LAND PROPERTY RIGHTS AND AGRICULTURAL PRODUCTIVITY: EVIDENCE FROM PANAMA

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Abstract

This paper estimates the effects of land property rights on agricultural productivity in Panama. Using district level panel data to investigate the impact of privately owned land on agricultural productivity from 1990 to 2010, I find that land privatization increases rice yield in agriculture labor intensive districts, but it does not have any significant impact in non-agriculture intensive districts. Then, using household level data I find that households with registered land titles are more likely to obtain an agriculture loan and undertake land-attached and land mobile investments.

Key Words: Agricultural productivity, investments, Panama, panel data, property rights,

1. Introduction:

Land property rights are key to improving use of land resources; encouraging higher levels of investment and credit; and maximizing allocative efficiency. There is empirical evidence which suggest that land tenure affects productivity through three main channels: Investments, borrowing and land transfer. The idea that tenure security can positively impact agriculture output is hardly controversial. Previous studies dealing with the effects of land private rights have offered insight into how secure land rights can affect the agricultural sector.

First, secure land rights provide incentives to farmers to invest and use land productively, this is due to farmers perception that investments in and proper use of land will give rise to significant benefits. Secondly, land can be used as collateral in the formal credit market. This of course, is dependent on the existence of a formal credit market in the first place. Finally, land rights can be transferred, resulting in more efficient land allocation. Brasselle et al. (2002) respectively refer to these channels as "assurance," "collateralizability," and "realizability" effects, suggesting that these channels are the key reasons why complete land rights should encourage investing.

Formal land titling is a common way to ensure land tenure rights, but in majority of cases, it is expensive and difficult to carry out. The most common way to insure land rights was through land and agrarian reforms, introduced in almost every country in Latin America since the 1960's. Although these reforms failed to alleviate the land inequality and lack of land titles in rural households,[1] national governments and international development agencies extensively sponsor land titling programs in order to improve the use of land in developing countries. Atwood (1990) argues that in the case of Africa there is enough evidence to be against the conventional view of land registration because the cost of titling might be high and without the expected effects. However, more recent literature have found evidence that increasing land rights in African countries may indeed improve land tenure security and land related investments (Fenske 2010; Fenske (2011))

This paper focuses on formal land property rights and their effect on agriculture productivity in Panama. I analyze the impact of land title registration to explore the main channels through which property rights impact productivity in the agricultural sector. As in other Latin American countries, agrarian reform

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[1] See de Janvry (1989) for an explanation of the lack of success of land reforms in Latin America.

and land certification programs have been common in Panama since the 1960's. The first agrarian code was introduced by the Law 37 of 1962. The agrarian code has been modified multiple times and it aims to insert people from rural areas in the economic growth process and increase the efficiency of land through land titling. Certification programs are also common in Panama, however they tend to be highly bureaucratic and without remarkable results. For example, in 1960, 27\% of the land used for agriculture purposes was completely titled, whereas in 2010, 49\% of this land was titled. In other words, after 50 years of intense struggles, different regulations and land authorities still less than half of the land used for agriculture is not properly registered.

The impact of land registration programs and land property rights on agriculture productivity and investment incentives has been vastly researched. According to Besley (1995), there are four reasons why complete rights should affect economic activity: property rights strengthen claims to the fruits of investment; improve access to capital; facilitate gains from trade; and reduce unproductive costs. On agricultural productivity, for example, Chankrajang (2015), using partial land rights that cannot be transferred, finds that land security impacts labor productivity but it does not have an effect on yields in Thailand.

The empirical findings on land rights and investment have yielded contradictory results. Fenske's (2011) meta-analysis in Western Africa points out that econometric techniques using binary investment measures and studies that control for household level heterogeneity are unlikely to find an impact of land rights on investment. However, the author finds a strong relationship between land rights and fallowing. Similarly, Goldstein and Udry (2008), using social and political characteristics of farmers as Instrumental Variables, found that secure land tenure is associated with higher levels of investments in Ghana. In the case of Latin America, Deininger and Chamorro (2004) estimate the impact of land formalization on investment in Nicaragua. Their findings suggests that properly registered land titles have a significant investment enhancing impact, and land title registration is associated with an increase in land values which might have a positive distributional effect. Land titling is also associated with higher levels of investments in Peru (Fort, 2008).

There is empirical evidence that confirms that land certification increases access to credit in developing countries. In Thailand, Feder et al. (1988) found evidence that farmers with more secure land rights were able to borrow more than their counterparts. However, studies focused on African countries could not find the same evidence; instead, Migot-Adholla et al. (1991) found that farmers with individual tenure of land had no better access to credit than those with other types of tenure systems. In Central America, better access to credit due to land reforms is not clear. In Honduras and Nicaragua an expansion

of land titling reforms is not associated with better access to formal credit. Small holders have lower credit market participation after titling reforms in Honduras, while in Nicaragua rural financial markets are not sufficiently evolved to improve credit access (Boucher et al., 2005).

Higher levels of land security should improve land markets, reallocating land to more efficient users. Boucher et al. (2005) using a descriptive analysis, suggest that land titling reforms activate land rental markets in Honduras and Nicaragua. However, the authors also mention that land rental markets are not having any effect in operated farmland distribution in the Central American countries. Other study focusing on Nicaragua found that big landowners are more likely to purchase land and this could be for unproductive reasons. Also, households without land titles are less likely to rent out land. In other words, lack of title is a disincentive to participate in land market activity because of the danger of losing land (Deininger et al., 2003).

The previous literature of land formalization and registration on investment, access to credit and land transfer shows that the evidence is far from conclusive and even contradictory in some cases. This research aims to contribute to the literature of land rights and agricultural productivity with new empirical findings, exploiting panel district, corregimiento cross section and household level data. The main findings of this research are the following: First, land privatization increases rice yield per hectare in agriculture labor intense districts in Panama, but it does not have any significant impact in non-agriculture labor intense districts. Second, an increase of private land per district is not associated with a raise in labor productivity. Lastly, households with land title deeds properly registered are more likely to obtained an agriculture loan, undertake land-attached and land mobile investments. To the best of my knowledge no similar study has ever evaluated the impact of land registration on agricultural productivity in Panama.

The rest of the paper is organized as follows: Section 2 provides the background. Section 3 describes the data sources, empirical strategy and descriptive statistics. Section 4 presents the results of land rights and agricultural productivity in Panama. Finally, section 5 concludes the paper.

2. Land reform and privatization movements

Small scale farmers tend to suffer from land tenure insecurity in Latin America. To solve this issue, land reforms were introduced in a plethora of Latin American countries including Panama. Majority of these reforms were implemented at the beginning of the 1960's under the Inter-American Committee of Agricultural Development, which was created by the United States' plan called Alliance for Progress. In the case of Panama, the agrarian reform was institutionalized by the Law 37 of 1962. The Law 37 of 1962, coupled with more recent acts, aimed to insert farmers and people from rural areas of Panama in the

economic growth process, with more equal distribution of land, better access to agriculture credit and technical assistance in order to improve their productivity and standards of living.

The Law 37 of 1962 explained in detail the roll of the Agrarian Reform Commission and fomented peasants to register their land in order to increase tenure security and have easier access to credit. Even though the reform was not really successful, 5 years after the Law 37 came into force, there was a growing demand for land certification. However only a small amount of the land title requested were granted. In fact, the certification and registration process was highly bureaucratic and it discouraged farmers to obtain and formally register their land titles. As in other Latin American countries the agrarian reform failed to make the structural change needed in order to improve the agriculture sector, raise the living standards of farmers and distribute land more equally.

In Latin America farmland distribution is completely unequal. Lipton (2009) constructs a table on operated farmland Gini for 49 developing countries around the world in order to compare land inequality. According to this table, Panama's farmland Gini in 1950 was 0.72, whereas in 1990 farmland distribution suffered an increased in the Gini coefficient to 0.87. In other words, farmland distribution inequality increased after the land reform movements. Only Chile, Paraguay and Venezuela had larger farmland inequality on Lipton's table, and Panama had the largest land inequality of all Central American countries.

Land reforms had mixed results according to many studies. Recently the focus has changed towards land titling and certification programs, sponsored by national governments and development international agencies. The main goal of these type of programs is to foster agricultural productivity and offer land property rights to farmers. Panama has received loans from international agencies to implement registration policies in the last 30 years, and the percentage of agricultural land with registered titles has drastically increased from near 30% to almost 50%. Unsurprisingly, this raise in private land in the agricultural sector has occurred in a period where Panama is politically and economically stable. Furthermore, during this period of study, labor in the agriculture sector has decreased sharply form 27% in 1990 to only near 13% in 2010. However, in rural areas of Panama agriculture is the most important activity for a majority of households, and it is the most important economic sector in a great amount of districts.

Land legislations continue changing in Panama. In 2010 a new land authority was established in order to administer and regulate land property rights. ANATI (National Authority of Land), among many other functions, is in charge to mediate in land related disputes, dictate the policies with regard to indigenous' people land and improve the cadastral system. The most updated change that the Agrarian Code suffered was in 2011, regulating agrarian activities, contracts and sustainable land use. As we can see, land regulations are constantly changing and they are still a polemic topic in Panama.

3. Data and empirical strategy

3.1. Data

The main dataset is from the Panama's Agricultural Census of 1990, 2000 and 2010, compiled by the National Institute of Statistics and Census of Panama (INEC). I also use data from National Census of Population and Housing of 1990, 2000 and 2010 collected by INEC. The National Institute of Statistics and Census is the governmental institution that collects, processes and prepares the Panamanian statistics. The first Agricultural Census in Panama took place in 1950, and the most updated Agricultural Census was held in 2010. The data used in this paper is at district and corregimiento level. Panama is divided by provinces, districts and corregimientos. Figure 1 shows the administrative political division of Panama at corregimiento level.

The Agricultural Census offers aggregated data in number of plots and hectares by province, district and corregimiento. There were some political changes at the district level during the time this study focuses. First, in 1997 Comarca Ngobe Bugle, an indigenous people's province, was created. Indigenous people's provinces are called "Comarcas" in Panama, I omit Comarca's districts and all districts that suffered political changes from the creation of the Comarca because of their special land holding system[2]. Then in 2001 the district of Montijo was split into two districts. I added the results of the two districts in order to use them in the panel data analysis. Rice is produced in all districts in Panama.

From 1990 to 2010, Panama suffered a great amount of political changes at the corregimiento level. That is the reason why in this research corregimiento level data is just used in cross section analysis. In 2012, Panama was divided in 621 corregimientos. I drop all corregimientos that do not produce rice and from the metropolitan areas of Colon and Panama.

This paper uses Living Standards Measurement Study by World Bank to analyze the mechanisms at household level from 1997 and 2008. LSMS is a household survey organized by World Bank and the Ministry of Economic and Finance in Panama. Three independent rounds have been held in Panama in 1997, 2003 and 2008. The data is pooled cross-sectional.

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[2] Comarcas are the indigenous areas in Panama. The main land tenancy system in these areas is collective land holdings; therefore they are not included in this research.

3.2. Empirical strategy for baseline analysis

To investigate the impact of privately owned land on agricultural productivity this paper uses district level panel data with fixed effects from 1990 to 2010 in Panama. To measure the impact of land property rights on agricultural output, the specification is:

$$(1) \quad y_{dt} = \alpha_d + \beta_t + \gamma x_{dt} + \delta z_{dt} + \varepsilon_{dt}$$

Where, y_{dt} is log of some agricultural yield. α_d is district fixed effect and β_t represents year fixed effect. x_{dt} is complete land rights, defined as the share of privately owned land to total land used for agricultural activities and z_{dt} represents time variant control variables.

The main variable used to capture the effect of land private rights at district level is share of privately owned land. I define it as the share of land used for agricultural purposes by district where the owner possesses the title deed formally registered to the legal authority (Registro Publico de Panama). I use two proxies for agricultural productivity: Rice land yield and labor productivity. Rice yield is defined as rice harvested (in hundredweight) divided by the net rice sown area (in hectares) per district. Labor productivity is defined following Chankrajang (2015) as rice harvested (in hundredweight) divided by the number of farmers by district. Not all farmers are rice producer, this variable is under the assumption that the percentage of rice producers is constant throughout time[3]. Rice is a staple grain in Panama, it is produced in every district. No other crop is cultivated in every district. Then, share of privately owned land measures the impact of land certification and registration on agricultural productivity.

This paper's empirical strategy could be argued to have endogeneity. First, reverse causality. For example, districts that are poor, less productive and with lower levels of investment may attract government attention to implement land registration policies. However, these are, until some extent, time invariant characteristics; thus using fixed effects at district level mitigates this concern. Another issue of the strategy above is that land registration may correlate with unobservable district specific characteristics that also impact agricultural outcomes. I deal with this endogeneity concern including important district specific control variables at district level.

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[3] Chankrajang (2015) argues that cultivation for rice requires a specific skill, fixed investments and long-term preparation. Then, the share of rice farmers in a district could be constant. Using logarithmic form and fixed effect captures this effect.

I use OLS cross section at corregimiento level in order to alleviate the possibility of heterogeneity within districts. Using data from 2010 permits the inclusion of more control variables.[4] The cross section corregimiento specification is the following:

$$(2) \quad y_i = \alpha + \beta x_i + \gamma z_i + \varepsilon_i$$

Where, y_i is log of rice yield. As before, rice yield is defined as rice harvested (in hundredweight) divided by the net rice sown area (in hectares) per corregimiento. x_i is complete land rights, defined as the share of privately owned land to total land used for agricultural activities and z_i represents time variant and invariant control variables.

A more disaggregated level of data as household is arguably preferred to study the impact of land certification and registration. Therefore, I use household level data to explore some possible mechanisms through which land registration impacts agricultural productivity: loans, land attached and mobile investments, and low cost investments. I will explain the empirical strategy at household level in section 4.2.

Table 1 here

3.2.1. Descriptive statistics

Table 1 shows the summary statistics of main variables at district and corregimiento level. The upper part of table 1 shows the summary statistics at district level data from 1990 to 2010, meanwhile, the lower part indicates the descriptive statistics at corregimiento level in 2010. At district level, in the interval of 1990 and 2010, the mean of rice yield was 36.11 cwt per hectare, the district with higher productivity yielded 103.34 cwt per hectare while the least productive one yielded 5.65 cwt per hectare. From 1990 to 2010 rice productivity steadily increased and so did share of privately owned land at district level. Corregimiento level data shows similar patterns to district level data, but the dispersion of the results tends to be higher.

4. Results

4.1 Effects of land title registration on agriculture productivity

This section presents the results of the empirical specification in equation No. 1 and No. 2. I divide the aggregated data in two groups, agriculture intensive and non-agriculture intensive. In the dataset, the median value of the share of workers in the agriculture sector is near 45% and 42% per district and

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[4] More data is available in 2010 than in 1990.

corregimiento respectively. For this reason I define as agriculture labor intensive areas those where farmers represent 40% or more of the total working population.

<div align="center">***Table 2 here***</div>

Table 2 shows the baseline results using district-level panel data. The coefficient of share of private land in Column 1 indicates that an increase in land privatization raises rice land yield after including year and district fixed effects which control for year shocks, time invariant geographical characteristics and labor market opportunities that might affect the results. The coefficient of private land loses its significance in Column 2 when I include important time variant district characteristics as population density, illiteracy percentage and median income. Population density coefficient is positive but not statistically significant. Illiteracy measures human capital and the coefficient is negative and statistically significant. Lastly, median income measures the income status of an average person in a district and it does not have a significant effect in Column 2. In Column 3, I repeat the analysis done in Column 2, but this time I restrict the sample to agriculture intensive districts. The coefficient of share of privately owned land is positive and statistically significant in Column 3, indicating that an increase in land privatization raises rice land yield in agriculture intensive districts. In Column 4, I use non agriculture intensive districts and the coefficients are negative but not statistically significant. In sum, Panel A of Table 2 implies that agriculture labor intensive districts with higher share of complete land rights have a greater improvement in rice output per cultivated area.

Panel B of Table 2 shows the effects of land rights on labor productivity. The coefficient of share of privately owned in Column 5 is positive, but not statistically significant after including fixed effects and time variant controls. Similarly in Column 6, the coefficient of share of private land is not significant in agriculture intensive districts. In Column 7, I restrict the sample to non-agriculture intensive districts and, similar to Column 4, the coefficient is negative and it is not statistically significant. These results indicate that there is no statistically significant impact of land privatization on labor productivity.

Panel A and Panel B of Table 2 measure different types of rice productivity. The results of Table 2, indicate that in Panama in agriculture intensive districts with higher share of land security measured by land registration, land productivity is statistically significantly higher but labor productivity is not. It might seem baffling that land registration impacts land yield but it does not have any effect in labor productivity in agriculture intensive districts. However, this difference indicate that in agriculture labor intensive districts land registration changes land allocation to more productive farmers, promote land reallocation to different activities and increase investments that make land more productive.

4.2 Robustness check: Land privatization on land yield

It is interesting to see that while the share of privately owned land has a statistically significant positive relationship with rice land yield in agriculture labor intensive districts; in non-agriculture labor intensive districts, the relationship is not statistically significant. To provide a robustness check of these results, I explore the effect of the share of privately owned land per corregimiento on land rice yield. Corregimiento is a less disaggregated level of data than district, allowing to control for heterogeneity within districts. It is a cross section analysis, thus the results of these estimations have to be taken with caution because of endogeneity concerns related to time variant and invariant unobservable characteristics. I mitigate this issue including variables that control for soil, meteorologic, demographic and income characteristics per corregimientos.

The results in Column 1 of Table 3 show that the coefficient of the share of private land is positive and significant at the 1\%, highlighting that an increase in land privatization is associated with a raise in rice yield. Column 1 also shows that an increase in rainfall by corregimiento decreases rice yield. Furthermore, the coefficient of share of irrigated land is negative and statistically significant, indicating that an increase of the share of irrigated land by corregimiento decreases rice productivity. The most common type of rice cultivation in Panama is upland rice. Upland rice is highly dependent on weather conditions and type of soil. In Panama corregimientos with higher shares of irrigated rice might have less suitable characteristics for rice production. Another statistically significant control variable in Column 1 is the share of mechanized land, an increase of the share of mechanized land is associated with a raise in rice yield.

Column 2 restricts the sample to agriculture intensive corregimientos. The coefficient of share of private land in Column 2 is positive and statistically significant after controlling for a number of variables. This shows that an increase in land privatization is associated with a raise of land rice yield in agriculture labor intensive corregimientos. I repeat the same analysis in Column 3, restricting the sample to non-agriculture intensive corregimientos. This time, the coefficient of share of private land is positive but has no statistical significance, indicating that an increase of land privatization in non-agriculture labor intensive corregimientos is not statistically related with a raise of land productivity.

The results of the previous tables suggest that in Panama improving property rights in agriculture intensive areas impacts efficiency of allocation, limiting expropriation and improving market transactions as in Besley and Ghatak (2010). In both corregimiento and district cases, in agriculture labor intensive areas, a higher share of complete land rights is associated with an increase of rice yield while, in non-agriculture intensive areas, the relationship is not statistically significant. In agriculture intensive areas land privatization incentivizes farmers to be more productive. There might be better access to credit, higher

incentives to invest in land improvements, land reallocation to more efficient activities and farmers and reallocation of labor to other markets.

Table 3 here

4.3 Mechanisms

I have shown that an increase in the share of private land is associated with a raise on land productivity in agriculture labor intense districts. The purpose of this section is to explore the possible mechanisms through which complete land rights impacts productivity. I use household level data to analyze the effect of land regularization on access to credit; and on land attached, land mobile and low cost investments.

I use pooled cross-section data from 1997 and 2008 at household level in this section. This data comes from Living Standard Measurement Survey conducted by the World Bank and the Ministry of Economics and Finance of Panama. LSMS surveyed 4,945 and 7,045 household in 1997 and 2008 respectively. I only use households working either full or part time in the agricultural sector that considered themselves as land owners. LSMS asks the following question, have you used your own land for agricultural purposes in the lasts 12 months? I restricted the sample to households that answered yes to the previous question.

To measure the impact of land property rights on access to credit and investments, the specification is

$$(3) \quad y_{it} = \beta x_{it} + \gamma z_{it} + \delta_t + \varepsilon_{it}$$

Where y_{it} is a dummy variable that takes the value of one if the household received an agricultural loan or undertook an investment, zero otherwise. x_{it} is a dummy variable that takes the value of one if the household possess the land title deed properly registered, zero otherwise. z_{it} controls for household and plot characteristics. δ_t represents year fixed effect.

I use probit and linear probability models. The previous specification has two typical endogeneity concerns found in the literature of land rights and investments. The most common concern in the literature of land rights in investments is reverse causality. Sjaastad and Bromley (1997) argue that land insecurity may incentive land-attach investment to strength security. This would lead to overestimated and biased coefficients. The best way to solve for this issue is using instrumental variables. Common instruments used are previous investments (Besley 1995; Brasselle et al. 2002, etc.), historic characteristics (Banerjee and Iyer, 2005) and modes of plot acquisition (Fenske, 2010). I deal with this issue restricting the sample to households that considered themselves as land owners. This mean that all households have high levels of

land security and investments in land are not related to the decision of certification and registration of the land title. Another endogeneity concern is unobserved households-specific characteristics. Deininger and Chamorro (2004), argue that farmers with better access to credit or investment environment are more likely to register their land. I mitigate this concern adding districts and year dummy variables in the specifications, under the assumption that households in the same district have a very similar access to credit and investments.

Even though all the households used in the analyses considered themselves as land owners, only around 35\% had a registered title and 10\% of the households had a possession right certificate (derecho posesorio). Possession right certificates are land use rights in Panama. Possession right certificates can be exploited for agricultural purposes and transferred, but they cannot be used as collateral in the formal credit market. To get a possession right certificate, the occupier has to meet a number of requirements, e.g. proving that she has settled the land for a long period of time and being of a lower income household.

*** Table 4 here***

4.3.1 Credit access

Land titling and privatization might increase access to credit, as farmers can use their land as a collateral for loans. This subsection explores the effect of holding a registered title on applying for and obtaining loans. In Column 1 of Table 4, I use a dummy variable that takes the value of one if the household applied for an agricultural loan in the last 12 months as dependent variable. The variable of interest in Table 4 is registered title. In Column 1 the coefficient of registered title is positive and statistically significant, using probit model. In Column 1 controls for plot specific and household characteristics, and the statistically significant control variables are area, area squared and consumption. I repeat the analysis, using linear probability and fixed effects in Column 2. The coefficient of registered title is statistically significant, indicating that farmers with registered titles are 3.7% more likely to apply for an agriculture loan than their counterparts without titles.

I use a dummy variable that takes the value of one if the household obtained an agricultural loan in the last 12 months as dependent variable in Column 3 and 4 of Table 4. In Column 3 the coefficient of registered title is significant using probit model. Using linear probabilities in Column 4, confirms that the propensity of obtaining an agriculture credit is higher for households with registered titles. Deininger and Chamorro (2004) point out that farmers with better access to credit are more likely to formally register their land, household specific unobservable characteristics might affect the results of Table 4. I mitigate this

issue including district and year fixed effects in the linear probability model, and adding plot specific and household specific control variables.

These results are not consistent with other Latin American countries evidences where land tenure security improvements are not translating into better access to credit. For example Carter and Olinto (2003) findings suggest that there are no credit supply effects of tenure security on small farmers in Paraguay. Jansen and Roquas (1998) found that land titles were not used as a collateral, instead producers mortgaged their houses or their production in Honduras. In fact, the authors argue that few farmers actually received credit from formal institutions. In my specification, the data have no information whether households use their land as a collateral or if they use their houses or production. Nonetheless, according to Columns 3 and 4 of Table 4, households with registered titles are around 3.8% more likely to obtain an agricultural loan. This might be one of the mechanisms which through complete land rights improve rice yield.

4.3.2   Investments

Insert Table 5 here

Complete land rights might incentivize farmers to invest on machinery, land improvements and land conservation. Deininger (2003) found that registration of land titles increases the propensity to undertake investments in Nicaragua. I explore different types of investments that might be associated with land privatization, using probit and linear probability models. First, I explore the probability of investing on different types of land attached and land mobile investments when household have complete land rights. The dependent variables are dummy variables that take the value of 1 if the household undertakes an investment and 0 if it does not. Result from Table 5 Column 1 shows that the coefficient of registered title deed is positive and statistically significant. In Column 1 the dependent variable is investment on sheds which it's a type of land-attached investment. The propensity to undertake this investment increases 2.7% when the title is properly registered. Column 2 confirms the investment enhancing impact of land registration on sheds, including fixed effects. Possession right certificate coefficients are negative in both Column 1 and 2. Farmers with possession right certificates have some higher degree of security than farmers lacking any certification, however possession right holders are not more likely to invest on land attached investments than title-less farmers.

Then, I focus on other types of investments: trucks, agricultural sprayers and tractors. All of them are land mobile investments. The coefficients of registered title is positive and statistically significant in Column 3, indicating that households with a registered title are around 1.7% more likely to invest in trucks. Using linear probability in Column 4 confirms the results, but the effect is stronger. In Column 5, the

coefficient of registered title indicates that households with a complete land rights are 7.6% more likely to invest in sprayers. The Coefficient of register title in Column 6 corroborates this result. Interestingly, the propensity of invest in tractors does not increase for households with complete land rights, according to the coefficients of registered title in Column 7 and 8 which are not statistically significant.

In Table 5 the coefficients of area and household consumption are statistically significantly in all the estimations. It indicates that farmers with larger plots and with higher well-being status have a higher propensity to undertake land related investments. These results indicates that farmers have high incentives to invest when they own the land title, knowing that the returns of the investment will be earn by them.

Insert Table 6

Higher levels of land security may motivate farmers to invest in low costs investments that improve land yield. Then, I focus on the following low costs investments: seeds, natural fertilizers, other fertilizers and pesticides. Column 1 of Table 6 suggest that having a registered title does not have any statistical significance on the probability of investing on high yield seeds and plants. The coefficient of registered title in Column 2 is negative, but not statistically significant. This indicate that registering the title, does not increase the propensity to invest in natural fertilizers. The dependent variable of Column 3 is other fertilizers and, again, the coefficient of registered title is not statistically significant. This confirms that households with registered title are not necessarily more likely to invest in fertilizers than their counterparts without title. The coefficient of registered title is positive and statistically significant in Column 4, indicating that households with complete land rights are 4.4% more likely to use pesticides. The coefficients of registered title deed in column 1, 2 and 3 are not statistically significant. Household consumption is always significant, and this shows that household's well-being increases the probability of buying low cost inputs.

The results of this section suggest that the main channels through which land registration impacts agricultural productivity are loans, investment on machinery, land-attached investments and higher use of pesticides.

5   Concluding remarks

This paper used panel data to analyze the impact of land property rights on agricultural productivity in Panama. The findings show that an increase in land rights in agriculture intensive districts is associated with a raise in land productivity. Then, it used LSMS household data to explore potential mechanisms through which property rights affect productivity. It indicates that households with registered land titles are more likely to obtain agricultural credit, undertake land-attached and land mobile investments and use

pesticides. Due to data constraints this paper could not investigate the impact of more secure property rights on land transfers which could be a potential significant mechanism.

The impact of property rights or land tiling programs on the agriculture sector in Latin America has been repeatedly studied, however, these studies have found different results. Like this paper, other studies also find a positive impact of land titling on agricultural outcomes in Latin America. For example, in Nicaragua a land titling and registration program resulted in an increase in land-attached investments (Deininger and Chamorro, 2003). Also, lack of land title is a strong disincentive to participate in the rental market in Nicaragua (Deininger et al., 2003). In Mexico, De Janvry et al. (2015) findings suggest that land certification allows for more efficient land and labor allocation. While in Paraguay, tenure security has a strong effect on demand for land-attached capital. However, these effects might only benefit large scale producers (Carter and Olinto, 2003).

Some studies did not find a positive effect of titling on the agriculture sector. For example, Jansen and Roquas (1998) argue that a land titling program in Honduras was not associated with an increase in investment and productivity, instead the land titling program exacerbated land related conflicts. Then, a major expansion of land titles, in Nicaragua and Honduras, did not increase formal credit market participation (Boucher et al. 2004). There might be two reasons why the results of these two previous studies are completely different from the findings of this paper. First, in Panama land registration increases tenure security, while in Honduras, according to Jansen and Roquas (1998), the title program was poorly implemented and did not increase land security. Secondly, in majority of Central American countries rural credit markets are not sufficiently evolved, therefore property rights are not improving credit access. Panama has a well-functioning financial system, there might be access to formal credit in rural areas. In fact, in Panama agricultural credit has increased in the last years.

Table 1: Descriptive Statistics

District level 1990-2010				
Rice Yield (cwt per ha)	Share of privately owned land	Total land (ha)	Farmers	Rice produced per farmer
36.11	0.42	43063.13	2646.52	34.67
Standard 23.72	0.22	48624.38	2205.83	67.69
Maximun 103.34	0.87	497746.6	10519	554.34
Minimun 5.65	0.01	384.53	103	0.17
Mean in:				
1990 32.71	0.32	46634.44	3121.16	23.61
2000 35.86	0.38	43869.38	2505.84	39.32
2010 39.74	0.54	38685.57	2312.57	41.07
Log of rice	Pop. density	Illiteracy	Log of labor	Workers in
Mean 3.38	88.27	13.47	2.50	45.1
Standard 0.64	309.83	9.25	1.46	22.96
Maximun 4.64	2771.7	50.4	6.32	83.99
Minimun 1.73	2.4	1.6	-1.79	1.25
Corregimiento level 2010				
Rice Yield (cwt	Share of privately	Total land	Farmers	Rice produced
Mean 32.46	0.54	4781.02	375.90	50.38
Standard 34.26	0.26	5830.53	352.53	172.35
Maximum 420.46	0.99	58430.34	2546	2219.44
Minimum 0.12	0	112.17	14	0.01
Log of rice	Pop. density	Illiteracy	Rainfall	Log of labor
Mean 3.16	87.06	10.28	33406.55	1.96
Standard 0.79	268.04	6.73	1930.47	1.94
Maximum 6.04	3734.2	33.26	33836	7.70
Minimum -2.09	0.3	1.08	1280.4	-4.95

Table 2: Effects of land titling on agricultural productivity 1990-2010

	A: Log rice yield				B: Log labor productivity		
	All dataset (1)	All dataset (2)	farmers>40% (3)	farmers <40% (4)	All dataset (5)	farmers>40% (6)	farmers< 40% (7)
Share of privately owned land	0.401*	0.427	0.481*	-0.539	0.08	0.265	-0.539
	(0.237)	(0.277)	(0.254)	(0.585)	(0.468)	(0.393)	(0.585)
Population density		0.0003	0.005	0.0001	-0.001***	0.004	0.000
		(0.0003)	(0.021)	(0.0004)	(0.0003)	(0.034)	0.0004
Log median income		-0.154*	-0.135	-0.137	-0.553***	-0.457***	-0.137
		(0.092)	(0.106)	(0.421)	(0.026)	(0.17)	(0.421)
Illiteracy Percentage		-0.021*	-0.012	-0.081	-0.092***	-0.063***	-0.081
		(0.011)	(0.012)	(0.065)	(0.026)	(0.019)	(0.065)
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	171	171	101	70	171	101	101
Adjusted R-squared	0.144	0.01	0.077	0.07	0.031	0.005	0.07

Note: Robust standard errors are in parenthesis
  ***, **, * stand for significant at 1%, 5% and 10%. FE means fixed effect

Table 3: Effects of land privatization on log agricultural productivity 2010

A: Log Rice Yield

	All dataset(1)	Farmers>40% (2)	Farmers<40% (3)
Share of privately owned land	0.26***	0.249**	0.199
	(0.101)	(0.108)	(0.195)
Pop. Density	-0.0001	-0.003*	-0.002*
	(0.0001)	(0.002)	(0.0001)
Illiteracy %	0.003	-0.0001	-0.009
	(0.006)	(0.006)	(0.014)
Sex ratio	-0.001	0.002	-0.011**
	(0.004)	(0.006)	(0.005)
Rainfall	-0.00002*	-0.00003*	-0.00001
	(0.00001)	(0.00001)	(0.00003)
Share of irrigated land	-1.095***	0.172	-1.102***
	(0.241)	(0.174)	(0.198)
Share of mechanized land	1.761***	1.781***	1.686***
	(0.068)	(0.108)	(0.095)
Log median family income	0.121*	0.055	0.107
	(0.074)	(0.089)	(0.185)
Observations 498	498	266	232
R-squared 0.038	0.496	0.52	0.525

Note: Robust standard errors are in parenthesis

***, **, * stand for significant at 1%, 5% and 10%.

Table 4: Probability of applying for and obtaining agricultural loans

	Applying for loans		Obtaining loans	
	(1): Probit	(2): OLS	(3): Probit	(4): OLS
Registered title deed	0.037***	0.037***	0.038***	0.041***
	(3.60)	(0.012)	(3.83)	(0.012)
Possession right	0.026	0.022	0.021	0.017
	(1.63)	(0.17)	(1.31)	(0.015)
Area	0.001***	0.001***	0.001***	0.001***
	(6.04)	(0.0002)	(5.85)	(0.0002)
Area squared	-2.22E-06***	-3.39E-07***	-1.98E-06***	-3.03E-07***
	(-3.79)	(1.06E-07)	(-3.70)	(1.02E-07)
Years of posssession	-0.0005	-0.0002	-0.0005	-0.0002
	(-1.59)	(0.0003)	(-1.62)	(0.0003)
LogHousehold consumption	0.021***	0.026***	0.019***	0.024***
	(4.25)	(0.007)	(4.01)	(0.007)
Year fixed effect	No	Yes	No	Yes
District fixed effect	No	Yes	No	Yes
Observations	2129	2129	2129	2129
(Pseudo) R-squared	0.128	0.085	0.132	0.083

Notes: Probit regression coefficients are average marginal probabilities and robust z-statistics on parentheses. For linear probability model robust standard errors are in parentheses. ***, **, * Significant at 1%, 5% and 10% respectively.

Table 5: Probability of having made land attached and machinery invest- ments.

	Sheds		Trucks		Sprayers		Tractors	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Registered title	0.027**	0.036**	0.017**	0.022*	0.076***	0.085***	0.002	0.006
	(2.29)	(0.015)	(2.01)	(0.11)	(3.62)	(0.024)	(0.43)	(0.006)
Possession right	-0.029	-0.019	0.002	-0.006	-0.021	-0.015	0.003	0.003
	(-1.25)	(0.016)	(0.14)	(0.010)	(-0.63)	(0.033)	(0.43)	(0.007)
Area	0.0003**	0.001***	0.0004**	0.0005**	0.004***	0.001***	0.0002***	0.0003*
	(3.43)	(0.0002)	(3.24)	(0.0002)	(7.87)	(0.0003)	(2.67)	(0.0002)
Area squared	-2.27E-	-3.51E-	-5.05E-	-2.44E-	-7.39E-	-5.63E-	2.20E-07	-1.44E-07*
	(-2.81)	(-1.13E-	(-1.96)	(1.02E-	(-5.85)	(1.76E-	(-1.74)	(7.52E-08)
Years of possession	0.001*	0.0001	-0.0005*	-0.0005**	-0.0002	0.0005	-0.0002	-0.0002
	(1.69)	(0.0004)	(-1.78)	(0.0003)	(-0.37)	(0.001)	(-1.15)	(0.0002)
LogHousehold	0.066***	0.058***	0.046***	0.049***	0.114***	0.102***	0.016***	0.019***
	(10.24)	(0.008)	(8.19)	(0.007)	(11.20)	(0.013)	(4.47)	(0.006)
Year fixed effect	No	Yes	No	Yes	No	Yes	No	Yes
District fixed effect	No	Yes	No	Yes	No	Yes	No	Yes
Observations	2129	2129	2129	2129	2129	2129	2129	2129
(Pseudo) R-squared	0.151	0.172	0.288	0.183	0.105	0.189	0.269	0.097

Notes: Probit regression coefficients are average marginal probabilities and robust z-statistics on parentheses. For linear probability model robust standard errors are in parentheses. ***, **, * Significant at 1%, 5% and 10% respectively.

Table 6: Probability of having made investments

	Seeds	Natural Fertilizers	Other Fertilizers	Pesticides
Registered title deed	-0.013	-0.008	0.014	0.044**
	(-0.83)	(-0.55)	(0.70)	(2.02)
Possession right	0.019	0.010	-0.013	-0.027
	(0.81)	(-0.45)	(-0.42)	(-0.80)
Area	0.0002	-0.0001	-0.0005**	0.0004
	(0.83)	(-0.50)	(-2.14)	(1.35)
Area squared	-2.49E-07	4.57E-08	2.53E-07**	-5.41E-07**
	(-1.63)	(0.62)	(2.10)	(-2.00)
Years of posssession	-0.001*	0.0001	-0.0006	-0.0005
	(-1.92)	(0.22)	(-1.08)	(-0.81)
LogHousehold consumption	0.057***	0.055***	0.121***	0.079***
	(7.19)	(8.06)	(13.53)	(7.71)
Observations	2129	2129	2129	2129
Pseudo R-squared	0.042	0.048	0.077	0.033

Notes: Probit regressions. Average marginal probabilities. Robust z-statistics on parentheses. ***, **, * Significant at 1%, 5% and 10% respectively.

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