia (2014b) and the evidence from GAEZ in Adamopoulos and Restuccia (2014a) on the limited quantitative importance of land quality differences across countries for productivity implications.

and for sale to the market. 2) Cash crops, which include mainly sugarcane and some coffee, coconut, and rubber, are crops for which production is undertaken on a commercial scale for the purpose to sell to the market and/or export. We note that the dominance of sugarcane production as a cash crop was facilitated by the establishment in 1977 of a sugar mill in the area named Bukidnon Sugar Company (BUSCO), which provided farmers with the opportunity to switch from corn and rice to sugarcane production.

To compare productivity across farms and across time (from 1984-85 to 2003-04) we construct constant-price measures of farm productivity such that our real measure of productivity is devoid of differences in prices over time and across farms. We use the average 2003-04 crop and intermediate input prices to calculate value added for all farms. Productivity by farm in 1984-85 is calculated as the weighted average of productivities over the four rounds in that first wave of the survey. Similarly, productivity by farm in 2003-04 is calculated as the weighted average of productivities over the five seasons in this second wave of the survey. We measure real labor productivity as value added at constant 2003-04 prices over the number of full-work days. The total number of work days includes both family labor and hired labor. In order to control for farmer ability and location we only focus on the farms that are present in both 1984-85 and 2003-04. This allows us to construct a two-year balanced panel, with observations for the same set of farms in each year. There are 167 farms with productivity data in both years. We group the cash crop farms and mixed crop farms together because they are similar in their characteristics. Thus it should be clear that the category "cash crop" farms includes both those that produce only cash crops and those that produce cash crops and some food crops. The category "food crops" includes those that produce only food crops.

Table 2 reports summary descriptive statistics from our data. The table reports aggregate changes in farm size and agricultural productivity between the 1984-85 and the 2003-04 rounds as well as the corresponding changes by crop type. We note a shift from food-crop farms to cash-crop farms. Given that the set of farms is the same in each year, this indicates that some farmers switched from producing food crops to cash crops.[9] In 1984-85 cash-crop farms are on average larger (more than

[9] In 1984-85 the mixed crop farms are the biggest component of "cash crop" farms (97 out of 103). By 2003-04 mixed farms still remain the largest component of cash crop farms (76 of 123) but there is a major increase in the number of

double in average farm size) and more productive (almost 3 times more) than food crop farms. Also, average farm size falls for both types of crops while labor productivity increases for both (although these effects are more pronounced for food crop farms). We also note that for all farms, average farm size dropped by 18% while labor productivity increased by 45%. This is consistent with the aggregate data reported earlier. Why this happens is not obvious at first sight since the tendency is for average farm size to increase as productivity rises and labor moves out of agriculture (see for instance Adamopoulos and Restuccia 2014b).

Table 2: Size and Productivity By Crop

	1984-85	2003-04	% change
All Farms			
% of Farms	100	100	–
<5 Ha	77.8	84.4	–
5+ Ha	22.2	15.6	–
Average Farm Size	3.7	3.1	-17.6
Labor Productivity	257.5	372.7	44.7
Cash Crop Farms			
% of Farms	61.7	73.7	–
<5 Ha	42.5	59.3	–
5+ Ha	19.2	14.4	–
Average Farm Size	4.6	3.7	-19.8
Labor Productivity	298.2	386.1	29.5
Food Crop Farms			
% of Farms	38.3	26.3	–
<5 Ha	35.3	25.1	–
5+ Ha	3.0	1.2	–
Average Farm Size	2.1	1.3	-39.0
Labor Productivity	101.2	201.0	98.7

Notes: Average farm size is calculated as the ratio of total land in farms within each crop category over the total number of farms in that category. Labor productivity is calculated as the total value added in constant 2003-04 input and output prices over total workdays.

We also note that as expected, the land reform produced a shift from large scale farms to small scale farms, with the share of farms less than 5 hectares increasing from 77.8% in the 1984-85 rounds to

pure cash crop farms.

84.4% in the 2003-04 rounds. This shift to smaller scale farms occurred for both types of crops. The shift to smaller scale production occurs even though there is an overall switch from food crops (smaller scale) to cash crops (larger scale). This shift to cash crops indicates the presence of an aggregate trend in the economy in addition to the land reform.

As discussed earlier from the census data, the number of farms over 5 hectares is not eliminated with the land reform. In our panel for the 2003-04 rounds, there are 15.6% of farms operating more than 5 hectares. As described previously, the fact that there are farms whose operational scale is larger than the maximum ownership restricted by law may be a reflection of the enforcement of the law and/or the fact that ownership can be divided among several family members. Whatever the reason, what matters for our analysis is whether operational scales were effectively altered by the land reform.

We use the PCCP survey data, before and after the reform, in order to assess the extent to which the land reform affected productivity. As a first pass, we do so empirically using two complementary approaches. First, we study the impact of the land reform on farm-level productivity using a difference-in-differences approach which isolates the effect of the reform on the productivity growth of the affected farms. Second, we conduct a productivity growth decomposition to illustrate the importance of within-farm growth and reallocation across farms over this period and argue how this process may have been potentially affected by the land reform.

We start with the difference-in-differences analysis. The approach allows to isolate the effect of the reform on the affected farms by controlling for factors trending over time that would have affected all farms. The limitation of this approach is that it focuses on the within-farm effects abstracting from reallocation effects that also affect aggregate agricultural productivity. The reformed farms (treatment group) are the large farms—more than 5 hectares–subjected to the ceiling. The unreformed farms (control group) are the small farms as well as the large farms that were not subjected to the reform, either because the ceiling was not enforced on the farm or because the farm managed to separate ownership among family members while still operating as one large-scale farm. Our identifying assumption is that in the absence of the reform, average productivity growth would have been the same for the reformed and unreformed farms. This assumption is plausible in our context as the study area is geographically contained in one province on one island, where weather shocks would be common to all farms, and general macroeconomic trends and agriculture-specific or region-specific factors and policies would be affecting all farms. Even "technological" changes, such as the 1990s high-yield-variety seed adoption program were implemented across the board for all farms and all major crops in our sample. Then the difference-in-differences growth rate between reformed and unreformed groups represents the effect of the land reform alone.

We estimate the effect of the reform on two outcome variables, labor productivity measured as value added per work day described previously and a measure of total factor productivity which is constructed from the micro data using the following farm-level value added production function: $y_i = Z_i(l_i^{\alpha} n_i^{1-\alpha})^{\gamma}$, where Z_i is farm-level total factor productivity which includes economy-wide factors, crop-specific factors, and farm-specific factors, l_i is the amount of land used by the farm, and n_i is the amount of hired labor days. We assume $\alpha = 0.3$ and $\gamma = 0.7$. This specification and parameterization of agricultural production follows our quantitative analysis in Section 4. We report estimates for the balanced panel of farms but we emphasize that our results are similar if we instead use the unbalanced panel. We obtain the difference-in-differences estimate of the land reform using the following equation:

$$d_{it} = \delta_0 + \delta_1 \cdot \text{Reformed}_i + \delta_2 \text{Time}_t + \delta_3 \cdot (\text{Time}_t \cdot \text{Reformed}_i) + \varepsilon_{it} \tag{1}$$

where d_{it} is the logarithm of the outcome variable (either our measure of labor productivity or total factor productivity) for individual farm i at time $t \in \{1984, 2003\}$. Reformed_i is a dummy variable indicating treatment status: it takes the value of 1 if farm size prior to the reform exceeds the ceiling and drops after that, and 0 otherwise. ε_i is an error term. Time_t is a time dummy that takes the value of 1 in the post-reform period and 0 in the pre-reform period. $\text{Time}_t \cdot \text{Reformed}_i$ is an interaction dummy indicating when $\text{Time}_t = \text{Reformed}_i = 1$. The treatment effect is captured by the difference-in-difference estimator of parameter δ_3. The results of these estimates are reported in Table 3. The land reform had a significant negative effect on both labor productivity and TFP for the farms that were subjected to the reform. The results in the second column for example suggest that the average negative productivity effect of the reform on affected farms is roughly equal in magnitude (but of opposite sign) to the average increase in productivity experienced by all farms (coefficient on time trend). The quantitative negative impact of the land reform is somewhat larger when measured by TFP rather than labor productivity. While not reported, these estimates of the reform are robust to clustering standard errors at the village or the municipality level. Overall, these results constitute strong evidence of the negative productivity impact of the land reform on affected farms.

The difference-in-differences estimates of the land reform are limited from a macroeconomic perspective as they only provide evidence of within-farm effects and not on the aggregate impact of the land reform. A common theme in the misallocation literature is the importance of the reallocation of factors across production units and distortions in occupational choices for aggregate productivity implications. Typically for manufacturing plants in the United States, reallocation across plants accounts positively for between 1/3 to 1/2 of the aggregate productivity growth. To gain further insight into these factors we also perform a productivity growth decomposition in the spirit of Foster et al. (2001) (see also Foster et al. 2008). We also provide a breakdown of this decomposition between reformed and unreformed farms, as well as farms that switched from food to cash crops. We report the results in Table 4 using the balanced panel. We emphasize three important findings. First, reallocation of factors across farms has a negative contribution to overall agricultural productivity growth and this effect is substantial. For farms that do not switch crop production, the reallocation term is negative and around 1/3 of the overall growth in farms.[10] Second, within-farm growth is substantially affected by the land reform. Consistent with the difference-in-differences analysis, the within-farm growth is -.82 (82 percentage points lower) in reformed farms relative to unreformed farms, and -.64 for non-switchers which is similar to the -.64 difference-in-differences estimate. Third, switching from food to cash crops had a substantial positive farm growth effect for farms that were unaffected by the reform, more than doubling the within farm growth. While the growth effect from switching to the cash crop technology

[10]We note that the reallocation term in Table 4 does not include the effect of entry and exit. In the unbalanced panel, exiting farms are fairly similar to continuing farms, for instance exiting farms have 95 percent the labor productivity of continuing farms. The unbalanced panel does not have a good representation of entering farms as it only interviews the children of farmers in the original sample that become farmers. Nevertheless, the labor productivity of entering farms is 65 percent of that of incumbent farms in 2003. Given the nature of the implementation of the land reform favoring reallocation of land to landless individuals and the fact that prior to the reform land markets were fairly active, we expect labor productivity to drop as a result of reallocation from entry, a channel we capture in our quantitative assessment of the land reform in Section 5.

Table 3: Effect of Land Reform on Productivity

	Balanced Panel Dependent Variable (in logs): Labor Productivity	 Total Factor Prod.
	(1)	(2)
Reformed	0.894***	1.291***
	(0.214)	(0.244)
Time	0.715***	0.514***
	(0.128)	(0.146)
Time · Reformed	-0.650**	-0.837**
	(0.303)	(0.345)
Intercept	4.548***	6.991***
	(0.091)	(0.103)
Observations	334	334
R^2	0.121	0.106
Adjusted R^2	0.113	0.098
Residual Std. Error	1.128	1.463
d.f.	(330)	(330)
F statistic	15.08***	13.02***
d.f.	(3, 330)	(3, 330)

Note: All columns contain OLS regressions of individual farm log productivity on a time dummy (that takes the value of 1 in 2003-04), reform status (that takes the value of 1 if farm size in 1984-85 $\geq$ 5 hectares and drops by 2003-04), and an interaction dummy of time and reform status. In addition, columns (2) and (4) control for cash, food, or mixed crop choice. The sample is an unbalanced panel that includes all farms. Standard errors are in the parentheses, *** and ** represent significance at the 1% ($p < 0.01$) and 5% ($p < 0.05$) level respectively.

may be unrelated to the reform, the results indicate that only farms that were unconstrained by the land reform actually switched and benefited from the switch.

Table 4: Labor Productivity Growth Decomposition

	Aggregate	Within	Reallocation
(1) All Farms	0.447	0.617	-0.169
Switchers	1.622	1.959	-0.336
Non–Switchers	0.363	0.529	-0.166
(2) Unreformed Farms	0.892	1.077	-0.185
Switchers	2.224	2.497	-0.273
Non–Switchers	0.713	0.903	-0.190
(3) Reformed Farms	0.064	0.255	-0.191
Switchers	0.192	0.020	0.172
Non–Switchers	0.111	0.261	-0.150

Note: Calculations in this table are for the balanced panel and as a result the reallocation term does not include the effect of entry and exit. "Reformed Farms" refers to farms that were above the 5 hectares ceiling in 1985 and experienced a drop in their farm size by 2003, "Unreformed" are the remaining farms. "Switchers" refers to farms that produced food crops in 1985 and switched to cash crops by 2003, "Non-switchers" are the remaining farms.

These results suggest that the land reform could have impacted not only within-farm growth but also reallocation and which farmers switch from food to cash crops. We know from our description of the land reform that the reform also involved reallocation of land to landless individuals who then become farm operators with negative consequences for aggregate productivity. It is also important to disentangle the effect of the reform from other changes over time. For these reasons, we develop a model in Section 4 that allows us to construct counterfactual experiments and assess the extent to which the land reform impacted aggregate agricultural productivity via within-farm effects as well as through the reallocation of factors across incumbent farms and through distortions in occupational choices. Moreover, through our model we can assess the importance of the post-reform functioning of the land market for the aggregate consequences of the reform.

4 Model

We consider an industry model of agriculture in the spirit of Lucas (1978) and Adamopoulos and Restuccia (2014b), extended to allow farm operators to choose a cropping technology: cash versus food crop. We also extend the theory to allow for a land reform policy that closely mimics the land reform implemented in the Philippines. To make the analysis more transparent we abstract from the allocation of labor between agriculture and non-agriculture and from capital. These features are well understood in the literature and they are known to magnify the farm size and productivity impact of land reforms.[11] We instead focus on the distortionary impact of land reforms within the agricultural sector. In what follows we describe the economic environment in detail.

4.1 General Description

Technology The production unit in agriculture is a farm that requires as inputs the labor input with managerial skills of a farm operator, the land input (which defines farm size) and hired labor. There are two technologies to produce agricultural goods, which we denote as cash c and food f crops. The production of a farm unit with farmer productivity s, land input l, and hired labor n is described by a decreasing returns to scale technology:

$$y_i(s) = (A\kappa_i s)^{1-\gamma}(l^{\alpha}n^{1-\alpha})^{\gamma}, \qquad \gamma \in (0,1),$$

for each crop $i \in \{c, f\}$. The idiosyncratic productivity of farmers s is drawn from a discrete set S according to a known distribution with cdf $F(s)$ and pdf $f(s)$. A is an economy-wide productivity parameter that captures aggregate factors affecting all production units. The span-of-control parameter $\gamma \in (0,1)$ and the land elasticity parameter $\alpha \in (0,1)$ are the same across the two crops. The two technologies differ in two dimensions: the crop-specific TFP parameter κ_i and the crop-specific fixed cost of operation C_i in units of output of the crop.

[11]For a treatment of distortions to agriculture in a model with these features see Adamopoulos and Restuccia (2014b).

Market Structure and Occupational Choice Markets for hired labor and land are competitive. We denote the exogenous price of each crop by p_i. The rental prices of capital and hired labor are q and w. The profit of the farmer with productivity s in each crop is given by

$$\pi_i(s) = \max\{p_i y_i - wn - ql - p_i C_i\},$$

The first order conditions with respect to land and hired labor inputs imply that it is optimal for farmers in both types of crops to choose the same hired labor to land ratio regardless of size/productivity:

$$\frac{n}{l} = \frac{(1-\alpha)}{\alpha}\frac{q}{w}.$$

From the first order conditions of these problems, the input demand functions are the following:

$$l_i(s) = \left(\frac{\alpha}{q}\right)^{\frac{1-\gamma(1-\alpha)}{1-\gamma}} \left(\frac{1-\alpha}{w}\right)^{\frac{\gamma(1-\alpha)}{1-\gamma}} (\gamma p_i)^{\frac{1}{1-\gamma}} A\kappa_i s,$$

$$n_i(s) = \left(\frac{\alpha}{q}\right)^{\frac{\gamma\alpha}{1-\gamma}} \left(\frac{1-\alpha}{w}\right)^{\frac{1-\gamma\alpha}{1-\gamma}} (\gamma p_i)^{\frac{1}{1-\gamma}} A\kappa_i s.$$

Given these demands, output in each farm/crop $y_i(s)$ can be readily computed. Profits can be written as:

$$\pi_i(s) = (1-\gamma)p_i y_i(s) - p_i C_i.$$

Note that the input demand functions are linear in s and so is output. Profits are also an affine function of s. Thus, more able farmers operate larger farms, demand more labor, produce more output, and make more profits. Then, for a given distribution of managerial ability, the model implies a distribution of farm sizes.

Given that $\pi_i(s)$ is affine in s, there are two thresholds that determine the fraction of workers, cash crop farmers, and food crop farmers. We denote the occupational choice by $o_i(s)$ with the convention that $o_i(s) = 1$ if $\pi_i \geq \max\{\pi_{-i}(s), w\}$ so that an individual with ability s chooses to operate a farm in crop i and 0 otherwise. For reasonable parameter values that are in line with the calibration ($\kappa_c > \kappa_f$

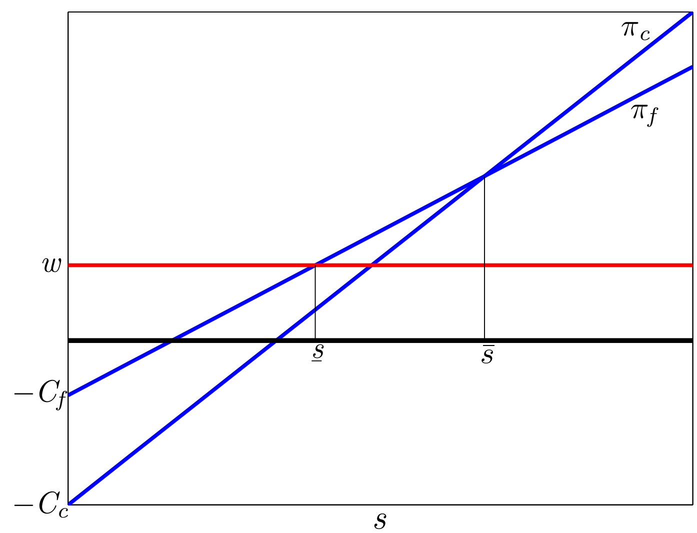

Figure 4: Occupational and Technology Choices

and $C_c > C_f$) the occupational choice and crop choice decisions of farmers are characterized by two thresholds $\underline{s}$ and $\overline{s}$, such that,

$$\pi_f(\underline{s}) = w,$$

$$\pi_f(\overline{s}) = \pi_c(\overline{s}).$$

In Figure 4 we show how farmers are sorted across occupations and crop technologies for this configuration of parameters and for a given wage rate. The profit function for cash crops has a lower intercept (higher fixed cost) and is steeper (higher TFP) than the corresponding food crop profit function. Then, farmers with ability below $\underline{s}$ become hired workers, farmers with ability between $\underline{s}$ and $\overline{s}$ become food farm operators, and farmers with ability above $\overline{s}$ become cash crop operators. In other words, $\underline{s}$ determines the split between workers and farmers (occupational choice decision) and $\overline{s}$ determines the split between cash and food farm operators (crop technology choice). We note that the occupational choice in this model causes no effect in aggregate labor supply as labor is required to operate a crop technology and to work as hired labor. However, changes in occupational choice may cause changes in aggregate measured productivity as individuals differ in their ability to operate a farm. The assumption that individuals either supply labor as operators or hired workers is an abstraction of reality but we argue it roughly conforms with the high degree of specialization observed in the data.

Definition of Equilibrium A *competitive equilibrium* is a set of prices (q, w), occupational decision rules $\{o_i(s)\}_{i\in\{c,f\}}$, and farmers decision functions $\{n_i(s), l_i(s), y_i(s), \pi_i(s)\}_{i\in\{c,f\}}$ such that: (i) Given prices, farmers optimize, (ii) given prices, o_i are optimal occupational choice decisions, and (iii) land and labor markets clear, i.e.,

$$\sum_i \int_s l_i(s)o_i(s)f(s) = L,$$

$$\sum_i \int_s n_i(s)o_i(s)f(s) = N_w,$$

where $N_w = \sum_i \int_s (1 - o_i(s))f(s)$ is the fraction of workers in the economy.

4.2 Land Reform

We model the land reform to mimic the implementation of CARP in the Philippines as a government-mandated land redistribution program. In particular, we model the land reform to account for four key features of CARP: (1) a land ceiling; (2) imperfect enforcement (as there are farmers above the ceiling following the reform); (3) redistribution of land above the effective ceiling to both landless and smallholders; and, (4) prohibition of transfer of the redistributed lands. To account for the ban on transfers of awarded land, we make the land market inoperative. In other words, the land awarded to each farmer under the redistribution program is treated as an endowment, and farmers cannot adjust their farm size by renting in or renting out land.

We use the following parameters to model the government-mandated land redistribution program:

- Land ceiling l_{max}: the legislated maximum size of land holdings.
- Degree of enforcement $(1 - \theta)$: where θ is the probability that farmers above the ceiling retain their previous farm size. This occurs mainly because there are informal arrangements among

family members that permits ownership to abide by the reform while operation can remain above the threshold or simply because the implementation of the land redistribution takes time and is subject to enforcement problems.

- Landless beneficiaries ψ_0: the fraction of landless (hired workers) that receive land.
- Smallholder beneficiaries ψ_1: the fraction of smallholders that receive land.

These parameters fully determine the post-reform distribution of farms. In particular, each individual farmer of ability s is endowed with the awarded amount of land $\bar{l}$. The vector $(s, \bar{l})$ defines a farmer, who cannot adjust the amount of land used in production. The only choice variable for a farmer is the amount of hired labor n.

The production function is the same as before but now each individual is characterized by a vector $(s, \bar{l})$. The output and profit of a farmer with productivity s and land size $\bar{l}$, under crop $i \in \{c, f\}$, are given by,

$$y_i\left(s, \bar{l}\right) = (A\kappa_i s)^{1-\gamma}(\bar{l}^{\alpha} n^{1-\alpha})^{\gamma},$$

$$\pi_i\left(s, \bar{l}\right) = \max\{p_i y_i - wn - p_i C_i\}.$$

The optimal demand for hired labor by a farmer facing $\left(s, \bar{l}\right)$ is,

$$n_i\left(s, \bar{l}\right) = \left[(1-\alpha)\gamma \frac{p_i}{w}\left(A\kappa_i s\right)^{1-\gamma} \bar{l}^{\alpha\gamma}\right]^{\frac{1}{1-\gamma(1-\alpha)}}.$$

Given this labor input choice, output $y_i\left(s, \bar{l}\right)$ can be readily computed, and profits can be written as,

$$\pi_i\left(s, \bar{l}\right) = \left[1 - \gamma(1-\alpha)\right] p_i y_i\left(s, \bar{l}\right) - p_i C_i.$$

To implement the land reform and determine the land (farm size) endowment $\bar{l}$ associated with farmer idiosyncratic productivity s we proceed as follows. First, we find the set of farmers that prior to the reform had a farm size in excess of the ceiling l_{max}. We define an indicator variable z, which takes the value of 1 if $l > l_{max}$, and 0 otherwise. For potentially constrained farmers (those with $z = 1$), with probability θ they get to keep their pre-reform land holdings l, and with probability $(1-\theta)$ they can only keep farm size equal to the land ceiling l_{max}. Then, effective land holdings for any farmer that operated a farm before the reform are,

$$\bar{l}(s) = (1-z)l(s) + z\left[\theta l(s) + (1-\theta)l_{max}\right].$$

If $\mathcal{C}$ is the set of constrained farmers, then the excess land to be redistributed is,

$$\Delta\frac{L}{N} = \frac{L}{N} - \int_{s\in\mathcal{C}} \bar{l}(s)f(s)ds.$$

This extra land can be given to landless individuals (hired workers) and/or smallholders. As noted above we denote by ψ_0 the fraction of landless (those under $\underline{s}$ before the reform) that receive reformed land. We assume that when land is distributed to the landless it is given to a fraction ψ_0 of all ability types among this group (i.e., for each $s < \underline{s}$). Given that we do not target landless beneficiaries on the basis of ability, this approach is more neutral. Further, it is consistent with the actual reform, as the government had no way of assessing the farming ability of potential landless beneficiaries.[12] We assume that the fraction ψ_1 of smallholders that receive land, are the ones with the smallest farms before the reform. For simplicity we assume that every recipient of redistributed land (landless or smallholder) receives the same amount l^*. We define a reform beneficiary indicator function $b(s)$ that takes the value of ψ_0 if $s < \underline{s}$, the value of 1 if $\underline{s} \leq s < s_1^*$, and 0 otherwise. s_1^* is determined by the parameter ψ_1 as follows,

$$F(s_1^*) - F(\underline{s}) = (\text{share of hired workers}) \cdot (1+\psi_1).$$

Then it must be that the redistributed land exhausts the above-ceiling land of the large landholders,

$$\int_{s_{min}}^{\underline{s}} l^* b(s)f(s)ds + \int_{\underline{s}}^{s_1^*} l^* b(s)f(s)ds = \Delta\frac{L}{N}.$$

[12]Nevertheless, we have also experimented with giving the land to the lowest ability landless, as well as the highest ability landless, and find quantitative results that are in the same ballpark.

The implied land amount given to each farmer is,

$$l^* = \frac{L/N}{\int_{s_{min}}^{\underline{s}} b(s)f(s)ds + \int_{\underline{s}}^{s_1^*} b(s)f(s)ds} = \frac{L/N}{F(s_1^*) - (1-\psi_0)F(\underline{s})}.$$

The equilibrium of this version of the model is determined by a system of two equations in two unknowns, the technology choice cutoff $\overline{s}$, and the wage rate w. The first equation is the no-arbitrage condition between operating a cash crop farm vs. a food crop farm. The marginal farmer of ability $\overline{s}$ must be indifferent between the two options,

$$\pi_f\left(\overline{s}, \bar{l}\right) = \pi_c\left(\overline{s}, \bar{l}\right).$$

The second equation is the labor market clearing condition,

$$N_w = \int_{s_{min}}^{\underline{s}} n_f(s, \bar{l})\psi_0 dF(s) + \int_{\underline{s}}^{\overline{s}} n_f(s, \bar{l}) dF(s) + \int_{\overline{s}}^{s_{max}} n_c(s, \bar{l}) dF(s).$$

4.2.1 Government-Mandated vs. Market-Based Land Redistribution

A key feature of CARP was the ban on all transfers (rent or sale) of the redistributed lands. Our modeling of the land reform explicitly accounted for this aspect of the program. In this program, redistribution of the land above the effective ceiling took place through a government mandate, whereby the government identified and assigned the lands to be reformed, as well as facilitated the land exchanges between large landowners and recipients. To emphasize the importance of this mode of redistribution, we also implement a market-based land redistribution whereby the land in excess of the ceiling is redistributed via a rental market for land where the price of land adjusts to clear the land market. While this market assignment of land does not reflect how CARP was implemented in the Philippines, it serves to illustrate the quantitative importance of the mode of redistribution for the aggregate impacts of the reform. It also allows to ask the counter-factual question: what would have been the effect of the land ceiling alone had the land market been permitted to function following the reform?

We model the market-based land redistribution as a constraint on farm size, given by the ceiling l_{max}. Similar to the previous case farm operation cannot exceed this level although in practice there are a few farms that do. We model this aspect of the land reform as a probability θ that the operation can remain at the optimal level (dictated by the productivity of the farmer) while with probability $(1-\theta)$ operation is at the constrained level.

We define the indicator function $c_i(s)$ to take the value 1 if the optimal demand of the farmer is potentially constrained by the ceiling limit, i.e., $c_i(s) = 1$ if $l_i(s) \geq l_{max}$ and 0 otherwise. When a farmer is constrained, land size is l_{max} and hired labor is $n_{i,max}$ given implicitly by the first order condition for hired labor with $l_i = l_{max}$. We can write land and hired labor demand functions as,

$$\hat{l}_i(s) = (1 - c_i(s))l_i(s) + c_i(s)[\theta l_i(s) + (1-\theta)l_{max}],$$

$$\hat{n}_i(s) = (1 - c_i(s))n_i(s) + c_i(s)[\theta n_i(s) + (1-\theta)n_{i,max}],$$

and profits as,

$$\hat{\pi}_i(s) = (1 - c_i(s))\pi_i(s) + c_i(s)[\theta \pi_i(s) + (1-\theta)\pi_i^{l_{max}}(s)],$$

where $\pi_i^{l_{max}}(s)$ is the profit associated with the constraint $l = l_{max}$. Then the occupational choice decisions are $\hat{o}_i(s) = 1$ if $\hat{\pi}_i(s) \geq \max\{\hat{\pi}_{-i}(s), w\}$ and 0 otherwise.

The market clearing conditions in this case are,

$$\sum_i \int_s \hat{l}_i(s)\hat{o}_i(s)f(s) = L,$$

$$\sum_i \int_s \hat{n}_i(s)\hat{o}_i(s)f(s) = N_w.$$

where N_w is the share of hired labor in the economy, i.e., $N_w = \sum_i \int_s (1 - \hat{o}_i(s))f(s)$. Hence, the market-based land reform affects not only land demand directly, but indirectly also affects hired labor, and occupational choice decisions of all farmers through general equilibrium effects.

5 Quantitative Analysis

5.1 Calibration

We calibrate a benchmark economy without any restriction on farm size to pre-reform Philippines, using the 1984-85 survey data from the balanced panel. An identifying assumption we make is that this benchmark economy is undistorted. We discuss below the appropriateness of this assumption in the Philippine case before the land reform and potential biases for our assessment of the aggregate effects of the land reform. The parameters to be calibrated are: technological parameters $\{A, \kappa_c, \kappa_f, C_f, C_c, \alpha, \gamma, \{s\}\}$, parameters of ability distribution, and the land endowment L. Some parameter values are chosen based on a priori information, while others are solved for as part of the solution to the model's equilibrium in order to match targets in the data. The model parameters along with their targets and calibrated values are provided in Table 5.

Table 5: Parameterization

Parameter	Value	Target
Technological Parameters		
A	1	Normalization
κ_f	1	Normalization
p_c/p_f	1	Normalization
γ	0.7	span-of-control
α	0.3	land income share
κ_c	1.21	Ratio of average crop productivities
C_f	-0.56751	Share of hired labor in total farm labor
C_c	-0.51119	Share of cash crop operators in total operators
Parameters of Ability Distribution		
μ	-0.85714	Size distribution
σ	1.25	Size distribution
Land Endowment		
L	1.4393	Average farm size

We choose the distribution of farmer ability to match the distribution of farm sizes in the 1984-85 survey data. The distribution of farmer ability is approximated by a log-normal distribution with mean μ and variance σ^2. We approximate the set of farmer abilities with a linearly spaced grid of 6000 points in $[s_{min}, s_{max}]$, with s_{min} close to 0 and s_{max} equal to 15 which ensures a maximum sized farm of 23 hectares, the largest farm in our panel in 1984-85. Our calibration involves a loop for the parameters of the productivity distribution: given values for (μ, σ), we construct a discrete approximation to a log-normal distribution of ability and solve the model matching the rest of the targets. The model then implies a distribution of farm sizes. We choose (μ, σ) to minimize the distance between the size distribution of farms in the model relative to the data.

We normalize economy-wide productivity A and the food crop-specific productivity κ_f to 1 for the benchmark economy. Given that the two crop prices are exogenous in our formulation we normalize their prices to unity. We set the span-of-control parameter to 0.7 and then choose α to match a land income share of 20%. The aggregate land endowment is chosen to match a pre-reform average farm size of 3.7 hectares from the panel data for 1984-85. We then choose the remaining parameters, the two fixed operating costs (C_f, C_c) and the cash crop TFP κ_c, to match three targets in the pre-reform round of the survey: (1) a share of hired labor in total farm labor of 61.1%; (2) a share of cash crop operators in total operators of 61.7%; and (3) a ratio of average farm labor productivity between cash crops and food crops of 2.95.

The calibrated model matches reasonably well the pre-reform farm-size distribution from the survey data, by choice of the parameters of the ability distribution (see Figure 5, Panel A). The model also captures other aspects of the data that were not targeted in the calibration. In particular, the model generates a reasonable distribution of land by reproducing, for example, the observation that about 45% of the land is in farms of less than 5 hectares (see Figure 5, Panel B). The model is also consistent with the positive relationship between labor productivity and farm size observed in the survey data (see Figure 5, Panel C). Finally, the model roughly captures the absence of a systematic relationship between the hired labor to land ratio and farm size (see Figure 5, Panel D).

We now discuss our strategy of calibrating an undistorted benchmark economy to the Philippines prior to the land reform. Calibrating to an undistorted economy not only provides substantial tractability to our analysis, but also roughly captures the features of the Philippines economy prior to the reform. There is evidence of intense land market activity, both in terms of rentals and sales, prior to the reform.

Figure 5: Calibrated Model versus Data by Size

For example, based on information in our sample on all households interviewed in in 1984, over half of the parcels are operated on the basis of some rental contract (share tenancy, fixed term contract, prenada contract, or other arrangement), with the rest of the parcels being operated with land owned by the farm operator. In addition, during the relatively short period of the four rounds of the survey over 1984-85, 18% of the all interviewed households either purchased or sold some land. This evidence would run against the idea that land markets in the Philippines were fettered in the 1980s. These observations imply that in the data prior to the reform, it is unlikely that high productivity individuals are landless, and that land is severely misallocated across productive farms.

In our quantitative assessment of the land reform below, the allocation of land to landless individuals depresses agricultural productivity since these individuals have lower productivity in operating a farm as disciplined by the calibration of the model. While one can possibly envisage a potential benefit of the reform in the Philippines being the allocation of land to landless individuals that are of high productivity, we think this is unlikely to be the case given the extent of rental land markets prior to the reform, but also unlikely to be successfully achieved given the centralized allocation of land during the reform. Neither government officials allocating land nor analysts have observable data to establish that landless individuals are more productive than active farmers in operating the land. Among operating farms, the land input and hired labor are both strongly positively correlated with our measure of farm productivity, suggesting a limited role of factor misallocation prior to the reform. The likely bias in calibrating farmer's productivity to farm sizes is that the range of productivities is slightly more compressed than in the data and this means that the reallocation across these farms and from these farms to the landless may have a smaller impact on aggregate productivity than if we calibrate directly to farm productivity observations. This is indeed what we find when we compare our calibrated measure of TFP across farms versus farm-level TFP data. TFP by farm size class category (relative to the average) ranges from 0.7 for the smallest farms to 1.6 for the largest, when the corresponding range in the data is 0.3-2.6.

5.2 Quantitative Results

The main quantitative experiment we conduct is the following. From the benchmark economy calibrated to pre-reform Philippines, we implement a land reform following CARP as the government-mandated land redistribution program described in Section 4.2. We first study the size and productivity effects of CARP on impact as if this is the only change occurring in the economy. We also vary the enforcement parameter θ to gauge its quantitative importance on the magnitude of the size and productivity effects. We then analyze the importance of the mode of redistribution, by comparing the results from CARP to an alternative market-based land redistribution and studying the mechanisms through which the two reforms impact size and productivity. Finally, we consider the effects of CARP together with other aggregate changes occurring at the same time. This is important to consider, as the implementation of land reforms takes time, and as a result often the pre- and post-reform analysis includes a period of ten years or more.

5.2.1 Aggregate Effects of Land Reform

The implementation of CARP as a government-mandated land redistribution program requires the determination of four parameters: the ceiling l_{max}, the degree of enforcement $(1-\theta)$, and the fractions of the landless ψ_0 and smallholders ψ_1 that are recipients of land. We set the ceiling equal to the legislated level of 5 hectares. We choose θ to match the farm-size distribution above 5 hectares after the implementation of the reform. This target implies $\theta = 0.8$. Note, that this value of θ implies a fairly lax enforcement of the reform which as discussed earlier includes not only effective enforcement but also any other formal or informal arrangement allowing the farm scale operation to remain above the established ownership ceiling. We choose ψ_0 and ψ_1 to closely match the share of farms under 1 hectare and the share of farms in the $1-2$ hectares bin after the reform. Note, that we do not allow farmers with farm size above 3 hectares to receive land, as 3 hectares was the legal ceiling for recipients of redistributed land discussed earlier. We find that $\psi_0 = 0.33$ and $\psi_1 = 0.08$ most closely match those bins in the post-reform farm-size distribution. The implied amount of land given to each beneficiary is $l^* = 0.34$ hectares.

In the first column of Table 6 we report the aggregate effects that result from the government-mandated land redistribution program in the model calibrated to CARP, in terms of changes in average farm size, agricultural productivity, and the share of landless in the economy. In the model, the share of landless is equivalent to the share of hired workers. In the second column we report the aggregate changes for the Philippine economy before and after the reform. The percentage change in average farm size results from comparing this statistic in the 1981 Census to the 2002 Census. The change in agricultural productivity is over 1989-1993 based on aggregate data from the Bureau of Agricultural Statistics in the Philippines (reported in Section 3.1). The change in the share of landless in the economy is calculated as the total certificates of land ownership awarded under CARP by 2007 (World Bank, 2009), as a share of total agricultural employment in 1991 (1991 Census of Agriculture).

Table 6: Aggregate Changes of Land Reform

	Model Government-mandated Land Redistribution	Data
Average Farm Size	-34.2	-29.6
Agricultural Labor Productivity	-17.0	-11.6
Share of Landless	-20.0	-19.0

Note: Average farm size and labor productivity in agriculture are reported as percentage (%) changes relative to their pre-reform values (in the benchmark economy). The share of landless is reported as the absolute change relative to its benchmark value. Data: change in average farm size from Census of Agriculture (1981, 2002); change in agricultural productivity 1989-93 from Bureau of Agricultural Statistics, Philippines; change in share of landless calculated as share of certificates of land ownership awarded in total agricultural employment in 1991.

Table 6 shows that on impact after imposing the land reform, average farm size, agricultural productivity, and the share of landless in the economy all drop. Further, these changes are close to the changes observed in the data for the Philippines in the period after the reform. In the model, farm size and productivity fall because of: (a) the government reassignment of land from large-productive operators to small-less productive smallholders and landless, and (b) the induced selection effects. In other words, the land reform causes a distortion in farm size of incumbent farmers and in occupational choices leading to lower farm size and productivity. The substantial drop in the share of landless is due to the fact that they are largely the beneficiaries of the reassigned land.

5.2.2 Distributional Implications of Land Reform

Our quantitative model allows us to examine the micro-level implications of the theory. We examine the distributional implications of the reform for the number of farms, the amount of land, value added per worker, and hired labor-to-land ratio by farm size category. We can compare these statistics in the model with the survey data for the post-reform values in 2003-04. We should note however that the implications of the model are for the land reform on impact whereas the data correspond to several years after the reform. We also note that the survey data in the post-reform period only includes farms that existed prior to the reform. We report the distributional implications of the model's government-mandated land redistribution in Figure 6 along with distributions from the 2003-04 round of the survey panel. Given the parameterization of the reform the model accounts well for the farm-size distribution in the post-reform period in Figure 6, Panel A. Despite the limitations of the data just discussed, the model also does reasonably well in accounting for the 2003-04 distributions of land shares, relative labor productivity, relative hired labor-to-land ratio by farm-size in the survey data reported in Figure 6, Panels B, C, and D.

5.2.3 Importance of Enforcement of Reform

In the baseline experiment the value of θ required to account for the farm-size distribution above the legislated 5 hectare ceiling, implied a fairly lax enforcement of the reform, understood broadly as the extent to which the reform effectively affected operational scales of large farms. What would the size and productivity effects of CARP be if the reform had affected operational scales more strictly? Table 7 shows the effects of the government-mandated land redistribution program in our model for varying levels of θ. The first column provides the results of the baseline experiment. A lower θ implies stricter enforcement, with $\theta = 0$ being the case of perfect enforcement. The results indicate that the magnitude of the drops in productivity and average farm size are larger the greater the degree of enforcement. A stricter enforcement of the reform could have lead to considerably greater losses in size and productivity, as high as 47% in farm size and 34% in productivity. These are substantial impacts for any single policy to generate.

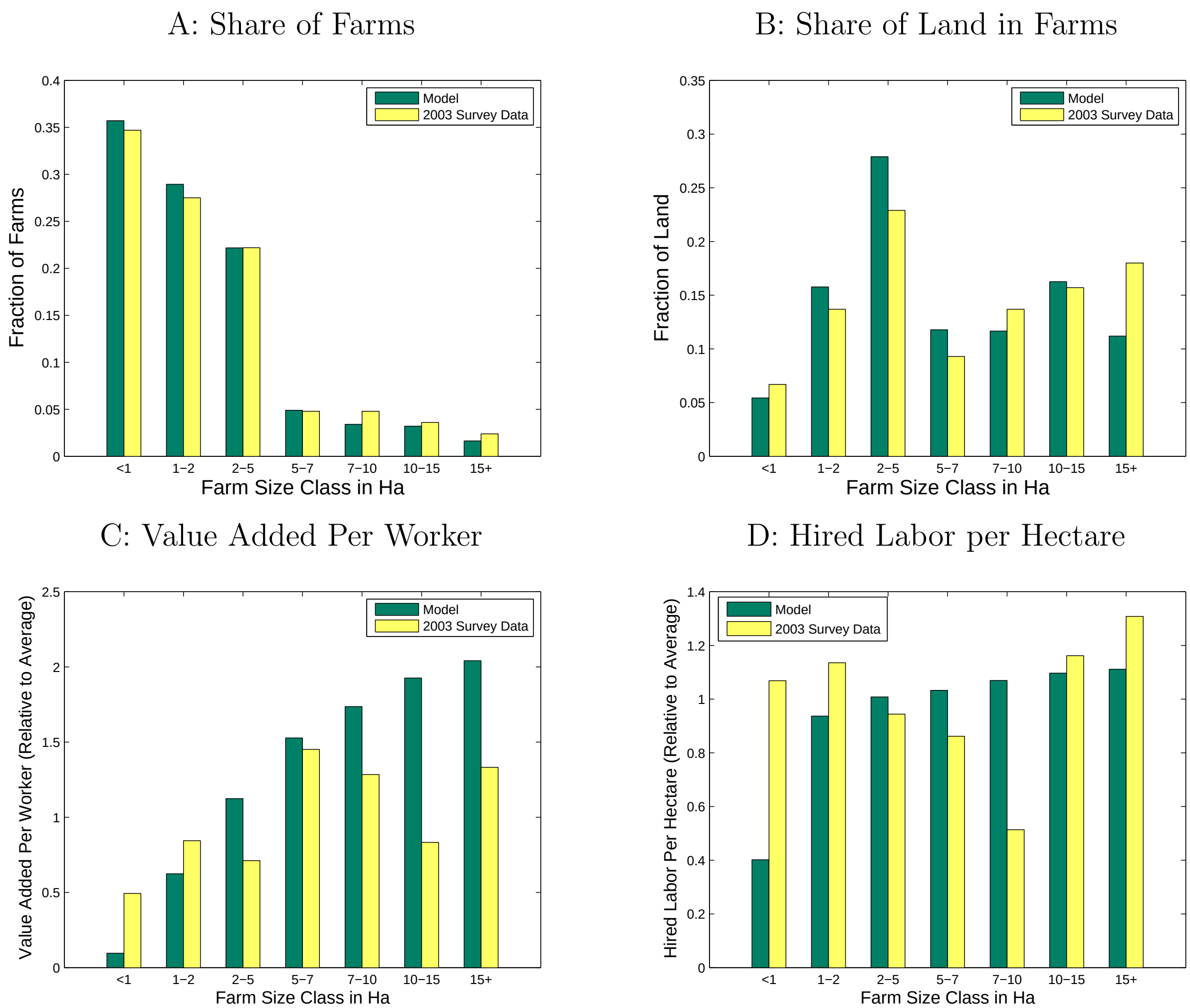

Figure 6: Distributional Properties of Model Government-mandated Land Redistribution

Table 7: Impact of Enforcement in the Model

	Enforcement			
	$\theta = 0.8$	$\theta = 0.4$	$\theta = 0.1$	$\theta = 0$
Average Farm Size	-34.2	-39.2	-42.5	-46.5
Ag. Labor Productivity	-17.0	-22.6	-27.5	-34.2

Note: Average farm size and labor productivity in agriculture are reported as percentage (%) changes relative to their pre-reform values (in the benchmark economy).

5.2.4 Importance of Mode of Redistribution

In the baseline experiment the land market is inoperative as per the provisions of CARP. Here we contrast the aggregate changes in the model induced by the baseline government-based redistribution to those induced by a market-based redistribution program, that imposes the same ceiling but in which the land market is operative. In the market-based redistribution the land in excess of the ceiling is redistributed through the market, whereby the rental price of land adjusts to clear the land rental market. While average farm size and aggregate labor productivity fall under the market-based reform, these drops are considerably less pronounced than those induced by the baseline government-mandated redistribution (less than 1/3). It is not surprising that under the market mode the effects are smaller since conditional on the ceiling the market efficiently allocates land for those under the ceiling and this allocation is regulated through adjustments in the rental price of land. In particular, the excess land above the ceiling leads to a drop in the rental price of land which would induce those previously under the ceiling to increase their farm size. Even though the market-based redistribution is less obtrusive than the government assigned mode, the ceiling is still distortionary as it restricts farm growth for the more talented farmers, and "artificially" props-up less productive farms.

The fact that the market-based redistribution cannot account for the reality of the CARP in the Philippines is further confirmed by the distributional implications of this mode of redistribution. Figure 7 shows the distributional properties of the reform for the number of farms (Panel A), the amount of land (Panel B), value added per worker relative to the average (Panel C), hired labor-to-land ratio relative to the average (Panel D) by farm size category, against the corresponding distributions in the

Table 8: Impact of Redistribution Mode in the Model

	Model Government-mandated Land Redistribution	Model Market-based Land Redistribution
Average Farm Size	-34.2	-9.3
Agricultural Labor Productivity	-17.0	-5.0
Share of Landless	-20.0	-4.0

Note: Average farm size and labor productivity in agriculture are reported as percentage (%) changes relative to their pre-reform values (in the benchmark economy). The share of landless is reported as the absolute change relative to its benchmark value.

2003-04 survey data. This figure is the counterpart to Figure 6 in the baseline government-mandated redistribution mode. In contrast to the Philippine government-mandated reform, the market-based one cannot account for the post-reform distributions. The reason is that the ceiling on farm size in combination with the adjustment in the rental price of land induces a concentration of farms in the 1-2 and particularly 2-5 hectare bins under the ceiling.

5.2.5 Mechanism and Decomposition

The model allows us to separate the channels through which productivity and farm size change with the land reform. We focus on the changes in average productivity by crop (food vs. cash) and the allocation of labor across crops and occupations (operator vs. hired worker). Table 9 presents the breakdown in the model for the government-based redistribution in the first column and for the market-based redistribution in the second column.

In the government-mandated land redistribution, farm size is not a choice variable for any farmer. The government reassigns the land of large landowners, those above the effective ceiling, to some of the landless (fraction ψ_0) and some of the smallholders (fraction ψ_1). While the total amount of land expropriated balances with the total amount of land redistributed there is no rental price of land to regulate the allocation of the resource. This land reassignment from large-productive units to small-less productive ones reduces aggregate farm size and productivity. The fraction of landless that are

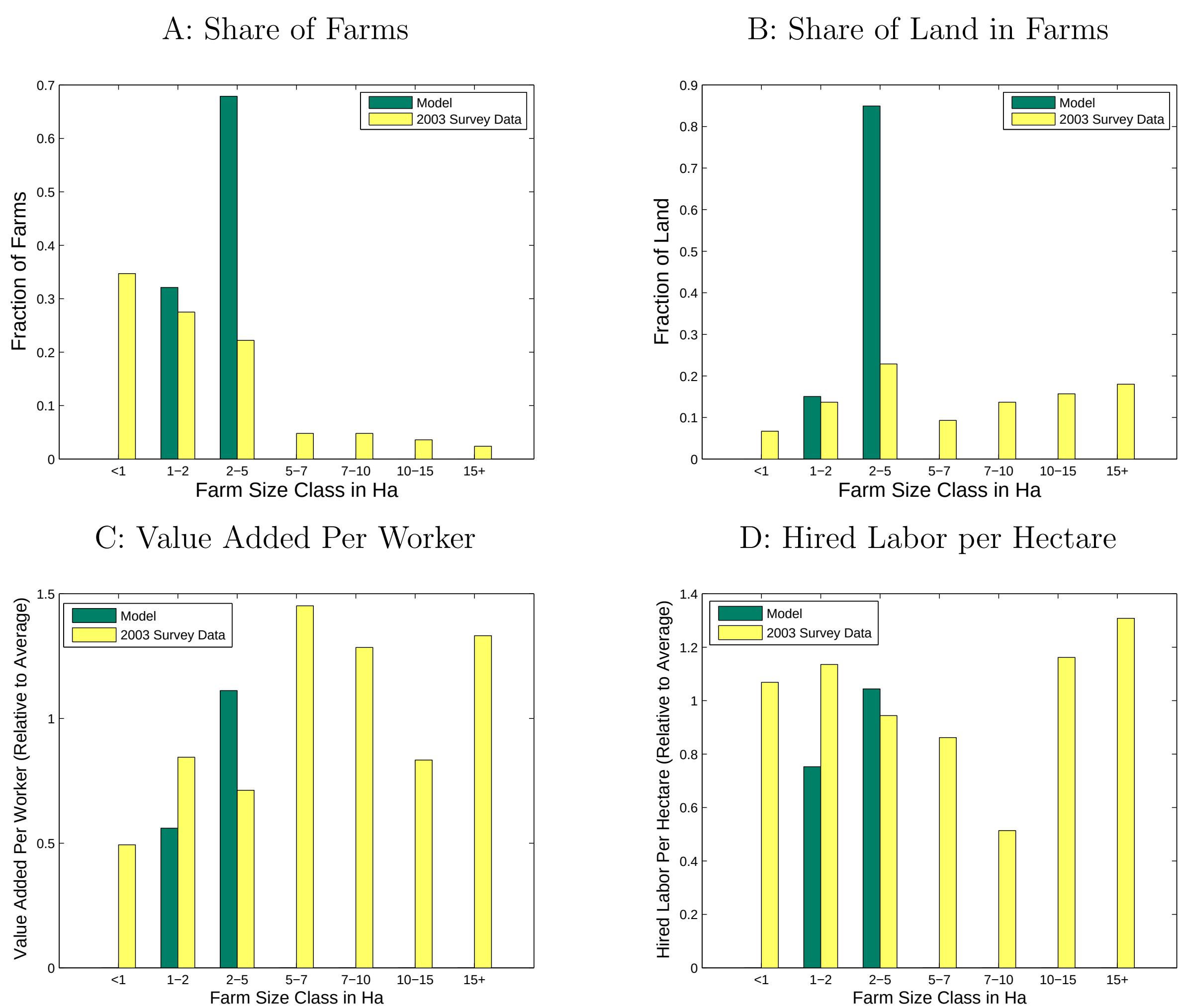

Figure 7: Distributional Properties of Model Market-based Land Redistribution

Table 9: Accounting for Productivity Change of Land Reform in the Model

	Model Government-mandated Land Redistribution	Model Market-based Land Redistribution
Agricultural Labor Productivity	-17.0	-5.0
Labor Productivity:		
Cash Crops	10.1	-6.9
Food Crops	-31.0	3.3
Share of Occupation:		
Hired Workers	-20.0	- 4.0
Cash Crops	-3.6	5.0
Food Crops	24.0	-1.0

Note: Labor productivity in agriculture, food crops, and cash crops are reported as a percentage (%) change relative to the corresponding pre-reform value. The shares of hired workers, food crop operators and cash crop operators are reported as absolute changes relative to the benchmark values.

beneficiaries of the reform operate food crop farms. The influx of many low ability farmers leads to a drop in average labor productivity in food crops. At the same time, the reduced supply of hired labor leads to an increase in the real wage rate, reducing profits of all farmers but more for cash crop operators than for food crop operators. This implies a switch from cash to food crops. This influx to food crops is dominated by the earlier effect of low productivity entrants so the overall effect is a fall in productivity in food crops. The switch of low ability cash croppers to food crops raises average productivity in cash crops. The implication of the model for the switch from cash to food crops might appear at odds with the observation from the panel data that the incidence of cash cropping increased in our sample from 1984-85 to 2003-04. We emphasize that comparing the reform on impact from the model to the panel data after 19 years could be misleading, as other factors besides the reform could be encouraging the adoption of cash crops. When we compare in our panel data farms that were affected by the reform (reformed farms) to those that were not (unreformed farms) we find that indeed cash cropping increased for both types. However, this effect was much stronger for unreformed farms: the percentage net flow of farms from food crops to cash crops (switchers from food to cash crops minus switchers from cash to food crops) was almost two times higher for unreformed than reformed farms (22% vs. 12%). This is consistent with the prediction from the model: the land reform slowed down the switching to cash crops for the farms that were affected by it.

The intuition for the market-based reform works quite differently since conditional on the ceiling all the effects operate through markets. The ceiling reduces farm size for all constrained farmers, i.e. those with a farm operation previously above the ceiling (direct effect), and also reduces their demand for hired labor which reduces both the rental price of land and the wage rate. Lower factor prices implies that unconstrained farmers increase their demand for hired labor and land (general equilibrium effect). This reduces the share of hired labor who select into food crops. Lower factor prices increase profits for all farmers but more for cash crop than food crop farmers. That is, some food crop operators switch to cash crops. The influx of low ability operators (previously landless) in food crops, and the switch of the more able food crop farmers to cash crops, reduces productivity in food crops. But food crop farmers are less likely to be constrained by the ceiling. Due to general equilibrium effects in prices food crop farmers hire more and produce more. This positive productivity effect dominates the effect of selection and food crop farming productivity increases in equilibrium. The flow of low ability operators in cash cropping and the constraint on size dampen average productivity in cash crops.

We summarize the effects on aggregate productivity into two components. First, the reallocation of farming activity from large-productive farmers to pre-existing smaller-less productive farmers which we call "incumbent reallocation effect". Second, changes in the cut-off levels of productivity that determine the splits between operators vs. hired workers and between cash crop vs. food-crop operators which we call the "selection effect". The incumbent reallocation effect captures the distortion of the land reform in the allocation of aggregate resources across a given set of operating production units, whereas the selection effect captures the distortions in the entry and technology choice decisions of farmers (distortion in occupation decisions). Table 10 reports the results of this decomposition in the model for the government-mandated redistribution and the market-based redistribution. In the government-mandated redistribution, the bulk of the productivity drop arises due to selection (i.e. distortions to occupational choices). The incumbent reallocation effect across existing production units is -1.1% which accounts for only 6.5% of the overall productivity drop.[13] In contrast, under

[13] We note that the importance of selection into the overall misallocation effect caused by the land reform is reminiscent of the effect of financial frictions in models of production heterogeneity, for instance Buera et al. (2011) and Midrigan

the market-based redistribution, the incumbent redistribution effect accounts for 60% of the overall productivity drop, although the absolute drop accounted for by this effect is fairly small in both cases. The negative reallocation effect among incumbents is consistent with the negative effect of reallocation emphasized in Table 4 from the micro data, however, the magnitude of the negative effect is much larger in the data (-16.9%). We note that the negative effect in the model captures only the on impact effect of the reform whereas the micro data captures the effect of the reform and other changes over a 19-year period.

Table 10: Decomposition of Change in Agricultural Productivity

	Model Government-mandated Land Redistribution	Model Market-based Land Redistribution
Change in Agricultural Productivity	-17.0	-5.0
Incumbent Reallocation Effect	-1.1	-3.0
Selection Effect	-15.9	-2.0

Note: Effects on agricultural labor productivity are reported as percentage (%) changes relative to their pre-reform values (in the benchmark economy). The "incumbent reallocation effect" refers to the productivity effect induced from reallocating land across pre-existing farms. The "selection effect" refers to the productivity effect induced by distortions in the occupational and technology choices of farmers.

The model implies that quantitatively the most important channel driving the negative effect on productivity is entry of low productivity landless individuals (selection channel) and the accompanying ban on land transfers of redistributed land. A key factor for this effect in the model is that the new entrants are of lower productivity than incumbent farms. While there is no representative data of entrants to assess the productivity of new farmers associated with the land reform we argue the effect in the model is reasonable given the following considerations: (i) as discussed earlier there is substantial land market activity prior to the reform so it is unlikely that very productive landless individuals were constrained in operating land; (ii) by mandate of the law, the reformed land was given primarily to landless, corroborating the argument that there was indeed a lot of "entry"; and (iii) from our limited sample of farms formed by the children of the 1984-85 households, we find that TFP was 64% of that

and Xu (2014).

of incumbent farms.

5.2.6 Other Factors

A key feature of land reforms is that they take time to be implemented. The land reform experiments show that aggregate agricultural productivity falls on impact following the reform. In fact, in the aggregate data in the period right after the reform productivity does fall. However, over a longer horizon productivity increases. For example, in the aggregate data agricultural labor productivity increases a total of 17.3% over 1989-2004. Our micro data indicate that for the set of farms in our panel average productivity increased 44.7% over 1984-2003. How do we reconcile these observations with our finding of a negative productivity impact of the land reform? We argue that in the time series data, whether aggregate or micro, there are other changes that have occurred besides the land reform, which are also impacting agricultural productivity and, as a result, can confound the negative productivity effects of the reform. For instance, there is general growth in the economy and there are growth-enhancing changes that are specific to agriculture. The key is to measure these factors in the data and capture them in the model to assess their quantitative effects alongside the reform.

We examine two sets of factors. First, non-agricultural productivity increased over the period 1988-2004 by almost 10% (Groningen Growth and Development Centre, 10-Sector Database, Philippines). In the model, we capture this growth in the rest of the economy through an increase in economy-wide TFP A, which affects all production units operating any technology. Second, a major trend within Philippine agriculture in general, and in our survey data in particular, is the adoption of high-yield-variety seed for rice, corn, and sugarcane. The high-yield-variety seed has large productivity gains for farmers relative to conventional seed. The FAO reports gains in terms of average yield for rice, between high-yield and conventional varieties as high as 65% for the Philippines in the 1990s (FAO 2000). In the model, we capture the adoption of high-yielding varieties of seeds for all crops as increases in the technology-specific productivity parameters for each crop κ_f, and κ_c. We first feed in a 10% increase in economy-wide TFP (A) in addition to the land reform and examine the size and productivity effects. These results are reported in the second column of Table 11. The first column contains the effects of the land reform alone. We then increase κ_f and κ_c by 65%, in addition to the increase in A, and the land reform. These results appear in the third column of Table 11. We also report the size and productivity effects that would result from the market-based redistribution along with these other changes. The comparison serves to illustrate the importance of the government-mandated nature of the reform in generating the overall changes in size and productivity observed over time.

The results show that the increase in A, and κ_f, κ_c, along side the reform leads to a reversal of the negative productivity effects imparted by the reform alone. While this is true under both the government-assignment mode and the market mode, under the market mode the overall effect ends up being strongly positive (as it starts from a much smaller negative reform impact). What is important to note however, is that under the market-based redistribution the effect on farm size is also reversed as it moves in the same direction as productivity. In the government-mandated reform the negative effect of the reform on size remains intact. The baseline government-mandated reform can therefore reconcile a positive trend in productivity over a longer horizon with a negative effect on farm size. The standard model with complete markets cannot account for a drop in farm size with a substantial rise in productivity. We conclude from these experiments that other changes occurring in the economy and/or the agricultural sector can mask the negative effect of the reform on productivity, and that the government-assignment of lands is key for breaking the positive relationship between farm size and productivity.

Table 11: Effect of Land Reform and Additional Factors in the Model

	Land Reform	$+\uparrow A$	$+\uparrow \kappa_f, \kappa_c$
Model Government Redistribution			
Average Farm Size	-34.2	-34.2	-34.2
Agricultural Productivity	-17.0	-14.5	-0.5
Model Market Redistribution			
Average Farm Size	-9.3	-7.1	4.7
Agricultural Productivity	-5.0	- 1.5	18.0

Note: Labor productivity in agriculture is reported as a percentage (%) change relative to the corresponding pre-reform value. Average farm size is reported as a percentage (%) change relative to the corresponding pre-reform value.

6 Conclusions

We studied the effects on farm size and agricultural productivity of the 1988 government-mandated land reform in the Philippines using a quantitative model and micro-level data. In our quantitative theory the land reform depresses agricultural productivity by reallocating land from large to existing small farms and by distorting occupational and technology choices. Our model and micro data have allowed us to quantitatively evaluate: (a) the overall impact of the reform alone; (b) the channels through which the reform impacts productivity (across-farm vs. within-farm changes); (c) the importance of each of the components of the reform (ceiling, enforcement, government-assignment of land and ban on land transfers); (d) the importance of other changes occurring in the economy along with the reform.

We showed that in our model overall the land reform reduced average farm size by 34% and agricultural productivity by 17%. These effects were primarily due to the distortions in the decisions of farmers across occupations and technologies, in particular the large reassignment of land to previously landless farmers. A stricter enforcement of this reform could have generated considerably larger drops, as high as 47% in size and 34% in productivity. If redistribution had occurred through the market the effects on size and productivity would have been considerably smaller, less than 1/3 of those generated under the government-assignment of land and the ban on land transfers. We also find that, given that reforms take time to implement, other changes occurring in the economy over time, such as general growth and the adoption of high-yield varieties in agriculture, would tend to mask the effects of the reform in time series data. Measuring and assessing quantitatively the contribution of other factors on productivity growth such as the reduction in protectionism, the improvement in transportation infrastructure, or the more intensive use of intermediate inputs would be interesting.

While our analysis has focused on the institutional detail of the Philippine land reform in order to exploit the micro-level data, we think our conclusions have implications for other countries as well, as many of the features of the Philippine land reform are shared by many reforms in the developing world. Importantly, our analysis sheds light on the components of the reform that are more costly in terms of productivity, which could provide guidance for policymakers. Specifically, we conclude that policies and institutions that impede the operation of the land market could prove particularly detrimental when accompanying land reforms. A well functioning rental market for land can mitigate the productivity effects of imposing a ceiling on farm size.

We caution that our analysis has focused on the pure productivity effects of land reforms. However, land reforms are often justified on grounds other than productivity: promote equity, reduce poverty, secure nutrition of land-poor, correct social injustices, avert social unrest, all features from which we abstract in our analysis. Assessing the different economic and political costs and benefits and weighing their importance against the potential productivity losses is an area in which more work is needed in the future. Also, studying the impact of other agricultural reforms such as tenancy reforms or changes in land administration would be fruitful.

Our work demonstrates that land reforms in the presence of restricted land markets can be an important source of misallocation and productivity losses in agriculture in developing countries. We see benefits to be reaped by studying in more contexts establishment-level policies coupled with factor market frictions both in agriculture as well as other sectors of the economy, for both developed and developing countries.

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