Scaling Farms to the Frontier

The case of non-traditional agricultural exports in Peru

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Productivity is a topic that has both intrigued and fascinated us since we began studying economics. It was not surprising that we ended up writing our SYPA on it. Agriculture, on the other hand, was an exploratory journey. Focusing our obsession of growth towards a sector that is often overlooked – but that still represents the main source of economic activity for millions of people around the world – gave our work meaning.

We dedicate this SYPA to Ani and Sari. Our work process would not have been the same without them. Apart from giving us very useful comments and advice, they were a constant support throughout the year, a source for debating ideas, and our road-trip partners for visiting farms in Peru.

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Table of contents

Tables, figures and boxes

1. Executive Summary

Peru is a country endowed with several natural ecosystems. Since the early 2000s, Peruvian agriculture has experienced a boom in exports – mostly due to non-traditional crops such as asparagus, cocoa, coffee, mangos, avocados, bananas and grapes. The boost in exports reflects that some Peruvian agro-export firms are producing at levels comparable to international market leaders. However, if we compare the productivity of these firms with the rest of the country, we get yields far less impressive.

The work for this Second Year Policy Analysis (SYPA) is motivated by what appears to be different realities across the country in terms of agricultural productivity. It is also motivated by the potential opportunity Peru has to strengthen its position as a world class competitor in non-traditional crops.

We focus our analysis on non-traditional agricultural products because of their huge untapped potential. We explore differences across farms' size, rather than across regions, as scale has been less analyzed in Peru. There is also little international consensus on whether size is positive or negatively related with productivity. Our main finding is that plot size is a significant determinant of productivity of non-traditional crops in Peru, explaining a larger percentage of variance in yields than what regional differences can explain. Non-traditional crops require scale to achieve higher productivity.

Given this positive association between plot size and productivity, we focus our attention on smaller farms to explore how they could increase their size. Agricultural cooperatives are associations between farmers to pool resources and achieve greater scale. Our estimates confirm that joining a cooperative is positively correlated with productivity. The main mechanism through which they work is by granting access to international markets and modern inputs. We also find that, in smaller farms, having a younger farmer in charge leads to higher output and likelihood of joining a cooperative.

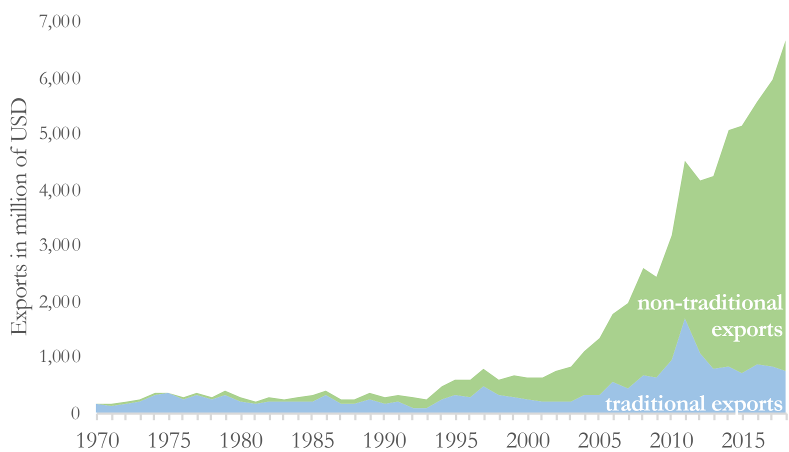
Given our findings, we propose that the Ministry of Agriculture release a policy package aimed for improving productivity through increasing farms' scale. First, we propose that they foster cooperatives between small farmers. We predict significant gains in productivity per farmer for joining a cooperative. For example, for banana farmers, these gains represent an increase in their income of PEN 450 (~USD 125) per year. Second, we propose a quasi-universal rural pension to promote farmer retirement which would allow for an intergenerational transition among farmers. We estimate that productivity gains from this policy offsets almost 40% of the cost of the program. Finally, we propose to enhance property rights as a way of boosting the effect of the two previous policies.

2. Introduction

Peru is a country with a huge endowment of natural ecosystems where agriculture still represents a large share of employment (~27%) and GDP (~7%). There have been recent successes in the development of new agricultural exports and agro-export firms in the last few decades. Currently, Peru is one of the top five world exporters of asparagus, avocado and grapes – crops with high yield per hectare. However, this strong agricultural productivity is not homogeneous for every firm that produces these crops. Furthermore, productivity is even more unequal among crops with less impressive yields.

Since the early 2000s, Peruvian agriculture has experienced a boom in exports, growing at a CAGR[1] of 13.9% in the last two decades (Peruvian Central Bank, 2000-2018). Approximately 90% of the increase in agriculture exports came from non-traditional crops (mainly asparagus, coffee, mangos, avocados, grapes, and others), which grew at a CAGR of 16.2%. By contrast, exports of the traditional agricultural sector grew less rapidly (6.4% CAGR).

Figure 1 - Peruvian agricultural exports



Source: Own elaboration based on Banco Central de Reserva.

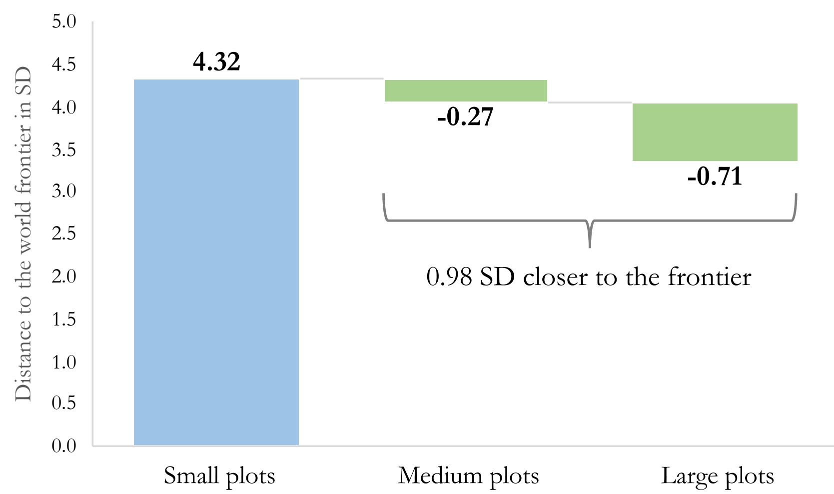
The export boom was possible in part due to an initial effort from the Government to boost the agricultural sector through a special tax and labor regime. This regime lowered the income tax rate from 30% to 15%. It also established a special labor regime for agricultural firms reducing their obligations to workers, including fewer vacation days, lower health insurance payments and lower severance pay (World Bank, 2017b). The subsequent boom demonstrated the potential Peru has to

[1] CAGR refers to Compound Annual Growth Rate.

become a leading exporter of premium products, given the right incentives and policies in the agriculture sector for firms.

The special regime was a first step in boosting exports and enabled some agriculture companies to come closer to the international frontier of productivity[2], but there is still much to be done. Non-traditional crops require formal and responsible producers that can meet high international standards in terms of certifications, time and quality. This is not feasible for many new entrants into non-traditional crops. The conditions under which many operate are still suboptimal, and there is significant heterogeneity across the country. As a recent study from the World Bank (2017a) states: "*although macro-level data suggests that agricultural productivity has been growing, important differences persist between regions and between categories of producers*"[3].

Figure 2 - Distance to world frontier by size



Note: Small plots are those with less than 10 hectares, medium plots are those between 10 and 50 hectares and large plots are large plots are those bigger than 50 hectares. The distance to the international productivity frontier is calculated using seven different crops.
Source: own elaboration based on ENA 2015 and 2016.

We propose that an important source of variation between high-productivity and low-productivity farms is explained by their size. As shown in Figure 2, there is a significant difference in productivity[4] depending on farm size. On average for all the crops selected for this study, large plots are almost one standard deviation closer to the international productivity frontier than small plots.

[2] The international productivity frontier is defined by the level of yield per hectare of the most productive country in the world for each specific crop.
[3] Own translation from World Bank (2017a), page xiv.
[4] Productivity is estimated as a standardized distance to the international productivity frontier. For more information see Box 1.

The work for this Second Year Policy Analysis (SYPA) is motivated by these different realities, as well as by the potential Peru has to strengthen its position as a world class competitor in non-traditional crops. Our objective is to analyze productivity in the agricultural sector and provide a diagnosis for the gaps and high variability of productivity in Peru.

We will focus our analysis on non-traditional agricultural products, which seem to have the biggest potential for growth in Peru. Rather than approaching this problem as a regional one (which has already been studied at length), we focus on differences in productivity based on size of farms. We want to contribute new evidence to the exploration of a relationship between scale and productivity in agriculture. To the best of our knowledge, this is the first study that explores this relationship in Peru.

To analyze farm productivity, we constructed a variable that compares the yield of each farm by crop with the average yield of the world's most productive country in that crop. This gives us a farmer-crop level dataset. We then standardize this distance across all crops for comparison purposes. Additionally, using a large Peruvian agricultural survey we are able to estimate how the usage of certain modern inputs and other farm and farmer's characteristics are linked to farms' productivity.

We then use these datasets to estimate several variance decomposition and regression exercises and explore what are the determinants of agricultural productivity in non-traditional crops. The idea is to test whether – besides exogenous climate conditions – plots size is the main explanatory variable of productivity and to provide a package of productivity-enhancing policy recommendations for the Ministry of Agriculture (MINAGRI).

The rest of this document is organized as follows. First, we will start with a literature review of different approaches regarding agricultural productivity and its relationship with different variables, as well as what has been studied in Peru. Second, we will follow with the empirical strategy where we will explain our measure of farm's productivity, the different databases that we use, the division we perform of the country into ecoregions, and the selection of non-traditional crops for our in-depth analysis. Third, we will present a section with the main results of our analysis where we estimate a model of agricultural productivity. We will first show results for all the farms in our dataset, and then we will focus in the subset of smaller farms. Finally, we will conclude with 3 policy recommendations that the MINAGRI could implement to boost productivity in non-traditional agriculture.

3. Literature Review

It is well-stablished that agriculture's shares of GDP and labor decline as countries develop (Todaro and Smith, 2011). Thus, as expected, agriculture still occupies a key role in the economy of developing countries –-it employs 57% of labor and contributes 21% of GDP (World Bank, 2019).

Peru is an interesting case because, despite its natural-resources potential, only a few high-productivity farmers are found in the country, concentrated around certain crops and regions. The sector's overall productivity is low and heterogeneous, which implies an enormous wasted potential from "getting plots closer to the frontier" in terms of economic growth, efficiency and living standards.

Productivity differentials for agriculture have been broadly studied in the literature. The following review of the literature tries to offer an overview of the different approaches to agricultural productivity that have been taken by experts. More than an exhaustive review, we will try to provide as many different approaches to agriculture productivity as possible to get a better understanding of how it is measured and what are the relevant questions we should be asking.

We will start this section with an overview of papers that highlight the importance of studying productivity, as a way to further motivating our analysis. We will proceed with evidence on the relationship of different variables with productivity included in the literature. We will complete this analysis with an overview of what has been done in the context we are focusing in Peru. Finally, we will specify how this SYPA fills a gap in the literature.

3.1. On why we study agricultural productivity

Between-country analysis shows that agriculture's productivity in the richest countries was 78 times higher than that of poor countries in 1985 (Restuccia et al, 2008). And yet, poor countries allocate 86% of their labor in agriculture. These facts raise the question of why agriculture is so relatively unproductive in poor countries. The authors answer this question by providing a model that calibrates two components: economic-wide productivity and barriers to the use of modern inputs. They find that removing constraints in the latter increases aggregate productivity in poor countries.

With a different approach, Gollin et al (2002) examine data from FAO for the period of 1960–1990 and find that increases in productivity in agriculture result in a general growth of GDP per worker, not just in that sector. Raising agriculture productivity releases labor to other sectors in the economy. This adds to our motivation of increasing agriculture productivity.

3.2. On the variables that have been tested

Farm Size

The relationship between plot size and productivity is critical in the agricultural literature. There is, however, little consensus on the direction and strength of this relationship. In some developing regions, bigger farms are correlated with higher yields per hectare, while smaller ones remain unproductive. And yet, in others, small farms persist and even have higher productivity. The lack of consensus comes from the fact that plot size significantly varies between regions and within countries, which makes it difficult for meta-analysis to find a pattern.

In a comprehensive study, Gollin (2018) compares the differences in output per hour of maize in 19 countries (from 16 studies). According to him, the mixed results can be explained by a U-shaped relationship between the size of the farm and the productivity of labor. In smaller farms, there is a clear inverse relationship; whereas at high levels of farm size the relationship is positive. The latter is especially true for crops where there are potential for investment in capital and mechanization. Such relationship is not causal, but it seems intuitive that farmers with access to large amounts of land -and to capital and technology- would produce more output per worker than their counterparts.

Cooperatives

Agricultural cooperatives are voluntary formal associations between farmers that pool their resources to meet a common goal (ILO, 2012). Generally, cooperatives can be focused on services or on workers that unite to offer jobs between them. Agricultural cooperatives are used as a way to improve technology adoption and welfare. They can relax the constraints of farmers by offering credit, market information, better prices, and by pooling resources to create economies of scale (Wossen et al., 2017)

In an analysis of Nigerian farmers, Wossen et al. (2017) find that cooperative membership has a positive and significant effect on technology adoption and household welfare. In the same line, Wollini and Zeller (2007) find that being part of a cooperative is positively linked to the probability of a farmer growing a specialty coffee in Costa Rica -receiving higher prices for their production. Finally, Zhang et al. (2019) find that cooperatives have a positive effect on technology adoption in Sichuan, China.

Technology

Evidence has established that technology may be an important determinant of agricultural productivity. For instance, Jin et al. (2002) decompose the 1980-1995 growth period of total factor productivity in rice, wheat and maize in China; and found that new technology (enhanced seed quality) accounts for around 80% of the productivity growth. Similarly, Minten and Barret (2007) find that the introduction of technology on rice in Madagascar significantly increased the crop yields and the welfare indicators of farmers. Mendola (2007) does the same for Bangladesh, exploring whether adopting modern seeds increases crop productivity and income and finds a robust positive effect.

From a global point of view, Rosegrant et al (2014) explore the role of 11 agricultural innovations on the world's main crops (maize, rice, and wheat). The technology includes crop protection, drip irrigation, drought tolerance, heat tolerance, soil fertility management, among others. They found that each innovation by itself increases crop's yields by around 20%.

Training

Technology and productivity have a direct and robust relationship. This is true when technology is *actually* adopted, but several farmers do not. A potential explanation is that farmers may find it difficult to understand new technologies on their own. Several studies point that governments' investments in traditional training programs have been unsuccessful in many settings. For example, Beaman et al (2018) run an experiment in Malawi to measure the impacts of training seed farmers on the adoption of a new technology. They found that direct training did not have any impact on the adoption of technology nor on their productivity. Similarly, Waddington et al (2014) explore the impacts of farmer field schools to reduce the over-use of pesticides on agricultural outcomes. Relying on around 500 studies from 90 countries, they found that farmer schools only work for small pilots, none has been effective when taken to scale.

However, literature shows that farmer-to-farmer training seems to work. In this scheme, *key farmers* are the ones who receive training and then they oversee the training of other farmers. The idea behind this experiment is that farmers will be more willing to learn and receive training about a new technology if they see someone else implementing it. Macours et al (2018) estimates the impact of a farmer-to-farmer training program on Ugandan dairy farmers' productivity and revenues. The training increased the farmer's milk production by 20%. In the same line, Yuko et al (2018) explore how farmer-to-farmer training on irrigation increases the productivity of rice farmers in Tanzania. They found that production of farmers increased from 3.1 tons to 5.3 tons per hectare.

Land reform

The relationship between land reform and agricultural productivity has been widely studied in the development economics literature – yet it is still not conclusive. For our study, we define land reform as property-redistribution from a small number of landowners to peasants who work the land (from the richest to the poor). A strand of the literature finds a positive relationship. Besley and Burgess (2000) estimate the impacts of land reform on agricultural productivity in India. They analyzed productivity and growth during 34 years in the 16 main states of India and found that the reform consistently increased growth and productivity. Banerjee et al. (2002) also analyzed the Indian land reform in West Bengal during 1977 and found that it had a large and positive effect on productivity.

Another strand of the literature finds a negative relationship. Adamopoulos and Restuccia (2019) estimate the effects of the 1988 land reform on farm size and agricultural productivity in Philippines. They found that the land reform reduces average farm size by 34% and agricultural productivity by 17%. Simlarly, Ghatak and Roy (2007) make a review of the impact of land reform on agricultural productivity in India. Contrary to Besley and Burgess (2000), they find a negative impact in the land reform in India, mainly driven by one state where the land reform was more intense, West Bengal.

3.3. On the case of Peru

As mentioned above, Peru has experienced a boom in its agricultural sector. Given the increase in exports, the sector became more interesting from a research perspective. A recent study from the World Bank (2017a) provides a synthesis of this transformation. They find a consistent increase in productivity of around 2% to 3%, but also significant differences in the productivity between the three main regions of the country and types of producers, after doing a TFP analysis. They also find that some variables are important to reduce inefficiencies across all regions (i.e. connectivity, credit, market access, and technical assistance), while others were specific to a region (i.e. land titling in the Coast, insurance in the Andes, and better integration to markets in the Amazon).

Using the agricultural survey and census of Peru, Escobal and Armas (2015) constructs a typology to define small and medium farms, and how to differentiate them from subsistence farming. They design different policy solutions catered to each type of farm. For example, subsistence farming requires diversification to face the risks and uncertainty associated with their economic activity.

Using the same database, Fort and Vargas (2015) focus only on small and medium farms to understand what type of policy would be more suitable to improve aggregate output and life quality of farmers. They focus on two types of policy guidelines that have been present in the Government: associativity of small producers and articulation with other actors in the chain. The authors find that in general, being part of a cooperative, and or having links with agro-export firms, is better than being on their own, as measured by access to international markets, better agricultural practices, and access to credit.

Following the literature on size and cooperative, Zegarra (2019) estimates a model of firm survival to understand which farms have a higher probability of persisting over time. The author estimates a semi-parametric Cox model and finds that larger farms have a higher probability of survival (around 40% higher). This supports the argument of scale in Peru. In addition, the model also shows that small firms which are part of cooperatives have a higher probability of surviving, especially if they export.

An alternative view on what small and medium farmers need in Peru is developed by Escobal et al (2015), where the focus is less on the condition of being in a cooperative and more on the management capacity that these groups require. They study the emergence of management services offered to small farmers that do crop sharing. They show that these services were successful and allowed farmers to reduce risks associated with their activity, as well as increasing profits.

3.4. On the void of the literature

Although the revised literature from Peru is related to productivity in agriculture, none of the papers deal directly with the topics this SYPA intends to. From our search, we have come across few papers that directly estimates productivity in the sector. Galarza and Diaz (2015) estimate agriculture productivity by constructing a production function that captures productivity as a residual. Similarly, Cespedes et al. (2014) estimate productivity at a firm level in all the economy. They find that agriculture is among the less productive sectors in Peru.

However, none of them provide a clear understanding of why productivity is low, nor do they offer an explanation of productivity differentials. This paper intends to fill this void by providing evidence of how differences in plot size explain part of the observed difference in productivity. By doing so, it also contributes to the debate of whether returns to scale in agriculture are positives. This paper takes this topic further and proposes a couple of alternatives on how to increase scale, providing empirical evidence and a roadmap of implementing these policies.

4. Empirical strategy

This section starts by defining and explaining how we measure farms' productivity, the main outcome of interest of the SYPA. We will also detail the different databases and sources that we use in our analysis. We will then continue with a brief analysis describing the main characteristics of Peruvian farms, followed by an analysis and comparison between the different ecoregions of the country. Finally, we will select a subset of seven non-traditional crops to do an in-depth analysis of their productivity levels. We will detail commonalities and differences between their main observable characteristics as preamble for the following section of results.

4.1. Definition of productivity

There are different ways of measuring productivity in agriculture, such as output per worker or output per hectare. **Along this document, we use a measure of yield in kg per hectare as our main productivity indicator.** The main reason for this is that the national available data for Peru (mainly ENA, the National Agriculture Survey) collects more effectively data on output (yields) than labor, as in smaller plots there is no clear difference between family members and workers[5].

To analyze agricultural productivity in Peru and compare it to the world, we construct a variable called "*distance to the world frontier*"[6] (see Box 1) that allows us to standardize the productivity of each crop and plot in order to be comparable. We begin by estimating the yield per hectare (kg/ha) for each crop under each farmers' plot. We then compare this yield with the yield of the most productive country in the world for each crop, according to the Food and Agriculture Organization of the United Nations (FAO). From this comparison we get a distance to the world frontier. Finally, we standardize this distance using the standard deviation of that crop. The resulting variable indicates the standardize distance to the frontier, which is comparable between crops. As is a distance to the frontier, the productivity gap will be smaller when it approaches to zero.

[5] It is also important to remark that our output measures do not adjust for quality of the product as we do not have access to that information.

[6] We also construct a variable of distance to the national frontier to check the robustness of our results. .

Box 1 - Distance to world frontier definition

We construct a variable standardizing the distance to the world frontier of productivity in order to compare productivity between crops. We use the following formula:

$$Distance_{ic} = \frac{Frontier\ Yield_c - Yield_{ci}}{SD\ world_c}$$

Where $Frontier\ Yield_c$ is the yield of the most productive country for a specific crop, $Yield_{ci}$ is the yield of each crop at the farm level, and $SD\ world_c$ is the standard deviation of the yield of each crop at an international level.

4.2. Databases

We perform the quantitative analysis of this paper using data from Peru and international data. To extract values from the frontier and select the crops for the analysis we use the international dataset from FAO. The organization provides information on exports, imports, production, and productivity. Export information allow us to identify the most important crops for Peru, to include them in our analysis. We gather the highest productivity (yield per ha) for each crop selected from this data as well.

To analyze the production of crops and their productivity within Peru, we mainly use the National Agricultural Survey (ENA) of 2015 and 2016. This survey is done by INEI, covering the activity of small, medium and big farmers in all the country. The sample is based on the 2012 Agricultural Census, with an overrepresentation of small farms. The survey collects information on production, use of resources, prices, costs, farm characteristics, among many others. This survey is realized at the plot level with georeferenced data, which allows us to compare the characteristics and inputs used by crop and region. Using this georeferenced data, and the ecoregion delimitations from the Ministry of Environment, we define a unique ecoregion for each one of the plots of the survey.

Finally, we also rely on qualitative analysis. We conducted expert interviews in Peru during December 2019 and January 2020 with public officials, medium and large farmers and firms, and researchers. Figure 19 on the Appendix shows some of the information collected from these interviews.

4.3. Descriptive statistics

Peruvian farm plots are on average small but vary significantly in size. According to ENA, on average farm plot in Peru have less than 4 hectares. Peruvian agriculture also presents high variability in terms of usage of modern inputs for production. Only half of the producers use fertilizer or pesticides. Almost two thirds of the farms are dependent on rain.

Peruvian agriculture is divided in ecoregions, which share a similar climate and geography. There are six different ecoregions based on their natural conditions and altitude: Costa, Quechua, Puna y Paramo, Bosque seco, Selva alta and Selva baja. This division creates different regions in the country almost in a north-south continuum, starting from the coast region near the pacific and ending in "Selva baja" (low jungle) in the Amazonian border with Brazil in the east (see Figure 15 in the Appendix for a detailed map). Each ecoregion has also its own cultural and historic characteristics that may also impact how crops are produced and its current productivity level.

These regions across the country show different types of crops and levels of productivity (see Table 2 in the Appendix). For example, grapes are mostly produced in the Coast, while coffee is produced in the Selva alta. Other crops like mango and avocado are produced across the entire country (for a detailed map by crop see Figure 20 in the Appendix). Some puzzling facts about this divisions are that first, while the Coastal region is the least fertile region of the country -it is a desert, it is by far the most productive, with success export stories in asparagus and avocados.

On the other hand, the biggest share of the agricultural employment is in the Andes and the Amazon, regions that have a significantly lower productivity and a large share of informal employment. Moreover, this productivity gap has been widening (World Bank, 2017a). The Amazon and the Andes are mainly composed by small farmers that produce near a subsistence level with a poor integration to the market. Many of them have restricted access to technology and best practices, including fertilizers, machinery and irrigation systems, all of what could be precluding higher productivity levels (see for more descriptive stats by ecoregion).

4.4. Selected crops

To further our understanding of the agricultural landscape in Peru, we decided to focus on a subset of crops that represent different levels of industrialization and productivity across the country. All of the chosen crops are non-traditional agro-exports, which is the focus of our SYPA. For the selection of crops, we have taken into consideration the most exported Peruvian products and the most valuable products (in terms of its unitary value). Therefore, as the theory of comparative advantages states, these agricultural products which Peru exports the most, are also the ones where Peru is going to be more productive. Furthermore, these are products where Peru has the knowhow to efficiently produce them and may be one of the best ones for us to focus on. Taking all of these into consideration, the crops that we will focus on are listed in Table 1, which combined represent half of the agricultural exports of the country (7% of the total exports).

Table 1 - Selected crops (2017)

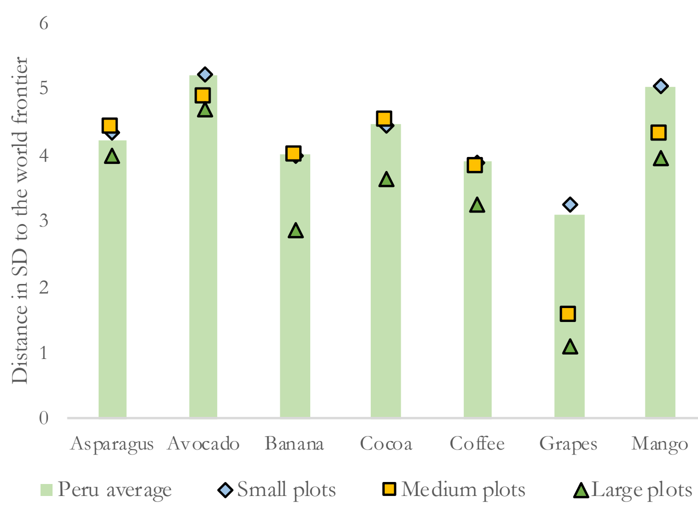
Crop	Area harvested		Production	Yield	Exports	
	Hectares	Share	(tn)	(kg/ha)	Quantity (tn)	Million $
Asparagus	39,629	1.0%	383,098	11,837	115,427	410
Avocados	65,700	1.6%	466,758	11,820	247,363	581
Bananas	145,700	3.5%	245,000	30,625	202,926	149
Cocoa	142,200	3.4%	121,825	839	72,601	218
Coffee	425,400	10.2%	346,466	818	246,066	710
Grapes	43,800	1.1%	645,012	21,661	269,662	653
Mangos	39,000	0.9%	385,304	13,140	162,938	192
Total	**901,429**	**21.7%**	**2,593,463**	**n/a**	**1,316,983**	**2,914**

Notes: Cocoa exports includes derivatives such as butter, paste and powder. Area harvested is for 2012.
Source: Own elaboration based on FAO and Agricultural Census 2012 (for area harvested)

Differences between crops

Our first approximation to the selected crops is to analyze their productivity under the definition of standardized distance to the world frontier. When comparing the productivity of each plot by crop with that of the most productive country in the world, we get plot-level standardized distances. To get a more aggregate result, we then group these distances by the size of the plots. Figure 3 reflects the differences in the distances to the world frontier by crop and size of plot.

Figure 3 - Distance to the world frontier by crop and size



Source: own elaboration based on ENA 2015 and 2016.

The most salient result of this analysis is the difference between crops. Peruvian grapes are on average highly productive, at 3.1 SD from the most productive country in the world. Asparagus, banana, cocoa and coffee follows with productions of around 4 SD away from the most productive countries. Peruvian mangos and avocados have low productivity - around 5 SD away from the world frontier. These differences in productivity bacons the question of why some crops are so much productive than others in Peru and whether this is common across countries.

This question has been previously addressed in the agricultural literature, where findings point to exogenous climate and soil conditions as some of the main determinants of differences in productivity. Masters and Wiebe (2000) pose the question of why agricultural productivity varies so much around the world. They propose two alternative answers, one related to biophysical factors and the other one related to scientific innovation. The authors find that climate traits are correlated with higher investments in agricultural inputs, greater production and better soil quality. They also find other relevant variables such as quality of governmental institutions.

Exogenous factors, as the soil and the weather, provide an explanation of why there is variation on who is the country leader in productivity depending on the crop. Such is that Peru, for example, is the most productive country of Latin America in the production of cocoa beans, well above the productivity level of Brazil. And conversely Brazil is the most productive country of Latin America in the production of coffee, well above the productivity level of Peru. Further switches in country leaders can be found in Ritchie and Roser (2020) article on crop yields.

There are some crops that are more sensitive to geographic and climatologic factors than others, as shown by the geographical concentration of their production. Coffee is an example of them. It grows in the subtropical and equatorial regions at certain altitudes. As a result, coffee grows only in a band called “coffee belt”. Peru lays within it, being the 5th most productive country among the biggest producers in the world.

The case of grapes is also an example of a sensitive crop to climatologic conditions. Grapes require long summers. Average temperatures cannot go below 10 degrees Celsius in order for them to thrive but cannot stand extreme summers either. Thus, grapes are also produced in two bands.

Peruvian grapes are some of the most productive of the world and it is a crop that is significantly closer to the world frontier than the rest of the crops under study in the present document (3.1 SD from the world frontier on average, and as close as 1.1 SD in the case of large farms). This is a result of several different factors that impact the grape's yield in Peru.

On the one hand, Peru has an excellent climate for grape production mainly in the coastal region where it has stable tropical temperatures along the year without significant rains. As a result, Peru can produce grapes during the whole year, being able to export between northern and southern hemisphere seasons with better prices. However, the success of the grapes cannot be only assigned as a result of the excellent natural conditions of the region as shown in Figure 4. The Bosque Seco region in northern Peru -mainly in the district of Piura- has the best yield level of all Peru, partially as a result of the climate. However, when analyzing by size we see how farms with large plots have similar productivity level in the three different regions. This suggests that there are other factors involved different from the natural conditions of each region.

Figure 4 - Grape distance to the world frontier, by region and firm size

Source: own elaboration based on ENA 2015 and 2016.

The success of Peruvian grapes is also a result of economies of scale, where production has been led by large-scale and vertically integrated firms with a strong exporting focus and modern technology (Fernandez-Stark et al, 2016). Many of these companies seem to have beneficiated by knowhow from Chile, which has an older and consolidated industry. Moreover, they have also established a strong organization -Provid- that helped finding new markets and leveraged its power to work with the public sector to ensure that SENASA -public agency in charge of food export certification- was able to meet the phytosanitary requirements (MINCETUR, 2016; MINAGRI, 2019).

It is important to remark that while grapes are one of the most productive crops in Peru, it does not seem to be possible to competitively produce it in all the regions of the country -only half of the regions have plots larger than 10 hectares of grapes-, nor that it would be advisable in terms of productive diversification of the agriculture sector. Therefore, in this document we will focus on the factors that policy can impact to improve the productivity of each crop, reducing the distance between different farms producing the same crop.

Similar to grapes, many other crops show a relevant difference in productivity depending on plot size: the bigger the size of the plot, the closer the distance to the frontier. However, this relationship between size and productivity does not seem to be linear. For some of these crops, avocados, grapes and mangos, medium sized plots (between 10 hectares and 50 hectares) produce at a similar level than large sized plots (larger than 50 hectares). Yet, for coffee, banana and cocoa, medium farms produce at a level similar to small farms (smaller than 10 hectares). There appear to be different realities across the country when it comes to productivity, and our hypothesis is that they conceal differences in agricultural practices, technology, modern inputs, and so on.

While part of these differences could be explained as a result of the particular necessities of each crop, as we have explored for the case of grapes and coffee, the majority of our selected crops are in almost all the Peruvian ecoregions. Thus, leading us to think that the characteristics of each crop are not enough to explain the significant differences between them. In the following section we will take a closer look at endogenous characteristics that may be explaining this difference.

Descriptive stats: Selected crops

There is a significant heterogeneity between the different selected crops in terms of plot size, technology usage, training availability and financial services[7]. As seen in Table 2, there seems to be three different categories within the seven selected crops. First, we have banana, mangos, coffee and cocoa, all of them with 99% of the plots smaller than 10 ha of area and with an average of less than 2 ha. Second, we find avocado and grapes where plot sizes are larger but still relatively small, with grape's plot size almost twice as big in average than the avocado's ones. Finally, we have asparagus -a more industrialized crop- with significantly larger plot size and with more than half of them exporters.

[7] For a larger set of variables by crops see in Table 4 in the Appendix.

Table 2 – Crop's main characteristics (2015 & 2016)

	Banana	Mangos	Coffee	Cocoa	Avocado	Grapes	Asparagus	Weighted Average
Plot characteristics								
Distance to world frontier (in SD)	4.0	5.0	3.9	4.5	5.2	3.1	4.2	4.3
Area harvested (ha)	0.6	0.8	1.9	1.6	7.4	13.9	189.8	4.2
Medium & Large plots (>10ha)	0.2%	1.0%	0.9%	0.7%	2.9%	8.5%	44.4%	1.7%
Rain dependant	75%	30%	90%	85%	26%	0%	0%	60%
Owner with property title	24%	47%	14%	29%	38%	55%	61%	30%
Production inputs & others								
Technology index	23%	31%	27%	23%	42%	43%	72%	29%
Fertilizer	84%	53%	34%	33%	33%	98%	58%	59%
Pesticides	84%	59%	41%	39%	46%	97%	55%	64%
Training index	17%	13%	20%	27%	16%	18%	59%	18%
Credit	16%	20%	16%	21%	16%	17%	42%	17%
Certified production	3%	2%	4%	2%	4%	9%	43%	4%
Cooperative member	4%	2%	7%	6%	2%	0%	0%	4%
Exporter	2%	2%	12%	13%	4%	7%	52%	6%
Number of observations	10,936	3,851	4,686	2,921	4,315	1,668	225	28,647

Source: own elaboration based on ENA 2015 and 2016.

This categorization is not completely exclusive, as the borders become diffuse when comparing different variables. For example, we could separate crops by their dependence on rain. While banana, coffee and cocoa almost entirely depend on rain, mangos and avocados plots have a strong presence of irrigation systems. Similarly, grouping could be in terms of usage of modern inputs related to technology and good practices included in our technology index[8], or using our training index[9].

Finally, and based on our expert interviews, we observed how they invest significantly also in other type of technologies that are not included in the ENA. Some of these firms have invested heavily in monitoring technology, including machinery, cameras and cellphone apps. The goal was of mechanizing as much as possible the process inside the farm to make it less dependent on the quality of the workers itself. Cameras and GPS transmit information in real-time, and different apps updated information about the requirements of each of the plants. This could lead to a different type of problem that we did not focus on, related to lack of adequate human capital in the farmers/employees. These large firms could be, following growth diagnostic methodology, bypassing the constraint and be literally hippos in the coastal desert.

[8] We constructed the "Technology index" as a proxy of the usage of modern inputs and practices in agriculture. It includes variables related to the usage of fertilizers, pesticides, biocontrol and pest-control techniques. A plot with 100% would use all of these inputs.

[9] We constructed the "Traning index" as a proxy of capacitation of farmers and workers. It includes variables related to capacitation and technical assistance that the farmers and/or workers received in the last 3 years.

5. Results

The following section estimates a model of agricultural productivity for the selected crops. Following the discussion developed in the literature review, we start our analysis by providing evidence of how for the case of Peru size of the plot matters more than the region. We then test additional explanatory variables based on what we found in the international literature. Once we establish that size is our policy-relevant variable, we turn our focus to smaller farms. We explore what other characteristics are key for achieving high productivity in the subset of smaller farms.

5.1. Determinants of productivity for the entire sample

Testing size vs regions

We have shown so far that certain crops are closer to the world frontier in terms of yield per hectare, while other still stand quite far from it. Grapes are only 3.1 SD away from the world frontier, while mangos and avocados are around 5 SD away from it. However, this does not mean that productivity is homogeneous within crops. On the contrary, as the literature points out, productivity is quite heterogeneous between regions and size of farms (Escobal and Armas, 2015). Important productivity gaps emerge within each crop.

To better understand this gap, we perform an Anova exercise in which we decompose the variance of our productivity variables (see Box 2 for the specification of this exercise). In other words, we look at the differences in productivity and analyze which variable is the most responsible for the variation. We perform this analysis with the size of the plot and the ecoregion where it is located, to evaluate which of these variables is more explanatory for non-traditional agricultural exports.

Box 2 - ANOVA specification

We perform a factorial ANOVA to estimate the total variance of the observed data:

$$SS_T = \sum_{i=1}^{n} (y_i - \bar{y})^2$$

Where SS_T is the total sum of squares, y_i is the dependent variable of interest for the plot i (in this case the standardize distance to the frontier) and $\bar{y}_i$ is the mean of that variable. When a model fits perfectly the data, we say that the total sum of squares (SS_T) is equal to the sum of squares (SS_R). When a model doesn't explain perfectly, the deviations from the model are captured in the error term:

$$SS_E = \sum_{i=1}^{n} e_i = \sum_{i=1}^{n} (y_i - \hat{y_i})^2$$

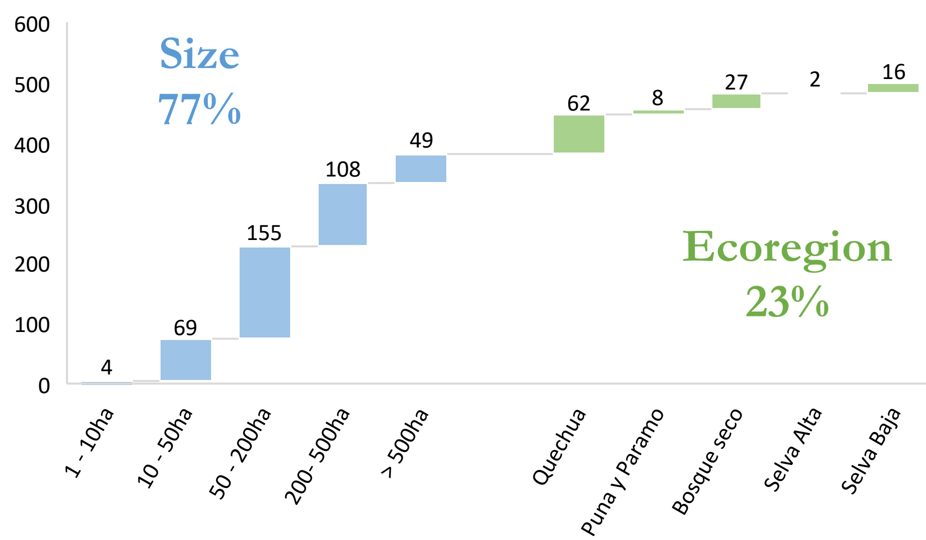
Where SS_E is the error sum of squares, y_i is the dependent variable of interest for the plot i (distance to frontier), and $\hat{y_i}$ is the predicted distance from the model. The sum of square of a model is then defined as the sum of the total sum of squares and the error sum of squares:

$$SS_R = SS_T + SS_E$$

For analyzing the explained variation of productivity and which variable is more important, we perform the ANOVA analysis for the distance to the world frontier at the plot level as a function of size of the plot, region and type of crop: $Distance\ Frontier_i(size_i, region_i, crop_i)$

After controlling for type of crop, the size of the farm is significantly more important in explaining the difference in productivity than location: 77% of the explained gap in productivity within each crop is explained by the size of the farms, while only 23% is explained by the ecoregion (see Figure 5) [10]. Although the model provides a relatively good fit[11], there is still a lot of unexplained variation in our model. This suggests that there are still other variables that need to be tested into this model.

Figure 5 – The size of the plots matters more than the location
(when explaining the difference in productivity)



Source: own elaboration based on ENA 2015 and 2016.

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[10] In the Appendix, see Table 5 for the entire result of this exercise and Table 6 for disaggregation by crop of this exercise.

[11] We refer to the explained gap in productivity using size of the plot and its location -ecoregion- controlling by crop. This model explains 39.7% of the total variation.

Testing other farm characteristics

Beyond the size of farms and location, we want to understand what other characteristics are positively correlated with having high levels of productivity. For this we do a regression explained in Box 3. Our goal is to identify what makes farms most productive, once controlled for size, ecoregion and crop.

Ideally, we would want to take the results from this exercise as causal and point out how a specific variable has an impact on productivity. However, to make such a statement we would need to control for everything that determines productivity. The data that we are working with does not ask for every characteristic of the farm, which means that there are things that we would not be able to control for. And even if the survey did ask for everything, there would still be unobservable characteristics of farms and farmers that would make them more productive. For example, the grid farmers have while working on their farm. Thus, we cannot consider our analysis as a causal one. We limit our analysis to simple regressions and ask our readers to be thoughtful of the fact that our findings are not causal. Although we only present correlations, we belief our explanations are compelling enough to convince out reader.

Box 3 - General regression model

The reduced form estimation of this exercise is the following:

$$Distance\ Frontier_{cpi} = \beta_0 + \sum_{s=1}^{5} \beta_{1s} size_{si} + \beta_2 rain_i + \beta_3 technology_i + \beta_4 certification + \beta_5 training_i$$

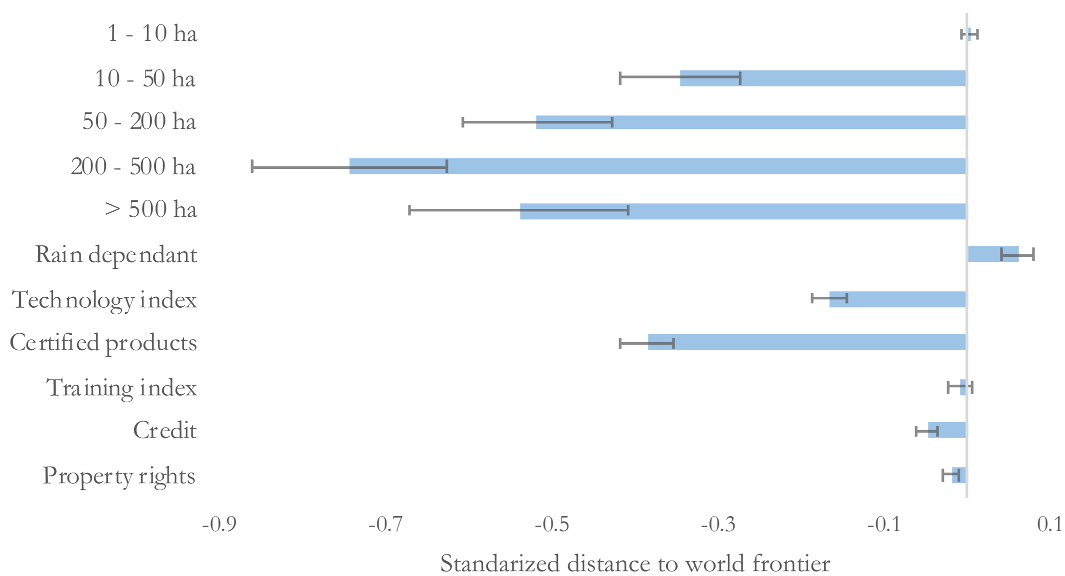
$$+\beta_6 credit_i + \beta_7 property\ rights_i + \beta_8 year + \sum_{s=1}^{5} \beta_{9s} region_{si} + \sum_{s=1}^{6} \beta_{10s} crop_{si}$$

Where the distance to the frontier ($Distance\ Frontier_{cpi}$) of each type of crop, in each plot for each farmer i, is explained by $size$, which represent different sizes of plots, $rain$ that represent the fact that certain crop relies on rain, $technology$ which is an index of the use of technology in the farm, $training$ which is another index of the level of training that the farmers receive, $credit$ that represents the availability of credit, $property\ rights$ that recovers whether the farmer has property rights over their farm. We control for year and add fixed effects for ecoregion and crop.

Our division of size is based on the division of MINAGRI, where micro farms are those with less than 1 hectare, small farms are between 1 and 10 ha, medium farms are between 10 and 50 ha, large farms are between 50 and 200 ha, and there are even larger divisions of 200 to 500 ha, and larger than 500 ha.

A caveat for interpreting these results is that when a characteristic increases the productivity of a crop, it appears as a negative component in our exercise because it reduces the distance to the world frontier. A more intuitive way of interpreting these results is shown in Figure 6 below[12].

Figure 6 – Model of productivity



Note: Confidence intervals at 95% level.
Source: own elaboration based on ENA 2015 and 2016.

There are 4 key results from this analysis. The first one is that, as previous analysis showed, the size of the plot is important for productivity across crops. Not only that but the bigger the size of the plot, the bigger the contribution to productivity. Thus, a plot size between 200 hectares and 500 hectares is correlated with higher productivity than a plot size of 50 hectares to 200 hectares, and in turn those plots are associated with higher productivity than that of plot sizes of between 10 hectares and 50 hectares. Size in Peru matters, and policy recommendations should consider this finding.

A second finding is that having certified products is almost as important as plot size. As our expert interviewers pointed out, having access to international markets changes the way of doing things in agriculture. In order to export, products must pass a series of tests and comply with international norms. Thus, it is reasonable that farms that have certifications for their products are more productive and closer to the world frontier.

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12 The results of this regression can be found in Table 7 in the Appendix. A disaggregated version of this regression by crop can be also found in the Appendix in Table 8.

A third finding is that technology also makes a difference in productivity. As explained before, we constructed an index of technology that recovers information on whether or not the farm used modern inputs in their production. This index includes the usage of fertilizers, pesticides, biocontrol and pest-control techniques. We find that high use of these modern inputs is correlated with higher productivity, as measured by the reduced distance to the world frontier. This finding is also supported by the literature, which states that in Peru many farms do not use enough fertilizers. From our database, only a third of farmers of avocado, coffee and cacao use them.

Finally, a fourth finding is there are other less important characteristics that also correlate with higher productivity. Getting access to credit, having access to an irrigation system or having property rights can improve productivity. These are straight forward policy variables that could be changed to trigger improvements in agricultural productivity.

Again, it is important to note that many of these characteristics feed each other. Take the case of scale, for example. We confirmed in our interviews that there are certain technologies and access to certifications that are only feasible for farms that are able to produce certain scale.

Prediction

We must note that statistical significance is not the same as policy relevance. So far, we know from literature and two different exercises that the size of the plot has a statistical importance in the level of productivity. However, how important is a question we cannot solve through these exercises. To understand whether this is a variable relevant for policy we will perform a third exercise (see Box 4). In this we predict the aggregate gains in productivity of small plots if there were to increase its plot size, given the model we estimated before.

Box 4 – Farm's size. Prediction exercise.

The gains in productivity from increasing size are calculated as follows:

$$\widehat{\Delta y\left(\frac{kg}{ha}\right)}_c = \sum_{i=1}^{N} (\hat{y}_{ic}(small = 0) - \bar{y}_{ic}(small = 1))$$

Where the predicted gain in productivity (measured in kg per hectare) for every crop is calculated as the difference in the mean output per crop for smaller farms and the predicted value of output if every small plot were to be bigger, holding all other variables constant. These variables are the ones specified in the previous model (Box 3).

The main finding from this exercise, summarized in Table 3, is that the extent in which size matters depends on the crop. For the case of grapes, increasing the size of small plots would result in an increase of 61.2% in the productivity of that crop (understood as kg per hectare). Avocado, on the other side, would only benefit from an increase of 8.5% from increasing the size of the plot to that of a medium plot. Coffee would also yield a similar result of an increase of 8.8%. Mango, on its side, would benefit of a spike of 25.8%. Overall, there is an average 12.7% increase in productivity (kg/ha) of the selected crops. This increase is sufficiently high to make it a finding that is relevant for policy[13].

Table 3 - Predicted gain in kg per hectare from increasing size by crop (from small to medium plot)

		Coffee	Grapes	Mango	Avocado	Cocoa	Asparragus	Banana	Weighted average
A	Yield for small farmers (kg/ha)	687	9,793	9,204	8,733	684	5,508	10,527	n/a
B	Predicted yield for bigger farmers (kg/ha)	748	15,788	11,577	9,478	637	4,889	10,450	n/a
C	Difference in yield (B - A)	61	5,995	2,373	745	-46	-618	-77	n/a
	Percentage change	**8.8%**	**61.2%**	**25.8%**	**8.5%**	**-6.8%**	**-11.2%**	**-0.7%**	**12.7%**

Source: own elaboration based on ENA 2015

5.2. Cooperatives for increasing productivity

Given this positive statistically significant and policy-relevant association between plot size and productivity, we now focus our attention to smaller farms to explore how they can increase their size. The rest of our analysis is done with a subsample of data of smaller farms (less than 50 hectares).

An alternative to changing size for small farmers is to group themselves in an association, such as a cooperative. As Fort and Vargas (2015) find, being part of a cooperative promotes good practices and increases welfare. We are interested in exploring what is the relationship of belonging to an association of farmers with productivity, and what are the benefits of being in such an association (see Box 5).

Box 5 - Cooperatives regression model

The exercise performed in this section is base in the reduced form equation of the previous section. We add to the model the variables of belonging to an association and access to benefits from them:

$$\begin{aligned} Distance\ Frontier_{cpi} &= \beta_0 + \beta_{1s} association_i + \sum_{s=1}^{5} \beta_{2s} access\ to\ benefits\ through\ association_i + \sum_{s=1}^{5} \beta_{3s} size_{si} \\ &+ \beta_4 rain_i + \beta_5 technology_i + \beta_6 certification + \beta_7 training_i + \beta_8 credit_i + \beta_9 property\ rights_i \\ &+ \beta_{10} year + \sum_{s=1}^{5} \beta_{11s} region_{si} + \sum_{s=1}^{6} \beta_{11s} crop_{si} \end{aligned}$$

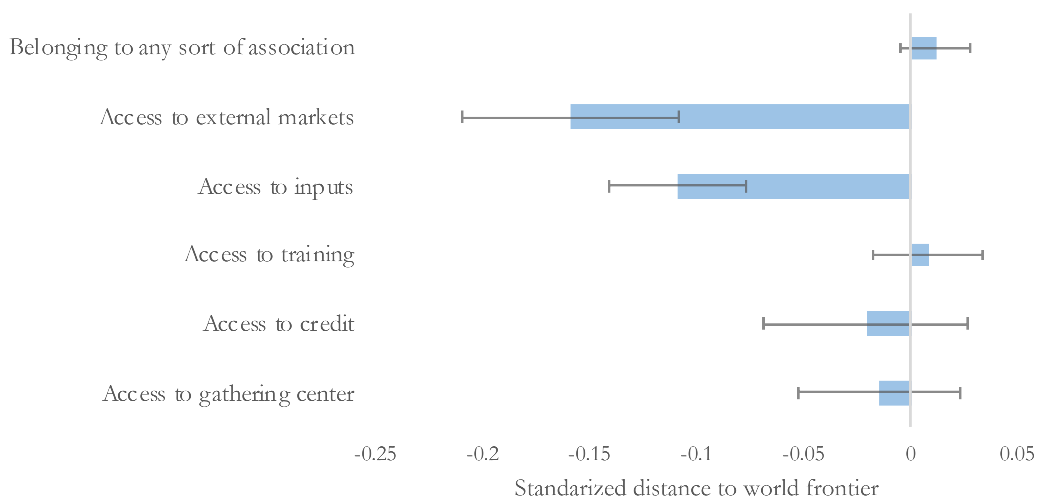
[13] When replicating this exercise from medium to big plot size, the results differ. Almost no crop would benefit from an increase in productivity from changing the scale from medium to big. Yet, bananas are a significant exception (170% predicted increase). For coffee, the gains in productivity are of around 27%.

We find two key results from running this model (see Table 10 in the Appendix). The first finding is that belonging to an association (either a cooperative or a committee) is negatively related with the distance to the world frontier. In other words, belonging to a cooperative is associated with a higher level of productivity[14].

The second most important finding is that belonging to a cooperative takes away some of the importance of size of the plot. This was an expected result, as theory points out that as cooperatives between farmers are used to pool resources together allowing to replicate some of the scale benefits achieved by larger farms. We are able to confirm this hypothesis with our estimates (see difference between models in Table 10).

Finally, we are also able to distinguish what type of benefits or services are more important for productivity. As shown in Figure 7, associations that help farmers access international markets exhibit the largest increases in productivity. Another important benefit from cooperatives is the access to inputs, such as fertilizers and seeds. Contrastingly, training, credit, access to gathering centers and refrigeration do not appear to be relevant for productivity. Thus, we conclude that it is not only the mere access to a cooperative, but certain benefits that these cooperatives bring farmers, what helps them increase their productivity.

Figure 7 – Cooperatives for increasing productivity



Note: Confidence intervals at 95% level.
Source: own elaboration based on ENA 2015 and 2016

[14] When analyzing crop by crop, we observe that the result holds for coffee, cacao and banana. While for the rest of the selected crops we found non-significative coefficients. See Table 10 in the Appendix for disaggregated information by crop.

5.3. Farmer's characteristics for increasing productivity

A final dimension we wanted to take into consideration for the productivity analysis are famers individual characteristics. We wanted to understand whether there are individual characteristics associated with higher levels of productivity. For example, what role does the farmer's age play in how productive its activity is? Or, does education determine in any way the level of production of a farm?

For this analysis we focus only on small farms (below 10 ha) and on the variables of education, age and number of children, because the individual surveys are only performed on smaller farms and mainly capture these variables. We perform a demographic characterization of the farmers based on in these variables and find that on average farmers are 52 years old, 73% are men, have completed primary education, and have 1.6 children.

Box 6 - Farmer's characteristics regression model

A more thorough analysis regarding farmer characteristics comes from estimating the following equation:

$$Distance\ Frontier_{cpi} = \beta_0 + \beta_1 Old_i + \beta_2 Family\ working\ on\ the\ field_i + \beta_3 Old_i$$

$$* Family\ working_i + \beta_4 education_i + \beta_5 male_i + year + \sum_{s=1}^{2} \beta_6 size_{cpi} + \sum_{s=1}^{5} \beta_7 region_{cpi} \sum_{s=1}^{5} \beta_8 crop_{pi}$$

Where Old_i is a dummy variable that takes the value of 1 if the *i*-farmer is older than 60 years old, $Family\ working\ on\ the\ field_i$ is a dummy variable that takes the value of 1 if the farmer has family working on the field with him (sons or daughters), $Old_i * Family\ working_i$ is an interaction of the two previous variables, $education_i$ is a variable with the level of education of each famer and $male_i$ is a dummy variable that takes the value of 1 if the farmer is a male. The estimates are controlled for fixed effects of size, region and crop.

From this analysis, as shown in Figure 8, we found that the age of the farmers is an important variable for productivity[15]. Being older than 60 years old is associated with a lower productivity for the crops. This effect is somehow offset for the older farmers that have help from their family on the field. Farmers' education does not seem to play a significant role on productivity and on average male farmers are more productive than women.

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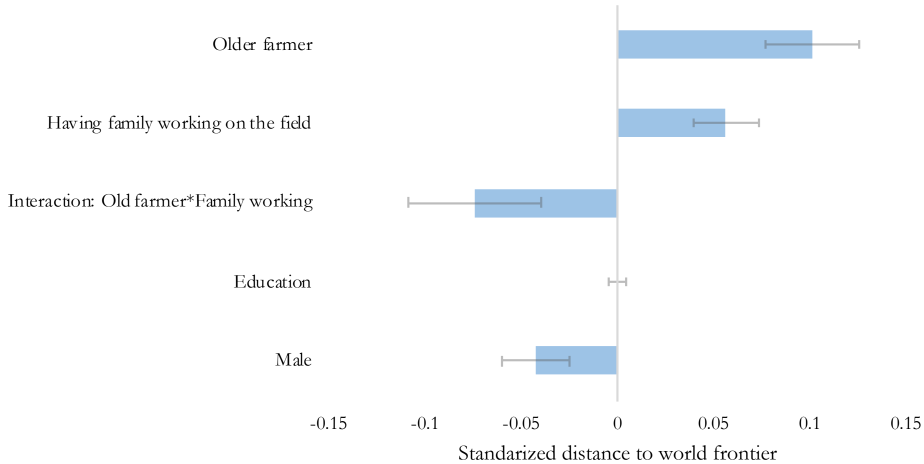
[15]In the Appendix, see Table 12 for the regression analysis of individual characteristics, and Table 13 for disaggregated results by crop.

Figure 8 – Individual Farmer's characteristics associated with productivity



Note: Confidence intervals at 95% level.
Source: own elaboration based on ENA 2015

We will focus our attention in the variable of age. The literature points out to a cyclical relationship between age and productivity for farmers (Loomis, 1936; Long, 1950). Output productivity and use of inputs increases with age until certain point and then starts decreasing again, with 35 to 44 being the optimal age (Tauer, 1995). Our results confirm this hypothesis[16]. What is interesting for the case of Peru and the selected crops is that there is a large proportion (31%) of farmers over 60 years old working on the plots (for an age histogram, see Figure 16 in the Appendix). Among them, less than half have children working in the plot with them. This is a suboptimal use of the land.

Prediction for older farmers

The findings on suboptimal use of land due to age of farmer opens the question of why older farmers are still working on their land. Or more specifically, why is there no inter-generational change in labor on these farms? Although there may be many explanations, including behavioral traits from the younger generations, we will focus on one explanation that came up in several expert interviews on the field: older farmers cannot retire due to lack of pensions.

Peru has low levels of pension coverage, as compared to OECD countries. The percentage of Peruvian workers affiliated to a pension system also compares very poorly with other countries in the region – Peru is the second to last country on percentage of affiliates with less than 20% (BID, 2015). This

[16] Estimates of a continuous variable of age are negative, while squared age is positive. This points out that lower levels of age are associated with closer distance to world frontier and bigger levels of age are associated with a larger distance to the world frontier.

situation is worse if we consider only the rural population, where only 8.8% of workers are affiliated to a pension system (INEI, 2016).

Since 2011, the government has established a social pension program called Pension 65 for the poor elderly that do not have access to pension. However, many farmers do not meet the requirements for the social pension. To receive such a pension, users must be part of the System of Focalization (SISFOH) which does not include anyone with a property, including agricultural plots. Thus, most farmers are left without access to this social program. Section 6.2 will further explain this theory and propose a policy recommendation on (quasi) universal pension system for rural population.

As a preparation for the policy recommendation section, we estimate the gains in productivity from having younger farmers working on the plots which are currently farmed by older ones (as explained in Box 7).

Box 7 - Farmer's age. Prediction specification

The gains are calculated as follows:

$$\Delta y \widehat{\left(\frac{kg}{ha}\right)}_c = \sum_{i=1}^{N} (\hat{y}_{ic}(old = 0) - \bar{y}_{ic}(old = 1))$$

Where the predicted gain in productivity measured in kg per hectare for every crop is calculated as the difference in the mean output per crop managed by an older farmer and the predicted value of output if those same plots were managed by a non-elderly individual, keeping all other variables constant. This prediction is made on the basis of the previous model explained in Box 6.

From our estimates, we find that the highest increases in productivity would be from coffee, grapes and mangos. For the case of coffee, changing the farmers' age only for the plots where farmers are older, would mean an increase of 20% in the yield in kilos per hectare. Changes in age of farmer for grapes would yield a 10% increase in yield per hectare. And for the case of mangos and bananas this increase would be of 6%. Some of the selected crops would not yield any increase from this change (avocados) and other smaller (cacao) or negative change (asparagus). Still, overall, the weighted increase in productivity would be 6.4%. Details from these estimates are further explained in Table 17 (Panel A).

6. Policy Recommendations

The main finding of this study is that the plot size is a key determinant of the productivity of non-traditional crops in Peru, as these require scale to reach their productivity potential. Two additional findings are that large-scale productivity can be mimicked by grouping small-scale plots into cooperatives, and that the likelihood of joining a cooperative decrease as the age of farmer increases.

In this section we propose different policies to address the lack of scale and increase productivity. We could approach scale in many ways, but this document will focus in three mechanisms: fostering cooperatives, providing rural pensions to generate an intergenerational change of farmers, and enhancing property rights.

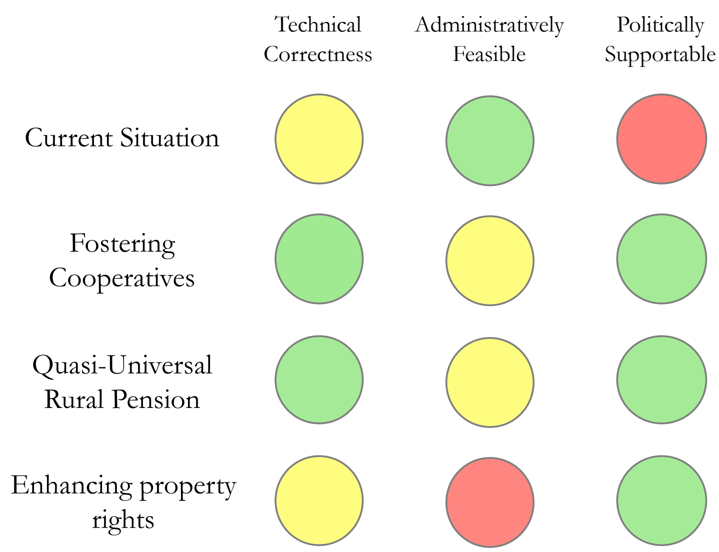
In general terms, plot size could be increased using the land market – promoting land leasing from smaller farm owners to larger ones which already have access to modern technologies. However, this is not happening in Peru. The economic theory suggests that large-scale productive firms are the ones that will continue increasing their size – buying or leasing adjacent land – as the marginal cost of an extra hectare of land becomes decreasing after certain scale. For this to happen, land markets require clear and enforceable property rights, as well as credit markets to finance the leasing or purchasing of the new land. As a result of the 1970 land reform, large farms were expropriated and transferred to peasants in the form of communal property. Most of these communal arrangements disintegrated over the next two decades and were transformed into small private family plots. **Many of these small farmers still lack a property title today, making it hard to exchange a piece of land** (see Table 2).

In such context of atomized small farmers without property rights, we propose alternative solutions to increase scale. First, we suggest a policy to foster cooperatives. Incentivizing farmers to group their plots to access the large-farms benefits (i.e. access to technology or credit) is a more realistic way of supporting the Peruvian agriculture sector. **Second**, as our evidence shows that younger farmers are more likely to engage in cooperatives and contract with bigger firms, **we propose a quasi-universal rural pension that would allow for an intergenerational change in farmers**.

"…other owners ask us that in addition to renting the field we hire them to work it. The problem is that I can't hire workers that way, many of them are older than the workers we have." (Expert interview, see Figure 19).

Finally, as a complementary and more traditional policy, we propose improving property rights by reactivating a previous land titling program. This would increase the likelihood of forming cooperatives and renting or selling the land to larger firms that are more productive. Although one would expect such a policy to be central in the policy recommendations, we have opted to present it as a complementary policy due to administrative requirements that the policy will need. Starting with the first two policies is more realistic and has a higher chance of being implemented. Figure 9 shows a summary of the feasibility of our proposed policies, which are explained in detail in the following subsections (see Figure 17 for a detailed summary).

Figure 9 - Policy recommendations feasibility



Note: Red refers to Low, Yellow to Medium, and Green to High.
Source: Own elaboration.

Political economy of the reform - Recent Congress elections

Before presenting each policy recommendation, this section explains the political economy that currently characterizes Peru – and evaluates the support that a package of agricultural policies would have in this context.

On January 2020, Peru had a snap Legislative election to renew the National Congress for a short period of one and a half years. Validated by the Constitutional Court, the president dissolved the Congress on September 2019 following a strong and continuous confrontation with the opposition majority.

The results of the election exposed a large anti-system sentiment in the country. The party with more votes obtained only 10.3% of the valid votes. Each of the other 8 parties obtained between 6% and 8% of the valid votes – a significant atomization of the electoral preferences. Furthermore, the electoral rules establish that parties which obtain less than 5% of the valid votes will not be part of the Congress. As a result, and signaling the strong anti-system sentiment, most of traditional political parties were left outside the Congress.

One of the greatest surprises of the election was the second position of a virtually-unknown social conservative political party: "*Frente Popular Agrícola del Perú*" (Frepap – Popular Agricultural Front of Peru). Apart from the suburban area of Lima, this party had a strong support in many of the smaller rural areas of the in the Andes and the Amazon. Its campaign proposals included policies aimed at improving the living conditions of small farmers. Frepap is not the only victorious political party that campaigned for better conditions for small farmers. *Union Por el Peru* (UPP – Union for Peru) had a large support in the southern Andean region. It is a leftist and nationalist party that aims to re-value the Inca culture. Among other proposals, they propose to prioritize agriculture over mining.

The importance of these two parties in the election and their focus on small farmers are signals of the need for a new approach towards small and medium farmers across the country. That is why we consider that policies regarding agriculture will be politically supportable and that the Ministry should focus on improving the current status-quo.

6.1. Proposed Policy 1 - Fostering cooperatives

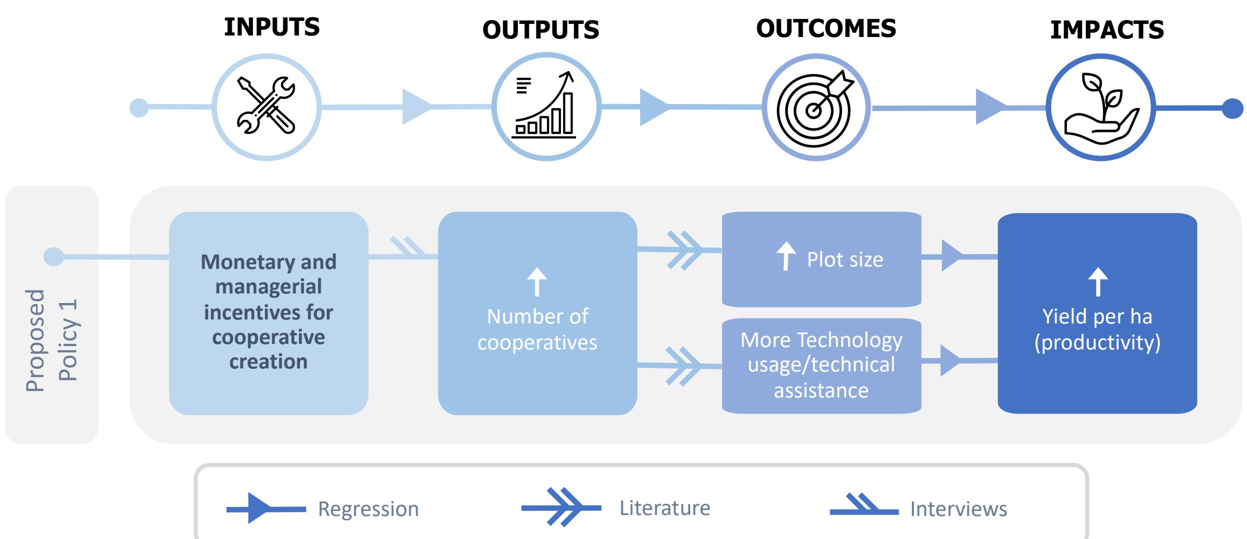
One way to increase farm size is to encourage the association between small farmers through cooperatives. As shown in Figure 7 (Section 5.2), being part of a cooperative is related to higher productivity. While this could be explained by selection bias – *better* farmers choosing to join while less-productive ones do not – cooperatives could also be giving extra value to their members.

Currently, Peru has a program called "Agroideas" that has similar characteristics to our proposed policy. However, this program has not had the desired impact. First, the number of cooperatives created and the ones receiving incentives has been decreasing in the last years – mainly because of a decrease in the budget allocation. Second, during our expert interviews, small producers told us that the targeting of potential beneficiaries is not well-executed and the incentives are not aligned. Finally, they do not follow up on associations. We propose to correct the current program by improving targeting, extending benefits and including monitoring. Once corrected, we propose to scale-up the program to target small farmers in different regions of the country.

Theory of change

Figure 10 shows our first proposed policy – we aim for increasing farm's yield per hectare by increasing plot size through formal cooperation between farmers. The figure shows the theory of change of this policy, where some arrows indicate that the mechanism were taken from the literature, others from our interviews and the rest from our estimates, as the legend of the figure indicates. We propose to incentivize the creation of cooperatives by providing monetary support to register the cooperative and managerial capacity to run it. From our interviews with government officials, we learnt that these incentives would be effective in fostering the number of cooperatives.

Figure 10 - Theory of Change - Proposed Policy 1



Source: Own elaboration

First, creating a cooperative is a straightforward way of increasing plot size as small plots are arranged to work together as a bigger one. And on average, as our regression estimates point out, the bigger the size, the higher the yield of the land for non-traditional crops.

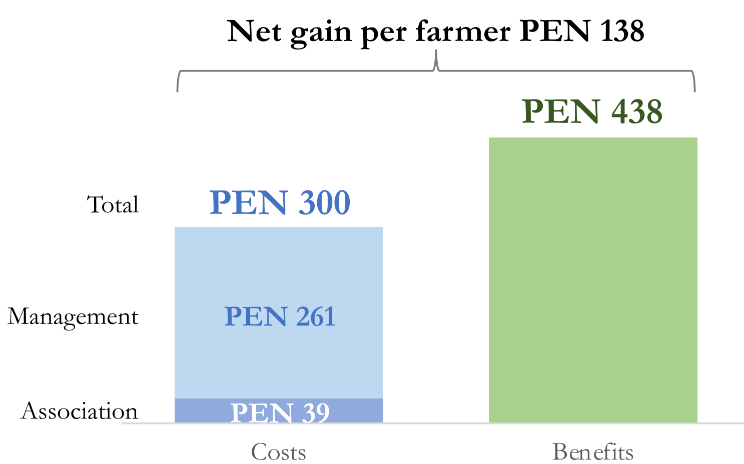
Second, cooperatives are a way of accessing resources traditionally inherent to bigger farms. They reduce the required scale to make investments feasible – mainly in machinery and other technological inputs. Our estimates show that cooperatives improve the productivity of their farm members through supply of modern inputs and access to the external markets.

Third, cooperatives increase the managerial skills of farmers (Escobal et al, 2000). For example, currently one of the most important cooperatives in Peru is *Junta Nacional del Café* – a coffee cooperative – which provides training and access to inputs to produce the world's more-demanded varieties of coffee. A quarter of the total Peruvian coffee exports are from cooperatives.

Cost-Benefit Estimation

To estimate the potential net benefits of this policy, we use bananas as example. Our analysis finds that there are large potential gains from forming cooperative for this crop. Similarly, we also find that several of our selected crops show large net estimated gains from cooperatives.

Figure 11 - Cost-Benefit analysis - Proposed Policy 2 – Example for bananas



Source: own elaboration based on ENA 2015 and 2016 and MEF 2016

Our prediction exercise from the previous section[17] estimates an increase of 19% in productivity for banana plots which are part of a cooperative. The difference in yield from a plot associated to a cooperative and a similar non-associated plot goes from 10,200 kg to 12,160 kg per hectare, an increase of around 2,000 kg per hectare. We also know that the non-associated banana farmers have on average plots of 0.43 hectares. If these non-associated farmers join a cooperative, we estimate that each farmer would increase their annual income by PEN 438 (~USD 124). This amount is calculated using the 2015 prices from MINAGRI – at the time, bananas were sold by farmers at PEN 0.52 per kg.

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[17] For estimates of the predicted gains by crop, see Panel C of Table 17 in the Appendix.

Based on the current Agroideas program, which has similar components to our policy, we estimate a lower-bound of the costs of our proposed program[18] (MEF, 2016). In their financial statements, they report the average costs per beneficiary (farmer) per year: management services cost PEN 261 and registration fees cost PEN 39. Therefore, the estimated net gain per farmer per year is PEN 138 (see Figure 11).

Implementation Analysis

The creation of new cooperatives will be encouraged using monetary incentives for farmers. This will be in the form of: (i) waiving legal fees for their creation, (ii) offering co-financed management services (salary of a manager), and (iii) offering co-financed investments of new technology and other modern inputs (e.g. modified seeds).

The program should be built on top of the existing Agroideas platform. In addition to the abovementioned services to improve Agroideas, we suggest improving the targeting strategy. We recommend the Ministry to start this policy with one specific crop to show the potential benefits. As our analysis points out, bananas would be the ideal crop to start with. After iterating with the program and refining the policy in an *agile* way, we propose its scaling up to the remaining non-traditional crops.

However, implementation could demand a meticulous task – requiring not only several different small farmers to organize but also the Ministry to correctly target them. As a result, we propose the Ministry to select "champion cooperatives" across the country. This means picking (or encouraging to create) cooperatives only for a specific crop on each region. The process should be as transparent as possible, setting public benchmarks – as number of active members, an export target, usage of modern inputs – which must be met to remain part of the program.

Implementing this policy requires the support of the Ministry of Finance and the Congress. The Ministry of Finance needs to increase the budget allocated to the existing program, which will then need to be approved by the Congress. Furthermore, as the policy improvement includes new specifications, the MINAGRI must draw and present a new bill to the Congress for approval. However, given the share of pro-agriculture political parties in the Congress, we are confident that it will get a high level of approval.

[18] We estimate this would be a lower-bound because Agroideas is not able to follow cooperatives and the program has not been scaled up. Scaling and monitoring would make the program more costly.

6.2. Proposed Policy 2 - (*Quasi*-) Universal rural pension

Peru's economic growth has been followed by a reduction in the informal rate, going from 91.1% in 2004 to 68.9% in 2017. However, Peru still has a high informality rate when compared to similar countries. As a result, the majority of the elderly do not have a pension. **Currently more than 90% of the adults living in rural areas lack a pension[19].** For many of them, their land is their only real asset. They obtain their basic monthly income by farming it themselves – either directly as owners or as employees when they lease it to a bigger firm. However, because of their age, the latter is uncommon as firms do not find it profitable to hire them.

Even though Peru established a basic non-contributory pension program (Pension 65) in 2011 for poor elderly, many rural farmers don't meet the conditions to receive it. The pension grants PEN 250 every two months (~USD 70). However, to be included in this program, the beneficiaries have to prove that they are extremely poor. A large part of rural elderly cannot be part of the program, as many of them are landowners and are still (unproductively) farming their land.

Theory of change

We propose to establish a quasi-universal rural pension program that aims to generate an intergenerational change in the tenure of small farms, allowing a new generation to be in charge of the management of the farms. As explained in the previous section, having a younger farmer in charge is correlated with an increase in productivity.

> *"There is little generational change. (…) The productivity of the land begins to fall as they get older. Also, their plots are small so they can't incorporate much technology" (Expert interview, see Figure 19).*

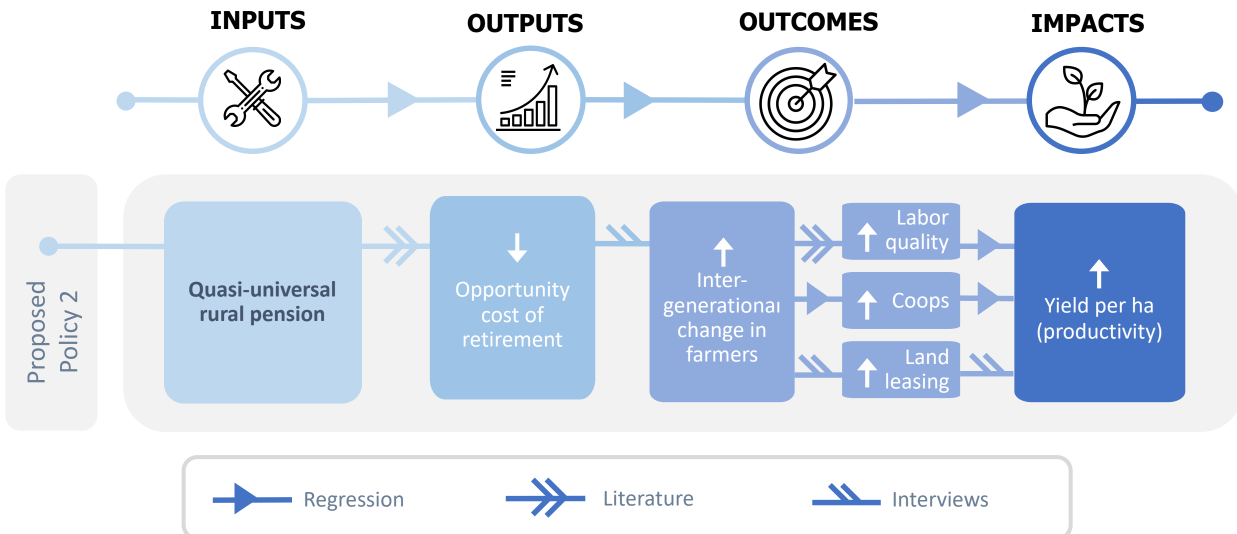
As shown in Figure 12, our goal with the quasi-universal rural pension – apart from reducing rural poverty – is to generate an intergenerational change in farms' management, promoting the retirement of the older generation by giving them a steady income that can offset the opportunity cost of retirement.

The literature shows that similar rural pension programs have been effective while reducing elderly labor participation. Carvallo Filho (2008) estimates that increasing social security benefits for rural elderly workers in Brazil reduced their hours worked per week by 22 hours – and that increased their

[19] The average in the whole country (rural and urban) is around 60%.

probability of retirement by 38%. Similarly, Juarez and Pfutze (2015) find a decrease of 30% in labor force participation of rural elderly men after receiving pensions in Mexico, an effect that increases in the lowest quintiles. Finally, outside Latin America, Ardington et al. (2009) find that a large cash transfer to the elderly increased prime-aged adults labor supply (and reduced elderly's) in South Africa. These findings align with and reinforce what experts told us during our interviews in Peru.

Figure 12 - Theory of Change - Proposed Policy 2



Source: Own elaboration.

By increasing the intergenerational change in farmers, we expect to impact the yield per hectare of the plots through three mechanisms. First, younger farmers have better human capital – mainly health. Second, younger farmers are more prone to be part of a cooperative. Our estimates show that younger farmers are around 5% more likely to join a cooperative than their older counterparts[20]. Moreover, during our interviews, experts explained to us that older generations are less likely to join a cooperative due to mistrust, mainly from their bad experiences during the land reform of the 1970s. Following the same line, younger farmers are more likely to lease their land to larger and more productive farmers, either to work as salaried farmers or in another sector.

This program could end up being more fiscally prudent than what a back-of-the-envelope calculation would show as it can increase the productivity in many farms along the country. Hence, being a social security program that, apart from redistributing wealth, can also increase the pie.

[20] See Table 12 in in the Appendix for the estimation of a Logit model.

Cost-Benefit Analysis

We propose to set some restrictions to be eligible for the program, thus its quasi-universal nature. The government should exclude adults who already have a contributory private pension or own plots over 10 hectares (medium or big plots) to reduce leakage.

As in the previous-section exercise, we perform a prediction analysis to estimate the production gains of having younger farmers. We take coffee as an example, as it is a crop that would benefit greatly from an intergenerational change of farm's leadership. The predicted difference in yield of a young-farmer plot and a similar old-farmer plot is of 130 kg per hectare per year (a 20% increase). By multiplying this increase by the coffee price in 2015 (PEN 6.4 per kg), we get an increase of PEN 829 per hectare per year. Panel A of Table 17 in the Appendix shows the estimates of this prediction analysis for all our selected crops and the cost-benefit analysis follows.

First, regarding benefits, productivity increases in five out of our seven selected crops – on average, this represents a gain of PEN 552 per hectare per year (~USD 160). These seven crops represent 27.9% of the total under-10-hectares (small) farms' area. If we include traditional crops – maize, potatoes, wheat, and beans – to our calculation, our average gain would become PEN 459 per hectare per year. These 11 crops represent 57.3% of the total small farms' area[21]. According to 2012 Agriculture Census, around one-third of small farms are owned by elderly farmers (60+ years old)[22] – this implies that our proposed program could increase productivity by 0.04% of GDP[23].

As explained in our theory of change, this program will also increase productivity through other channels. We predict that, after the intergenerational change, a share of young farmers will either lease their farms to bigger firms (increases productivity by up to 0.06% of GDP) and another share will join a cooperative (increases productivity by up to 0.02% of GDP). **As a result, productivity gains account for up to 0.12% of GDP**[24]. We also account for government savings as a share of beneficiaries will stop receiving Pension 65. We estimate savings of 0.06% of GDP[25].

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21 As we use prices that farmers directly received -and not the final consumer prices- we consider that our estimations are conservative.

22 According to the agricultural census, 28.8% of all the farms under 10 hectares is owned by farmers over 60 years old, they represent 96% of all the farmers above 60 years old. We assumed that this share holds for all the small farms and for each crop on average. As a result, 71% of all the elderly rural population is in charge of a small farm.

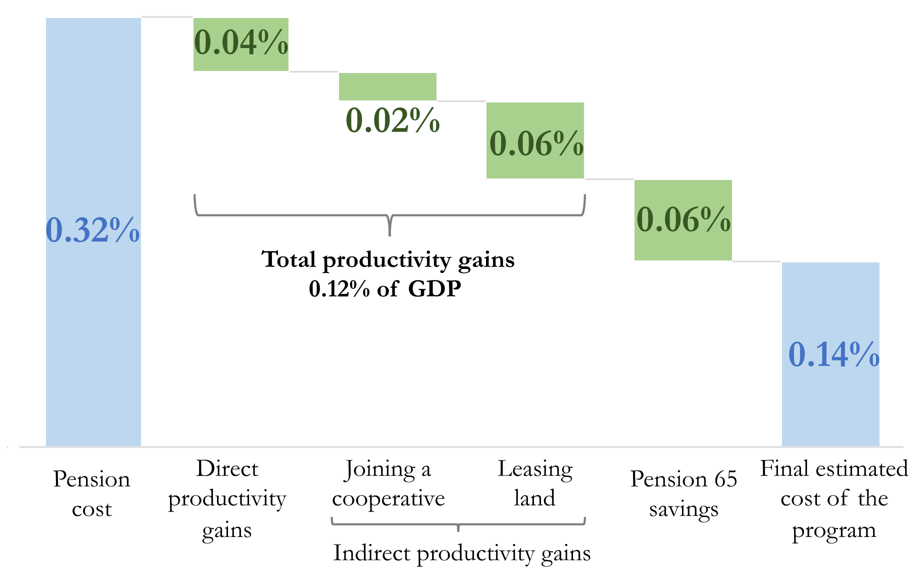
23 We estimated this gain by multiplying the average gain per hectare (PEN 459) by the total area occupied by small farms (2.2 million hectares) and by the share of small farms (28.8%) owned by elderly farmers. We used the current GDP in Soles of 2018.

24 As in the previously, we multiplied the average gain per hectare by the share of the total area occupied by small farms that are owned by elderly farmers. See Table 17 in the Appendix to a detailed description of the estimated productivity gains per crop and effect.

25 According to the Peruvian government, there were 297,371 rural beneficiaries in December 2017 (Pension 65, 2017).

Second, we estimate the program will cost 0.32% of GDP. According to the 2017 Population Census, there are 850,000 elderly people in rural areas (60+ years old). We first exclude elderly who own medium or big farms and elderly who receive a private *contributory* pension (8% of the total rural elderly population). Out of the remaining, only one-half work on small farms. Even though our policy is targeted to small farmers, we cannot exclude the remaining ones – they are elderly who do not own a farm and are living out of their non-contributory pensions, Pension 65. It would be administratively and politically unfeasible. Thus, we propose to include all rural elderlies in our scheme – after excluding the initial 8% – and to give them a quasi-universal monthly pension of PEN 250 (twice the current amount of Pension 65). **Given the proposed targeted population and transfer amount, we estimate a cost of 0.32% of GDP** (see Table 18 in the Appendix). Figure 13 shows that the final estimated economic cost of the policy is less than half of the direct accounting cost (the one obtained by multiplying number of beneficiaries and transfers). We must also note that this economic cost-benefit does not incorporates one of the biggest social impacts of the policy: reducing rural poverty. Even without account for it, **our numbers show how a social security policy produces significant productivity gains that could offset more than half of the cost of the transfers.**

Figure 13 – Efficiency gains of the quasi-universal rural pension as % of GDP.



Source: Own elaboration based on ENA 2015 and 2016, Agriculture Census 2012, and SEPA-MINAGRI for 2015 prices.

Implementation analysis

Our proposed policy is to hand a non-contributory pension to elderly population living in rural Peru who do not receive a contributory pension or own a medium/big plot. The hardest part of implementation is how to transfer the pension to all beneficiaries. Two limitations arise: (i) rural areas in Peru are spread out and very remote, which makes it hard for the government to physically reach them, and (ii) financial inclusion in rural areas is low, which makes it harder to deploy a program using bank transfers.

We propose to implement this policy using mobile money transfers. The biggest advantage of mobile payments is that users do not need a bank account to receive the benefits – they only need a cellphone. According to the INEI (2019), 92% of the households in Peru have at least one cellphone (82% in remote rural areas). Moreover, the country has established a national financial inclusion strategy that includes mobile payments as one of its pillars (SBS, 2015).

Furthermore, mobile transfers have smaller transaction costs than comparable cash transfers – in terms of time, coordination and money – and are as transparent as bank transfers. As Aron and Muellbauer (2019) summarize, there is plenty of international evidence showing how mobile money transfers foster savings in previously unbanked population and facilitate risk-sharing in the case of negative shocks, as family members are able to easily transfer money.

We are also aware of potential drawbacks that may need to be addressed. For instance, cellphone penetration across elderly is lower than average. Nonetheless, most of the households report having a younger family member with at least one cellphone. While not ideal, this represents a second-best scenario. Another concern with our policy is the leakage – filter variables need to be closely monitored to prevent it. Given that a 10-hectares cut-off is easy to spot, social pressure has the potential of playing an important role. Beneficiaries should be aware that no one with a large plot is eligible to receive the pension and exert social pressure accordingly.

The program should be built separately from Pension 65 and must take into account mobile money key characteristics. Our targeting mechanisms, benefit amount, delivery strategy and – equally important – objective differ from the alleviating-poverty strategy of Pension 65. Therefore, targeting of the program should start with a Population Census of individuals living in rural areas to acquire information on their socio-economic and farming status. This will allow the government to establish a list of beneficiaries. Afterwards, there should be training to the elderly and family members on how to monitor their payments and withdraw their money using a cellphone. At this stage, alliances with local (district-level) banks are key to ensure the ubiquity of access points. Finally, during the transfer roll-out, a monitoring mechanism should be established and tested.

Such effort will require a high level of coordination at the national government. MINAGRI will need to work alongside other national ministries – mainly the Ministry of Finance – to ensure the feasibility and roll-out of the program. The program requires additional budget from the Executive Branch and approval from the Legislative Branch. Finally, for the program to be effectively deployed, a bill needs to be passed in Congress.

6.3. Complementary Policy - Enhancing property rights

A complementary policy we propose is to enhance property rights. Specifically, we propose increasing the share of farmers who hold a property title and improving the enforcement of the law. We categorize it as a complementary policy because it (indirectly) affects the productivity by reinforcing the previous ones.

The first land reform in Peru – the Agricultural Reform – took place in the 1970s during the military government of President Velasco. The reform expropriated land from large *haciendas* (large farms owned by a single landowner) and transferred it to peasants who worked the land by establishing a joint-ownership scheme, the cooperative (Fort, 2008). Although the reform aimed to reduce inequality between landowners and peasants, most of these cooperatives went bankrupt in the following decades – mainly because the reform lacked managerial and planning support for the new landowners (Caballero, 1980).

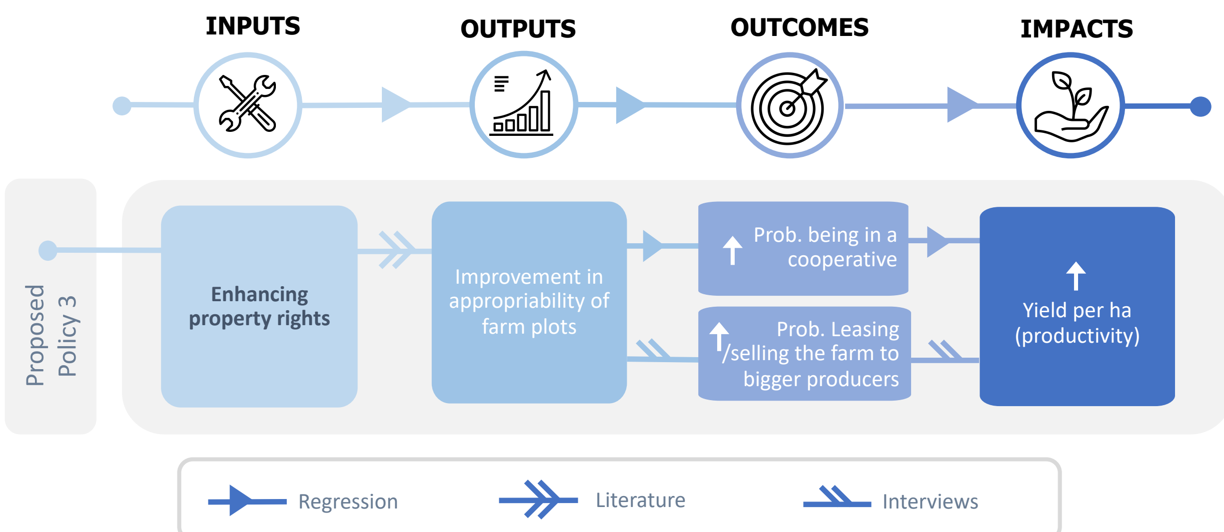
In 1981, social pressure from farmers led to a law decree that allowed cooperatives to break the joint property rights. However, the new law resulted in fragmented pieces of land with informal documents instead of legal property rights (Fort, 2008). In 1992, the Executive Branch established a new project called PEPP to formalize and register these informal property rights. During its validity (until 2005), the program managed to transfer 1.5 million property titles to farmers. There have been subsequent efforts to reactivate the program – but a combination of lack of resources, little interest from local governments and little state capacity have led to an overall failure (FAO, 2013).

According to the Ministry of Agriculture, half of the micro and small farms still lack formal land titling. We propose a renewal in the land titling efforts. Beyond its potential direct impacts on agricultural outcomes, we estimate that a land titling policy could enhance the productivity gains of the two above-mentioned policies as these would reach more farmers. The theory of change behind our proposal is explained in the following subsection.

Theory of Change

Figure 14 shows **that this policy acts as complement of our main proposed policies.** First, improving property rights will lead to an improved sense of appropriability of farmers over their lands. This, in turn, could lead either to an increase on the probability of joining a cooperative or an increase in the probability of leasing their plots to a bigger firm. For the former, we estimate a logit model of the impact of having land titles on the probability of joining a cooperative (see Table 15). We found that holding a title increases the likelihood of joining a cooperative by around 5%. Regarding the latter, we rely on the qualitative data from our interviewees who confirmed that, despite farmers' willingness to lease their land, the firm is not able to formally contract with them due to lack of property rights.

Figure 14 - Theory of Change - Proposed Policy 3



Source: Own elaboration.

Our estimates show that joining a cooperative is associated with an increase in yield per hectare by reducing the distance to the world frontier in about 0.1 SD. And going from a small farm to a medium farm also increases the productivity in 0.3 SD. **Thus, this policy acts as enabler – it enhances the interactions between inputs, outputs and outcomes of the previous policies.**

Implementation Analysis

Enhancing property rights will require a thorough analysis of the areas where no titles have been yet provided. This requires identifying *where* are the information gaps and *how* to close them.

This implies dealing with property titling cases where there is little to no data available – or worse, with conflicting data. Furthermore, the registration of property rights is managed at the regional level, which may lead to significant geographic differences in implementation.

The implementation of a land titling program should be based on the success of the previous PETT program carried out in the early 2000s. The previous program started by building a cadaster-database of all the plots in each region. Although this cadaster could be used as a base, an updated version will be necessary. This process could be easily done by taking advantage of access to new satellite images and geographical technologies to identify plots from one another. Adding to these images, census data should also be collected for each of the plots to gather information about the possessors of the land. The second stage in PETT was to register the ownership of the plots. We propose that this should also come as a natural next step. Both the cadaster database and the census information should be used as cross reference for registering a title. In addition, some proof of ownership – previous titles, private transfers or proof of peaceful possession for a minimum of 5 years – should be presented. This would ensure that titles are granted fairly.

We believe that MINAGRI should lead the policy. Specifically, they should be the ones in charge of gathering the cadaster-database and designing the steps to issue the titles. However, it should be up to the municipalities (1851 across Peru) to lead the data collection efforts and oversee the issuing of land titles. The Ministry should persuade their local counterparts about the importance of this policy.

As the policy depends on municipal offices, the amount of state capabilities needed is high, thus making it administratively hard to implement. Furthermore, as it is a decentralized process, several corruption-related issues may threaten the policy. For example, two years ago in a northern Peruvian city, a Congressman was accused of fraud in land titling due to usurping private lands to his favor (Peru21, 2018). This example illustrates how a policy may fail because of misaligned incentives between the different government levels or local corruption practices.

Similar to the two abovementioned policies, the Ministry of Finance must assign a budget to the land titling program and the Congress must approve it. However, as the PEPP already exists (and is just deactivated), the Executive Branch could activate it through a direct Supreme Decree. This means that, unlike the two other projects, land titling does not require a new bill from Congress.

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Frank. Chief Agricultural Operating Officer, Large Agro-Exporter Firm. Ica, Peru

Gabriel. Executive Director, Firm's Association. Lima, Peru

Javier. Agriculture Economist, Important Peruvian Think-Tank. Lima, Peru

Oscar. Director, Medium Agro-Exporter Firm. Cajamarca, Peru

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8. Appendix

Figure 15 - Map of ecoregions in Peru

Source: own elaboration based on Ministry of Environment of Peru

Table 4 - Ecoregions

	Bosque seco	Costa	Puna y Paramo	Quechua	Selva alta	Selva baja
Plot characteristics						
Area harvested (ha)	7.37	14.84	0.77	0.69	1.63	4.10
Micro plots (>1ha)	80%	70%	94%	88%	85%	72%
Rain dependant	27%	0%	61%	8%	78%	99%
Owner with property title	37%	44%	10%	32%	17%	29%
Production inputs & others						
Technology index	39%	48%	36%	44%	29%	13%
Fertilizer	76%	75%	50%	63%	41%	17%
Pesticides	71%	74%	53%	66%	45%	32%
Training index	13%	14%	9%	12%	13%	18%
Credit	26%	22%	10%	14%	12%	16%
Cooperative member	2%	1%	0%	0%	3%	3%
Exporter	6%	5%	0%	1%	1%	2%
Number of observations	15,661	16,288	54,729	17,944	40,083	27,289

Source: own elaboration based on ENA 2015 and 2016.

Table 5 - Crops characteristics

	Banana	Mangos	Coffee	Cocoa	Avocado	Grapes	Asparagus	Weighted Average
Plot characteristics								
Distance to world frontier (in SD)	4.0	5.0	3.9	4.5	5.2	3.1	2.2	4.3
Area harvested (average ha)	0.6	0.8	1.9	1.6	7.4	13.9	170.3	3.0
Rain dependant	74.6%	29.8%	90.5%	84.8%	26.1%	0.1%	4.4%	60.3%
Owner with propierty title	24.0%	46.8%	14.0%	29.4%	37.6%	54.8%	34.3%	29.9%
Plot size								
Micro (<1ha)	82.0%	96.1%	46.0%	52.5%	91.9%	81.1%	22.2%	76.3%
Small (from 1ha to 10ha)	17.7%	3.0%	53.1%	46.9%	5.2%	10.4%	33.3%	22.3%
Medium (from 10ha to 50ha)	0.1%	0.5%	0.7%	0.5%	0.8%	3.2%	11.1%	0.6%
Large (>50ha)	0.1%	0.5%	0.1%	0.2%	2.1%	5.2%	33.3%	0.8%
Technology and related services								
Certified production	3.2%	2.4%	4.0%	2.4%	4.1%	8.6%	37.8%	3.7%
Technology index	23.2%	31.1%	26.5%	23.2%	41.6%	42.9%	65.9%	28.8%
Training index	17.3%	12.6%	20.3%	27.3%	16.3%	18.1%	58.9%	18.1%
Technical assistence index	13.5%	10.8%	15.2%	22.4%	13.3%	17.0%	46.7%	14.6%
Fertilizer	33.5%	54.5%	32.9%	33.4%	53.2%	58.4%	84.0%	40.8%
Asociativity								
Member of some association	16.0%	10.7%	14.6%	15.5%	21.2%	7.5%	5.6%	15.3%
Cooperative member	4.1%	1.7%	7.4%	6.3%	1.9%	0.4%	-	4.0%
Exporting services	2.1%	0.7%	2.0%	1.0%	0.7%	0.5%	-	1.5%
Credit provided by coop	0.8%	0.8%	0.9%	1.8%	0.8%	0.6%	-	0.9%
Destination of the production								
Exporter	2.2%	2.2%	11.7%	13.0%	4.0%	7.3%	53.9%	5.5%
Industry supplier	0.1%	0.7%	1.2%	3.3%	0.8%	3.3%	20.0%	1.0%
Financial services								
Credit	15.8%	19.7%	15.6%	20.6%	15.9%	17.2%	57.8%	17.0%
Agricultural insurance	0.4%	0.5%	0.2%	0.7%	0.8%	0.2%	6.7%	0.5%
Cost structure								
Machinery (as % of total cost)	4.2%	4.0%	4.2%	6.4%	3.8%	2.6%	4.4%	4.2%
Wages (as % of total cost)	65.0%	53.4%	77.6%	69.8%	58.5%	51.5%	53.4%	64.2%
Water (as % of total cost)	5.8%	19.3%	0.9%	3.4%	14.1%	24.4%	7.5%	8.9%
Technical assistence (as % of total cost)	0.1%	0.2%	0.0%	0.1%	0.2%	0.3%	0.4%	0.1%
Number of observations	10,936	3,851	4,686	2,921	4,315	1,668	45	28,422

Source: own elaboration based on ENA 2015 and 2016.

Table 6 – ANOVA exercise

	Source	Dependent variable: Standardized distance to world frontier Sum of squares
Size	Size: between 1 - 10ha	3.85
	Size: between 10 - 50ha	68.72
	Size: between 50 - 200ha	154.65
	Size: between 200 - 500ha	107.94
	Size: more than 500ha	48.74
Ecoregion	Ecoregion: Quechua	62.44
	Ecoregion: Puna y Paramo	8.14
	Ecoregion: Bosque Seco	27.10
	Ecoregion: Selva Alta	1.75
	Ecoregion: Selva Baja	16.09
Crop	Crop: Grapes	481.82
	Crop: Asparragus	122.06
	Crop: Avocado	2493.24
	Crop: Cocoa	463.92
	Crop: Mango	1998.50
	Crop: Banana	19.30
	No. observations	28,496
	R-squared	0.397

Source: own elaboration based on ENA 2015 and 2016.

Table 7 - ANOVA exercise by crop

		Coffee	Grape	Mango	Avocado	Cocoa	Asparragous	Banana
Size	1 - 10ha	8.58	3.29	0.28	0.89	4.43	0.20	0.91
	10 - 50ha	0.51	126.22	7.90	3.69	-	0.03	0.08
	50 - 200ha	0.09	183.85	17.20	12.33	0.03	0.99	6.68
	200- 500ha	3.47	99.50	2.72	5.71	6.79	3.27	0.77
	> 500ha	-	44.98	-	4.33	-	2.25	0.00
Ecoregion	Costa	0.11	15.47	9.41	16.69	-	0.27	3.78
	Quechua	1.80	1.37	1.54	0.31	0.32	-	9.02
	Puna y Paramo	1.23	22.36	0.85	2.67	86.46	0.17	0.19
	Selva Alta	0.71	0.40	23.07	14.75	10.94	-	39.07
	Selva Baja	1.71	-	22.87	6.16	-	-	22.41
Size as percentage of explained variation		69%	92%	33%	40%	10%	94%	10%

Source: own elaboration based on ENA 2015 and 2016.

Table 8 – OLS: General model of distance to world frontier

	Dependent variable		
	Standardized distance to world frontier		
	(1)	(2)	(3)
Size: between 1 - 10ha	-0.0126	-0.0253**	0.00141
	[0.0103]	[0.0104]	[0.0103]
Size: between 10 - 50ha	-0.615***	-0.585***	-0.346***
	[0.0795]	[0.0782]	[0.0712]
Size: between 50 - 200ha	-1.028***	-0.960***	-0.518***
	[0.0861]	[0.0865]	[0.0893]
Size: between 200 - 500ha	-1.279***	-1.226***	-0.743***
	[0.115]	[0.114]	[0.117]
Size: more than 500ha	-1.085***	-1.019***	-0.540***
	[0.132]	[0.130]	[0.133]
Rain dependant			0.0603***
			[0.0194]
Technology index			-0.167***
			[0.0208]
Certified products			-0.385***
			[0.0317]
Training index			-0.0103
			[0.0148]
Credit			-0.0480***
			[0.0125]
Property rights			-0.0203**
			[0.00984]
Base controls			
Eco- region FE	No	Yes	Yes
Crop FE	Yes	Yes	Yes
Year	Yes	Yes	Yes
No. observations	28,602	28,602	28,602
R-squared	0.398	0.405	0.413

Notes: Robust standard errors clustered at the farmer level are reported in brackets.
*** p<0.01, ** p<0.05, * p<0.1

Source: own elaboration based on ENA 2015 and 2016.

Table 9 – OLS: General model of distance to world frontier by crop

	Dependent variable						
	Standardized distance to world frontier						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Coffee	**Grape**	**Mango**	**Avocado**	**Cacao**	**Asparragus**	**Banana**
Size: between 1 - 10ha	-0.0438**	-0.0863	0.0182	0.0848*	0.119***	-0.0210	-0.0252***
	[0.0192]	[0.0966]	[0.0664]	[0.0448]	[0.0246]	[0.183]	[0.00811]
Size: between 10 - 50ha	-0.119	-1.121***	-0.366**	-0.0704	0.158	0.155	-0.00203
	[0.0887]	[0.245]	[0.185]	[0.150]	[0.140]	[0.198]	[0.0581]
Size: between 50 - 200ha	0.112**	-1.352***	-0.618**	-0.113	-0.0316	0.158	-0.492
	[0.0550]	[0.265]	[0.263]	[0.136]	[0.415]	[0.230]	[0.330]
Size: between 200 - 500ha	-0.731**	-1.528***	-0.407	-0.195	-1.672***	-0.135	-0.183***
	[0.300]	[0.284]	[0.575]	[0.161]	[0.399]	[0.273]	[0.0383]
Size: more than 500ha		-1.312***		-0.239		-0.0269	
		[0.307]		[0.185]		[0.241]	
Rain dependant	-0.127***	0.983**	-0.395***	-0.169***	0.402***		0.158***
	[0.0408]	[0.407]	[0.102]	[0.0580]	[0.0762]		[0.0172]
Technology index	-0.275***	-0.147	-0.0933	-0.0800	-0.163***	-0.126	-0.0380**
	[0.0403]	[0.0938]	[0.0628]	[0.0592]	[0.0581]	[0.194]	[0.0179]
Certified products	-0.112**	-0.369	-0.350**	-0.255***	-0.338***	-0.330**	-0.454***
	[0.0522]	[0.232]	[0.156]	[0.0892]	[0.0960]	[0.138]	[0.0369]
Training index	0.0295	-0.149	-0.0443	-0.0162	0.0253	-0.0953	-0.0275**
	[0.0306]	[0.111]	[0.0632]	[0.0536]	[0.0314]	[0.120]	[0.0108]
Credit	-0.0665**	-0.0427	-0.0507	-0.0677*	-0.0580*	0.0202	-0.000787
	[0.0261]	[0.0790]	[0.0378]	[0.0407]	[0.0336]	[0.0930]	[0.0100]
Property rights	-0.0331	-0.0487	-0.0484	-0.0125	-0.139***	-0.0797	0.00901
	[0.0217]	[0.0629]	[0.0320]	[0.0357]	[0.0272]	[0.0893]	[0.00733]
Base controls							
Eco- region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. observations	4,686	1,668	3,851	4,315	2,921	225	10,936
R-squared	0.295	0.289	0.240	0.094	0.146	0.273	0.388

Notes: Robust standard errors clustered at the farmer level are reported in brackets.
*** p<0.01, ** p<0.05, * p<0.1

Source: own elaboration based on ENA 2015 and 2016.

Table 10 – OLS: The role of cooperatives

	Dependent variable		
	Standardized distance to world frontier		
	(1)	(2)	(3)
Size: between 1 - 10ha	-0.0214**	0.00111	0.0112
	[0.0105]	[0.0105]	[0.0104]
Size: between 10 - 50ha	-0.556***	-0.0548	-0.00593
	[0.0805]	[0.0726]	[0.0719]
Belonging to any sort of association		-0.0865***	0.0118
		[0.0128]	[0.0164]
Benefits from associations			
Access to external markets			-0.159***
			[0.0501]
Access to inputs			-0.109***
			[0.0320]
Access to training			0.00817
			[0.0253]
Access to credit			-0.0211
			[0.0476]
Access to gathering center			-0.0142
			[0.0378]
Access to refrigeration			-0.458
			[0.602]
Rain dependant			0.0622***
			[0.0195]
Technology index			-0.166***
			[0.0206]
Certified products			-0.268***
			[0.0368]
Property rights			-0.0230**
			[0.00992]
Base controls			
Eco- region FE	Yes	Yes	Yes
Crop FE	Yes	Yes	Yes
Year	Yes	Yes	Yes
No. observations	27,401	27,401	27,401
R-squared	0.390	0.387	0.393

Notes: Robust standard errors clustered at the farmer level are reported in brackets.
*** p<0.01, ** p<0.05, * p<0.1

Source: own elaboration based on ENA 2015 and 2016.

Table 11 - OLS: The role of cooperatives

	Dependent variable													
	Standardized distance to world frontier													
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Coffee	**Coffee**	**Grapes**	**Grapes**	**Mango**	**Mango**	**Avocado**	**Avocado**	**Cacao**	**Cacao**	**Asparragus**	**Asparragus**	**Banana**	**Banana**
Size: between 1 - 10ha	-0.0829***	-0.0657***	-0.0472	-0.0374	-0.0119	-0.0129	0.0775*	0.0686	0.128***	0.124***	-0.109	-0.0589	-0.0273***	-0.0231**
	[0.0192]	[0.0193]	[0.0967]	[0.0891]	[0.0687]	[0.0857]	[0.0462]	[0.0697]	[0.0249]	[0.0265]	[0.193]	[0.155]	[0.00892]	[0.00932]
Size: between 10 - 50ha	-0.154*	-0.139	-0.997***	-0.988**	-0.173	-0.208	-0.519***	-0.519	0.234*	0.227	0.183	0.211	-0.0118	-0.00691
	[0.0893]	[0.111]	[0.327]	[0.404]	[0.336]	[0.425]	[0.0680]	[0.646]	[0.138]	[0.190]	[0.214]	[0.191]	[0.0454]	[0.105]
Belonging to any sort of association	-0.0718**	-0.0348	0.0816	0.0818	-0.0748	-0.0124	-0.0173	0.0285	-0.0674**	-0.0621	-0.176	0.0525	-0.126***	-0.0334***
	[0.0280]	[0.0363]	[0.108]	[0.152]	[0.0477]	[0.0539]	[0.0457]	[0.0582]	[0.0297]	[0.0395]	[0.161]	[0.280]	[0.0123]	[0.0125]
Benefits from associations														
Access to external marke		0.0928		0.416		-0.141		0.145		0.156		-0.341		-0.568***
		[0.0778]		[0.378]		[0.183]		[0.191]		[0.137]		[0.392]		[0.0310]
Access to inputs		-0.0445		-0.202		-0.0516		-0.0288		-0.0217				-0.187***
		[0.0592]		[0.302]		[0.128]		[0.119]		[0.0729]				[0.0239]
Access to training		-0.0903*		0.0286		-0.0644		-0.0812		0.0895		-0.234		0.0243
		[0.0476]		[0.256]		[0.111]		[0.102]		[0.0559]		[0.435]		[0.0195]
Access to credit		-0.140		-0.0481		0.0315		-0.204		-0.166*				0.138***
		[0.0984]		[0.343]		[0.158]		[0.161]		[0.0946]				[0.0379]
Access to gathering center		0.0343		-0.492		-0.308*		0.0338		-0.160*				0.0403
		[0.0600]		[0.772]		[0.163]		[0.184]		[0.0953]				[0.0268]
Access to refrigeration								-1.576*		0.535				
								[0.918]		[0.664]				
Rain dependant		-0.145***		0.949		-0.344***		-0.161***		0.427***				0.153***
		[0.0336]		[0.727]		[0.0765]		[0.0489]		[0.0637]				[0.0128]
Property rights		-0.0393*		-0.0453		-0.0447		-0.00773		-0.153***		-0.117		0.00165
		[0.0233]		[0.0694]		[0.0357]		[0.0365]		[0.0278]		[0.0962]		[0.00767]
Base controls														
Eco- region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. observations	4,628	4,628	1,478	1,478	3,652	3,652	4,059	4,059	2,824	2,824	106	106	10,654	10,654
R-squared	0.284	0.288	0.130	0.133	0.233	0.239	0.083	0.087	0.118	0.146	0.162	0.182	0.351	0.397

Notes: Robust standard errors clustered at the farmer level are reported in brackets.
*** p<0.01, ** p<0.05, * p<0.1

Source: own elaboration based on ENA 2015 and 2016.

Table 12 - Probability of being in an association by age

	Dependent variable	
	Association	
	Logit	Marginal effect
Old farmer	-0.384***	-0.044***
	[0.0930]	[0.01015]
Age	0.0108***	
	[0.00279]	
Base controls		
Size FE	Yes	
Eco- region FE	Yes	
Crop FE	Yes	
Year	Yes	
Observations	12,467	

Standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Source: own elaboration based on ENA 2015 and 2016.

Table 13 - OLS: Individual farmers' characteristics

	Dependent variable	
	Standardize distance to world frontier	
	(1)	(2)
	General	General with controls
Old	0.101***	0.110***
	[0.0239]	[0.0241]
Gender (Men = 1)	-0.0425**	-0.0433**
	[0.0177]	[0.0178]
Sons/Daughter working on the field	0.0560***	0.0562***
	[0.0170]	[0.0169]
Old*Sons/Daughter working on the field	-0.0742**	-0.0749**
	[0.0344]	[0.0342]
Education	-0.000663	0.00144
	[0.00436]	[0.00436]
Rain dependant		0.0464
		[0.0354]
Technology index		-0.0595*
		[0.0354]
Certified products		-0.392***
		[0.0532]
Training index		0.0191
		[0.0235]
Credit		-0.0123
		[0.0217]
Property rights		-0.0384**
		[0.0162]
Base controls		
Size of plot FE	Yes	Yes
Eco- region FE	Yes	Yes
Crop FE	Yes	Yes
Observations	12,467	12,467
R-squared	0.337	0.342

Source: own elaboration based on ENA 2015 and 2016.

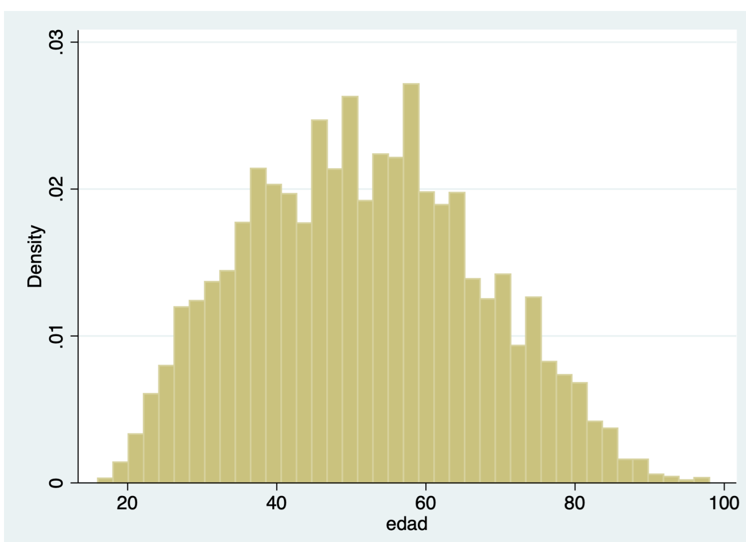
Table 14 - OLS: Individual farmers' characteristics by crop

	Dependent variable						
	Standardized distance to world frontier						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Coffee	**Grape**	**Mango**	**Avocado**	**Cacao**	**Asparragus**	**Banana**
Old	0.282***	0.210**	0.156**	-0.0113	0.0996	0.0101	0.0569**
	[0.0486]	[0.0987]	[0.0744]	[0.0623]	[0.0683]	[0.192]	[0.0228]
Sons/Daughter working on the field	0.104***	-0.0142	0.145**	-0.0678	0.0226	0.264	0.0508***
	[0.0356]	[0.131]	[0.0733]	[0.0626]	[0.0484]	[0.175]	[0.0132]
Old*Sons/Daughter working on the field	-0.175**	-0.0771	-0.145	0.0181	-0.0480	-0.500*	-0.0328
	[0.0718]	[0.172]	[0.109]	[0.0964]	[0.108]	[0.268]	[0.0311]
Base controls							
Plot size FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Eco- region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,206	694	1,563	1,775	1,316	50	4,863
R-squared	0.024	0.072	0.030	0.020	0.168	0.133	0.076

Source: own elaboration based on ENA 2015 and 2016.

Figure 16 – Histogram of farmers' age for selected crops

Only for small and medium farmers



Source: own elaboration based on ENA 2015 and 2016.

Table 15 - Probability of being in an association having a property title

	Dependent variable	
	Association	
	Logit	Marginal effect
Property	0.434***	0.046***
	[0.0457]	[0.0044]
Base controls		
Size FE	Yes	
Eco- region FE	Yes	
Crop FE	Yes	
Year	Yes	
No. observations	27,401	

Note: Standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

Source: own elaboration based on ENA 2015 and 2016.

Table 16 - Small Farms. Area by crop and age of the farmer

	Total area of small farms (ha)	Share of total national small farm area	Assumed owned by farmers >60y	Predicted annual gain per hectare
Coffee	330,704	14.9%	95,125	PEN 829
Cocoa	116,329	5.2%	33,461	PEN 315
Banana	115,069	5.2%	33,099	PEN 337
Avocado	23,395	1.1%	6,729	-PEN 46
Mango	17,303	0.8%	4,977	PEN 584
Grapes	10,568	0.5%	3,040	PEN 2,493
Asparagus	5,847	0.3%	1,682	-PEN 3,595
Total	619,214	27.9%	637,526	PEN 588

Source: own elaboration based on Agricultural Census 2012 and SEPA-MINAGRI for 2015 prices.

Table 17 - Predicted gains of younger farmer, cooperatives and increased size

Panel A: Older vs Younger farmers

		Coffee	Grapes	Mango	Avocado	Cocoa	Asparragus	Banana	Weighted average
A	Yield for older farmers (kg/ha)	632	11,322	9,584	9,164	771	6,371	11,573	n/a
B	Predicted yield for younger farmers (kg/ha)	762	12,365	10,152	9,144	814	5,414	12,221	n/a
C	Difference in yield (B - A)	130	1,043	567	-20	43	-956	649	n/a
	Percentage change	**20.5%**	**9.2%**	**5.9%**	**-0.2%**	**5.6%**	**-15.0%**	**5.6%**	**6.4%**
D	Price per kg (at farm)	PEN 6.39	PEN 2.39	PEN 1.03	PEN 2.27	PEN 7.35	PEN 3.76	PEN 0.52	n/a
	Predicted gain per hectare (C x D)	**PEN 829**	**PEN 2,493**	**PEN 584**	**-PEN 46**	**PEN 315**	**-PEN 3,595**	**PEN 337**	**PEN 552**
	Number of observations (A)	400	356	689	733	295	16	1,170	3,659

Panel B: Small vs Medium farmers

		Coffee	Grapes	Mango	Avocado	Cocoa	Asparragus	Banana	Weighted average
A	Yield for small farmers (kg/ha)	687	9,793	9,204	8,733	684	5,508	10,527	n/a
B	Predicted yield for medium farmers (kg/ha)	748	15,788	11,577	9,478	637	4,889	10,450	n/a
C	Difference in yield (B - A)	61	5,995	2,373	745	-46	-618	-77	n/a
	Percentage change	**8.8%**	**61.2%**	**25.8%**	**8.5%**	**-6.8%**	**-11.2%**	**-0.7%**	**12.7%**
D	Price per kg (at farm)	PEN 6.39	PEN 2.39	PEN 1.03	PEN 2.27	PEN 7.35	PEN 3.76	PEN 0.52	n/a
	Predicted gain per hectare (C x D)	**PEN 387**	**PEN 14,329**	**PEN 2,444**	**PEN 1,691**	**-PEN 340**	**-PEN 2,325**	**-PEN 40**	**PEN 1,368**
	Number of observations (A)	4,645	1,527	3,814	4,191	2,902	99	10,912	28,090

Panel C: Non-cooperative vs Cooperative member farmers

		Coffee	Grapes	Mango	Avocado	Cocoa	Asparragus	Banana	Weighted average
A	Yield for non-cooperative farmers (kg/ha)	679	9,743	9,094	8,716	668	5,363	10,201	n/a
B	Predicted yield for cooperative farmers (kg/ha)	727	9,273	9,573	8,836	704	5,061	12,160	n/a
C	Difference in yield (B - A)	48	-469	479	120	35	-302	1,959	n/a
	Percentage change	**7.0%**	**-4.8%**	**5.3%**	**1.4%**	**5.3%**	**-5.6%**	**19.2%**	**8.1%**
D	Price per kg (at farm)	PEN 6.39	PEN 2.39	PEN 1.03	PEN 2.27	PEN 7.35	PEN 3.76	PEN 0.52	n/a
	Predicted gain per hectare (C x D)	**PEN 305**	**-PEN 1,122**	**PEN 493**	**PEN 273**	**PEN 260**	**-PEN 1,137**	**PEN 1,018**	**PEN 516**
	Number of observations (A)	3,912	1,395	3,248	3,626	2,226	98	9,099	23,604

Source: own elaboration based on Agricultural Census 2012, ENA 2015 and 2016, and SEPA-MINAGRI for 2015 prices.

Table 18 - Annual cost of the pension program

Monthly pension	Annual cost: Million PEN	Annual cost: As % of GDP
PEN 100	947	0.13%
PEN 200	1,893	0.26%
PEN 250	**2,366**	**0.32%**
PEN 300	2,840	0.39%
PEN 400	3,786	0.52%

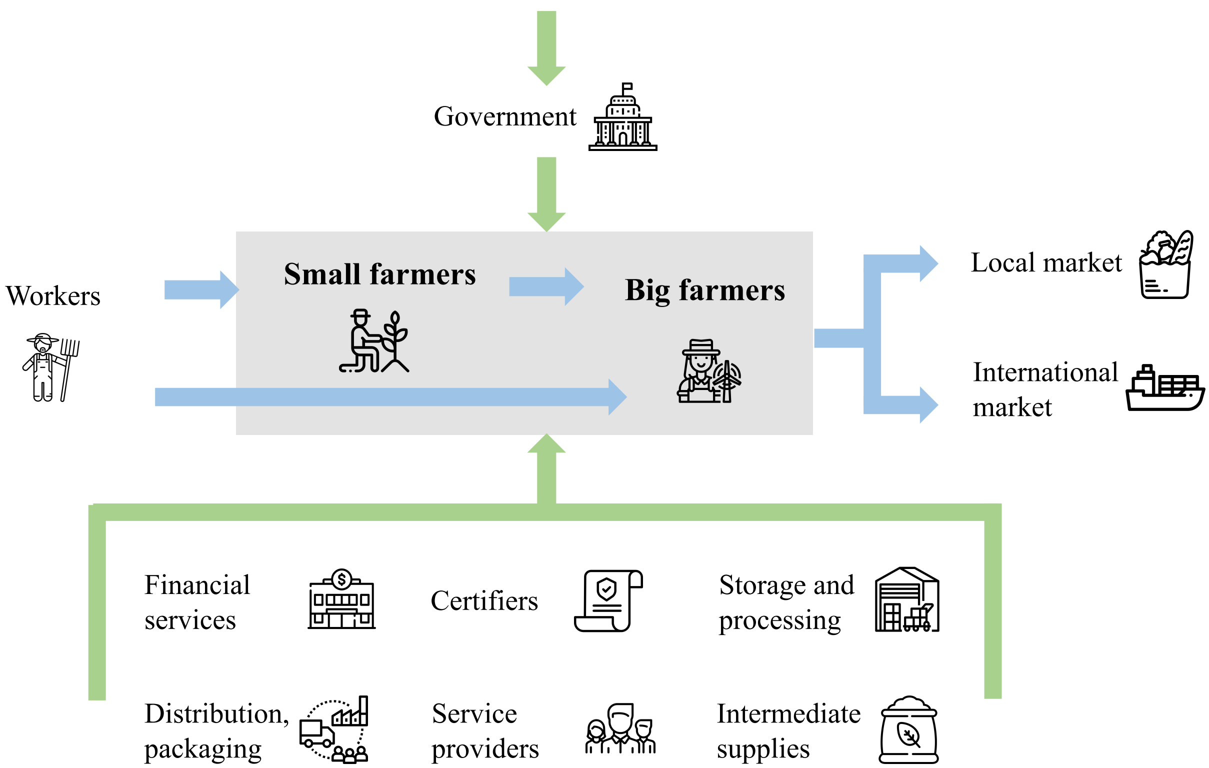
Note: using Peru GDP in current Soles for 2018
Source: Own elaboration based on INEI.

Figure 17 - Policy recommendations feasibility explanation

	Technical components	Political requirements	Administrative implementation
Fostering Cooperatives	Monetary and service incentives: 1. Waiving legal fees for their creation 2. Providing management services 3. Finance for plans related to modern inputs	1. Increased budget (MEF) 2. Budget approval (Congress) 3. New bill proposal (MINAGRI) 4. Bill approval (Congress)	1. Start with one crop (bananas) 2. Agile method to improve program in that crop 3. Choose champion cooperatives in other crops 4. Scale-up the program
	High technically correct	**High political support**	**Medium administrative feasability**
Establishing a quasi-universal rural pension	Non-contributory pension: 1. Pension of PEN 250 every month 2. All rural elederly excluding those with an existing pension and those with larger plots	1. Assign new budget to MINAGRI (MEF) 2. Budget approval (Congress) 3. New bill proposal (MINAGRI) 4. Bill approval (Congress)	1. Start with a rural CENSUS 2. Provide training of mobile banking 3. Form alliences with rural banks 4. Control and monitor mobile transfers
	High technically correct	**High political support**	**Medium administrative feasability**
Establishing a quasi-universal rural pension	Grant property titles: 1. Formal property titles. 2. Grant them to all the plots that were distributed after the Land Reform.	1. Assign new budget to MINAGRI (MEF) 2. Budget approval (Congress) 3.Reactivate bill by a Supreme Decree (President)	1. Start with satelite images of plots 2. Deploy a rural CENSUS 3. Register ownership of plots to farmers that can provide proof of ownership for over 5 years and crossreference these with satelite images and Census
	Medium technical correctness	**High political support**	**Low administrative feasability**

Source: Own elaboration.

Figure 18 – Stakeholder map



Source: own elaboration

Figure 19 - Quotes from expert interviews

Javier

Agriculture Economist
Important Peruvian Think-Tank - Lima

"There is little generational change. In some cases, it is because the father has stayed in the field. The productivity of the land begins to fall as he gets older. Also, the plots are small so they can't incorporate much technology. The way for the young man to enter is for the old man to retire. The issue is that the old man does not retire because the land is his pension. The old man could leave the EAP after receiving a pension, giving his land to his son, who can increase the productivity of the land. This can have a significant impact in productivity".

Frank

Chief Agricultural Operating Officer
Large Agro-Exporter Firm – Ica

"We are always looking for new fields to rent, the problem is that there is no well-established market. Sometimes the owners of the fields that we rent suddenly ask us for an increase, other owners ask us that in addition to renting the field we hire them to work it. The problem is that I can't hire workers that way, many of them are older than the workers we have. Therefore, we do not finally rent those fields".

Alejandro

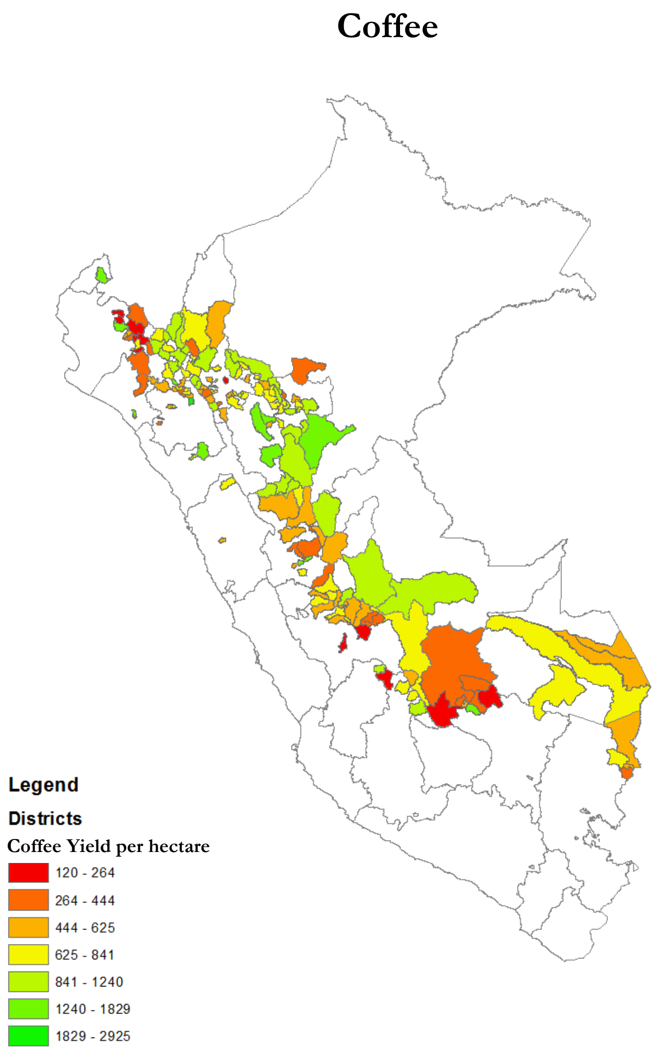
CEO
Large Agro-Exporter Firm – Ica

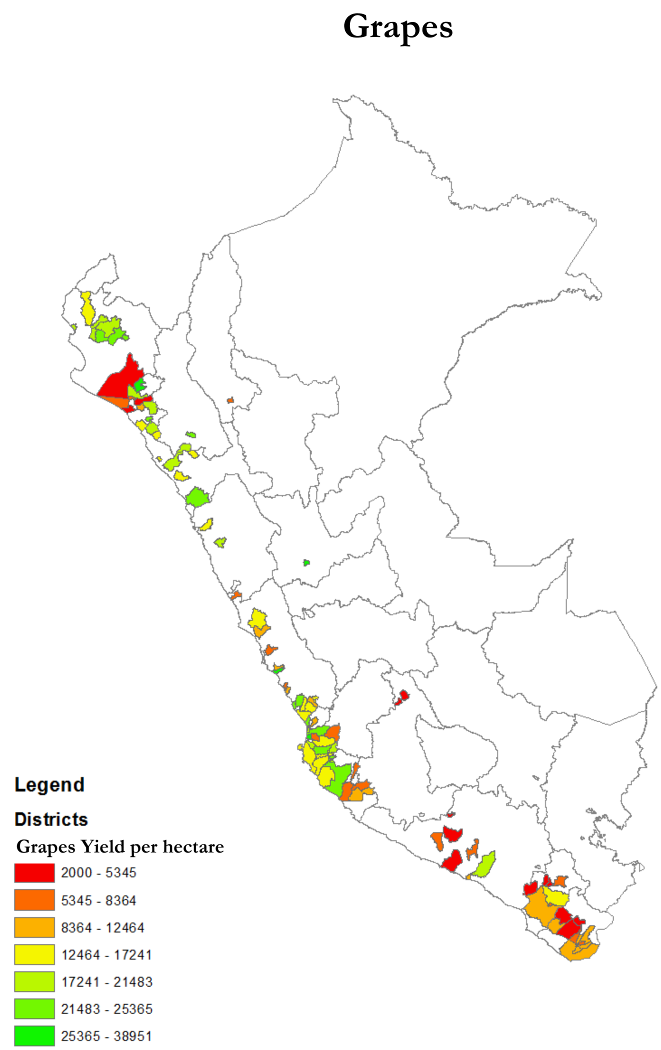
"It is necessary to promote the association between the agro-export company that has access to modern technology, external markets and the financial sector, with the producer next to it that has what the company needs (land, water and labor). Marriage is almost obvious; you have what I don't have, and I have what you don't have: we should be together. The reality is that we rent, but we don't associate with anyone. There is a big issue of distrust. Many people who benefited from the agrarian reform have already died, but there is no succession made, you don't know who owns the land.

At the same time, small producers should first associate with each other and then associate with us. Large companies cannot deal with so many micro producers, but we can do so with cooperatives. The state should encourage this cooperation".

Source: Own elaboration based on a selection of the interviews done in Peru during December 2019 and January 2020.

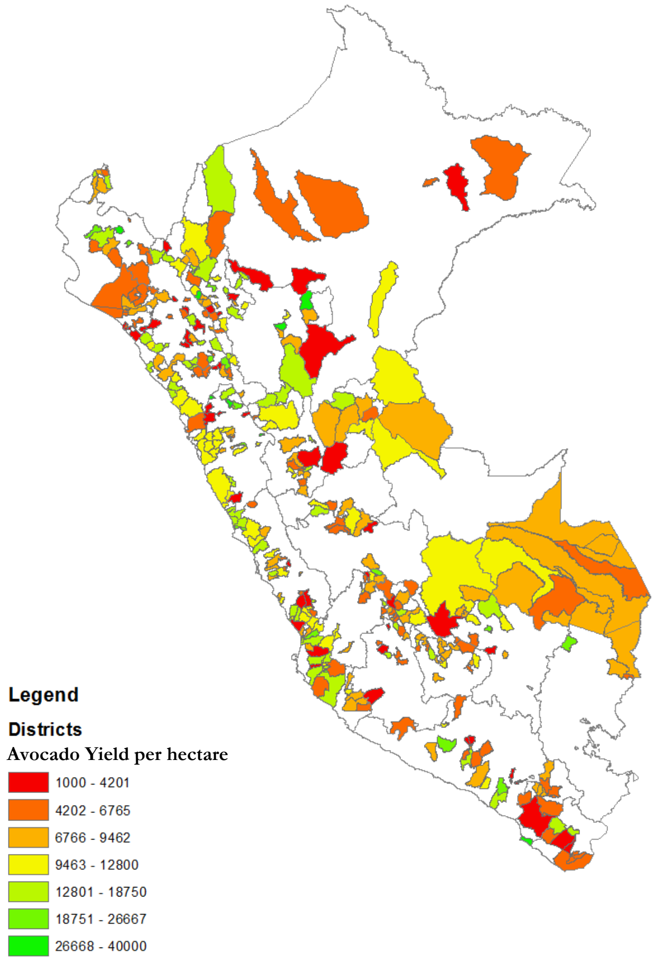
Figure 20 - Yield per hectare at the district level by crop



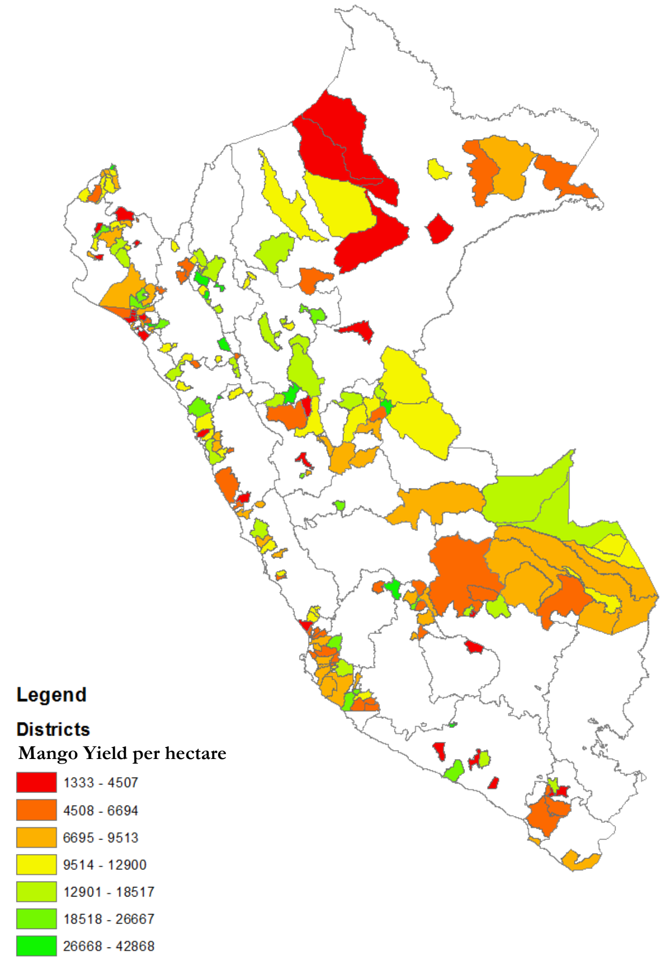


Source: own elaboration based on ENA 2015

Avocado



Mango



Source: own elaboration based on ENA 2015