Gaining Momentum in Peruvian Agriculture

Opportunities to Increase Productivity and Enhance Competitiveness

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Executive Summary

What is the future for agriculture in Peru? Once the principal source of employment and income for much of the population, Peru's agricultural sector has declined in importance as the national economy has expanded and urbanized. Economic activity in the sector has continued to grow, but economic activity in other sectors has grown more rapidly, leaving agriculture to make up an ever smaller share of the overall economy.

The future of Peruvian agriculture should concern policy makers for at least five reasons. First, agriculture makes up an important part of the economy, so if agricultural growth decelerates, overall growth will suffer. Second, an expanding agricultural sector diversifies Peru's economy and reduces dependence on extractives, so if the agricultural sector contracts relative to other sectors, economic growth could become more volatile. Third, agriculture-led growth is good for the poor, so if agricultural growth slows, an important means of reducing poverty will be lost. Fourth, Peru relies on food imports to make up production shortfalls, so if agricultural production fails to keep pace with population growth, national food security could be threatened. Fifth, climate-smart agricultural practices can play a major role in reducing greenhouse gas emissions and sequestering carbon, so if future agricultural practices are not climate smart, an important opportunity to help mitigate climate change will be missed.

This report synthesizes current knowledge about the ongoing transformation of Peru's agriculture and food system, assesses the recent performance of the agricultural sector with an emphasis on productivity and competitiveness, and highlights opportunities for enhancing the future contribution of the agricultural

sector toward meeting the country's development challenges. The report focuses on four key questions:

1. How is Peru's agricultural sector being affected by the larger structural transformation of the economy, and what are the major forces driving change in the sector?
2. How important is agriculture in Peru's economy, taking into account not only primary production but also forward and backward linkages?
3. How productive is Peruvian agriculture, within and between regions and farming systems?, and what are the opportunities to unlock future growth by reducing productivity differentials within agriculture and between agriculture and other sectors?
4. How competitive are Peru's farmers in domestic markets and in international markets, and what are the opportunities to increase competitiveness by overcoming constraints in Peru's agriculture and food value chains?

Agriculture in the context of structural transformation

Consistent with global experience, economic growth in Peru has been accompanied by structural transformation: the share of agriculture in the overall economy and the share of agricultural workers in total employment have both declined. But this does not mean that the agricultural sector has contracted in absolute terms. On the contrary, the volume and value of agricultural production have grown steadily. From 2000 to 2015, agricultural GDP growth in Peru averaged 3.3 percent per year, higher than in regional and structural peers.

Over the past 25 years, the agricultural, industry, and services sectors grew at comparable rates in Peru, so the contribution of each sector to GDP was determined by its size. Because disproportionately large numbers of the poor are employed in agriculture and services, these two sectors generated the largest income increases for the poor. The contribution of agriculture to reducing extreme poverty was particularly large.

The structural transformation pattern observed in Peru is consistent with the patterns observed in other countries, but there are also some interesting differences. For example, the rate of structural transformation in Peru has been unusually slow, as the composition of GDP has changed very little since the early 1990s. Similarly, while labor has moved from low-productivity rural agriculture to somewhat higher productivity services, often in the informal urban sector, agriculture continues to employ around one-quarter of the population, more than in many other urbanizing economies in the region. The fact that the share of agricultural employment has fallen so slowly in Peru and may even be leveling

off reflects the fact that the sector has grown in absolute terms and created large numbers of new jobs.

Importance of agriculture in Peru's economy

What is the real size of Peru's agricultural sector? To answer this question, an expanded measure of agricultural value added was calculated, taking into account intersectoral linkages in markets for intermediate goods. Capturing the multiplier effects associated with primary production activities is important for estimating the total contribution of agriculture to growth and poverty reduction, because the sector is often viewed as not being a key contributor as economies develop. An input-output matrix of national accounts was used to create an expanded measure of agricultural value added that takes into account the sector's forward and backward linkages. The strength of these linkages is proportional to the sector's participation in intermediate inputs used by other sectors and to the sales of upstream industries supplying agriculture.

When linkages are included, particularly forward linkages, agricultural value added increases significantly. Using the traditional measure that focuses narrowly on primary production activities, the contribution of agriculture to GDP in Peru is 7.3 percent. Using the expanded measure, the contribution is 11.3 percent, 4 percentage points higher.

Recognition of the real size of the agricultural sector could change the perceptions of policy makers about what should be the priorities for Peru's national development strategy. The lack of appreciation of the economic contributions made by primary agriculture through forward and backward linkages likely explains what appears to have been chronic public underinvestment in the sector. According to a recent public expenditure review for Peru (World Bank, 2012), public spending on agriculture expressed as a percentage of GDP remained low throughout the 2000-2010 period, starting at 0.7 percent, dipping to 0.3 percent, and ending at 0.6 percent. During the same period, total public spending increased from S/. 1.3 billion to S/. 2.5 billion, so public spending on agriculture fell sharply as a proportion of total public spending. The lagging public investment in agriculture may have resulted in part from a lack of appreciation on the part of policy makers of the true importance of agriculture and the larger food system. Had an expanded measure of value added been available, it likely would have been much easier to make the case for a higher level of public investment.

Productivity of Peruvian agriculture

How productive is Peruvian agriculture? What has been driving productivity growth in the sector in recent years, and are the traditional sources of productivity growth sustainable? Going forward, are there opportunities to accelerate productivity growth by tapping into new sources of growth? Do the answers to these questions differ by region? In the Costa region, have high levels of productivity growth been driven mainly by the uptake of high-value crops, and is this strategy sustainable? In the Sierra region, should farmers be encouraged to adopt improved technology for the production of traditional staples such as potatoes and maize, or should the focus be on encouraging them to substitute into high-value crops? In the Selva region, is rapid expansion of cropped area and cultivated pastures a sustainable path for agricultural growth, or should intensification receive more emphasis?

Productivity growth in Peruvian agriculture appears robust compared to productivity growth in other countries in Latin America. Since 1990, Total Factor Productivity (TFP) growth in the agricultural sector has been double that of previous decades, having increased at an average annual rate of 2 to 3 percent (Ludena, 2010; Trindade and Fulginiti, 2015; USDA, 2016). While Peru's performance ranks high within the region, the technological frontier for agriculture is set in industrialized countries, and compared to them, Peru and other Latin American countries continue to lag (Fulginiti and Perrin 1993, 1997, 1998, and 1999; Arnade, 1998; Bravo-Ortega and Lederman, 2005; Coelli and Rao, 2005).

Despite the relatively robust productivity growth recorded in recent years, the news from Peru's agricultural sector has not been uniformly good. While the macro-level data suggest that agricultural productivity has been rising, significant differences persist between regions and between categories of producers. Agriculture in Peru encompasses several sharply contrasting realities. One reality, visible throughout much of the Costa region as well as in a few advantageously located and better-endowed areas of the Selva region, features dynamic, highly productive, commercially successful agricultural systems that are well integrated into domestic and/or international value chains and that provide acceptable livelihoods for participants. The other reality, much more common throughout large areas of the Sierra and Selva regions, features static, unproductive, subsistence-oriented agricultural systems that are poorly integrated into the market and afford unacceptable livelihoods for participants. According to the 2012 Census, 80 percent of agricultural units are smaller than 5 ha, and large numbers of these smallholder farms engage in low-input/low-output agriculture, producing well inside the production frontier. Many make limited use of improved technologies, including seed of modern varieties,

fertilizer, crop chemicals, machinery, and irrigation. Lacking alternative employment opportunities, many rural inhabitants continue to work on the family farm, even though the returns to family labor are extremely low.

Recent productivity trends in Peru's agricultural sector were examined, with a particular focus on understanding how productivity growth has differed across regions and between farm types and sizes. Pooled (2007-2015) and cross-sectional (2015) survey data were used to estimate productivity measures, and the results were decomposed to reveal the sources of output growth (increased productivity vs. greater use of inputs). Output-input intensity ratios were calculated to provide insights into the performance of individual crops in different agro-climatic regions. Finally, a stochastic production frontier model was estimated to measure technical efficiency within the agricultural sector and provide insights into the factors that are contributing to inefficiencies within and between regions and farm types.

The results of the TFP analysis support the widely held view that agricultural productivity has been growing rapidly in the Costa region while essentially stagnating in the Sierra and Selva regions. As a result, the productivity gap has widened over time. The sources of productivity growth have varied by region. In the Costa region, output growth has been driven mainly by TFP growth. The robust TFP growth observed in the Costa region likely has resulted from expansion of the area planted to high-value crops, including export crops, both through expansion of total cultivated area and through substitution of high-value crops for the low-value crops that producers previously cultivated. In the Sierra region, output growth has been driven mainly by increased use of labor, both family labor and hired labor. The increased use of labor may reflect the lack of off-farm opportunities in the Sierra region, where members of rural households have little choice but to continue working on their own farms or to sell labor services to other farms. The fact that average farm sizes in the Sierra region are so small means that agricultural workers have limited possibilities for escaping from poverty. In the Selva region, output growth has been driven partly by TFP growth and partly by input growth. The relatively low TFP growth in the Selva region could be explained by the low productivity of recently deforested land, which is usually of low quality, with limited capacity for agricultural purposes. Another contributing factor could be the fact that coffee and cocoa farming are expanding in the Selva region, and coffee and cocoa farms tend to be relatively unproductive for some time following their initial establishment.

With the aim of exploring differences in productivity, the TFP analysis was disaggregated by farm size and type of producer. Generally speaking, the relationship

between farm size and TFP appears to be positive. Farmers with extremely small landholdings of less than 1 ha show the lowest levels of TFP. As farm size increases, so does TFP, but TFP remains unchanged or even decreases slightly when farm size exceeds 10 ha. Small farms show high yields but low productivity (TFP), which may be related to the more intensive use of inputs on small farms, especially family labor. In contrast, large farms may be favored by increasing returns to scale (or economies of scale) and the use of different technologies, which allow them to attain higher productivity levels (Sheng et al. 2015).

Analysis of the distribution of input shares shows a strong relationship between input use and farm size and type of producer. Larger farms and more consolidated producers are much more likely to engage in "technological production," using higher levels of technological inputs (purchased inputs, capital) and more land. Smaller farms and subsistence-oriented producers are much more likely to engage in "traditional production," making limited use of purchased inputs and capital and relying much more heavily on family labor. Although the observed variability in input use could be caused to some extent by differences in the mix of crop and livestock production activities, as well as by systematic differences in agro-climatic factors (for example, soil quality), overall the results make it clear that larger farms and more consolidated producers are more technologically intensive.

To further explore sources of variability in farm-level productivity and efficiency, stochastic production frontier (SPF) analysis was used to assess the sensitivity of production to different inputs and other factors. A single-step Maximum Likelihood procedure was used to estimate simultaneously the parameters of the production frontier, along with exogenous determinants of inefficiency. Three variables were found to be important in all three natural regions (Costa, Sierra, and Selva) for reducing inefficiency: those relating to (i) access to technical assistance, (ii) access to credit, and (iii) educational achievement. These results suggest that efforts are needed to build innovation capacity within the country. Strengthened capacity to innovate will have to be complemented with improvements in the "last-mile delivery" of technical assistance through the deployment of effective extension networks. The availability of improved technologies will make little difference, however, if the technologies remain unaffordable for producers, and for that reason initiatives to strengthen extension networks will need to be complemented with efforts to promote greater access to credit. On the supply side, it will be important to increase the number of financial intermediaries active in the rural space and expand the range of financial products on offer. One potential strategy for doing so would be for the government to provide credit guarantees to development banks

that target agricultural producers, including subsistence-oriented producers in the Sierra and Selva regions. On the demand side, the introduction of new financial products will need to be accompanied by initiatives to increase financial literacy among producers, especially producers who have not previously participated in formal financial markets. Finally, producers will be in a better position to access productivity-enhancing innovations, and take advantage of innovative financial products to do so, if they are sufficiently well educated to be able to assimilate new information and put it to good use. Education can play a critical role in reducing inefficiency in Peruvian agriculture, because better-educated farmers make better decisions about their production and marketing activities and consequently achieve better agricultural outcomes. This emphasizes the importance of investments made outside the sector to improve the reach and quality of basic education services.

In addition to these three cross-cutting variables that contribute to greater productive efficiency in all three regions, other variables representing technical, economic, and institutional factors were found to be important only in certain regions, such as income diversification, land titling, irrigation coverage, access to markets, and market information. The regional importance of these factors is discussed in some detail, and policy implications are spelled out.

The productivity analysis shows that productivity levels and the underlying determinants of efficiency vary not only between natural regions, but also between types of producers. The TFP and SPF results make clear—as expected—that commercial farms are more productive on average and more efficient than subsistence-oriented farms. The role and magnitude of the individual drivers of efficiency differ by type of producer. For example, better market integration is associated with higher levels of efficiency among all types of producers except subsistence-oriented producers, who do not participate actively in markets and face other binding constraints. Risk mitigation strategies and services (crop diversification) appear to be particularly effective for reducing inefficiency for subsistence-oriented producers, probably because they are more vulnerable to shocks than transitional and consolidated farmers. These results highlight the need for agricultural support strategies that are differentiated not only by natural region, but also by type of producer.

Competitiveness of Peruvian agriculture

How competitive are Peruvian farmers in domestic and international markets? What has the government done to promote the competitiveness of the agricultural sector? What are the key factors influencing the competitiveness of Peruvian agriculture?

What can be learned from the Peruvian value chains that have emerged as global success stories? Going forward, what are the key challenges that will have to be overcome to ensure the continuing successful development of Peruvian agriculture? And where are the most promising opportunities for future success?

These questions are crucial, as continued strong growth of Peru's agricultural sector will be possible only if Peruvian farmers, livestock keepers, and other value chain actors are able to compete effectively, both domestically and abroad. The productivity analysis presented in this report provides insights into factors operating at the farm level that influence competitiveness, primarily by influencing productivity, which determines the unit cost of primary production. But the unit cost of primary production is only one factor among many that determine the ability of Peruvian farmers, livestock keepers, and other value chain actors to compete in domestic and international markets. Any advantage conferred by efficiency in production can be lost through inefficiencies at other stages in the value chain that drive up costs, reduce product quality, create uncertainty in supply, or otherwise make products less attractive to buyers and eventually consumers.

To a large extent, the engine driving Peru's successful agricultural export growth and diversification strategy has been the private sector. Not always appreciated is the fact that the emergence in Peru of a thriving agro-export sector was made possible by policies that created a favorable business environment to stimulate private investment while at the same time exposing agribusiness firms to the winds of competition. Using a coordinated set of policy reforms and economic incentives, the government put together an enticing value proposition that facilitated access to productive resources, allowed private firms to share investment risks via tax concessions and other incentives, and demonstrated strong commitment to trade openness. Particularly significant policy interventions occurred in five areas: (i) labor markets, (ii) land markets, (iii) taxation, (iv) trade, and (v) sanitary and phytosanitary compliance.

What has been the overall impact of the policy reforms implemented over the years by the Government of Peru to promote a more open, productive, and competitive economy? Evidence from global benchmarking initiatives suggest that the government's efforts to establish a business-friendly environment by reducing transaction costs and eliminating inefficiencies is bearing fruit, in the sense that Peru's rankings have improved in many areas. At the same time, evidence from case studies of selected agricultural commodities make clear that there is still considerable scope for improving the performance of logistics systems.

Peru's successful agro-export development experience provides important lessons that can help in the design of policies going forward. Over the past 25 years, Peru has captured a significant share in global markets for a range of agricultural products. The development of value chains for high-value agricultural exports required substantial "hard" investments in irrigation infrastructure, processing and storage facilities, and logistics, along with an important cohort of "soft" investments—for example, to improve market coordination and strengthen value chain integration, to enhance compliance with quality and safety standards, and to meet a host of market entry requirements, including buyer-imposed private standards.

Where, then, are the opportunities to make agricultural value chains in Peru more inclusive, with the goal of spreading the benefits to a larger number of people, including the poor? Peru, like many other export-oriented countries, aspires to incorporate small-scale producers into markets for highly specialized products that can be sold into specialized niche markets (characterized in this report as Level 5 and 6 markets), because these products tend to have very high value and appear to offer the best opportunities for farmers to capture added value. Yet in Peru and elsewhere, there are relatively few documented instances in which large numbers of small-scale producers have successfully integrated into Level 5 and 6 markets. This lack of success can be attributed to the fact that the barriers to entering these markets are very high—in terms of investment costs as well as the required level of knowledge and skills. More promising opportunities may be associated with markets for products produced in large volumes that have been de-commodified and differentiated into discrete specialty segments (these markets are characterized in this report as Level 3 and 4 markets). In Peru, when large numbers of small-scale producers have succeeded in penetrating international markets, usually they have focused on commodities with more modest market requirements, such as cocoa, coffee, and bananas. The main strategy to increase competitiveness and generate value for farmers and other actors has been to de-commodify these products through quality differentiation.

Overall performance of Peru's agricultural sector

Peru's agricultural sector has performed well on aggregate. Over the longer term, growth in the sector has been robust, and because agriculture constitutes a significant share of the economy and is the principal livelihood source for many of the country's poorest households, agricultural growth has played a disproportionately large role in helping to reduce poverty. Agricultural growth has been driven to a considerable extent by a dramatic expansion of agro-exports, with impressive production increases

in a variety of non-traditional products. As a result, the agricultural sector has been an important generator of export earnings. Income growth, combined with rapid urbanization, has sparked sweeping changes in the larger food system, offering many consumers a wider range of food products at lower prices. The emergence of a Peruvian food culture has helped launch "gastronomic tourism" and sparked the birth of a tourism sub-sector that is providing high-quality jobs for thousands. Finally, thanks to significant gains in the production of domestic staples, growth in the amount of domestically consumed food that is imported has slowed, contributing to enhanced national food security.

Challenges to be addressed

Viewed from high up, the performance of Peru's agricultural sector has been impressive. But viewed from ground level, it is clear that there is considerable room for improvement. Challenges remain to be addressed in a number of areas. Income levels among farming households are stagnating, and poverty rates in rural areas remain stubbornly high. Pronounced territorial imbalances are evident in the pattern of development, with some regions flourishing and others languishing. Many agricultural productions systems remain seriously vulnerable to shocks, especially extreme weather events associated with the El Niño effect and longer-term climate change. Beyond the farm, post-harvest infrastructure has failed to keep up with rapidly growing cities, adversely affecting the quality and safety of food and contributing to enormous losses. And while the national food system has broadened and deepened, malnutrition remains widespread, indicating that too many Peruvians still lack the resources and/or knowledge needed to ensure adequate and healthy diets.

Agriculture in Peru consists of three vastly different worlds. Because of spatial differences in resource endowments, climate, location, demographics, and policies, among other factors, the Costa, Sierra, and Selva regions offer widely divergent experiences and pose very different challenges. In the Costa region, the main challenges will be to maintain productivity growth in primary production, respond effectively to the increasing scarcity of productive factors, and maintain competitiveness in increasingly demanding global markets. In the Sierra region, the main challenges will be to boost productivity in the staples that are currently being grown, enable diversification into alternative high-value crops, better link farmers and livestock keepers to markets, and make farming systems more resilient. In the Selva region, the main challenges will be to find new sources of productivity

growth, improve connectivity, and ensure that agriculture develops in ways that are environmentally friendly and sustainable.

Key opportunities and entry points

Over the next 10–20 years, the contribution of agriculture to the economy of Peru will remain significant. Projected steady growth in the direct contribution of agriculture through primary production activities, which account for 7.3 percent of Peru's value added, will be complemented by even stronger growth in the indirect contribution of agriculture through forward and backward linkages within the broader food system, which is projected to contribute an additional 4 percent to value added over the direct contribution. Directly and indirectly, the sector will contribute to growth and diversification, provide a significant source of employment, and serve as a major driver of poverty reduction.

Unlocking the power of agriculture to perform these vital functions will require a comprehensive and multi-faceted approach to improve the productivity of subsistence-oriented traditional farming systems, stimulate the expansion of high-value commercial agriculture, promote growth in non-farm economic activities in rural areas, and help some people to move out of agriculture. The approach will need to include a multi-sectoral territorial development strategy, possibly similar to the one proposed under the National Strategy for Rural Development (ENDER) in 2004 but never implemented. For this approach to succeed, proposed public investments in rural areas will need to be analyzed holistically, taking into account potential synergies between complementary interventions. Such an approach would be quite different from what has been done in the past, for example under the SNIP system, which involved separate analysis of proposed investments in each sector.

Based on the recent performance of Peruvian agriculture, and taking into account the opportunities that are identified in the report to boost productivity and increase competitiveness, six entry points emerge as priorities for future interventions:

1. Promoting innovation
2. Strengthening input distribution and advisory services
3. Building capacity through education and training
4. Improving connectivity and access to markets
5. Promoting land markets
6. Facilitating risk management

The six entry points are quite diverse, but they have something in common: all depend on services that currently are in very short supply in Peru. In that respect, the primary challenge facing agricultural policy makers, as well as the agencies charged with implementing policies and programs in the sector, is how to build dynamic, efficient, and cost-effective markets for services. Such markets will depend critically on the ability of three principal actors to carry out their respective functions: (i) producers, producer organizations, and agribusiness firms will need to express effective demand for services; (ii) private firms, civil society organizations, and public institutes will need to provide adequate supplies of services; and (iii) government agencies and regulatory bodies will need to establish and enforce rules of the game to ensure that markets for agricultural services functions efficiently.

The relative importance of the six entry points varies by region, consistent with inter-regional differences in agricultural systems. In view of these inter-regional differences, a territorially focused, graduated strategy designed to provide support in step-wise fashion could be very effective in helping farmers in Peru to climb the development ladder. Subsistence farmers facing multiple constraints are likely to benefit most from basic productive tools (i.e., productive knowledge acquired through education and advisory services, better information) and income-smoothing mechanisms (i.e., income and crop diversification strategies) to increase their levels of technical efficiency. Once the initial set of constraints has been lifted, farmers in transition agriculture are likely to benefit most from improved availability of credit and improved access to markets as they improve their production methods and add value to their outputs through quality enhancements. Finally, consolidated farmers are likely to benefit most from improved availability of credit, better market integration, and improved telecommunication services, factors that will help them reach the scale and achieve the production efficiency needed to compete effectively in rapidly evolving domestic and foreign markets.

The results summarized in this report emerged from work undertaken to describe Peru's agricultural sector, diagnose constraints that are negatively affecting the performance of Peruvian agriculture, and identify opportunities to improve productivity and enhance competitiveness in major agricultural value chains. The work was never intended to be prescriptive, however. For that reason, no operational guidelines are presented or specific actions recommended. Still, it is important to recognize that to be successful, future initiatives to improve productivity and enhance competitiveness in Peru's agricultural sector will have to be designed and implemented taking into account the different roles of the three tiers of government: national, regional, and local. Consistent with the government's desire to empower

citizens by decentralizing decision-making authority away from Lima and conferring responsibility for program design and execution to the regional and local levels, each tier of government will logically have to play a different role in operationalizing the agricultural development agenda. Achieving effective coordination among the three tiers will not be easy, as opinions will always differ about what should be the overall policy priorities and what is the best strategy for pursuing them. Successful outcomes are within reach, but they will require a strong commitment to collaboration, along with mutual respect and a considerable level of trust.

Abbreviations and Acronyms

AGROIDEAS	Compensation Program for Agricultural Competitiveness (Programa de Compensasiones para la Competitividad)
AGRORURAL	Rural Productive Agriculture Development Program (Programa de Desarrollo Productivo Agrario Rural)
ASA	Advisory Services and Analytics
CIP	International Potato Center (Centro Internacional de la Papa)
COFOPRI	Informal Property Regularization Commission (national titling authority) (Organismo de Formalización de la Propiedad Informal)
COMTRADE	International Trade Statistics Database (Base de Datos de Estadísticas de Comercio Internacional)
CWR	Cancer World Report
DBI	Doing Business Indicators
EBA	Enabling the Business of Agriculture
ENA	National Agriculture Survey (Encuesta Nacional Agropecuaria)
ENAHO	National Household Survey (Encuesta Nacional de Hogares)
ENSO	El Niño – Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
FOB	Free on Board
FONCODES	Social Development Cooperation Fund (Fondo de Cooperación para el Desarrollo Social)
GCI	Global Competitiveness Index
GDP	Gross Domestic Product
ICT	Information and communications technology
IDB	Inter-American Development Bank

INEI	National Institute of Statistics and Informatics (Instituto Nacional de Estadística e Informática)
LPI	Logistic Performance Index
MERCOSUR	Common Market of the South (Mercado Común del Sur)
MIDIS	Ministry of Development and Social Inclusion (Ministerio de Desarollo e Inclusion Social)
MINAGRI	Ministry of Agriculture and Irrigation (Ministerio de Agricultura y Riego)
NGO	Non-Governmental Organization
NTE	Non-Traditional Export Sector
OTLA	US Office of Trade and Labor Affairs
PAHO	Pan American Health Organization
PETT	Special Program for Land Titling (Programa Especial de Titulación de Tierras)
PPP	Public-private partnership
PROCOMPITE	Support for Productive Competitiveness (Apoyo a la Competitividad Productiva)
PRODUCE	Ministry of Production (Ministerio de la Producción)
PROINVERSION	Private Investment Promotion Agency (Agencia de Promoción a la Inversión Privada)
SMEs	Small and medium enterprises
SPF	Stochastic Production Frontier
TFP	Total Factor Productivity
TT	Tornqvist-Theil
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
VA	Value added
VRAEM	Valley of Apurimac, Ene and Mantaro Rivers (Valles de los ríos Apurímac, Ene y Mantaro)
WDI	World Development Indicators
WHO	World Health Organization

CHAPTER 1

Introduction

Introduction

1.1. Context

What is the future for agriculture in Peru? Once the principal source of employment and income for much of the population, Peru's agricultural sector has declined in importance as the national economy has expanded and urbanized. Economic activity in the sector has continued to grow, but economic activity in other sectors has grown more rapidly, leaving agriculture to make up an ever smaller share of the overall economy.

The future of Peruvian agriculture should concern policy makers for at least five reasons. First, agriculture makes up an important part of the economy, so if agricultural growth decelerates, overall growth will suffer. Second, an expanding agricultural sector diversifies Peru's economy and reduces dependence on extractives, so if the agricultural sector contracts relative to other sectors, economic growth could become more volatile. Third, agriculture-led growth is good for the poor, so if agricultural growth slows, an important means of reducing poverty will be lost. Fourth, Peru relies on food imports to make up production shortfalls, so if agricultural production fails to keep pace with population growth, national food security could be threatened. Fifth, climate-smart agricultural practices can play a major role in reducing greenhouse gas emissions and sequestering carbon, so if future agricultural practices are not climate smart, an important opportunity to help mitigate climate change will be missed.

Recognizing the potential of agriculture to contribute to national policy goals, the Government of Peru has confirmed its commitment to modernizing the agricultural sector, narrowing the rural-urban income divide, and improving the welfare of the millions of rural households that sustain themselves primarily through agriculture. To realize these goals, Peru will need to raise the productivity and increase the competitiveness of its food and fiber value chains, including not only the crop farming and livestock production systems that make up the primary production sector, but also the processing, transportation, and distribution systems that add value to primary commodities while delivering food and fiber products to consumers in internal and external markets. This undertaking is daunting, not only because of the many structural issues that constrain existing systems, but also because agriculture in Peru is extremely heterogeneous, reflecting the country's agro-climatic diversity (see Box 1).

1.2 Objectives

This report synthesizes current knowledge about the ongoing transformation of Peru's agriculture and food system, assesses the recent performance of the agricultural sector with an emphasis on productivity and competitiveness, and highlights opportunities for enhancing the future contribution of the agricultural sector toward meeting the country's development challenges. The report focuses on four key questions:

1. How is Peru's agricultural sector being affected by the larger structural transformation of the economy, and what are the major forces driving change in the sector?
2. How important is agriculture in Peru's economy, taking into account not only primary production but also forward and backward linkages?
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4. How competitive are Peru's farmers in domestic markets and in international markets, and what are the opportunities to increase competitiveness by overcoming constraints in Peru's agriculture and food value chains?

BOX 1. GEOGRAPHY OF PERU

Natural regions of Peru

Peru is endowed with a complex geography characterized by diverse ecological zones that brings wealth in natural resources but also challenges. The massive Andean cordillera divides the country into three natural regions: the western Costa (arid coastal plains representing 11 percent of the land surface and home to about 57 percent of the population), the central Sierra (highlands representing 31 percent of the land surface and home to about 31 percent of the population), and the eastern Selva (low-lying Amazon rainforest representing 60 percent of the land surface and home to about 3 percent of the population).

The country's large size and varied topography pose challenges for connectivity, raising the cost of delivering goods and services and contributing to large regional disparities in development. The Sierra and Selva regions are difficult to traverse, which isolates the communities living there. Because of the large distances and relatively underdeveloped transport infrastructure system, transport and logistics costs are high, dividing domestic markets and hindering access to foreign markets (World Bank 2016).

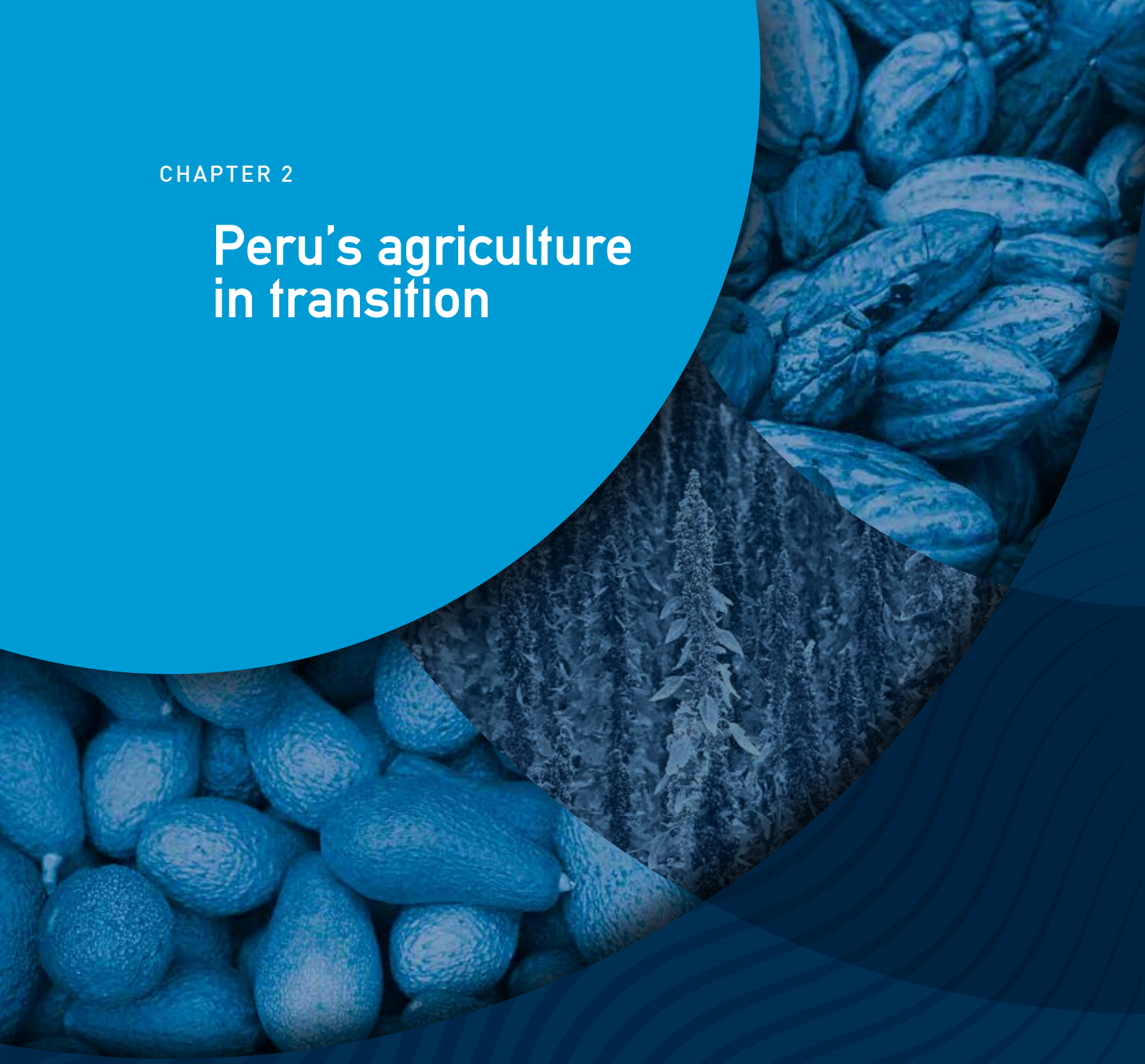
Table 1. Distribution of population by natural region, Peru (2015)

	Area (km^2)	Area (%)	Population (number)	Population (%)	Population density (persons/km^2)
Costa	137,216	11	12,180,000	57	89
Sierra	392,000	31	6,630,000	31	17
Selva	756,000	59	2,560,000	12	3
Total	**1,285,216**	**100**	**21,370,000**	**100**	**17**

The uneven distribution of the population combined with the relative inaccessibility of large parts of the country have contributed to very uneven development of Peru's agricultural sector across regions. The Costa region accounts for a relatively large share of the country's total agricultural GDP (44 percent), despite containing only 23 percent of the country's agricultural land. Meanwhile, the Sierra region contributes 42 percent of total agricultural GDP, despite containing 39 percent of the country's agricultural land, while the Selva region contributes only 14 percent of agricultural GDP, despite containing 38 percent of the country's agricultural land (MINAGRI, 2015).

CHAPTER 2

Peru's agriculture in transition

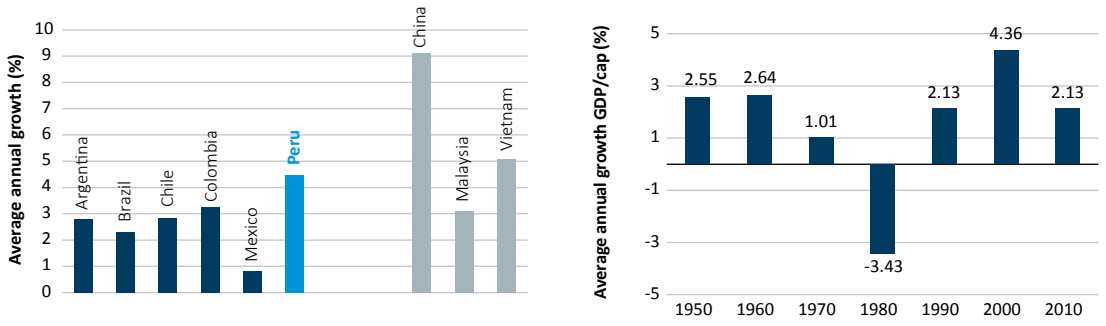


Peru's agriculture in transition

2.1 Macro overview

At the beginning of the 21st century, Peru has emerged as one of the fastest-growing and most stable economies in Latin America. During the 1980s, political instability and a prolonged period of civil disturbances precipitated by the Shining Path insurgency led to a contraction of the economy; GDP growth fell to -1.0 percent per year from 1980 to 1990. Since then, thanks to a combination of economic modernization, natural resource abundance, and continued improvements in governance, Peru has made significant advances in accelerating growth, reducing poverty, and promoting social development. From 2000 to 2014, growth averaged 5.3 percent per year, despite a weak external environment and a financial crisis in 2009 during which the economy continued to expand. During that period, per capita income doubled in real terms, enabling Peru to achieve high middle income status in 2008 (World Bank, 2016). Peru's three-pillared macroeconomic framework combining a flexible exchange rate, inflation targeting, and fiscal prudence has contributed to a long period of relative macroeconomic stability. Along with macroeconomic stability, the foundations of the recent gains can be found in the wave of structural reforms undertaken during the period 1990-1997, which included trade liberalization and reforms of the financial, labor market and industry, fiscal, and business sectors. Growth in Peru has outperformed that in many other countries in Latin America and has been comparable to growth rates experienced in the fastest-growing economies in East Asia (Figure 1).

Figure 1. Evolution of GDP per capita, Peru vs. comparators



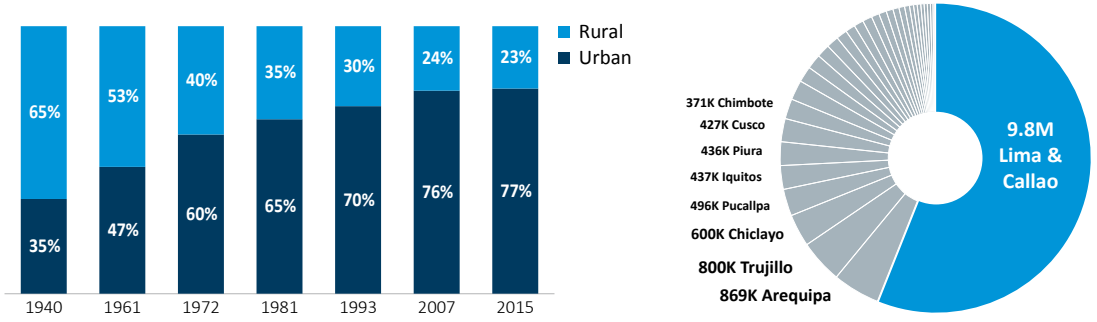
(a) Average annual GDP growth, 2000-2015

(b) Growth in GDP/capita, Peru, by decade

Source: World Bank, 2016.

Strong domestic consumption fueled by a young and rapidly growing urban population has contributed importantly to economic growth. Peru is urbanizing rapidly, and during recent decades millions of people have migrated from rural areas to cities. In 2015, about 76.5 percent of Peruvians lived in urban areas, up from 34.5 percent during the 1940s (Figure 2). The urbanization pattern in Peru is atypical by global standards, with an extremely large share of the urban population concentrated in a single region and city. Overall, the urban population is concentrated in Lima (41 percent) and in 22 intermediate cities (29 percent) and 51 small cities (11 percent) located throughout the country. The Costa region alone is home to 54.6 percent of Peru's population (and 62 percent of the total urban population), including Lima, a single city that holds 34 percent of the country's inhabitants (INEI, 2007) and accounts for 49 percent of national GDP.

Figure 2. Rural vs. urban population, Peru, 1940-2015



(a) Rural vs. urban population, 1940-2015

(b) Distribution of urban population, 2015

Source: ENAHO.

Impressive economic growth has allowed large numbers of Peruvians to enter the middle class and/or escape poverty. Incomes have grown steadily, both in urban and rural areas, although growth now shows signs of leveling off (Figure 3). Between 2000 and 2012, nearly one-fifth of the Peruvian population entered the middle class, the fastest rate in all of Latin America. As a result, the proportion of Peruvians classified as middle class rose from 15.2 percent in 2000 to 34.3 percent in 2012. Meanwhile, impressive gains were made in reducing poverty. The number of Peruvians living in moderate poverty fell from nearly 60 percent in 2004 to around 21.8 percent in 2015; during the same period, the share of those living in extreme poverty fell from 16 percent to 4.1 percent (Figure 4).

Figure 3. Rural and urban incomes, Peru, 2004-2015

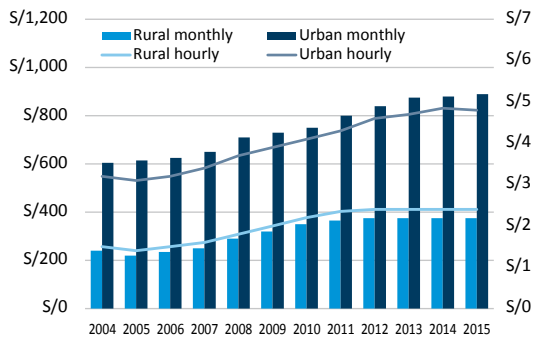
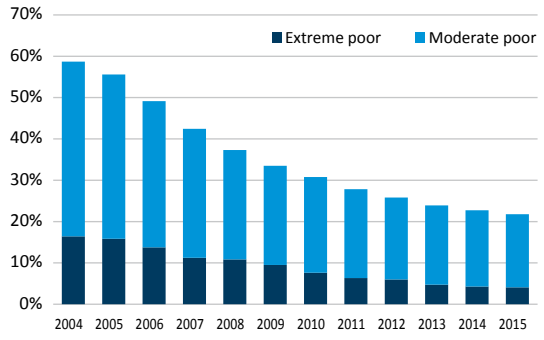


Figure 4. Poverty headcount, Peru, 2001-2015



Source: INEI 2015.

The recent economic gains have not benefited all groups equally, however. Although labor earnings in urban and rural areas both increased sharply over the past decade, with rural incomes growing at a faster rate,[1] in 2015 the median income in rural areas was still only 60 percent of the median income in urban areas. Wages in the Sierra and Selva regions were almost 40 and 30 percent lower than those in the Costa region. Similarly, wages in Lima were 60 percent higher than in the rest of the country, and urban areas continued to show marked differences with rural areas. As a result of these discrepancies, poverty in Peru remains disproportionately rural (Figure 5 and Figure 6). The rural population makes up about one-quarter of the total population, but it accounts for one-half of the poor

1 Median monthly real income in urban areas increased by 45 percent between 2004 and 2015, from S/. 611 to S/. 887. In rural areas, real median income growth was 54 percent. Hourly earnings show a similar behavior, with higher growth rates for rural areas (60 vs. 53 percent), reaching S/. 2.5 and S/. 4.8 per hour in 2015.

and 82 percent of the extreme poor. Rural poverty is particularly concentrated in the Sierra and Selva regions. About 47 percent of the total number of poor were living in the Sierra region, which also has a high proportion of indigenous people. Consistent with higher levels of poverty, human development indicators are lower in rural areas; for instance, child mortality and child malnutrition rates are about twice as high in rural as in urban areas, and educational outcomes are significantly lower (World Bank, 2016).

Figure 5. Rural and urban poverty, 2004-2015

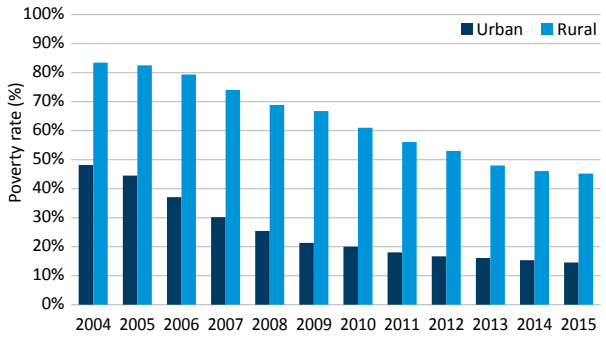
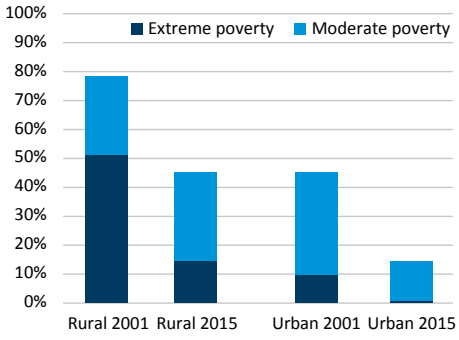


Figure 6. Moderate and extreme poverty



Source: ENAHO Data/Calculations.

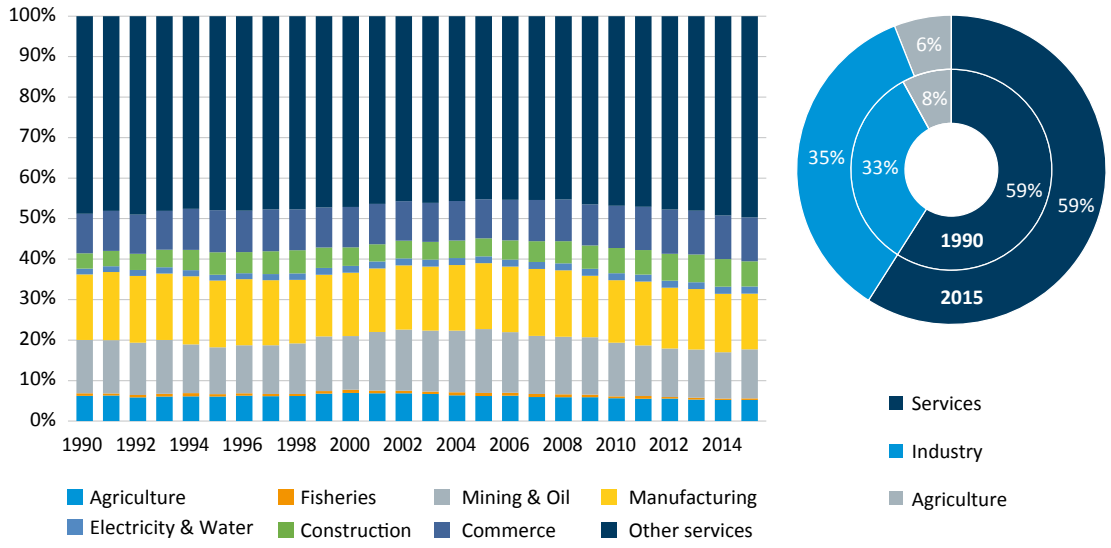
2.2 Structural transformation

As countries develop, the share of agriculture in the economy and employment gradually declines. This change is consistent with the idea of structural change. In economies in which income levels are still relatively low, agriculture is typically the sector that employs the most people and uses labor relatively unproductively. Over time, cross-sector productivity gaps tend to shrink as labor shifts out of agriculture, and returns to labor across sectors converge through the intermediation of factor markets. The declining share of agriculture in the economy is consistent with the reallocation of labor from a low-productivity agricultural sector to other, higher-productivity sectors such as manufacturing and services.

Consistent with global experience, growth in Peru has been accompanied by structural transformation, as evidenced by relative declines in the share of agriculture in the overall economy and in the share of agricultural workers in total

employment. The rate of structural transformation has been slow, however, as the composition of GDP has changed very little since the early 1990s (Figure 7). During the period 1990-2015, the agricultural, industry, and services sectors grew at comparable rates, so the contribution of each sector to GDP was determined by their size, with the services sector contributing about 3 percentage points to GDP growth, the industry sector about 1.8 percentage points, and the agricultural sector about 0.3 percentage points. Because disproportionately large numbers of the poor are employed in the agricultural and services sectors, these two sectors generated the largest income increases for the poor. The contribution of agriculture to reducing extreme poverty was particularly large (World Bank, 2016).

Figure 7. Sectoral decomposition of GDP, Peru, 1990-2015



(a) Sectoral decomposition, 1990-2015

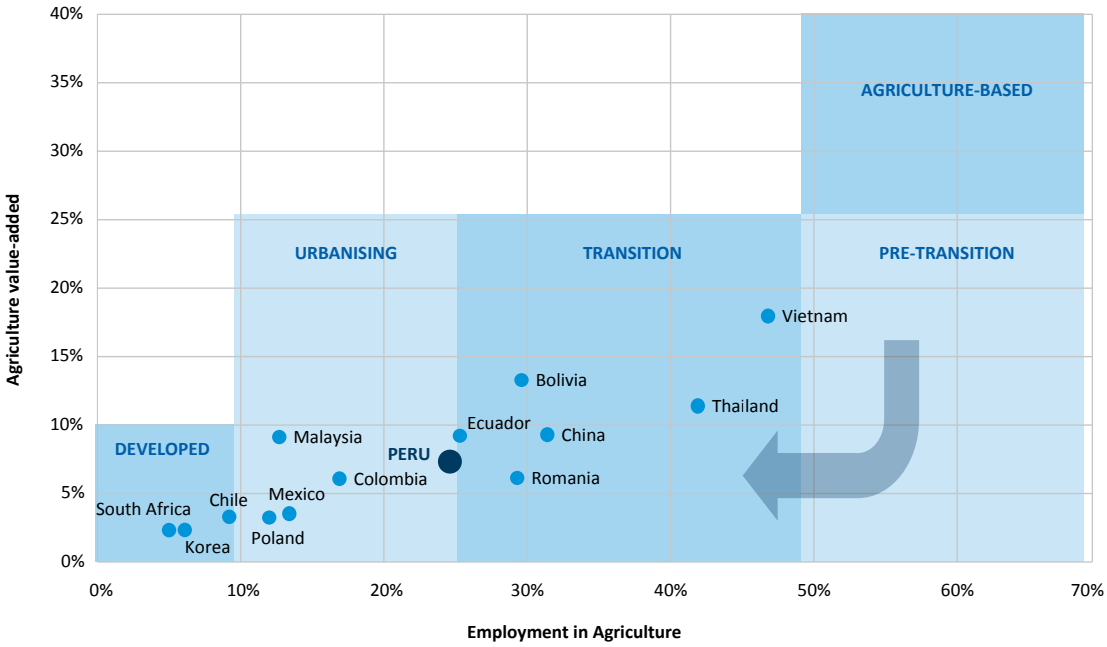
(b) Structural change, 1990 vs 2015

Source: Central Reserve Bank of Peru.

Peru's structural transformation path appears to be following the general pattern described in the *World Development Report 2008: Agriculture for Development* (World Bank 2007), which documented how economies worldwide have tended to move along a similar development pathway, passing through a series of stages described as agriculture-based, pre-transition, transition, urbanizing, and developed. Peru currently can be characterized as an urbanizing economy, as the

share of agricultural value added in total GDP has fallen to levels observed in many other urbanizing economies (Figure 8).

FIGURE 8. AGRICULTURAL TRANSFORMATION: PERU AND ITS REGIONAL, STRUCTURAL, AND ASPIRATIONAL PEERS

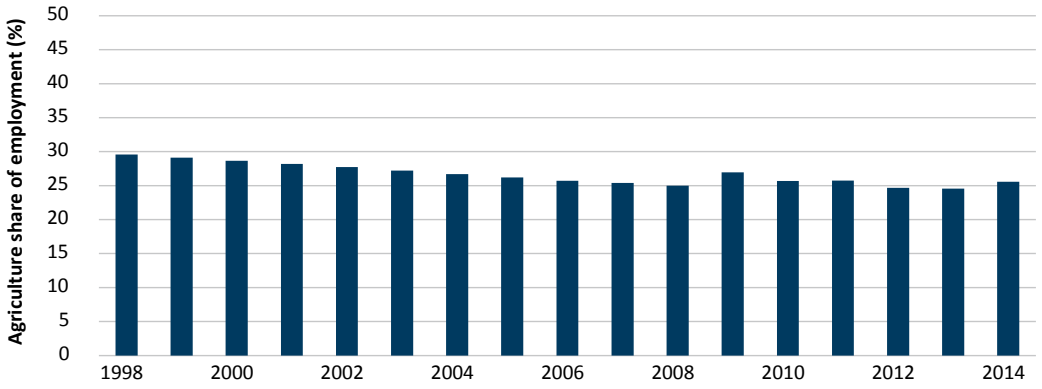


Source: World Bank 2008.

The structural transformation pattern observed in Peru is consistent with the patterns observed in other countries, but there are also some interesting differences. For example, in Peru the decline in the share of workers employed in agriculture is occurring very slowly (Figure 9). During the past 20 years, labor moved from low-productivity rural agriculture to somewhat higher-productivity services activities, often in the informal urban sector, yet agriculture continues to employ around one-quarter of the population, more than in many other urbanizing economies in the region. During the early 1980s the share of agricultural labor in total employment stood at just under 40 percent in both Colombia and Peru; by the early 1990s, the share in Colombia had already fallen to 25 percent, the share observed in Peru today. Currently, the contribution of agricultural value added to total GDP is similar in both countries, yet the share of agricultural employment in Colombia is much lower (only about 14 percent). The fact that the share of agricultural employment has fallen so slowly in Peru and may even be leveling

off reflects the fact that the sector has grown in absolute terms and created large numbers of new jobs. A recent analysis by FAO (2016) suggests that during the period 1984-2013, Peru was the only country in Latin America with higher growth in farm employment than in non-farm employment.

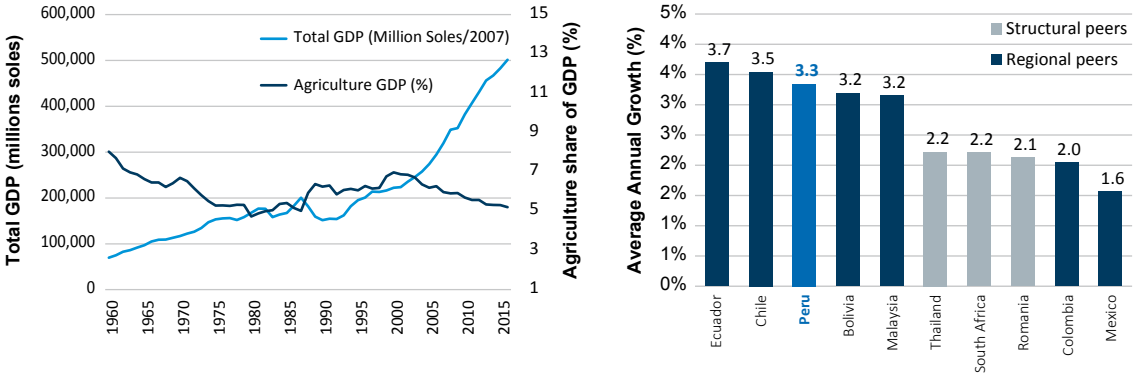
Figure 9. Agriculture share of employment, Peru, 1998-2015



Source: FAO, 2016.

The share of agriculture in the overall economy of Peru has fallen, but this does not mean that the agricultural sector has contracted in absolute terms. On the contrary, the volume and value of agricultural production have grown steadily. From 2000-2015, agricultural GDP growth in Peru averaged 3.3 percent per year, higher than in regional and structural peers (Figure 10).

Figure 10. Growth of agricultural value added, Peru, 2000-2015



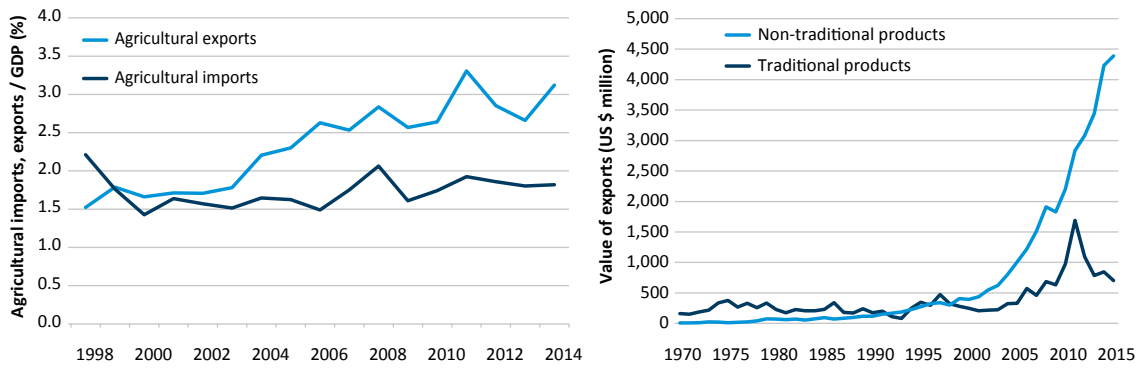
(a) Agricultural GDP as share of total GDP, 1960-2015

((b) Ag GDP growth, Peru vs. comparators, 2000-2015

Source: WDI 2016.

A second distinguishing feature of Peru's agriculture transformation experience is the increasing orientation of the sector toward external markets. Between 2000 and 2013, the agricultural sector of Peru grew in real terms at an average annual rate of 3.3 percent, and since other sectors grew even faster, the agricultural sector became less important in overall GDP. But because growth in the agricultural sector was driven to a large extent by exportable commodities, the sector became more important with respect to exports. Peru's integration in the global economy through the expansion of trade, especially agricultural trade, has been remarkable. At a time when agriculture was becoming less important in the overall economy, the share of agricultural and food exports expressed as a percentage of total GDP rose from 1.6 percent in 1998 to 3.2 percent in 2014, driven mainly by growth in exports of non-traditional products (Figure 11).

Figure 11. Agricultural export trends, Peru



(a) Agricultural imports and exports, 1998-2014

(b) Agricultural export composition, 1970-2016

Source. FAO.

Source. Calculations based on COMTRADE data and WDI

Structural transformation has impacted livelihood strategies at the household level, with many rural households turning increasingly from farm to non-farm activities. Espinal (2002), using ENNIV 1997 data, found substantial growth in household employment outside farming, with off-farm activities contributing 51 percent of the net income of rural households. Calculations based on Encuesta Nacional de Hogares (ENAHO) surveys for the period 2004-2010 suggest that agricultural and non-agricultural employment both rose in importance during the early years of the 21st century before leveling off. The survey data also suggest

that the share of off-farm income in net household income has remained relatively stable (Table 2).

Table 2. Sources of household income, rural households, Peru, 1997-2014

	1997	2004	2006	2007	2008	2009	2010
Agricultural income	**55.7**	**61.0**	**60.4**	**55.6**	**57.7**	**58.4**	**56.4**
• Wage income	6.7	14.3	15.1	12.8	12.3	12.4	11.2
• Non-wage income	49.0	46.7	45.3	42.8	45.4	46.0	45.2
Non-agricultural income	**44.3**	**39.0**	**39.6**	**44.4**	**42.3**	**41.6**	**43.6**
• Wage income	14.6	23.1	22.2	25.4	25.1	25.4	25.8
• non-wage income	29.7	15.8	17.4	19.0	17.2	16.2	17.8

Source: Calculations based on ENAHO data.

The overall picture that emerges is that while many rural households have come to rely increasingly on non-farm sources of income, agriculture remains an important livelihood source for a large and growing number of Peruvians. The number of people employed in agriculture in Peru grew by nearly half a million during the period 1994-2012. The growth was particularly spectacular in the Selva region, which experienced an increase of about 47 percent (albeit from a relatively low base). Significant growth in the number of farms was also registered in the Costa region (27.8 percent) and in the Sierra region (23.1 percent).

2.3 Changes in land use

Growth and structural transformation in Peru have been characterized by significant changes in land use. During the inter-census period from 1994 to 2012, about 3.36 million ha were brought into productive use, an expansion of about 9.5 percent. This increase, while significant, was much smaller than the increase experienced during the previous inter-census period from 1972 to 1994, when more than 11 million ha were converted to productive use. Looking beyond the absolute size of the two expansions, it is interesting to note the rising importance of agriculture. During the first inter-census period, 1.1 million ha, equivalent to 16 percent of the increase, were converted to agricultural use, whereas during the second inter-census period, 1.6 million ha, equivalent to 49 percent of the total increase, were converted to agricultural use.

The expansion of the agricultural frontier has had relatively little impact on the allocation of land to major cropping systems, in the sense that the same 15 crops that accounted for 85 percent of total harvested area in 1994 continued to account for approximately the same share of total harvested area in 2012. And the most dominant crops have maintained their dominance: the share of total harvested area allocated to the top four crops (coffee, maize, potatoes, rice) remained practically unchanged at just under 50 percent of total area harvested.

If the aggregate statistics on cropping patterns appear to show little change, the aggregate numbers conceal significant dynamics. The expansion of the agricultural frontier in Peru has been characterized by two important developments: (i) rapid growth in the area under high-value crops and (ii) substitution of annual crops for permanent crops and managed pastures. The area under staples such as maize, potatoes, and rice and other commodities destined for domestic markets has expanded, but the most dynamic area expansion rates are observed in non-traditional high-value export commodities, particularly vegetables and fruits, as well as in more traditional export commodities such as coffee, cocoa, and palm oil (Table 3). The area planted to these latter two groups remains small, but the economic impact is large. In 2015, 9 percent of agricultural value added was generated on only 235,000 ha through the production of high-value vegetables, compared to the 13.5 percent of agricultural value added generated on 1.2 million ha planted to cereals. Permanent crops have also gained in area, particularly in the Selva region, where annual crops have steadily been replaced by permanent crops (harvested area of annual crops fell by about 190,000 ha, while that of permanent crops increased by nearly 500,000 ha). Meanwhile in the Sierra region, about 109,000 ha formerly under annual crops were converted to improved natural pasture. In the Costa region, the area of under annual crops has expanded, but the area under permanent crops has expanded more rapidly.

Table 3. Crop expansion and contribution to agricultural value added, Peru, 1995 and 2015

Product	Area harvested (ha) 1995	Area harvested (ha) 2015	Increase (ha)	Increase (%)	Share of ag GDP 2015
Live animals and animal products					39.6
Agriculture products					60.4
Cereals		**1,292,036**			**13.8**
Maize	375,197	513,804	138,607	37	4.2
Rice, Paddy	239,453	399,501	169,048	67	8.1

Table 3. Crop expansion and contribution to agricultural value added, Peru, 1995 and 2015 *(continued)*

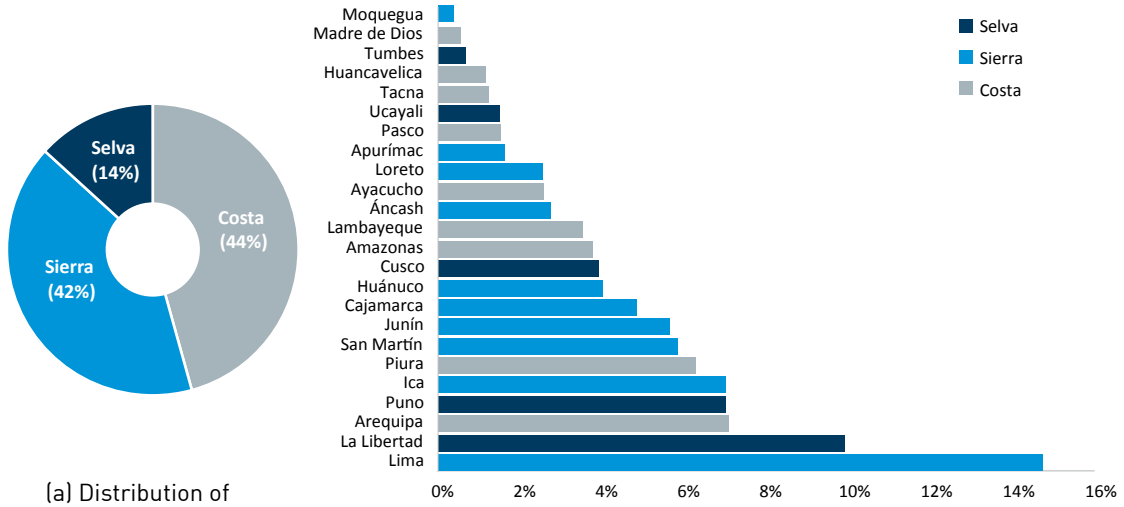
Product	Area harvested (ha) 1995	Area harvested (ha) 2015	Increase (ha)	Increase (%)	Share of ag GDP 2015
Quinoa	18,729	69,303	50,574	270	0.4
Horticulture		**234,036**			**9.0**
Asparagus	20,126	33,870	13,744	137	3.6
Artichoke	200	5,513	5,313	2,657	0.4
Fruits and Nuts		**437,327**			**11.2**
Avocados	6,115	33,989	27,874	456	1.4
Grapes	10,702	26,650	15,948	60	2.7
Mango	7,854	29,733	21,879	279	0.6
Plantain / Banana	69,401	167,839	98,438	142	2.3
Legumes		**281,011**			**1.4**
Beans, dried	61,920	76,770	14,850	24	0.6
Sugars		**119 019**			**2.4**
Sugar crops	59,603	84,574	24,971	42	1.9
Roots and Tubers		**495,892**			**9.1**
Potatoes	188,531	316,535	128,004	68	6.7
Cassava	51,791	101,453	49,662	96	1.3
Stimulant crops and species		**505,771**			**5.6**
Cocoa	36,324	120,374	84,050	231	1.4
Coffee	164,230	379,189	214,959	131	3.8
Oils seeds		**68,115**			**1.0**
Oil palm	5,188	43,140	37,952	732	0.7
Others		**167,454**			**6.7**
Cotton	123,681	26,711	-96,970	-78	0.6

Source: Calculations based on MINAGRI and FAO data.

The expansion of the agricultural frontier and the accompanying changes in land use patterns are leading to increasing specialization in agricultural production, both at the regional level and within individual departments. Among the three natural regions, the Costa region contributes 44 percent to agricultural GDP

and the Sierra region contributes 42 percent, both considerably higher than the Selva region's contribution of only 14 percent (Figure 12). Agricultural output varies significantly among departments. In 2015, 10 departments (out of a total of 24 departments in the country) contributed 71.4 percent of overall agricultural value added, including 34 percent generated in four Costa region departments (8.2 percent in Lima alone), 23.3 percent in four Sierra region departments, and 14.2 percent in two Selva region departments. In the livestock sub-sector, the concentration of productive activity is even greater. In 2015, 83 percent of livestock value-added was generated by the top 10 departments, with the top two (Lima and La Libertad) contributing nearly 50 percent.

Figure 12. Distribution of agricultural GDP by natural region and department, Peru, 2015



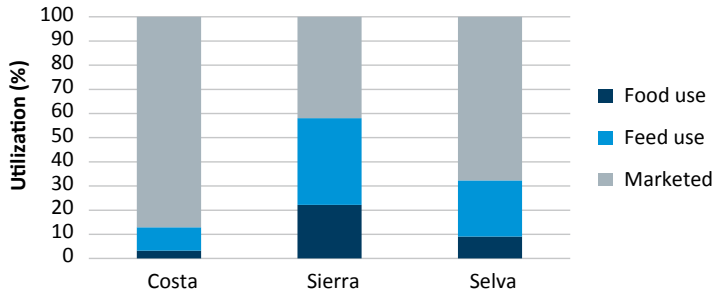
(a) Distribution of Ag GDP by region, 2015

(b) Distribution of Ag GDP by department

Source: Calculations based on MINAGRI and FAO data.

Farms in Peru are becoming more connected to markets. The 2012 census reveals the degree to which commercially oriented agriculture has increased over time. Still, the degree of market integration varies considerably by natural region (Figure 13). In the Costa region, more than 81 percent of harvested area was devoted to crops that were marketed (up from 74.1 percent in 1994). Meanwhile in the Selva region, 67 percent of harvested area was devoted to crops that were marketed (up from 54 percent in 1994). By contrast, in the Sierra region only 42 percent of harvested area was devoted to crops that were marketed (up from 15.5 percent in 1994), showing that agriculture in the Sierra region remains heavily oriented toward self-consumption.

Figure 13. Utilization of agricultural production, by natural region, 2015

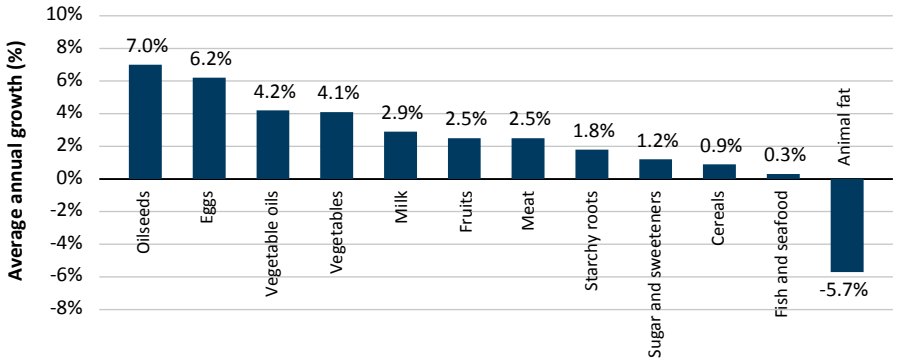


Source: MINAGRI.

2.4 Evolving food consumption patterns

To what extent have patterns of agricultural growth in Peru been influenced by changes in domestic demand for food that have been driven by dietary changes? Although the expansion of the agricultural sector has featured rapid growth in production of export-oriented commodities, changes in incomes and dietary preferences taking place within Peru have also played a role in influencing the foods that are produced locally, as reflected in the increased availability of high-value products such as fruits and vegetables and animal-based proteins (meat, eggs, milk), as well as the steady substitution of animal fats by vegetable oils (Figure 14).

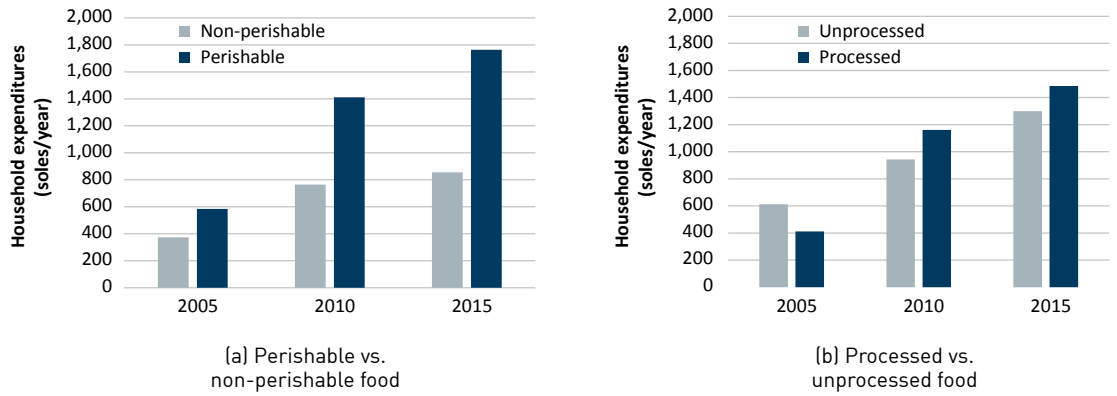
Figure 14. Growth in calorie availability, by product category, 2003-2013



Source: MINAGRI.

Diets in Peru are diversifying rapidly. Two trends are clearly observable (Figure 15). First, Peruvians are increasingly consuming perishable foods, including fresh fruits and vegetables, meat and fish, and dairy products. Second, Peruvians are increasingly consuming processed foods. While these shifts are similar to shifts taking place in other countries, Peru is lagging behind with respect to expected changes in the structure of food consumption. Particularly noteworthy is the slow growth in consumption of animal-based protein, which is very low by regional standards (Box 2). Cereals and starchy roots continue to make up a relatively high proportion of daily calorie availability, reflecting the importance that traditional sources of energy (mainly potatoes and rice) play in the food basket of most Peruvians. Calorie availability from sugar and sweeteners is low in Peru compared with the comparators. High-value products such as fruits and vegetables accounted for about 10 percent of daily calorie availability, significantly higher than in the other countries (e.g., the equivalent figure is less than 5 percent in Chile and Mexico, two countries facing significant obesity problems).

Figure 15. Changes in dietary patterns, Peru, 2005-2015



Source: Calculated from ENAHO data.

Consumption of processed foods is increasing in Peru, but the rate of growth seems to have slowed. Figure 15 shows a marked increase in the consumption of processed foods during the first half of the past decade, but little change during the second half. These numbers are consistent with growth taking place in the food industry: the sales of the 50 largest food processors (of the more than 3,000 processors currently in the business) were estimated at US$16 billion in 2014. A recent study by PAHO covering the period 1999-2013 found that sales of ultra-processed food and drink products (UPP) in Peru were four times lower than in Chile

or Mexico, which is good news because UPPs are key drivers of obesity, diabetes, cardiovascular diseases, and several cancers (WHO/WCR). Less encouraging, sales of UPPs in Peru were increasing more rapidly than in other countries in the region (although the rate seems to have slowed in the most recent years). Interestingly, Peru reports the lowest per capita consumption of ready-to-eat meals in Latin America and very low rates of consumption of carbonated drinks. The lower penetration of supermarkets in Peru, compared to other countries in the region, might explain to some extent the lower consumption of processed foods in Peru. The ongoing modernization of the retail food distribution system thus could potentially influence patterns of processed food consumption in the near future.

BOX 2. CHANGES IN DIETARY PATTERNS IN PERU

As diets in Peru diversify, a number of trends are clearly observable within particular food groups.

Consumption of animal-based protein is growing rapidly, particularly in urban centers, although it remains low by regional standards. In Peru, meat, eggs, and milk accounted for only 8.2 percent of total daily calorie availability in 2013, while in Chile, Colombia, and China, the respective shares were 20.4 percent, 16 percent, and 19.8 percent. Meat calorie availability was estimated in 2013 at only 100 kcal/day in Peru, more than four times lower than the calorie consumption in Chile, three times lower than in Mexico, and less than one half the level in Colombia. Pig meat and poultry meat calorie availability have grown at more dynamic rates. In fact, poultry is now practically a staple in Peru, with estimated national average per capita consumption rates of 46 kg/year; in Lima per capita consumption is estimated at 70 kg/year. Milk calorie and egg calorie availability are growing but still significantly lower by comparison with other countries in the region.

Table 4. Calorie availability and share of product categories, Peru vs. comparators, 2013

	Peru	Chile	Colombia	China	Indonesia	Mexico
Total (kcal/day/person)	2,700	2,989	2,804	3,108	2,777	3,072
Cereals	40.9	39.6	27.7	45.6	63.1	42.8
Starchy roots	14.3	4.5	6.2	4.9	6.0	1.0
Sugar & sweeteners	8.3	15.7	20.1	2.3	5.9	14.9
Oil crops	1.9	0.6	0.7	3.1	4.3	0.8
Vegetable oils	6.4	6.3	12.9	5.8	8.9	8.9

Table 4. Calorie availability and share of product categories, Peru vs. comparators, 2013 *(continued)*

	Peru	Chile	Colombia	China	Indonesia	Mexico
Vegetables	2.3	1.9	1.2	7.4	1.3	1.3
Fruits	7.1	2.2	8.5	3.3	2.7	3.4
Alcoholoc beverages	2.8	3.0	2.1	3.1	0.1	1.8
Meat, milk	3.7	14.2	8.2	15.5	2.6	10.0
Animal fat	3.8	5.0	6.4	1.9	0.7	5.3
Fish	0.6	3.1	1.0	1.2	0.3	1.9
Seafood	1.5	1.0	0.5	1.6	2.1	0.7
Eggs	0.7	1.2	1.4	2.4	0.7	2.1
Other	5.7	2.0	3.0	2.0	1.4	5.1

Source: FAOSTAT.[2]

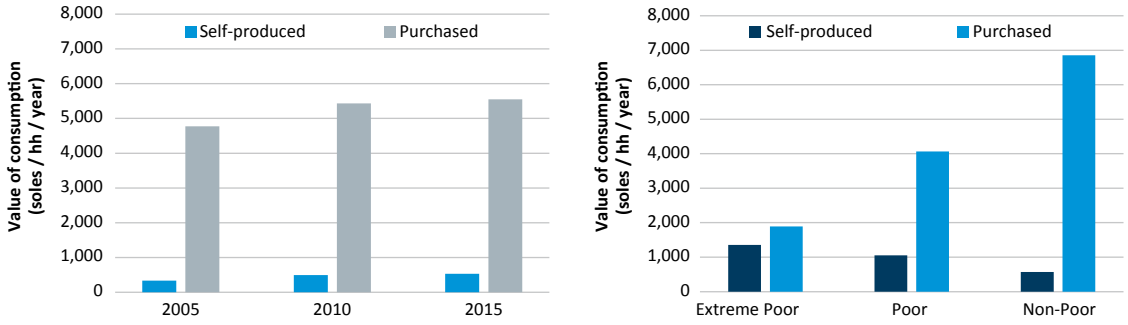
In the cereals group, rice continues to be the cereal most widely consumed in Peru, with consumption averaging around 58 kg/capita/year. Consumption of wheat has grown faster than consumption of rice and maize, however, boosted by sales of baked goods and high levels of pasta consumption. Per capita consumption of pasta (10 kg/year) is one of the highest in the region. Lima accounts for one-half of all pasta consumption in the country, but consumption in other areas is increasing rapidly. Per capita consumption of quinoa, while much lower than that of other cereals, is significant, averaging around 1.2 kg/year. More than 80 percent of Peruvians consume quinoa regularly. Consumption is greatest in Peru's highland regions.

A major trend observed in Peru and typical of many emerging economies has been the shift away from direct consumption of cereals to indirect consumption of cereals via the consumption of animal products. In Peru, rapid growth of the poultry sector has led to increased imports of ingredients used to formulate feed, particularly maize grain and soy meal, imports of which grew at an average annual rate of 14 percent between 2000 and 2015. To provide an idea of the magnitude, imports of maize increased from 85 thousand tons in 2000 to 3.04 million tons in 2015.

2 Calorie "consumption" as calculated in the FAO Food Balance Sheets is actually a measure of "availability" after industrial, feed, and other non-food uses (e.g., biofuels) have been deducted from the total domestic supply (production plus net trade). The consumption data do not net out spoilage, plate waste, and other losses, which are significant in most countries.

Peruvians are increasingly consuming food that is purchased, rather than food that was self-produced (Figure 16). The aggregate figures conceal considerable variability, however, as reliance on purchased vs. self-produced food varies greatly between income levels. While the non-poor rely heavily on purchased

Figure 16. Sources of food, trends and patterns, Peru, 2005-2015



(a) Changes through time, 2005-2015

(b) Variability by income group, 2015

Source: Calculated from ENAHO data.

food, which accounts for more than 90 percent of total food expenditures, the poor and especially the extreme poor continue to rely to a significant extent on self-produced food (Figure 16). Among the extreme poor, self-produced food makes up nearly 42 percent of total household consumption, reflecting the fact that a large share of the extreme poor continue to engage in subsistence-oriented agriculture.

Expenditure on food has grown at an annual rate of 1.6 percent, and diversification of diets is happening at all income levels. Zegarra et al. (2011) found that during the period 2002-2009, households in all income quintiles increased expenditures on food from animal sources as their incomes rose. In 2002, expenditures on animal-based proteins represented 22.8 percent and 33.9 percent of all expenditures made by the lowest and highest deciles, respectively; by 2009, these figures had risen to an estimated 30.3 percent and 37.6 percent.

While it is encouraging that diets are improving and diversifying, too many Peruvians still are not getting enough to eat. Food expenditure makes up a significant share of total expenditure—about 40 percent in 2014 for the average household, but as high as 80 percent for the poorest households (INEI 2014). The level of expenditure

is deficient in many cases: in 2014, nearly one out of every 20 Peruvians was unable to meet the cost of the basic food basket.

Unequal access to calories and a lack of food diversity can give rise to extreme differences in nutritional status between socioeconomic groups. Under-nutrition is more common among the poor, many of whom are located in rural areas but a significant share of whom also live in cities, while the middle class—which is concentrated in urban areas—is at greater risk of over-nutrition (Dixon et al., 2007). These differences, already very evident in Peru, are becoming more pronounced. In 2008, 46.2 percent of rural households in the Sierra region and 38.5 percent of rural households in the Selva region had a caloric deficit, well above the national average of 31.6 percent (Zegarra 2010). A high proportion of Peruvians lives with a caloric deficit even though the availability of calories per day per person has increased. Progress made in reducing the numbers of people who are undernourished or underweight has been offset by rapid increases in the number of people who are overweight or obese, which poses a risk factor for many chronic non-communicable diseases.

Two trends are particularly worrisome: (i) the rising rate of obesity among children, and (ii) the rising rate of obesity among women. Peru's main nutritional problem remains malnutrition—close to one-fifth of Peruvian children are chronically undernourished, and stunting rates remain high at 19.5 percent. Nevertheless, between 2008 and 2011 the rate of obesity rose from 7 percent to 10 percent among school-aged children, and the obesity rate among women in urban areas was at least twice as high as it was among women in rural areas. Similar patterns are common on other countries in the region, including Chile and Mexico. Over-nutrition and undernutrition frequently coexist within the same department, community, and even within the same family. The coexistence of undernutrition and obesity poses enormous difficulties for nutrition-related interventions. Despite these challenges, the government has shown considerable proactivity in addressing nutritional challenges, and it has achieved some impressive results to date (including significant reductions in the incidence of malnutrition).

2.5 Food system modernization

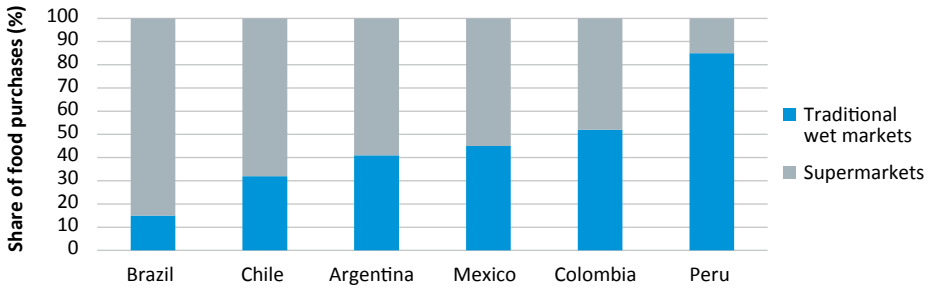
The dietary transformation taking place in Peru has been accompanied by rapid expansion of the food service sector, especially in urban areas. Traditional restaurants still account for the largest share of food service sales (44 percent), but fast food outlets are growing quickly in importance, accounting for an estimated

33 percent of food service sales in 2014. Coffee shops, bars, and other independent outlets account for an additional 18 percent of total food service sales. The food service sector is expected to grow by close to 7 percent per year through 2018 (GAIN 2014a), fueled not only by domestic demand but also by the government's active promotion of Peru as a cultural destination with a unique gastronomy. From the gourmet restaurants in Lima to the more accessible restaurants in intermediate cities and smaller towns, Peru's gastronomy industry makes use of fresh, often exotic ingredients sourced from every corner of the country, boosting demand for local products and giving new vibrancy to the food service sector.

The ongoing changes in dietary patterns and food consumption habits are affecting the food marketing system. The increasing concentration of people in cities and towns has led to the emergence of urban open-air wholesale markets linked to regional and national networks. These open-air wholesale markets in turn have supported the expansion of networks of small grocery stores that distribute food to local consumers. Today, this traditional food distribution channel includes about 2,500 urban wholesale markets linked to an estimated 200,000 small grocery stores. Lima alone is home to an estimated 1,250 wholesale markets and about 70,000 grocery stores (GAIN, 2014b).

Beginning in the 1980s, the developing world experienced the so called "supermarket revolution," which originated in South America and subsequently spread to East and Southeast Asia, Central America, and finally parts of sub-Saharan Africa (Reardon and Berdegué, 2002). Supermarkets typically appear first in major cities, where they initially target upper- and middle-income consumers, but then they move rapidly into secondary cities and eventually into towns and villages, broadening their customer base as they go (Berdegué, et al., 2014). In Peru, the supermarket revolution has been less dynamic than in other countries in the region, but it is gathering pace. The penetration rate of supermarkets in Peru is still low by regional standards: supermarket sales make up 15-20 percent of total food retail sales in Peru (about 30 percent in Lima and about 14 percent in the interior of the country), compared to 70-80 percent in neighboring Chile, Colombia, and Brazil (Figure 17). Approximately 80 percent of total retail food sales in Peru take place in Metropolitan Lima, and although to date the focus of the supermarket expansion has been middle-income consumers, the leading supermarkets are now expanding into Lima's lower-middle-income districts as well, competing with small grocery stores and traditional markets that benefit from proximity to consumers.

Figure 17. Supermarket penetration, Peru vs. regional comparators, 2013



Source: Gutierrez, 2013.

Supermarkets are making inroads in Peru, but traditional markets have retained their importance and are still the preferred outlets for fresh product purchases, accounting for an estimated 75 percent of all food sales. Peru's small independent grocers have survived and even flourished by providing a range of affordably priced goods offered in smaller retail package sizes. Recent reports indicate that Peruvian consumers view supermarkets as good sources for processed food products, but they do not see them as the preferred sources for fresh produce. Consistent with this finding, most fresh fruits and vegetables entering Lima are still distributed through traditional marketing channels.

Change is clearly coming to the food distribution retail sector. As supermarkets continue to expand, traditional food retailers are stepping up their efforts to modernize, so as to be able to compete with supermarkets and keep pace with rapidly evolving consumer preferences. Modernization is certainly needed. As cities continue to grow, often in the absence of robust land use planning and without the benefit of needed infrastructure investments, many traditional wholesale markets have become serious bottlenecks to efficient food distribution, contributing to urban congestion, plagued by lack of security, chronically subject to poor hygiene, and a major cause of large post-harvest losses. These factors have generated renewed interest in the modernization of traditional wholesale markets.

The changes in dietary preferences described above—increasing consumption of perishable foods and increasing consumption of processed foods—have important implications for the food system. The strengthening preference for perishable

foods means that improved logistics systems are needed to ensure that food can be delivered from production regions to consumption centers quickly and cost-effectively, maintaining freshness, ensuring high standards of quality and safety, and preventing losses. Loss prevention is particularly important. FAO (2014) estimates that food losses represent enough nutrition to reduce hunger throughout the country by one-half: more than three million calories are wasted every day, enough to meet the nutritional needs of two million people.

At the same time, the strengthening preference for processed foods, produced locally to compete with exports, means that logistics systems will need to be reconfigured so that primary commodities can be assembled from production zones, delivered to processing facilities, and re-distributed from processing facilities to consumption centers. In Peru as in most other countries, many food processing facilities are located in urban areas, since these tend to be endowed with a plentiful labor supply and reliable energy. While this facilitates the re-distribution of processed food products to urban consumers, it also creates a need to transport food products from urban processing locations back into rural areas.

CHAPTER 3

Agricultural performance trends

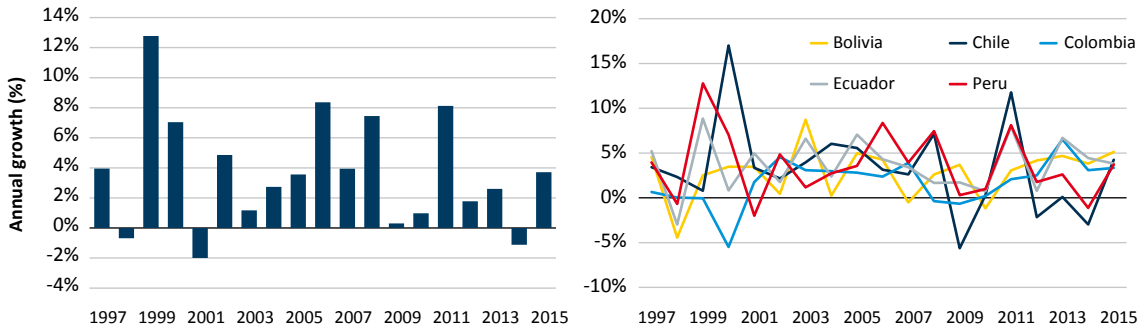
Agricultural performance trends

3.1 Agricultural production

Between 2000 and 2015, Peru's agricultural sector grew in real terms at an average annual rate of 3.3 percent. Over the same period, the manufacturing and services sectors grew on average by 5.6 percent and 5.5 percent, respectively, so the relative contribution of agricultural value added to overall GDP decreased moderately.

Two feature of Peru's agricultural growth experience are noteworthy. First, agricultural growth has tended to be quite variable, reflecting the fact that a large share of the country's crop and livestock production activities take place in areas subject to highly variable agro-climatic conditions (Figure 18). Similar variability

Figure 18. Average annual growth in agricultural value added, Peru, 1997-2015



(a) Annual growth in ag GDP (%)

(b) Ag GDP growth, Peru vs. comparators

Source: MINAGRI.

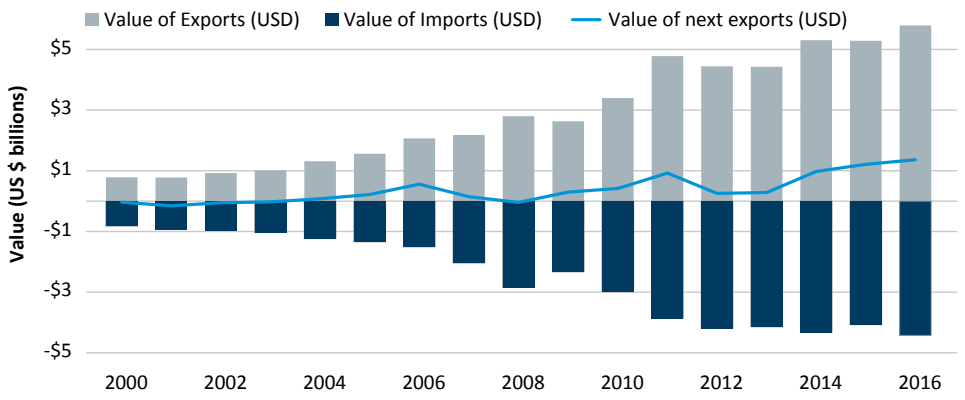
in agricultural growth was observed in regional peers, reflecting the similar vulnerability of other countries in the region to climatic effects.

Second, agricultural value-added activities are distributed unevenly throughout Peru. Of the three natural regions, the Costa and Sierra regions each contributes just above 40 percent of total agricultural value added, compared to only 13 percent for the Selva region. The regional totals themselves conceal considerable spatial variability. In 2015, 6 departments out of 24 in the entire country (Lima, La Libertad, Arequipa, Puno, Ica, and Piura) contributed 52 percent of the overall agricultural value added. Of this, more than one-half was generated in the Costa region, mainly in Lima. In the Selva region, agricultural activities are concentrated in just two departments (Amazonas and San Martin), with the other three Selva region departments contributing less than 2 percent in total.

3.2 Agricultural trade

During the past several decades, agricultural growth in Peru has been fueled in large part by rapid expansion of the export sector. Agricultural exports increased in value from US$758 million in 2000 to more than US$5.78 billion in 2016, growing at an average annual rate of 12.5 percent. Agricultural imports increased during the same period, but at a slower rate, and the agricultural trade balance has been positive for more than a decade (Figure 19).

Figure 19. Evolution of agricultural trade, Peru, 2000-2016

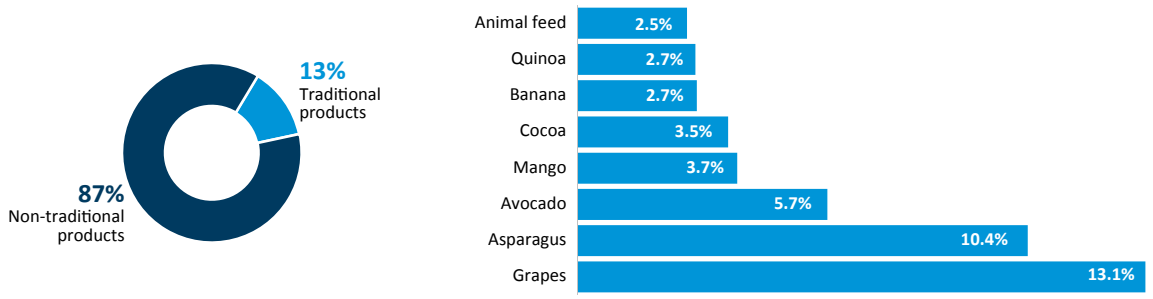


Source: MINAGRI.

The impressive growth in agricultural exports was accompanied by rapid diversification of the product range. In 2002, Peru exported 470 agricultural products; by 2016, the number had increased to 629 agricultural products, reflecting the successful penetration of Peruvian exporters into a large number of new markets. In 2002, the top five products made up 56.4 percent of total agricultural exports in terms of value; by 2016, the top five products accounted for only 42.4 percent of total agricultural exports by value, reflecting the more diversified export product range.

In recent years, agricultural export growth has been driven increasingly by rising exports of non-traditional products (Figure 20). Between 2006 and 2014, exports of traditional agricultural products such as coffee, sugar, and wool increased in real value, growing from US$574 million to US$840 million. During the same period, exports of non-traditional products including grapes, asparagus, avocado, and other fruits grew at an even faster rate. Coffee remains the most economically important agricultural export; the value of coffee exports increased in real terms from US$223 million in 200 to US$756 million in 2016. The share of coffee in total agricultural exports dropped, however, falling from 28.5 percent in 2000 to 13 percent in 2016.

Figure 20. Traditional vs. non-traditional agricultural exports, Peru, 2014



(a) Composition of ag exports, 2014

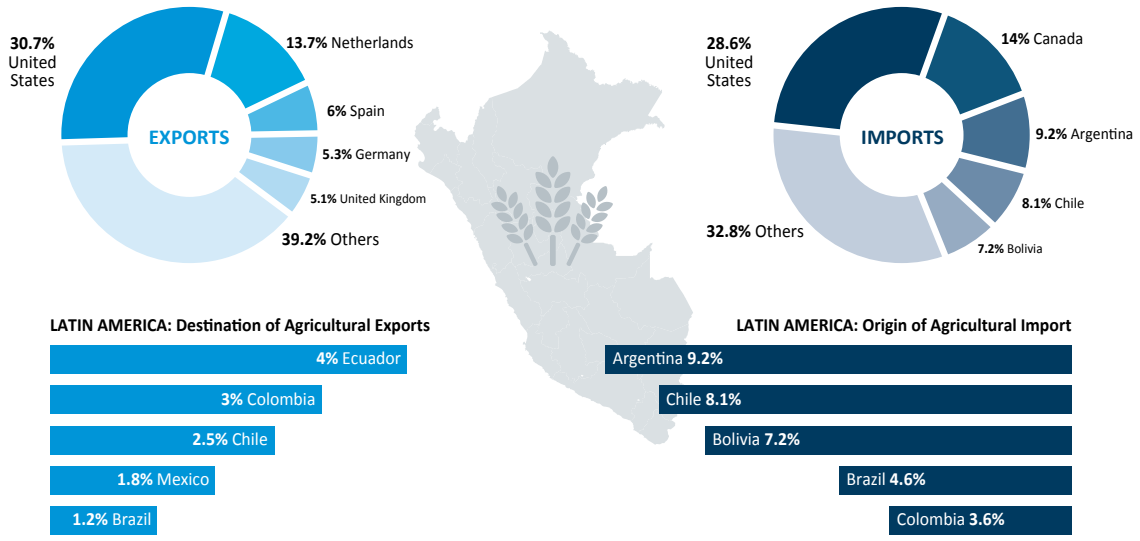
(b) Non-traditional ag exports, 2014

Source: MINAGRI.

The impressive growth in agricultural exports is reflected in a large and growing number of agro-exporters and export destinations (Figure 21). In 2005, 1,144 Peruvian firms were exporting agricultural goods. By 2012, this number had grown to 1,738, of which about 77 percent were either micro or small enterprises. By 2015, the number had grown even further to 2,017. The number of export destinations for

Peru's agricultural products rose from 99 countries in 2000 to 142 countries in 2016. Yet despite the increase in the number of export destinations, the diversification of export partners continues to be a challenge. In 2000, approximately 75 percent of all agricultural exports went to just 9 countries. Sixteen years later, the scenario had not changed appreciably: in 2016, 75.5 percent of all agricultural exports went to 10 countries, many of them linked to Peru through free-trade agreements. The USA continues to be the leading export destination, absorbing 30 percent of Peru's total agricultural exports by value, followed by several European countries. Agricultural exports to Latin American neighbors remain low.

Figure 21. Agricultural trade by partners, Peru, 2016



Fuente: MINAGRI.

3.3 Characteristics of Peruvian agriculture

Farming systems

Peru's agricultural sector is extremely heterogeneous. About 2 million small farms working less than 10 ha each, many of them family operated and subsistence oriented, coexist with about 25 thousand large-scale commercial farms working more than 100 ha each that use primarily hired labor. In between these two extremes, between 225 and 250 thousand mid-sized farms working between 10 ha

and 100 ha each focus mainly on commercial activities using a mix of family and hired labor. Farming systems vary by natural region.

Costa region: Beginning in colonial times, agriculture in the Costa region was for many years dominated by extensive systems of plantation agriculture, oriented originally to the production of sugar cane and cotton, among other crops. A small number of powerful elite families controlled much of the land; prior to the passage of the Agrarian Reform Law of 1969, about 80 percent of the arable coastal land was owned by only 1.7 percent of property owners. The great coastal estates were surrounded by thousands of smaller farms, producing a wide variety of food crops for subsistence and for sale into nearby urban markets. Farm land in the Costa region is extremely valuable due to the favorable climate, level terrain, reasonably reliable irrigation water, and location close to major consumption centers and export points. Because the intensive systems are highly productive, even though the Costa region accounts for only 3.8 percent of agricultural land in the country, it produces approximately 46 percent of the agricultural GDP.

Sierra region: Agriculture in the Sierra region is dominated by small-scale, subsistence-oriented mixed farming systems in which production of staples (potatoes, wheat, quinoa) is combined with livestock keeping. The vast majority of farms are less than five ha, with plots frequently dispersed across a range of micro-environments that vary in terms of altitude, soil quality, water availability, and climate. Food production is often insufficient to meet consumption needs, forcing many households to rely on off-farm earnings to supplement their incomes. Smallholder producers in the Sierra region typically take advantage of the different ecological niches at their disposal: at high altitudes, animals are grazed and specialized tubers grown (native potatoes, mashua, olluco, oca, and maca); at intermediate altitudes, grains (wheat, barley, rye, maize) are cultivated along with pulses (beans, peas, lentils), fruits (peaches, pears, apples, and citrus fruits), berries (blueberries, blackberries, raspberries, strawberries), and vegetables (onions, squash, carrots, peppers, and tomatoes); and in inter-Andean valleys many types of fruits are grown (avocados, oranges, lemons, bananas).

Selva region: Agriculture in the Selva region traditionally has been dominated by indigenous people, most of whom depend on fishing, hunting, and selective gathering from the forest. These livelihood strategies frequently are complemented

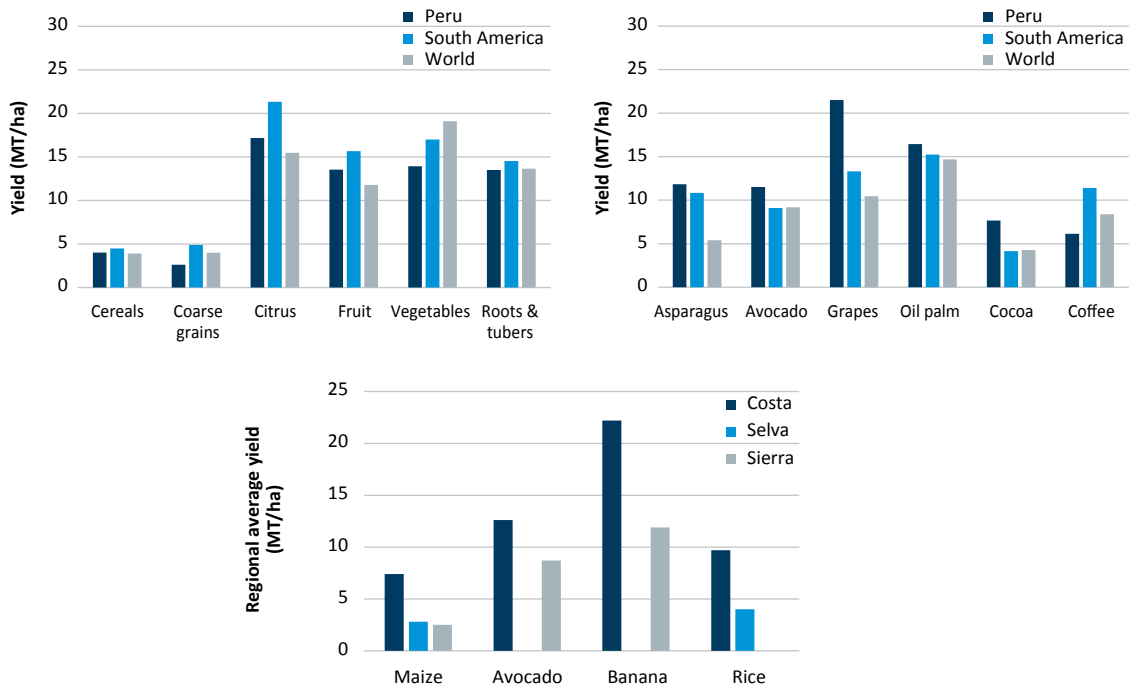
with slash-and-burn cultivation systems in which individual plots are cultivated for three to five years and then abandoned for an extended period, during which vegetation returns and the soil recuperates. Slash-and burn systems typically involve multi-cropping, with as many as 15 crops grown in associations that exploit synergies between different species. More recently, some areas of the Selva region have been opened for commercial agriculture, with a heavy emphasis on coffee, cocoa, tropical fruits, and oil palm.

Cropping patterns

Cropping patterns vary by natural region, consistent with differences in agro-climatic conditions and reflecting different expansion patterns. In the Selva region, an important expansion of the agricultural frontier has been accompanied by a shift in the crop mix, with annual crops being increasingly replaced by permanent crops. Between 1994 and 2012 in the Selva region, the area under annual crops fell by about 190,000 ha, while the area under permanent crops (mainly cocoa, coffee, and oil palm) rose by nearly one-half million hectares. In the Sierra region, potatoes remain the leading crop in terms of area, with increasing area being planted to sweet corn (choclo), Andean grains (quinoa, kiwicha), fruits, and alfalfa used for fodder. While the area under crops has expanded, the area under cultivated pastures has expanded even faster, reflecting the growing importance of livestock keeping. During the period 1994-2012, the area under cultivated pastures grew by nearly 200,000 ha. In the Costa region, irrigation allows a wide range of crops to be grown; the cropping pattern is extremely diverse and includes vegetables (asparagus, peppers, onions), fruits (grapes, mangos, avocados, berries), sugar cane, yellow corn destined for use as feed, and rice. In this region, the expansion of permanent crops has been particularly impressive. Nearly 200,000 ha were incorporated into permanent crops between 1994 and 2012.

Crop yields in Peru vary quite a bit, by crop and by region. Across large categories of crops, average yields in Peru compare favorably to average global yields and only modestly trail average yields in South American countries as a group (Figure 22). But when the comparison is restricted to Peru's leading export crops—asparagus, avocados, grapes, oil palm, cocoa, and coffee—average yields in Peru are higher than global and regional competitors. The relatively poor performance observed across the larger crop categories can be attributed to the generally very low yields being achieved in the Selva and Sierra regions.

Figure 22. Crop yields, Peru vs. comparators, 2014



Source: FAOSTAT.

Livestock production

Production of livestock has evolved over time as well. At the national level, the population of cattle, alpacas, guinea pigs, chickens, and pigs has registered strong growth. Meanwhile, the population of sheep and goats, which are raised mainly in the Sierra region and inter-Andean valleys, has declined significantly. Growth in the numbers of cattle occurred in all three natural regions, driven by strengthening demand for meat as well as dairy products. Growth in the number of alpacas was concentrated in the central and southern Sierra region, reflecting increased demand for wool and camelid meat. The poultry industry, which is concentrated in the Costa region close to major consumption centers, has had the most notable performance. The national chicken flock has grown exponentially in response to rapid increases in local demand for poultry meat. Chicken has become the main source of animal protein in Peru.

Land

Agricultural growth in Peru has been driven in part through extensification, as reflected in steady expansion over time of the agricultural land area (the term "agricultural land" is used here to include both crop land and pasture land). Since 1961, agricultural land has more than doubled, and currently more than 7.1 million ha are being used for agricultural purposes.

Fragmentation of agricultural land is a major problem in Peru. Even as the agricultural frontier has expanded, agricultural landholdings have become smaller on average. Nationally, the average area managed per agricultural household fell from 3.3 ha in 1994 to 3.1 ha in 2012. Small farms of less than 5 ha made up 82 percent of all agricultural units in 2012, a significant increase from the 73 percent recorded by the 1994 census. Conversely, the numbers of medium-sized farms (5-50 ha) and large farms (>50 ha) have fallen by 16 percent and 12 percent, respectively. Land fragmentation cuts across regions, but it is most extreme in the Sierra region, where 87 percent of farms worked less than 5 ha in 2012 (up from 79 percent in 1994). In the Selva region, expansion of the agricultural frontier has often been dominated by smallholder households linked to coffee and cocoa production.

Agricultural land in Peru is very unequally distributed. Small-scale farmers, despite being very numerous, control a relatively small share of total agricultural land. About 77 percent of all agricultural land is controlled by just 23 thousand large-scale commercial farms with landholdings in excess of 100 ha, which represent just over 1 percent of all farming units (Table 5).

The unequal distribution of land and the predominance of small farms is problematic, because small farm sizes are associated with higher levels of subsistence production. It is estimated that of the total 2.2 million farmers in Peru, 71 percent operate at the subsistence level, about 22 percent are in different stages of transition, and only 8 percent are consolidated farmers (Escobal, 2016).[3] The circumstances of small-scale family farmers are particularly dire. According to Escobal and Armas (2015), nearly three-quarters of all agricultural units are subsistence-oriented family farms whose members lack sufficient land, livestock, or productive infrastructure to generate enough income—monetary or non-monetary—to cover the basic food basket.

3 A detailed description of this categorization is in the annex 3.

Table 5. Distribution of landholdings, Peru, 2012

Size of farm	Producers		Area	
	Number	Share (%)	Number (ha)	Share (%)
Without land	47,467	2.10	0	0.00
< 0,5	507,137	22.43	99,700	0.26
0,5 to 1	324,706	14.36	204,933	0.53
1 to 5	922,572	40.80	1,964,119	5.07
5 to 10	218,564	9.67	1,418,311	3.66
10 to 15	81,937	3.62	926,382	2.29
15 to 20	36,337	1.61	595,696	1.54
20 to 100	98,798	4.37	3,692,042	9.53
>100	23,455	1.04	29,841,281	77.02
TOTAL	**2,260,973**	**100**	**38,742,465**	**100**

Source: Based on INEI, VI Censo Nacional Agropecuario 2012.

The main driver of land fragmentation can be found in census data: 59 percent of all farms in Peru have been acquired through inheritance (including 66 percent in the Sierra region, 45 percent in the Costa region, and 29 percent in the Selva region). Farmers traditionally bequeath their land to their children, who end up with ever smaller landholdings. Consolidation of small landholdings into large units is uncommon, reflecting in part the lack of alternative livelihood sources for many rural households, but indicating also the lack of functioning land markets in many rural areas. As discussed elsewhere in this report, the difficulty of acquiring access to agricultural land, either through purchase or through rental, has important implications for productivity.

In an effort to address the fragmentation problem, in the mid-1990s the government (with support from IDB) launched the Programa Especial de Titulación de Tierras (PETT), a program designed to accelerate the titling of agricultural land.[4] When PETT started, it was estimated that more than 80 percent of agricultural plots lacked titles. The program was mostly concentrated in the Costa region, but some

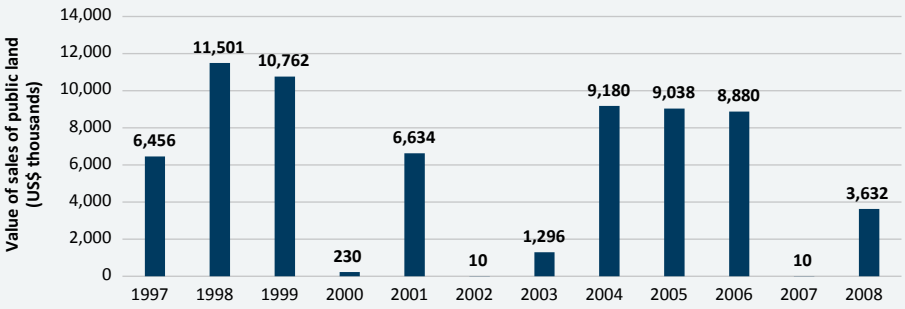
4 It is important to note that PETT did not reform the cadaster and titling registration system. This has been one of the main criticisms of the program, as it is still costly and time consuming for farmers to register land transactions or partitions in the formal system. As a result, the incidence of informal land ownership is once again rising.

areas in the Sierra region and to a lesser extent the Selva region were also covered. Between 1996 and 2003, PETT spent more than US$100 million providing free titling and registration services. More recently, land titling services have been provided at a more modest scale through programs implemented by the Informal Property Regularization Commission (COFOPRI) and by regional and local governments. These programs have left a legacy of uneven territorial coverage when it comes to land titling; the 2015 ENA determined that land titles are held by 48 percent of farmers in the Costa region, 17 percent of farmers in the Sierra region, and 23 percent of farmers in the Selva region.

BOX 3. EVOLUTION OF LAND POLICIES IN SUPPORT OF EXPORT AGRICULTURE, PERU

Following the land reform of 1969, land ownership in Peru became highly fragmented as agrarian cooperatives and collective enterprises dissolved under pressure from a series of economic crises and recurrent rural violence. Constitutional changes introduced in the early 1990s under the Fujimori government removed restrictions to private ownership of land, liberalized land markets, weakened land ownership rights of communities, and incentivized private acquisition of land in the Costa region. These measures were reinforced in 1994 by the enactment of the law for the promotion of private investments in State enterprises (Law 674), which created the legal framework that allowed COPRI (the Commission for Promoting Private Investment), today's ProInversión (Private Investment Promotion Agency), to sell public firms and public assets.

VALUE OF LAND SALES TO THE PRIVATE SECTOR, 1997-2008



With the legal framework in place, the government embarked on a series of public auctions, transferring ownership of much public land to the private sector. Private interest in land acquisition was stimulated by two large irrigation projects in the Costa region. In the years that followed (1997-2008), almost 68,000 ha in the Costa region were sold via more than 30 auctions, and more than 120 companies invested in agriculture for exports. Large plots of land were transferred to the private sector: the average size of holding sold was 350 ha, 100 times larger than the average landholding in the region of 3.5 ha in 1997. The income

for the State generated from the sales was modest (only about US$45 million for the 67,000 ha), but the sales were considered successful because they stimulated private investment in irrigation infrastructure, estimated at US$500 million.

From public investments to PPPs

In the early 2000s, Peru introduced a series of reforms to promote decentralization. Law 28059, enacted in 2002 to promote private investment in infrastructure in a decentralized manner, introduced a more direct mechanism for land acquisition by the private sector. Two subsequent decrees aligned with Law 28509 were particularly relevant for allowing access to land by private entities: (i) Legislative Decree 994, which authorized the sale of uncultivated public land to private entities for agricultural purposes; and (ii) Legislative Decree 1089, which removed legal barriers to granting of land ownership rights by the national titling authority (COFOPRI). The impacts of these legal reforms have been very visible. Leading up to 1997, the government had succeeded in launching a number of important irrigation projects (including Chira-Piura, Tinajones, Chavimochic I and II, Majes-Siguas), which brought about 40,000 ha under irrigation at a cost of about US$15 million. Since then, using mainly public-private partnerships (PPP), the government has signed contracts for three large irrigation projects: Olmos (2004, currently operating); Majes-Siguas (2010, under construction); and Chavimochic III (2013, under construction). These projects are expected to bring 140,000 ha under irrigation and generate more than 300,000 jobs, at a cost approaching US$500 million.

Large agribusiness expansion and land consolidation

The land transferred through the Chavimochic, Chinecas, and Olmos projects has accelerated land concentration. Today in the Costa region, around 30 companies control about 365,000 ha. The legal reforms implemented over the years have facilitated the process by allowing land transfers via auctions, but other factors have contributed as well, such as the privatization of producer cooperatives in the sugar industry, and rise of the biofuels industry, which encourage acquisition of land for the large-scale production of biodiesel crops, in the Costa region and also in the Selva region.

Fuente: ProInversión, 2010 y 2016; Escobedo, 2015; Bourliaud & Eresue, 2015

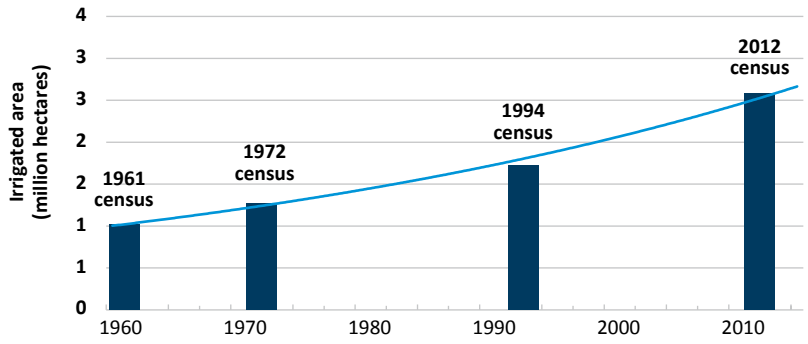
Irrigation

In Peru as in every country, agriculture is dependent on the availability of water. Without a reliable source of water, producing crops and keeping livestock become difficult if not impossible. When water is scarce or the supply of water is unreliable, irrigation development becomes necessary. Water is a critical consideration in Peru, as significant parts of the national territory receive little or

no rainfall on average. In the Costa region, there is almost no rainfall throughout the year, so agriculture in this region is heavily dependent on irrigation. In the Sierra region, precipitation is concentrated between the months of December to March, and there is generally a large water deficit between the months of April and November; agriculture therefore depends on irrigation during the dry months and also benefits from supplementary irrigation applied during the rainy season. In the Selva region, abundant rain falls virtually throughout the year, in most cases meeting if not exceeding the amount of water needed for agriculture. In a few areas of relatively low rainfall, for example the Ceja de Selva and the Selva Alta, supplementary irrigation is sometimes used.

The area developed for irrigation in Peru has increased steadily over time, reflecting robust public and private investment (Figure 23). The most accurate measurements are taken periodically at the time of the agricultural census. At the time of the most recent agricultural census in 2012, it was estimated that approximately 2.6 million ha had been developed for irrigation, representing 36.2 percent of the country's total agricultural area.

Figure 23. Growth in in irrigated area, Peru, 1961-2012

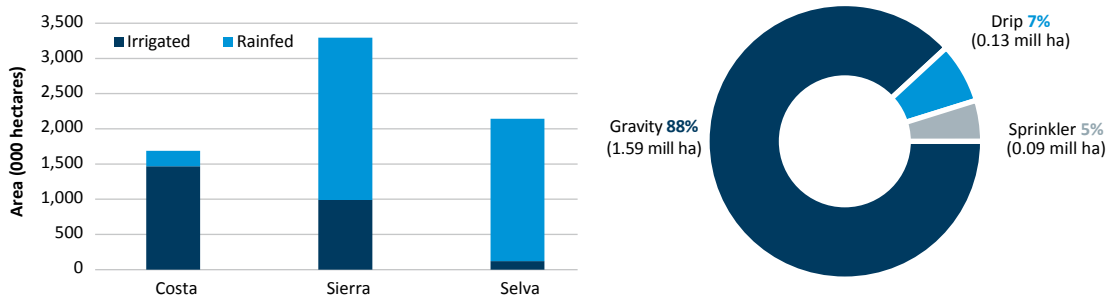


Source: Agricultural Census, 1961, 1972, 1994, 2012.

Consistent with the extreme variability in regional precipitation patterns, the importance of irrigation varies significantly between the three natural regions (Figure 24a). In the Costa region, just under 1.5 million ha are irrigated, representing 87 percent of total cultivated area in that region. In the Sierra region, approximately 990,000 ha are irrigated, representing 30 percent of total cultivated area in that region. In the Selva region, about 121,000 ha are irrigated, representing only 6 percent of total cultivated area in that region. Gravity systems are by far the most

prevalent, accounting for 88 percent of the irrigated area in the country (Figure 24b). More efficient drip systems and sprinkler systems have gained in popularity in recent years, but expansion is constrained by relatively high capital investment costs. It is important to note that a significant share of the area developed for irrigation is not cultivated in any given year.

Figure 24. Characteristics of irrigation in Peru, 2012



(a) Importance of irrigation, by natural region

(b) Area under different types of irrigation

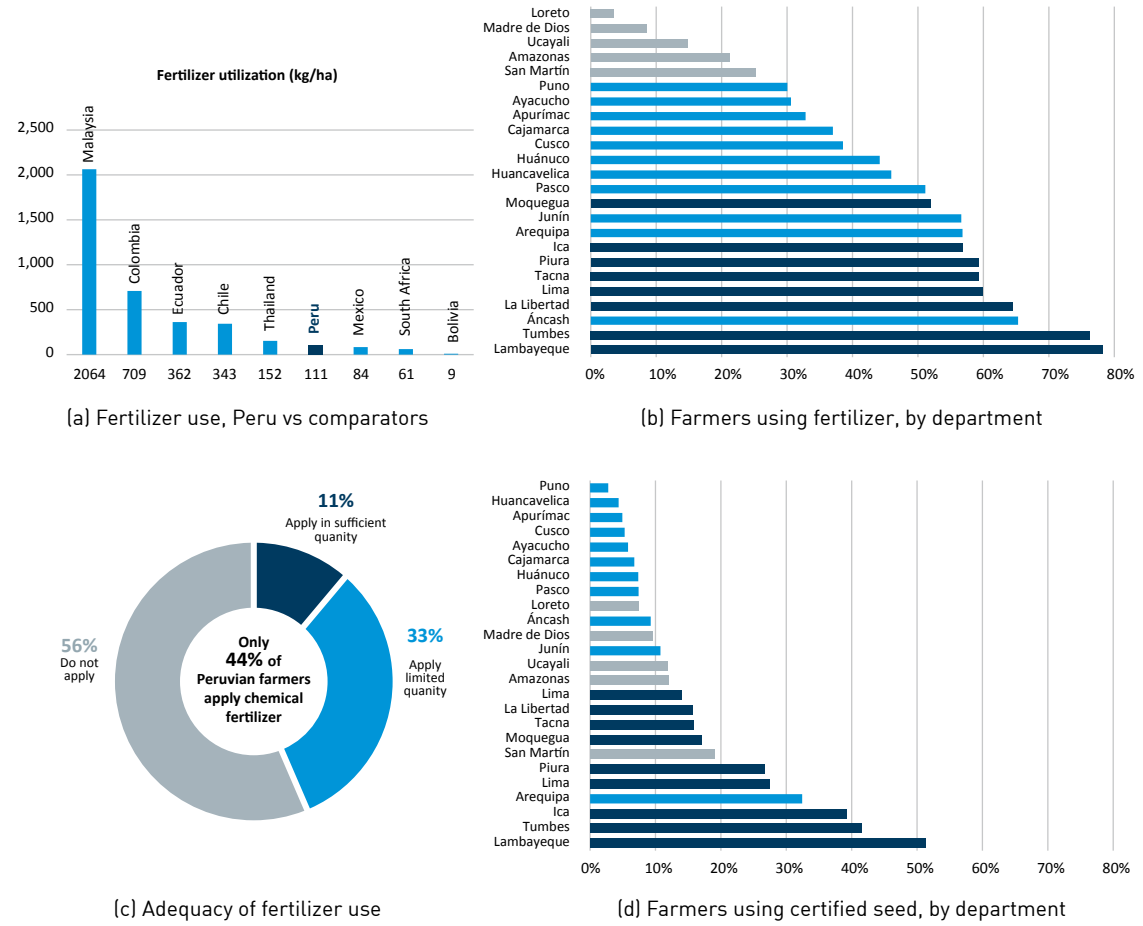
Source: CENAGRO IV 2012.

Input use

Input use in agriculture varies by natural region, reflecting the prevailing differences in farm types and production systems. The national average fertilizer application rate of 112 kg/ha is lower than average application rates in many regional comparators (Figure 25a). Moreover, the national average application rate conceals important regional variability, both in terms of the proportion of farmers who use fertilizer and in terms of application rates. The incidence of fertilizer use is highest in the Costa region and lowest in the Selva region, with the Sierra region falling in between the two extremes (Figure 25b). Nationwide, it is estimated that 44 percent of farmers were using fertilizer in 2012, but the majority of those who used fertilizer did not do so optimally; only about 11 percent of all farmers applied sufficient quantities (Figure 25c). Use of certified seed and seedlings is lower than use of fertilizer, once again with significant regional variability (Figure 25d).

Machinery use in Peruvian agriculture is still limited. According to 2012 census data, only 22.7 percent of farmers use tractors. Similar to the case of fertilizer and certified seed, large disparities are evident across the three regions. More than 50 percent of farmers in the Costa region use tractors, compared to 21 percent of farmers in the Sierra region and only 3.5 percent of farmers in the Selva region. Most tractor services are hired; fewer than 10 percent of farmers own the tractors they use.

Figure 25. Use of fertilizer and certified seed, Peru, 2012



Source: WDI.

3.4 Climate change and agriculture

Peru's agricultural sector is highly vulnerable to climate change. The main climatic hazards affecting agricultural activity are droughts, floods, frost, and cold waves (PLANGRACC-A, 2012). The negative impacts of these hazards are likely to increase over time, as it is projected that climate change will cause the El Niño – Southern Oscillation (ENSO) phenomenon to increase in frequency and/or intensity. ENSO, a major climate disruption triggered by elevated ocean water temperatures, directly affects precipitation patterns in Peru. In years when ENSO is pronounced, the resulting extreme weather events typically cause significant flooding and destructive landslides, primarily in the northern coastal regions of the country.

Extreme weather events are already having major impacts on the agricultural sector. During the first quarter of 2017, extremely high rainfall attributed to the ENSO phenomenon caused agricultural production to fall by an estimated 2 percent, with losses totaling more than US$380 million (Imedia, 2017). In addition to widespread damage caused to irrigation infrastructure, approximately 100,000 ha of crops were lost to flooding, and an additional 90,000 ha of crops were negatively impacted, affecting an estimated 1.5 million farmers (La Republica, 2017). Tree crops were most severely affected, suffering nearly 67 percent of total agricultural losses in value terms. Rice, bananas, maize, and potatoes accounted for much of the remainder.[5] Losses of this magnitude were hardly unprecedented, and in fact greater losses have been suffered in the past. For example, in 1997-98 the ENSO phenomenon caused agricultural losses estimated at around US$612 million, and in 1982-83 it caused agricultural losses estimated at US$1.1 billion (Galarza and Kamiche, 2012).

Looking to the future, climate change is expected to cause important shifts in agricultural production patterns in Peru. These shifts will particularly affect the rural poor, many of whom are extremely exposed to the potential impacts of climate change. Climate change projections suggest that average precipitation and average temperatures will increase nationwide with slight variations across natural regions (BID and CEPAL, 2014). Under different climate scenarios, it is expected that average annual precipitation will increase between 2 and 8 percent.[6] In some areas of the country, rainfall is expected to decrease in some months and significantly increase in other months. In other areas, there would be constant increases in rainfall throughout the year. Meanwhile, average temperatures are projected to rise by 1 to 3 degrees Celsius, affecting all parts of the country more or less equally (BID and CEPAL, 2014).

Climate change will particularly impact agriculture in Peru by affecting water availability. Water availability will be reduced mainly in low-lying environments such as the Costa region and lowland Selva region—areas in which agriculture is very productive and highly market oriented. Reduced water availability will result from higher temperatures (BID and CEPAL, 2014), which are expected not only to reduce rainfall levels but also to reduce the size of the glaciers that serve as natural storage reservoirs. With the storage capacity of the glaciers reduced,

5 Ministry of Agriculture and Irrigation. "International Seminary: Disaster Risk Management and Climate Change Adaptation in Agriculture Sector" Lima, Perú. June 22th, 2017.

6 Three scenarios were evaluated: B1, A1B, and A2. The B1 scenario assumes more ecologically friendly growth. The A1B scenario assumes rapid economic growth with a balanced emphasis on all energy sources. The A2 scenario assumes a heterogeneous world with different growth patterns.

flows of many rivers will decrease during the dry season (increasing the frequency and severity of droughts) and increase during the rainy season (increasing the frequency and severity of flooding). Climate change thus will increase hydrological uncertainty, making planning and designing of hydraulic infrastructure more difficult.

Reduced water availability will impact not only agricultural areas, but also urban centers, many of which face large and rapidly increasing water deficits. One-third of Peru's population lives in the Lima metropolitan area, which is essentially a desert with little rainfall, so the population relies heavily on water from glacial melt. SEDAPAL, the municipal water company, is already struggling to confront regular water shortages; these will only become more severe as the population of Lima grows and demand for water increases. Improving the efficiency of water use in urban areas thus will be needed as well.

Recent analysis suggests that the relationship between temperature and agricultural yields is non-linear. Temperature has a positive effect on yields up to certain threshold, above which further increases in temperature become harmful. An increase of 1 degree Celsius above the optimal level in the average growing season temperature would be expected to decrease agricultural yields by more than 10 percent in the Sierra region and by nearly 20 percent in the Costa region (Aragon, Oteiza, and Rud, 2017).

If climate change ends up increasing average temperatures in Peru by even 1 degree Celsius (an optimistic scenario given current projections), the impacts in the agricultural sector could be devastating. At the national level, production of many important agricultural products would likely decrease, including rice, maize, potatoes, and sugar cane. Cumulative losses resulting from a 1 degree Celsius rise in average temperature could approach S/. 5,000 million, equivalent to 24 percent of agricultural GDP. Projections through 2094 suggest that rice would be affected the most; production of rice would likely decrease by 15 to 30 percent. Maize would also be severely affected; production would fall by approximately 10 percent. Potatoes and sugar cane would suffer production losses of around 5 percent each. Interestingly, the impacts of increasing average temperature on some crops would be more mixed: in the case of coffee, for example, production would increase during an initial period, before declining slightly after the temperature rise becomes more pronounced (BID and CEPAL, 2014).

Changes in production caused by climate change in turn would affect prices. Saldarriaga (2016) estimates that an increase of one standard deviation above the

historical average temperature would depress prices of Peru's principal agricultural products between 3.5 and 4 percent, reducing net profits earned by producers by 10 to 11 percent. Impacts of such magnitude would undermine food insecurity and disproportionately harm poor households that spend a high proportion of their income on food.

The negative impacts on agriculture resulting from climate change could potentially be mitigated through human actions. One such action will be to shift the location of production in response to rising temperatures and evolving rainfall patterns. For example, in the Sierra region production of commercial potatoes, maize, and beans could shift to higher altitudes, moving onto land currently planted to native potatoes or used for grazing animals. Such changes would likely have to be supported by a plant breeding effort, as it would depend on the availability of varieties adapted to new sets of agro-climatic conditions. Similarly, in the Selva region production of cocoa and coffee could become unattractive in many current production areas, leading to the replacement of these two crops by alternatives that are better adapted to higher temperatures, such as bananas or cassava (World Bank, CIAT, CATIE, 2015).

In addition to shifting the location of production, Peruvian producers will also have to adjust their management practices. Evolving rainfall patterns attributable to climate change—particularly the reduced rainfall projected for many zones and/or more extended periods of drought—will require that increased attention be paid to water management. One obvious avenue to pursue is investing in irrigation infrastructure. Currently, about 36 percent of all crop land is irrigated, including about 52 percent of the crop land situated in the Costa region. Expanding the area under irrigation would certainly help protect agriculture from climate change, but the cost of irrigation infrastructure is often extremely high, which limits the rate at which expansion will take place. Alternative water harvesting and water conservation techniques may offer more attractive opportunities for improving water use efficiency in the short run, along with the use of more water-efficient crops and varieties.

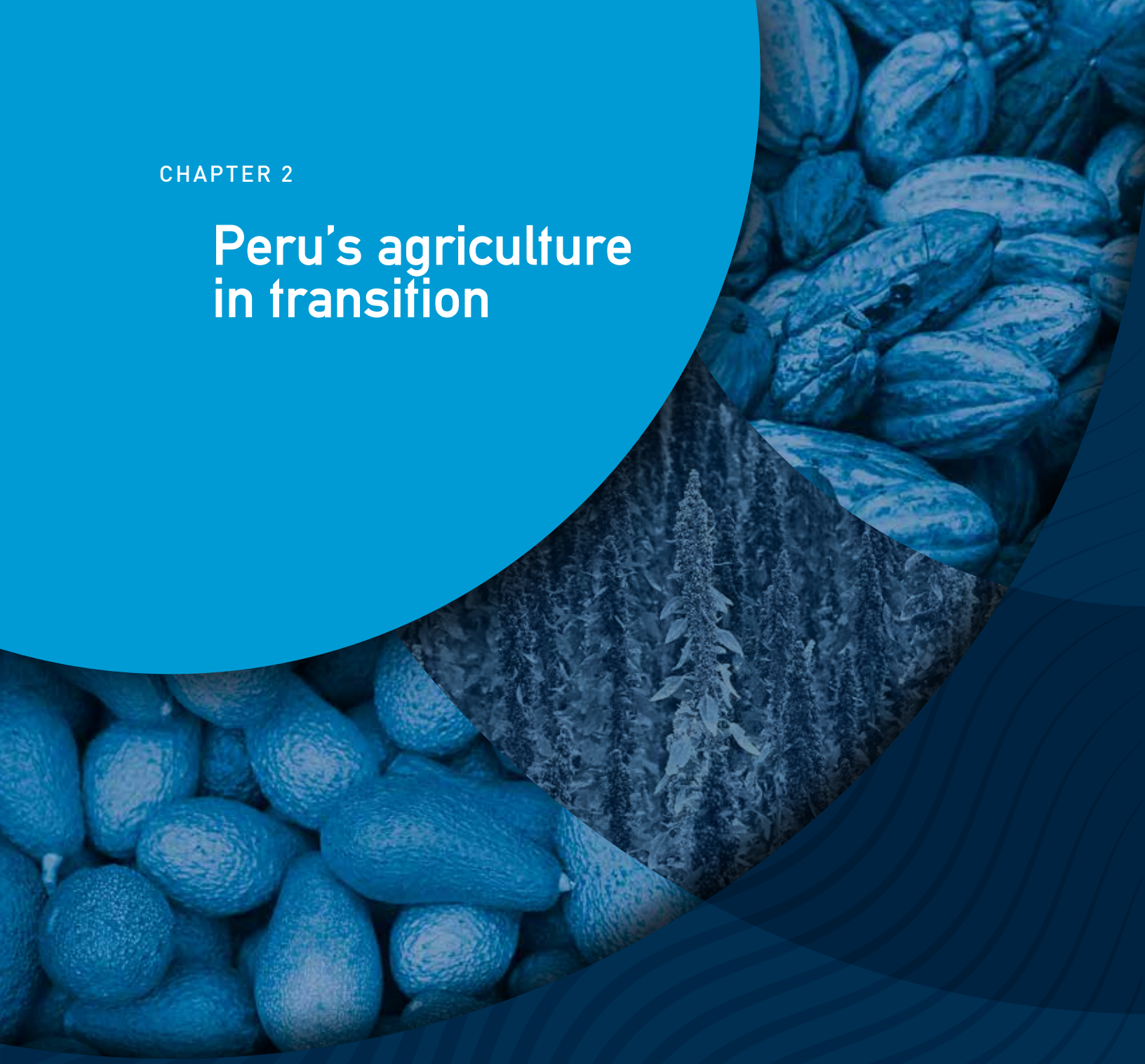
Technologies and practices designed to enhance resilience in the face of climate change are being used in Peru, but many have not yet been extensively adopted. Low rates of adoption may be due in part to institutional constraints, as the policies and programs charged with developing and delivering these technologies and practices tend to be poorly coordinated and underfunded. At the same time, financial incentives are often lacking for producers to take up technologies and practices that can enhance resilience in the face of climate change.

Global experience suggests that systematic approaches can dramatically accelerate adaptation to climate change in the agricultural sector by raising awareness of the potential benefits of so-called "climate-smart" technologies and practices and by strengthening the incentives to adopt. A systematic approach does not yet exist in Peru, although there are signs that the situation is now changing—for example, MINAGRI is one of several line ministries that have launched initiatives to climate-proof their investment programs. Meanwhile, even though financial instruments for managing climate risk are not yet widely available to most Peruvian farmers, some innovative products have appeared in the market in recent years and are beginning to attract attention[7] (World Bank; CIAT; CATIE. 2015).

7 For example, La Positiva, a local insurer, has promoted an insurance product in northern Peru, but its uptake has been limited. La Positiva offers El Niño coverage as "Business Interruption" insurance. The contract triggers when the surface temperature of the water in the ENSO 1.2 zone reaches levels of 24 degrees Celsius or above; such temperatures are indicative of a severe El Niño event, in which catastrophic flooding is more likely to occur in the region. In 2011, the first year of operation, only 586 policies were sold for agricultural loans for S/. 12.4 million. In 2012, 3,560 policies were sold for S/. 75 million (Miranda and Farrin, 2012).

CHAPTER 2

Peru's agriculture in transition



Rethinking the contribution of agriculture

4.1 Introduction

The importance of agriculture in a country's economy is traditionally measured as the direct contribution of primary production activities to overall GDP.[8] While national accounts measure the value added of primary production activities, any contributions of the sector extending beyond primary production, in particular through the agro-food industry, are captured in the value added of other sectors, including manufacturing, trade, and services.

Many analysts believe that the national accounts method of measuring the importance of the agricultural sector downplays the larger role of the sector in the economy, especially in countries in which the overall food and farming system has become more sophisticated and more integrated. The past century has witnessed a profound transformation in the way food is produced and consumed.[9] For thousands of years after the emergence of agriculture, most food was produced and consumed within the same household. Today, food moves from specialized surplus-producing farms to non-farming consumers. Along the way, it is subjected to numerous value-adding activities such as transportation, storage, processing, packaging,

8 In this context, what is generally referred to as "agriculture" often includes all of the natural resource sectors, i.e., crops, livestock, forestry, and fisheries.

9 The discussion here focuses on food, but the same argument holds for non-food agricultural commodities.

and retailing, the importance of which has increased over the years in response to changing consumer demand. In industrialized countries, a large and growing share of food consumption expenditures now go to highly processed manufactured foods (including meals consumed outside the home), whose prices include a small share of primary product and a large share of non-farm value-adding activities. Yet when the time comes to compile national income accounts, most post-harvest value-adding activities are not considered agricultural activity; rather, they are classified as manufacturing or services, which when translated into official statistics obscures their link to the food system and their dependence on agriculture. While a similar argument can be made for all primary production sectors, agriculture typically generates a much larger set of linkages, both backward (by stimulating demand for production inputs such as seed, fertilizer, agricultural chemicals, and machinery) and forward (by providing the raw material needed by manufacturers and services providers to meet the rapidly growing demand for healthy, nutritious, safe, and good-tasting food and beverage products).

Contributions both in labor and value terms of any productive activities occurring beyond the farm gate, for example in the food industry, are measured as non-farm labor and production in other sectors. In the case of Peru, activities such as processing and preservation of meats, fish, fruits, and vegetables; manufacture of dairy products; processing and refining of sugar; production of wines, beer, and other alcoholic beverages; and preparation of animal feed all are considered to be part of manufacturing, despite the significant share of these products' value added that comes in the form of inputs from agriculture. Similarly, many products serving as inputs into agriculture, such as animal feed, fertilizer, insecticides and pesticides, and fuel and transportation, are all listed as non-farm value added. These accounting conventions lead to underestimation of the size of the farm sector and its contribution to growth, which reduces the apparent urgency to focus on developing the sector. Agriculture would appear to be less important than what its true role in the economy would otherwise suggest. Recent evidence from Latin America shows, however, that when an expanded measure is used that takes into account forward and backward linkages, the size of the agricultural sector and its contribution to growth and poverty reduction are much larger than is conventionally believed (see, for example, de Ferranti et al., 2005; Bravo-Ortega & Lederman, 2005; Foster & Valdes, 2015; World Bank, 2015).

4.2 Methodology

What is the "real" size of Peru's agricultural sector? To answer this question, an expanded measure of agricultural value added was calculated taking into account intersectoral linkages in markets for intermediate goods. Capturing the multiplier effects associated with primary production activities is important for estimating the total contribution of agriculture to growth and poverty reduction, because the sector is often viewed as relinquishing its role as a key contributor as economies develop. An input-output matrix of national accounts was used to create an expanded measure of agricultural value added that takes into account the sector's forward and backward linkages.[10] The strength of these linkages is proportional to the sector's participation in intermediate inputs used by other sectors and to the sales of upstream industries supplying agriculture.[11] (For a more detailed description of the methodology, see Appendix 1.)

4.3 Analysis and results

When these linkages are included, agricultural value added increases significantly, particularly through forward linkages. Using the traditional measure that focuses narrowly on primary production activities, the contribution of agriculture to GDP in Peru is 7.3 percent. Using the expanded measure, the contribution rises to 11.3 percent, 4 percentage points higher.[12]

Table 6 shows the shares of total national value added coming from the renewable primary sector (farming, forestry, and fisheries), as a whole and disaggregated, as well as contributions to value added from other sectors. As in any middle-income country, in Peru the contributions of manufacturing and services are significantly larger than that of primary agriculture and forestry alone.

10 The most recent available input-output matrix dates from 2007. Data on the composition of GDP obtained from the Instituto Nacional de Estadística e Informática (INEI) show that the structure of Peru's economy has not changed significantly during the past decade, however, suggesting that the expanded measure of agricultural value added presented in this report reflects current reality.

11 As an illustration, consider the simple case of an expanded value-added measure as the sum of the national accounts value added, VA, plus a proportion of the value added of related industries, where F represents the "strength" of the linkage ($0 \leq F < 1$): $VA_{Ag\ expanded} = VA_{Ag} + FxVA_{Other}$. Forward linkages are measured by the participation of agriculture in the costs of post-harvest activities where farm products are intermediate inputs. For backward linkages, F measures the relative importance of agriculture as a buyer in comparison with the total use (intermediate consumption, direct sales and exports) of products from other sectors. See Foster and Valdés (2015).

12 The expanded measure of agricultural value added presented in this report (based on the input-output matrix) does not account fully for all multiplier effects. A computable general equilibrium-based approach would likely show even greater importance of agriculture, due to secondary and tertiary multiplier effects.

Table 6. Structure of the Peruvian economy: Value added (VA) by sector, 2007

	Activity description	Participation (% total VA)
1	**Renewable Primary**	**7.31**
1a	Agricultural crops	4.37
1b	Animal husbandry	1.80
1c	Hunting, forestry and logging	0.29
1d	Agricultural and livestock services	0.03
1e	Fisheries and aquaculture	0.81
Sum 1a-1b	Agricultural	6.18
Sum 1a-1c	Agroforestry	6.47
2	**Extractive industries (includes oil)**	**15.65**
3	**Manufacturing**	**18.01**
4	**Electricity, gas and sewage**	**1.88**
5	**Construction**	**5.57**
6	**Commerce**	**10.40**
7	**Services**	**41.18**
Total	**Sum 1 to 7**	**100.00**

Source: Instituto Nacional de Estadística e Informática (INEI), Cuentas Nacionales, 2007.

Forward linkages between broad categories of activities in renewable primary and other sectors are shown in Table 7. The largest contribution from primary production is to manufacturing and comes largely from intermediate inputs contributed from animals, agricultural crops, and fisheries. Collectively, the share of total value added generated via forward linkages from agriculture to manufacturing is 2.84 percent. Similarly, forward linkages between agriculture and services account for 0.76 percent of total value added in Peru's economy. Forward linkages between the renewable primary sector and other sectors are significantly weaker, as expected.

Table 7. Renewable primary sector forward linkages to other sectors, 2007

Activity code	Activity description	Manufacturing	Services
1001	Agricultural crops	0.952	0.603
1002	Animal husbandry	1.098	0.072
1003	Hunting, forestry, and logging	0.152	0.002
1004	Agricultural and livestock services	0.093	0.000
2001	Fisheries and aquaculture	0.545	0.079
	Renewable Primary	2.840	0.756

Note: Forward linkages with other sectors including commerce, construction, electricity and gas, and extractives are trivial.

Source: Authors' calculations.

Backward linkages between activities in renewable primary sector and other sectors are shown in Table 8. The use of intermediate inputs in primary production comes mostly from the contributions of manufacturing to animal husbandry and fisheries. The magnitude of backward linkages even at the upper bound is significantly smaller than corresponding forward linkages. Backward linkages between manufacturing and the renewable primary sector range from an 0.30, 0.21, and 0.19 percent share of the total value added for Peru, at the upper bound, midpoint, and lower bound, respectively. From the data in Table 8 it is also evident that some share of services is also used as an intermediate input into agriculture. At the midpoint, 0.18 percent of value added in primary production is through intermediate inputs from services. These results suggest that at least in the case of Peru, other sectors—particularly manufacturing—rely heavily on inputs from primary production, while the opposite is not necessarily true.

Table 8. Renewable primary sector backward linkages with other sectors, 2007

Upper bound			
Activity code	**Activity description**	**Manufacturing**	**Services**
1001	Agricultural crops	0.040	0.069
1002	Animal husbandry	0.153	0.054
1003	Hunting, forestry, and logging	0.009	0.006
1004	Agricultural & livestock services	0.000	0.001
2001	Fisheries and aquaculture	0.098	0.058
	Renewable Primary	0.300	0.188
Mid-point			
Activity code	**Activity description**	**Manufacturing**	**Services**
1001	Agricultural crops	0.028	0.065
1002	Animal husbandry	0.106	0.051
1003	Hunting, forestry, and logging	0.006	0.005
1004	Agricultural & livestock services	0.000	0.001
2001	Fisheries and aquaculture	0.068	0.055
	Renewable Primary	0.209	0.178
Lower bound			
Activity code	**Activity Description**	**Manufacturing**	**Services**
1001	Agricultural crops	0.026	0.063
1002	Animal husbandry	0.098	0.049
1003	Hunting, forestry, and logging	0.006	0.005
1004	Agricultural & livestock services	0.000	0.001
2001	Fisheries and aquaculture	0.063	0.053
	Renewable Primary	0.192	0.170

Note: Backward linkages with other sectors including commerce, construction, electricity and gas, and extractives are trivial.

Source: Authors' calculations.

The expanded measure of agricultural value added, calculated taking into account forward and backward linkages, is shown in Table 9.

TABLE 9. VALUE ADDED OF RENEWABLE PRIMARY SECTOR AND ITS LINKAGES, 2007

Activity code	Activity description	Share of sector in total VA (%)	Participation in forward sectors (%)	Participation in backward sectors at midpoint (%)	Forward and backward sum (%)	Participation in total expanded VA (%)
1001	Agricultural crops	4.37	1.56	0.10	1.66	6.03
1002	Animal husbandry	1.80	1.17	0.16	1.33	3.13
1003	Hunting, forestry, and logging	0.29	0.15	0.01	0.17	0.46
1004	Agricultural and livestock services	0.03	0.09	0.00	0.09	0.13
2001	Fisheries and aquaculture	0.81	0.62	0.13	0.76	1.56
	Renewable Primary	7.31	3.60	0.40	4.01	11.32

Source: Authors' calculations.

4.4 Discussion

The preceding analysis shows that the contribution of agriculture to value added far exceeds the contributions associated with primary production only. When linkages are taken into account, particularly forward linkages for annual crops, agricultural value added increases significantly. Total agricultural value added increases from 7.3 percent to 11.3 percent, based on an increase in the share for annual crops from 4.4 percent to 6.1 percent and in the share for livestock keeping from 1.8 percent to 3.1 percent. This analysis suggests that traditional measures of agricultural value added do not fully reflect the true contribution of the agricultural sector to growth and poverty reduction. It is clear that primary agriculture drives a great deal of economic activity in the service and manufacturing sectors, especially through food processing and food manufacturing activities, as well as through the restaurant and tourism industries.[13]

13 The "gastronomic tourism" that Peru is successfully promoting provides a good example of the way in which primary agriculture contributes to value addition in the manufacturing and services sectors through forward linkages: gastronomic tourism would not exist in the absence of distinctly Peruvian agricultural products.

How does Peru compare to other countries? Table 10, which includes information from the path-breaking Beyond the City report (de Ferranti et al., 2006) as well as from other more recent sources, presents estimates of expanded agricultural value added for selected countries in Latin America. In interpreting the estimates, it is interesting to note not only the level of agricultural value added in each country, but also the proportional increase relative to the traditional (non-expanded) share measures. In Peru, the expanded measure exceeds the traditional measure by 55 percent, which is not surprising considering that Peru is an urbanizing economy with active agricultural input industries and robust and extremely dynamic downstream agricultural processing and food services industries. The degree to which the expanded measure exceeds the traditional measure is much smaller in Nicaragua, a transition economy (16 percent) and much larger in Chile (89 percent), a more developed country with advanced agricultural input industries and a large and diverse set of flourishing food manufacturing industries.

A similar approach could be used to estimate an expanded measure of the number of jobs created by agriculture. According to government statistics, 25 percent of all jobs are in the agricultural sector, but officials in MINAGRI estimate that the number exceeds 40 percent when linkages are taken into account (Juan Escobar, Director of Planning, MINAGRI, pers. comm.).

Table 10. Estimated expanded value added from agriculture, selected countries

Country [a]	Official agricultural GDP share (%)	Expanded agricultural GDP share (%)	% increase in share due to forward and backward linkages
Chile 1996 I-O matrix, 2001 GDP	4.92	9.32	89.43
Colombia 2000 SAM matrix, 2000 GDP	14.42	18.51	28.36
Mexico 1980 I-O matrix, 2002 GDP	5.26	8.00	52.09
Country	**Agriculture share in national VA (%)**	**Expanded agriculture share in VA (%)**	**% increase in share due to forward and backward linkages**
Chile 2008 I-O matrix, 2008 VA [b]	3.82	6.41	45.36
Nicaragua 2006 I-O matrix, 2006 VA [c]	23.47	27.28	16.23
Peru 2007 I-O matrix, 2007 VA	7.31	11.32	54.86

[a] de Ferranti et al. (2005), [b] Foster and Valdes (2015), [c] World Bank (2015)

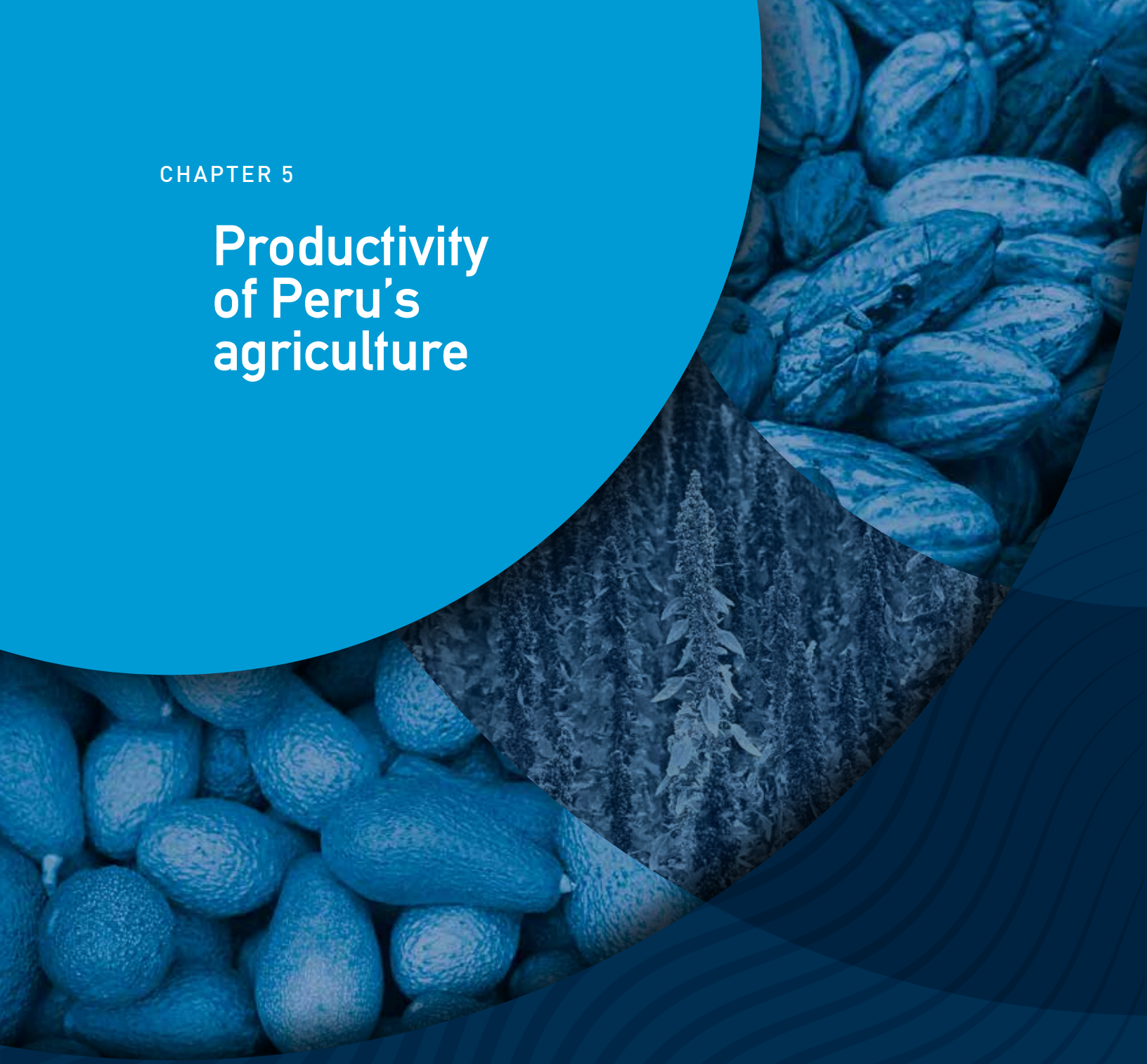
Source: Author's calculations based on official data.

In the case of Peru, Tables A1.1 to A1.3 in Annex 1 illustrate the extent and magnitude of the linkages between agriculture and various downstream activities. Table A1.3 lists 29 activities accounting for 17 percent of total value added in the economy to which agriculture is linked, including processing and preserving of meat, and manufacture of pasta, fish meal and oil, and other food products. In many cases, the strength of the linkages is significant. For example, Table A1.1 shows the heavy dependence of the meat sector on primary agriculture; animals make up over 90 percent of the cost of production of meat. Similarly, from Table A1.2, grapes alone account for 30 percent of the cost of production of wine. Given that many manufacturing activities are highly dependent on sales from agriculture, their performance is inextricably linked to performance in the crops and livestock sectors, making them good candidates for a cluster development strategy.

Recognition of the economic importance of the larger food system could change the perceptions of policy makers about what should be the priorities for Peru's national development strategy. The lack of appreciation of the economic contributions made by primary agriculture through forward and backward linkages likely explains what appears to have been chronic public underinvestment in the sector. According to a recent public expenditure review for Peru (World Bank, 2012), public spending on agriculture expressed as a percentage of GDP remained low throughout the 2000-2010 period, starting at 0.7 percent, dipping to 0.3 percent, and ending at 0.6 percent. During the same period, total public spending increased from S/. 1.3 billion to S/. 2.5 billion. In other words, public spending on agriculture fell sharply as a proportion of total public spending. The lagging public investment in agriculture may have resulted in part from a lack of appreciation on the part of policy makers of the true importance of agriculture. Had an expanded measure of value added been available, it likely would have been much easier to make the case for a higher level of public investment.

CHAPTER 5

Productivity of Peru's agriculture



Productivity of Peru's agriculture

5.1 Introduction

How productive is Peruvian agriculture? What has been driving productivity growth in the sector in recent years, and are the traditional sources of productivity growth sustainable? Going forward, are there opportunities to accelerate productivity growth by tapping into new sources of growth? And do the answers to these questions differ by region? In the Costa region, have high levels of productivity growth been driven mainly by the uptake of high-value crops, and is this strategy sustainable? In the Sierra region, should farmers be encouraged to adopt improved technology for the production of traditional staples such as potatoes and maize, or should the focus be on encouraging them to substitute into high-value crops? In the Selva region, is rapid expansion of cropped area and cultivated pastures a sustainable path for agricultural growth, or should there be more emphasis on intensification?

Productivity growth in Peruvian agriculture appears robust compared to productivity growth in other countries in Latin America (Figure 11). Since 1990, Total Factor Productivity (TFP) growth in the agricultural sector has doubled compared to previous decades, increasing at an average annual rate of 2 to 3 percent (Ludena, 2010; Trindade and Fulginiti, 2015; USDA, 2016). While Peru's performance ranks high within the region, the "technological frontier" for agriculture is set in industrialized countries, and compared to them, Latin American countries continue

to lag (Fulginiti and Perrin 1993, 1997, 1998, and 1999; Arnade, 1998; Bravo-Ortega and Lederman, 2005; Coelli and Rao, 2005).[14]

Table 11. Total Factor Productivity (TFP) growth, agriculture, Peru, 1960-2103

	1961-70	1971-80	1981-90	1991-00	2001-10	2001-13	2004-13
Mexico	0.0279	0.0202	-0.0204	0.0282	0.0190	0.0181	0.0156
Colombia	0.0129	0.0239	0.0134	0.0169	0.0148	0.0111	0.0085
Ecuador	-0.0004	0.0016	0.0211	0.0142	0.0169	0.0126	0.0113
Peru	0.0074	-0.0122	-0.0027	0.0187	0.0297	0.0280	0.0287
Brazil	0.0018	0.0103	0.0295	0.0240	0.0383	0.0316	0.0296
Chile	0.0138	0.0209	0.0096	0.0175	0.0250	0.0256	0.0291

Source: USDA 2013.

Despite the relatively robust productivity growth recorded in recent years, the news from Peru's agricultural sector has not been uniformly good. While the macro-level data suggest that agricultural productivity has been rising, it is clear that significant differences persist between regions and between categories of producers. Agriculture in Peru encompasses several sharply contrasting realities. One reality, visible throughout much of the Costa region as well as in a few advantageously located and better-endowed areas of the Selva region, features dynamic, highly productive, commercially successful agricultural systems that are well integrated into local and/or international value chains and that provide acceptable livelihoods for participants. The other reality, much more common throughout large areas of the Sierra and Selva regions, features static, unproductive, subsistence-oriented agricultural systems that are poorly integrated into the market and afford unacceptable livelihoods for participants. According to the 2012 Census, 80 percent of agricultural units have less than 5 ha, and large numbers of these smallholder farms still engage in low-input/low-output agriculture, producing well inside the production possibilities frontier. Many make limited use of improved technologies, including seed of modern crop varieties, fertilizer, crop chemicals, machinery, and irrigation. What is more, for

14 Relatively few studies have analyzed agricultural productivity with a focus on Peru. Galarza and Diaz (2015) use production function estimation techniques to capture departmental productivity differences, while De Los Rios (2013) focuses on technical efficiency of cotton producers in the Central and Southern Costa. A disadvantage of these studies that use farm-level data from surveys is that commercial agribusiness firms are excluded from the analysis, as they do not form part of the sample.

many farmers the use of family labor in agricultural production continues to be an important source of employment in the absence of other opportunities.

To date, relatively little effort has been made in Peru to go beyond aggregate country-level measures to explore differences in agricultural productivity across regions and between farm types and sizes. This represents an important knowledge gap, given the diversity of the production systems found in the country. Improved knowledge of patterns and trends in productivity across regions and between farm types and sizes could significantly improve understanding of the drivers of productivity and competitiveness in the agricultural sector and inform the design of policies that can help the sector adjust to meet the demands of a rapidly evolving global food economy.

This section of the report examines recent productivity trends in Peru's agricultural sector, with a particular focus on understanding how productivity growth has differed across regions and between farm types and sizes. Pooled (2007-2015) and cross-sectional (2015) survey data were used to estimate productivity measures, and the results were decomposed to reveal the sources of output growth (TFP vs. changes in input use). Output-Input intensity ratios were calculated to provide insights into the performance of individual crops within different agro-climatic regions. Finally, a stochastic production frontier model was estimated to measure technical efficiency within the agricultural sector and provide insights into the factors that are contributing to inefficiencies within and between regions and farm types.

5.2 Methodology

TFP is a measure that takes account of all of the inputs used in production and compares them with the total amount of output (in this case, crop and livestock products). TFP is defined as the ratio of total output (Y) over total inputs (X). If total output is growing faster than total inputs, TFP is said to be improving, i.e., productivity is growing.

Since TFP is measured as a residual, it is important to recognize that spatial and temporal differences in TFP can be caused by a wide range of factors. Spatial differences in TFP are commonly the result of structural factors, such as variability in climate, topography, and soil quality. Spatial differences in TFP can also result from locational differences in access to finance and to the capital embodied in infrastructure investments. By contrast, temporal differences in TFP are usually

caused by other factors, such as changes occurring over time in the mix of crops being grown, adoption of new technology, reductions in transaction costs due to the appearance of new information and communication technology (ICT), or improved connectivity to markets resulting from the construction of new transportation infrastructure. Other factors that could contribute to changes over time in TFP could be more difficult to measure, such as improved access to financial assets, the level of entrepreneurial ability within a region, and the attractiveness of a region to new entrepreneurs. In summary, TFP is a measure explained both by the context in which farmers operate and by their own decisions and productive abilities.

In contrast, technical efficiency is a concept closely related to the ability of a farm or firm to achieve the optimal combination and best use of inputs with a given technology. Unlike TFP, technical efficiency is determined by a set of factors that are largely under the control of the farm or firm. Understanding technical efficiency is useful, because it can help in identifying the factors that are undermining TFP in a given location or among a group of producers.

A combination of methods and data sources[15] was used for the TFP and technical efficiency analysis:

a. Multilateral Tornqvist-Theil (TT) analysis was used to examine aggregate trends in TFP growth across regions, using data from the Encuesta National de Hogares (ENAHO) 2007-2015, the only yearly dataset available for this purpose.
b. Multilateral TT analysis was used to map agricultural productivity within Peru, across regional domains, departments, farm-size groups, and types of producers, using data from the Encuesta National Agropecuario (ENA) 2015, the most detailed source for agricultural activities.
c. Stochastic Production Frontier (SPF) analysis was used to explore productivity drivers across regions and between groups of producers, using data from ENA 2015.

A multilateral TT index was calculated using share arithmetic means and quantity geometric means of all regions or groups of producers. Because of the way it was calculated, the TT index satisfies the property of transitivity, and it can be used to compare the relative productivity of a group of firms at a single point in time and over

15 Details about the particular features of these data sources can be found in Annex 2.

time (Caves et al., 1982).[16] The TT index captures TFP levels and changes between different groups and between discrete points in time, using the average shares from regions and time points as the weights for outputs or inputs.[17] The geometric mean of output and input, and the arithmetic mean of output and input shares, operate as a hypothetical representative country, region, or firm. The quantity estimate using a TT index is based on weights that can accommodate substantial changes in relative prices over time and space. Annex 3 provides details on the TT index and its empirical estimation, and it explains how longitudinal ENAHO data from 2007-2015 and ENA data for 2015 and specific inputs and outputs were used to model productivity using the index. The TFP calculations were performed at the regional and departmental levels, as well as for different groups of farm types and sizes. The typology of producers follows Escobal and Armas (2015) and is based on agricultural net income.

An SPF approach similar to that described in Battese and Coelli (1992) was used to measure technical efficiency, with data from the ENA. A production function was defined in terms of the maximum output that can be produced from a specified set of inputs, given the existing technology available to the firms involved. SPF analysis is a method to estimate a production frontier that reflects the current state of technology in the industry. The frontier defines the potential maximum or optimal level of production of the industry. Firms operate either on that frontier if they are technically efficient, or within the frontier if they are not technically efficient. Appendix 4 provides information on the variables used in the SPF analysis, as well as related summary statistics.

5.3 Analysis and results

5.3.1 TFP analysis by geographic area—natural regions, domains, and departments

TFP indices calculated at national and sub-national levels for the period 2007-2015 are presented in Table 12 and Figure 26 (Selva 2007 is used as the base year for all of the indices). The overall average annual TFP growth rate of 2.1 percent masks

16 Index-based methods are the standard technique for analyzing productivity differentials across time and space. Being non-parametric, they are very flexible and do not assume any specific functional form of the production function. In contrast, growth accounting methods assume a given functional form of the production function for all observations, an assumption that seems unrealistic given the heterogeneity observed in Peru across regions and between different types of producers.

17 The cost of capital was included in the TFP analysis (rent, purchase, and maintenance cost of machinery and equipment reported by family farms and firms in the ENA survey), so the TFP results should capture the effects of differential use of capital by larger vs. smaller farms. If larger farms are obtaining much lower prices than small farms, this difference could bias the results, but the range of farm sizes is fairly narrow and thus should not pose a problem. The TFP analysis using the TT Index includes a value for the cost of capital but avoids the price effect issue for output and inputs since it compares physical quantities.

notable differences between regions.[18,19] TFP grew rapidly in the Costa region, averaging 7.2 percent per year over the eight-year period, but TFP remained flat in the Sierra region (0.2 percent) and in the Selva region (-0.2 percent). The national result is very much in line with the result reported by USDA using a similar method and for a similar period (USDA 2015). These results support the widely held view that agricultural productivity has been growing rapidly in the Costa region while essentially stagnating in the Sierra and Selva regions, with the result that the gap in productivity has widened over time.

Table 12. TFP growth index by natural region, Peru, 2007-2015

	2007	2008	2009	2010	2011	2012	2013	2014	2015	Annual growth
Costa	114.7	149.3	166.5	127.4	155.5	152.4	154.2	180.9	182.9	7.2%
Sierra	102.1	68.3	76.4	87.8	109.2	107.2	79.8	86.4	85.7	-0.2%
Selva	100.0	126.6	105.0	90.8	97.5	111.3	102.8	100.6	94.4	0.2%
Total[20]	105.9	109.4	113.6	101.9	122.2	123.5	110.4	121.8	120.7	2%

Note: Selva 2007 = 100.

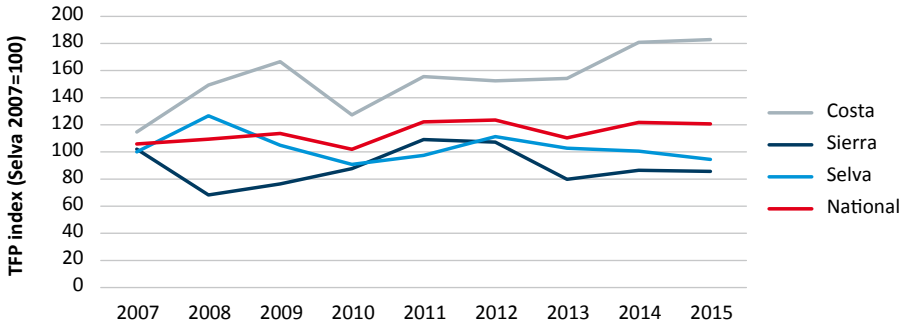
A decomposition procedure was used to analyze the sources of productivity growth in each region. TFP was decomposed to identify the relative contribution of individual factors of production and to indicate the extent to which productivity increases have resulted from intensification of factor use as opposed to improvements in efficiency. The findings provide insights into the relative attractiveness of extensification vs. intensification as potential strategies for achieving high and sustainable growth in the agricultural sector. The results of the decomposition analysis are summarized in Figure 27 and Table 13.

18 According to the Peru Systematic Country Diagnostic, aggregate productivity for the country as a whole is low and has stagnated over the past 20 years—TFP growth contributed only 11 percent to economic growth from 2000 to 2014 (World Bank 2017). While the results presented in this report use a different method for calculating TFP and therefore are not directly comparable, they show that from 2007 to 2015, the contribution of TFP growth to output growth in agriculture has been minimal in the Sierra and the Selva, but enormous in the Costa, where it has been the main contributor to output growth. The clear implication is that boosting TFP growth in the Sierra and Selva could significantly increase the contribution of agricultural growth to overall economic growth in Peru

19 The 2015 Peru report: "Hacia un sistema integrado de ciudades: una nueva visión para crecer", describes wide variance in TFP growth within the manufacturing and services sectors, with the services sector featuring many more industries with negative TFP growth than the manufacturing sector (World Bank, 2015). Interestingly, within the manufacturing sector, food manufacturing appears to play a significant role in raising aggregate TFP, because TFP growth in the food manufacturing sector has been high and because the food manufacturing sector accounts for a large share of total output. Food manufacturing arguably should be considered part of the agricultural sector, due to its high dependence on primary sector goods. The flagship study (2015) does not measure TFP for the agricultural sector, and numbers across sectors are not comparable due to differences in methodology (see Annex 3).

20 National average is the weighted average of regional estimates using revenue shares as the weights.

Figure 26. TFP growth index by natural region, Peru, 2007-2015



Source: Authors' calculations.

Figure 27. Output, input, and TFP growth index by natural region, Peru, 2007-2015

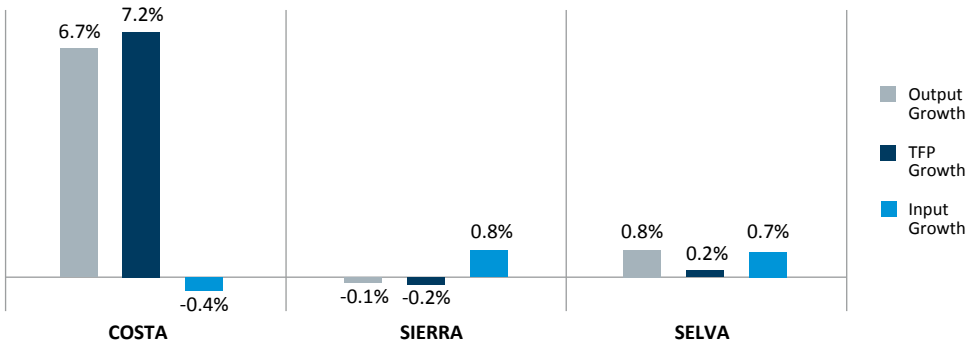


Table 13. Sources of output growth, 2007-2015

Natural region	Output growth	Sources of output growth		Input growth decomposition					
		TFP	Input	Land	Family labor	Hired labor	Intermediate inputs	Animal feed	Other inputs
Costa	6.7%	7.2%	-0.4%	0.5%	-0.4%	0.1%	0.2%	-0.5%	-0.3%
Sierra	-0.1%	-0.2%	0.8%	-0.5%	0.7%	0.1%	-0.2%	-0.3%	1.0%
Selva	0.8%	0.2%	0.7%	0.1%	0.0%	-0.2%	0.1%	0.7%	-0.1%

Source: Calculated by the authors.

In the Costa region, output growth has been driven mainly by TFP growth. Changes in input use have had a slightly negative impact on output. The input growth decomposition exercise shows differences in the contributions of individual inputs: agricultural land, hired labor, and intermediate inputs have made small positive contributions to output growth, while family labor, animal feed, and other inputs have made small negative contributions to output growth. The robust TFP growth observed in the Costa region likely has resulted from expansion of the area planted to high-value crops, including export crops, partly through expansion of total cultivated area, and partly by substitution of high-value crops for low-value crops that were previously being cultivated.

Figure 28. TFP index, by geographical domain

In the Sierra region, output growth has been driven mainly by increased use of labor, both family labor and hired labor. The increased use of labor may reflect the lack of off-farm opportunities in the Sierra region, where members of rural households have little choice but to continue working on their own farms or selling labor services to other farms. The fact that average farm sizes in the Sierra region are so small means that agricultural workers have limited possibilities for escaping from poverty.

In the Selva region, output growth has been driven partly by TFP growth and partly by input growth. Noteworthy in the input growth decomposition is the relatively large contribution of animal feed. The relatively low TFP growth in the Selva region could be explained by the low productivity of recently deforested land; according to a recent report on the national program for forest conservation,[21] recently

21 The document can be found here: http://www.bosques.gob.pe/archivo/ec4e0b_documento_prioridades.pdf.

deforested land is usually of low quality, with limited capacity for agricultural purposes. Another contributing factor could be the fact that coffee and cocoa farming is expanding in the Selva region, and many coffee and cocoa plantations have low productive capacity for several years following their initial establishment.

When the TFP analysis is disaggregated by Peru's seven geographical domains and 24 departments, the results are similar (for details, see Appendix 2 and Figure 28). Generally speaking, the results are consistent with previous analyses showing that while there is considerable spatial variability in productivity levels, the Costa region is by far the most productive region in the country, and the Sierra region is the least productive region. When the TFP analysis is disaggregated into the crops and livestock sectors, the regional rankings remain unchanged, but in the case of livestock the gap between the regions narrows considerably, which attests to the relatively high productivity of many of the extensive livestock systems found in the Sierra region. Livestock productivity is also very high in the Central Costa region, however, reflecting the high productivity of the many modern livestock production systems concentrated around Lima (including dairy, beef, hog, and poultry systems).

For the more disaggregated analysis, input shares and intensity of input use were also analyzed (for details, see Appendix 2). Across all seven geographical domains and 24 departments, the importance of family labor stands out, particularly in the Sierra region, and to a lesser extent in the Selva region. In the Sierra region, expenditures on family labor account for more than 60 percent of total expenditures on all inputs. In contrast, family labor is much less important in the Costa region, where hired labor and intermediate inputs (including manure, chemical fertilizer, pesticides, and seed) are particularly important. Land appears as an important input in many domains in the Costa and the Selva regions. Finally, it is interesting to observe the low use of capital (equipment and machinery) in all regions, particularly the Sierra region.

The results of the TFP analysis confirm the existence of marked regional differences in levels of productivity, historical rates of productivity growth, and sources of productivity growth. The results furthermore support the view that the high productivity levels and robust rates of productivity growth observed in recent years in the Costa region have resulted from the rapid expansion of the exportable crop sector (vegetables and fruits) and the associated widespread uptake of improved production technologies for those crops.

To further explore this hypothesis, crop-level analysis was carried out, with the goal of assessing the productivity of individual crops and estimating the levels of input use associated with the production of individual crops. As it was not possible to calculate TFP measures at the crop level,[22] productivity for individual crops was approximated by the ratio of output value over input value. Although this ratio does not measure TFP, it provides a reasonably good approximation of total productivity in the absence of crop-specific data.[23] The analysis was performed for a set of crops in the three natural regions using information from a sample of single-crop farmers (defined as farmers having 80 percent or more of their cultivated area planted to a single crop). Although the sample of single-crop farmers was not representative at the regional level, the selection procedure ensured that the sample included enough observations that valid conclusions could be drawn for each crop.

Table 14. Output value to input value ratios for selected crops, by region

Crop	Costa	Sierra	Selva	National
Asparagus	1.85			1.85
Banana	2.36		1.21	1.74
Mango	1.45			1.35
Rice	1.26		1.12	1.21
Sugar cane	1.16			1.07
Coffee		0.87	1.11	1.07
Cocoa			1.06	1.07
Avocado	1.58	0.79		1.03
Grape	0.94			0.99
Yucca			0.78	0.76
Potato		0.42		0.43
Maize	0.74	0.29	0.64	0.39

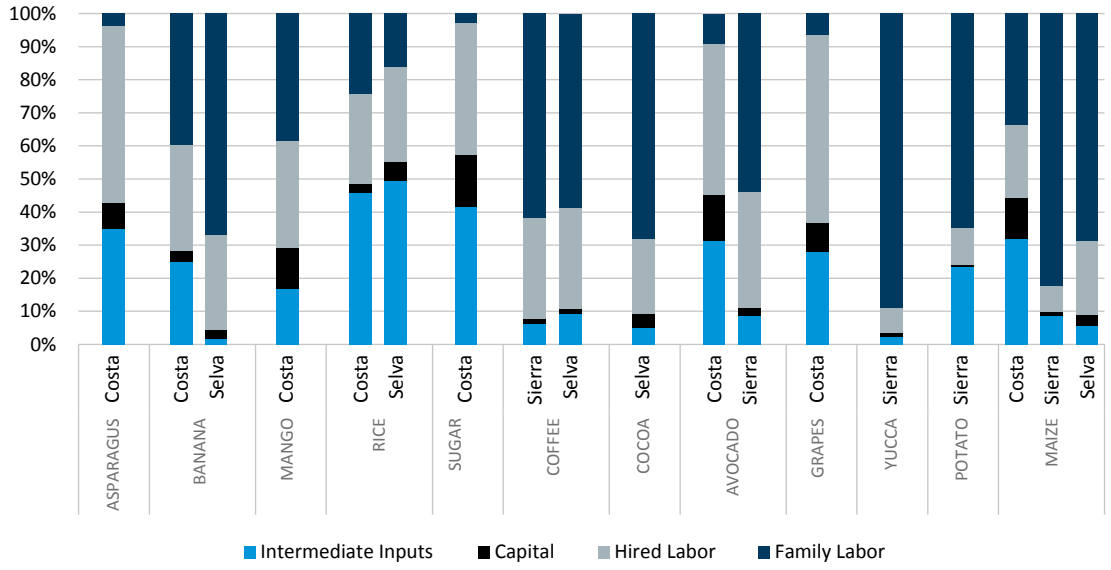
Source: Authors' calculations.

22 The ENA survey is not representative at this level and most Peruvian farmers are involved in mixed agricultural strategies, typically producing more than one crop and/or livestock commodity. Since input values and quantities are reported at the farm level, it is not possible to accurately associate input use to specific crop products.

23 For instance, the correlation coefficient between TFP and output value to input value ratio was 0.89 in the case of domains, 0.98 in the case of farmer types, 0.97 in the case of farm-size groups, and 0.75 in the case of departments.

The output value to input value ratios for a set of exportable and non-exportable products are shown in Table 14. The ratios are consistently high for crops grown in the Costa region (bananas, asparagus, mangos, avocados), both in absolute terms and relative to other regions, reflecting the generally high levels of productivity in the Costa region. For example, in the case of bananas the ratio in the Costa region is 2.36, more than twice as high as the 1.21 observed in the Selva region. These results likely derive from greater use of improved production technologies in the Costa region along with higher levels of input use, although they might also reflect differences between the two regions in destination markets. Bananas produced in the Costa region go mainly to international markets, whereas bananas produced in the Selva region are sold almost exclusively in local markets. A similar scenario pertains to avocados; avocado farmers in the Costa region make greater use of improved production technologies and apply higher levels of inputs, but they also increasingly have been specializing in the production of the Hass variety for export, while avocado producers in the Sierra region continue to produce mainly the Fuerte variety for local markets. The regional differences can be observed not only in non-traditional export crops, but also in traditional crops that are consumed domestically, such as rice and maize.

Figure 29. Input shares of selected crops, by region



Source: Authors' calculations.

Input shares associated with the same set of crops shown in Table 14 are presented in Figure 29. The input shares are classified into technological inputs (intermediate inputs, capital, and hired labor) and traditional inputs (family labor), with the aim of distinguishing between "technological production" and "traditional production." The input share data show that production methods prevailing in the Costa region are much more technological in terms of input use than production methods prevailing in the Sierra and Selva regions, in the sense that they rely much more heavily on the use of hired labor, intermediate inputs, and capital. In contrast, most of the production methods prevailing in the Sierra and Selva regions rely heavily on the use of family labor, which in nearly all cases represents 50 percent or more of the total input costs.[24]

The case of avocado provides a good example of "technological production" vs. "traditional production." As shown by the data in Figure 29, avocado producers in the Costa region use large amounts of hired labor (34 percent expenditure share), intermediate inputs (23 percent expenditure share), and capital (10 expenditure share), but they use only a small amount of family labor (7 percent expenditure share). In contrast, the avocado producers in the Sierra region rely heavily on family labor as the main production input (48 percent expenditure share), while the amounts used of hired labor, intermediate inputs, and capital are considerably lower than in the Costa region.

The distinction between "technological production" and "traditional production" applies not only to high-value export crops. As can be seen in the case of maize, which is produced mainly for domestic consumption, input use patterns clearly differ along the same lines between the Costa, Sierra, and Selva regions.

5.3.2 TFP analysis by farm size and type of producer

To what extent does agricultural productivity in Peru vary according to the characteristics of the farmer? With the aim of exploring differences in productivity between different groups of farmers, the TFP analysis was disaggregated by farm size and type of producer.

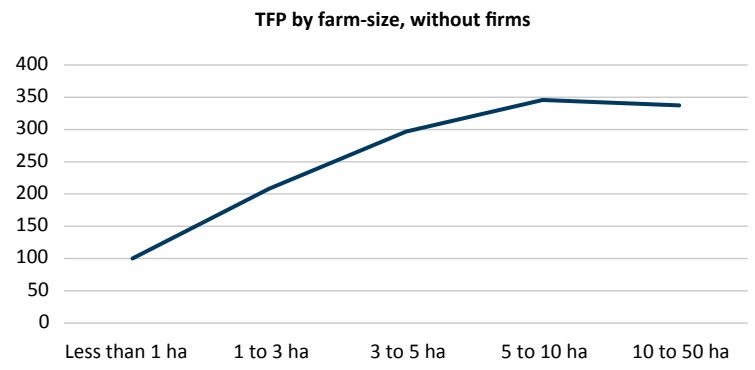
24 The use of family labor instead of contract labor depends on the opportunity cost of family labor. In the Sierra and Selva regions, the opportunity cost of family labor is likely very low.

Table 15. TFP levels by farm size, without and with firms

Farm size	TFP (without firms)				TFP (with firms) Total
	Total	Crops	Livestock	Total (irrigated equivalent area)	
< 1 ha	100	100	100	100	100
1 - 3 ha	208	234	168	221	210
3 - 5 ha	297	343	193	289	304
5 - 10 ha	346	405	205	328	359
10 - 50 ha	338	385	199	285	336
> 50 ha	---	---	---	---	201

Note: In the "without-firms" analysis, which includes the disaggregation between crops and livestock, farms larger than 50 ha were omitted, because there was an insufficient number of observations to make separate inferences for crops and livestock for farms in that size category.

Figure 30. TFP by farm size, Peru (index, <1 ha = 100)



Source: Authors' calculations.

The relationship between farm size and TFP appears to be positive, flattening out beyond 10 ha when firms are not included (Table 15, Figure 30). Farmers with extremely small landholdings of less than 1 ha show the lowest levels of TFP. As farm size increases, so does TFP, but TFP remains unchanged or even

decreases a bit when farm size exceeds 10 ha. When the sample is expanded to include firms (defined as farms exceeding 50 ha in size), TFP in the largest farm-size category declines sharply, falling below the level observed in the second smallest farm-size category. When the same relationship was estimated using irrigated-equivalent area to take into account differences in land productivity, the results were very similar, suggesting that the relationship holds up across a range of land qualities. These results, however, are strongly influenced by the farm-size cut-off points that were chosen to divide the sample into farm-size categories.[25]

The relationship between farm size and productivity has often been assessed using crop yields (land productivity) as a measure of productivity. The consensus in the literature is that farm size and land productivity are inversely related (IR). More recently, some authors have concluded that the relationship is actually U-shaped (higher for small farms, lower for medium-sized farms, and higher again for large farms), but the upturn among larger farms has not always been observed because large farms often are not present in significant numbers.[26] Binswanger et al. (1995) and others have argued that total factor productivity (TFP) is a better measure of productivity when considering the relationship with farm size, because TFP captures the productivity with which all inputs are used in the production process. From a policy perspective, it is important to consider the productivity of land, labor, and capital in the production process, particularly when considering land reform.[27] TFP as described earlier is a more comprehensive measure defined as the output produced per unit of input, where prices are typically used to weight the output and input quantities.

25 These cut-off points were chosen because they concentrate a suitable number of observations for making comparisons across farm-size groups. For instance, 61 percent of farms in the sample are less than or equal to 1 ha, 24 percent are between 1 and 3 ha, 7 percent are between 3 and 5 ha, 5 percent are between 5 and 10 ha, and 3 percent are between 10 and 50 ha. We decided not to further disaggregate farm sizes below 1 ha (although there were enough observations to do so), because we thought it would not be very useful to analyze productivity differences across such tiny farms.

26 In the past, many studies found an inverse relationship (for example, see Sen 1962, 1966; Carter, 1984; Eswaran and Kotwal, 1985, 1986; Barrett, 1996; Alvarez and Arias, 2004; Barrett et al., 2010; Carletto et al., 2013; Kagin et al., 2015). Binswanger et al. (1995) and Eastwood et al. (2010) review the theoretical and empirical evidence surrounding the farm size-productivity debate. As noted, recent work suggests that the relationship is a U-shaped (for example, see Foster and Rosenzweig, 2017; Kevane, 1996; Zaibet and Dunn, 1998). These authors find that the U-shaped relationship often is missed because many empirical studies use surveys that do not capture enough farms above 10 acres (4 ha), as bigger farms would have to be oversampled.

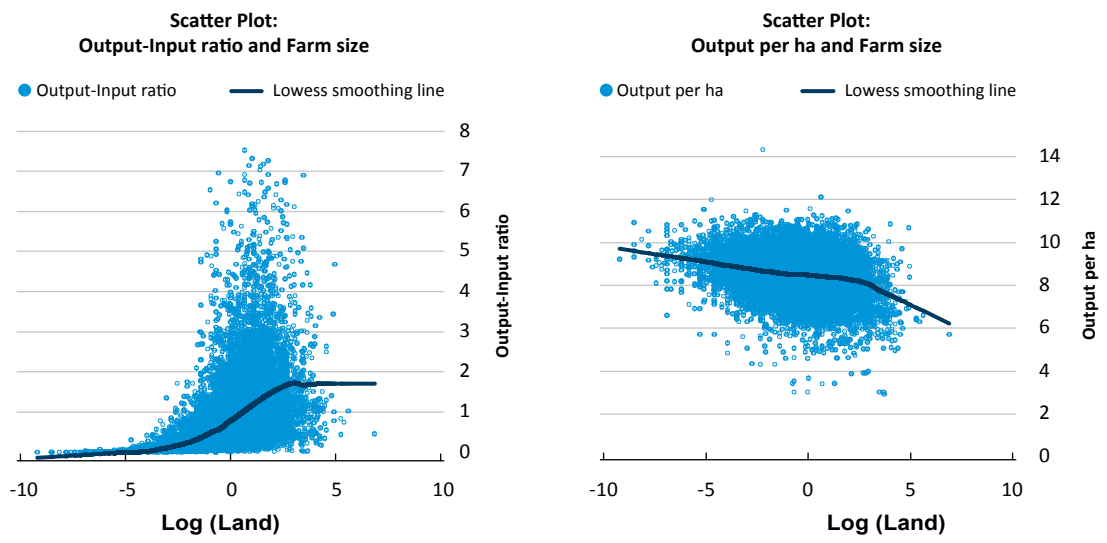
27 According to Helfand and Taylor (2017), use of yield and other partial measures of productivity to capture the farm-size–productivity relationship is widespread in the literature and an important weakness. "Theoretically it is clear that an inverse relationship between yield and farm size is neither necessary nor sufficient for an inverse relationship to exist between farm size and TFP. This is an important point, as empirical evidence on the yield and farm size relationship has driven the modern debate on the existence and determinants of the IR, and is often referenced in policy making, particularly in issues of land reform."(p.33).

Because most analytical work measuring the relationship between TFP and farm size is quite recent, there is still no clear consensus on the precise relationship. Key (2017), Sheng and Chancellor (2017), and Helfand and Taylor (2017) recently estimated the TFP–farm size relationship using data from the USA, Australia, and Brazil, respectively. The first two studies provide evidence of a positive concave relationship between farm size and productivity, indicating that large farms perform better than small farms in TFP. Helfand and Taylor's analysis in Brazil similarly shows that the largest farms have notably higher productivity than the smaller farm-size classes, though the relationship for farm sizes up to 100 ha appears to be flatter or marginally decreasing convex.

For Peru, small farms show high yields but low productivity (TFP), which may be related to the more intensive use of inputs on small farms, especially family labor (when it is included, as it is in this case). Larger farms, on the other hand, may be favored by the use of different technologies that allow them to attain higher productivity levels. These two considerations would allow farmers to achieve lower unit production costs as the scale of production increases. Moreover, the fact that the input mix differs between small and large farms (Table 13) indicates differences in production technology between farm sizes, implying differences in productivity that in this case favor large farms (Sheng et al., 2015; Kagin, Taylor, Yuñez-Naude, 2015).

Figure 31a shows a positive relationship between farm size and output-input value ratio (a proxy for TFP that can be calculated at the farm level), and a negative relationship between farm size and output value per hectare. The first result, which is a way to evaluate the farm size–TFP relationship in a continuous setting, is consistent with the positive relationship between farm-size and TFP (shown in Table 15). However, the data suggest a positive relationship that becomes flat after approximately 10 ha, not necessarily a concave relationship. The second result (Figure 31b) is very much in line with results from the many papers that have analyzed the farm size–productivity relationship, since they generally use yields or output value per hectare as the dependent variable.

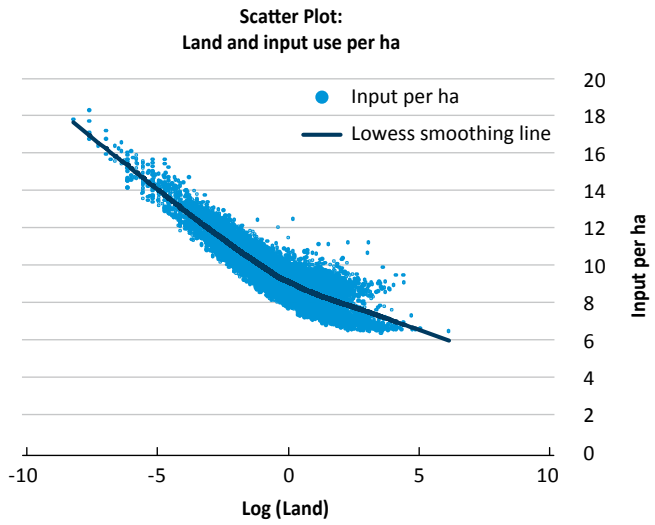
Figure 31. (a) Farm size and output-input ratio, (b) farm size and output per hectare



Source: Authors' calculations.

Taken together, these results suggest that while small farms may have higher land productivity, the efficiency or intensity with which all inputs are used is higher among larger farms. In his well-known paper, Carter (1984) recognized that although small farms produce more output per hectare, they tend to be less efficient since they use more inputs per hectare than do large farms. The relationship between farm size and input value per hectare shown in Figure 32 is negative, consistent with Carter's findings, but this time the negative slope is much steeper. Together, the results from the last two figures suggest that small farms produce more output per hectare, but they use even more inputs per hectare. As a result, small farms tend to be less productive than large farms, as suggested by the TFP results, and consistent with the positive relationship between the output-input ratio and farm size.

Figure 32. Farm size and input per hectare



Source: Authors' calculations.

When the multilateral TT approach is used to estimate the TFP–farm size relationship at the national level, an important concern is whether productivity and farm size vary across regions in some systematic way. While it is reasonable, and common practice in the literature, to estimate the farm size–productivity relationship at the aggregate national level, in this instance, because of the known differences across the Costa, Sierra, and Selva regions in farm size and factor usage, a possible concern with the TT index approach is the implicit assumption of a common production technology. To explore this issue, and as a robustness check, TFP measures for different farm-size groups were calculated for each region (see Annex 5). We present caveats regarding the distribution of farm-size groups within each region—that is, if the distribution of farmers across farm-size categories in each region is fairly balanced.

Generally speaking, the regional results show the same positive relationship between farm size and TFP that was observed at the national level. In the Costa region only, a slight downturn in TFP was observed in the largest farm-size group (10-50 ha), but it is likely that the downturn observed in the Costa region is driven by the limited number of observations in the Costa region in the 10-50 ha farm-size category. The observed downturn at the national level in the TFP–farm-size relationship among very large farms thus is most likely driven by the apparently

anomalous results from the Costa region. To further test the robustness of the results, an alternative farm-size grouping based on farm-size quintiles defined within each region was used to balance the distribution of observations among groups. Using this alternative grouping, the relationship between TFP and farm size was again found to be positive in all regions. When the alternative approach is used, a flattening or downturn of the relationship beyond 10 ha is not observed.

TFP was calculated for four types of producers, as defined by Escobal and Armas (2016): (1) subsistence agriculture, (2) agriculture in transition 1, (3) agriculture in transition 2, and (4) consolidated agriculture.[28] TFP is strongly correlated with the type of producer (Table 16).[29] TFP is lowest among producers who are engaged in subsistence agriculture and increases steadily as the type of agriculture being practiced becomes more and more commercially oriented. The pattern is similar in both the crop and livestock sectors, although in the case of the livestock sector, the difference between the two extremes is larger.

Table 16. TFP levels by type of producer, without and with firms

Type of producer	TFP (w/o firms)			TFP (w/ firms)
	Total	Crops	Livestock	
Subsistence agriculture	26	24	19	46
Agriculture in transition 1	60	55	45	56
Agriculture in transition 2	77	71	59	74
Consolidated agriculture	100	100	100	100

Note: In the "without-firms" analysis, which includes the disaggregation between crops and livestock, farms larger than 50 ha were omitted, because there was an insufficient number of observations to make separate inferences for crops and livestock for farms in that size category.

Source: Authors' calculations.

Analysis of the distribution of input shares[30] by farm size and type of producer shows a strong relationship between input use and farm size or farmer typology. Larger farms and more consolidated producers are much more likely to engage

28 See Annex 3 for a detailed description of the Escobal and Armas typology and its relevance for Peru.

29 The TFP analysis and the subsequent SPF analysis is disaggregated by producer type, rather than by farm-size group, because the producer typology proposed by Escobal and Armas is used broadly in the Peruvian empirical context. Despite being derived from net agricultural household income (an outcome of productivity), it captures many key structural characteristics of farms and households, all of which remain persistently monotonic across the typologies ranging from subsistence to consolidated (see Annex 3). Similar to the relationship between TFP and farm size, the relationship between TFP and producer type shows an increasing relationship as one moves from subsistence to consolidated farming.

30 Not shown here; available upon request.

in "technological production," using higher levels of technological inputs (hired labor, intermediate inputs, capital) and land. Smaller farms and subsistence-oriented producers are much more likely to engage in "traditional production," relying much more heavily on family labor. Although the variability in input use could be caused to some extent by differences in the mix of crop production and livestock production activities, as well as by systematic differences in agro-climatic conditions (for example, soil quality), overall the results make it clear that larger farms and more consolidated producers are more technologically intensive.

5.3.3 Analyzing technical efficiency in Peruvian agriculture through SPF analysis

To explore sources of variability in farm-level productivity and efficiency in Peru, SPF analysis was used to assess the sensitivity of production to different inputs and other factors. The production function was assumed to have a translog functional form (following Seymour, 2016; Lien et al., 2016; Yang et al., 2016; Ainembabazi et al., 2016; Sauer et al., 2015; Pfeiffer et al., 2009; Fulginiti et al., 2004; Ayenew, 2017; Melo-Becerra y Orosco, 2017). The translog functional form was selected over the commonly used Cobb-Douglas functional form because the translog form is more flexible; unlike the Cobb-Douglas form, it does not require the elasticity of substitution between factors of production to be constant.[31]

Based on the available data, a single-step Maximum Likelihood procedure described by Kumbhakar, Wang, and Horncastle (2015) was used to estimate simultaneously the parameters of the production frontier and the exogenous determinants of inefficiency (for details, see Annex 3). One advantage of this procedure is that it allows estimation of efficiency scores for individual farms and at the same time exploration of the effects of exogenous variables on the efficiency scores. Major categories of inputs were included as explanatory variables (expressed in value per hectare), as were several variables designed to account for variability in exogenous factors such as soil quality and climate (precipitation and temperature). The results of the SPF analysis provide insights into the distribution of farms by efficiency level, which will be helpful in identifying regions and farming systems where there are significant opportunities to boost farm-level productivity through targeted interventions.

31 To test the robustness of the results obtained using the translog functional form, estimation was also done using a Cobb-Douglas specification. The results did not change significantly. A generalized likelihood-ratio test was performed to determine the best specification for the model. Based on the test, the translog specification was preferred.

Results of the translog SPF model, in which the dependent variable is the value of agricultural output (expressed in logarithms), are reported in Table 17 (parameter elasticities of the production frontier) and Table 18 (exogenous determinants of inefficiency).

Table 17. Stochastic Production Frontier (SPF) model results, summary results of estimation

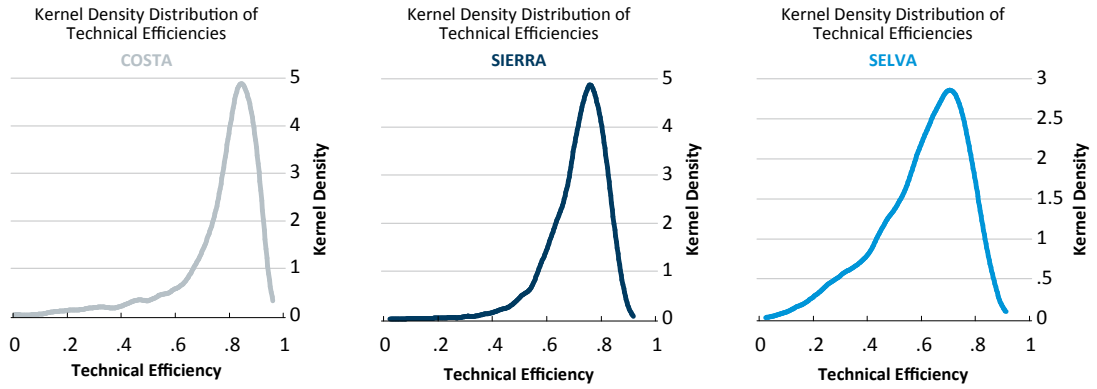
Log (Value of crop output per ha of cultivated land)	Natural region			Producer type			
Elasticities	**Costa**	**Sierra**	**Selva**	**Type 1**	**Type 2**	**Type 3**	**Type 4**
Intermediate inputs	0.18	0.23	0.02	0.18	0.10	0.09	0.11
Labor	0.08	0.09	0.12	0.16	0.36	0.38	0.27
Land	0.67	0.68	0.70	0.55	0.30	0.29	0.39
Capital	0.00	-0.05	0.03	-0.04	-0.03	-0.04	-0.02
Other inputs	0.07	0.03	0.01	0.04	0.02	0.01	0.03
Returns to scale	**0.99**	**0.97**	**0.87**	**0.88**	**0.75**	**0.73**	**0.79**
Error distribution assumption	**Half Normal**	**Half Normal**	**Half Normal**	**Half Normal**	**Half Normal**	**Half Normal**	**Half Normal**
Model	**Translog**	**Translog**	**Translog**	**Translog**	**Translog**	**Translog**	**Translog**
Explanatory variables: Input intensities (II,L,A,K,O)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Explanatory variables: Weather and soil	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Department fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,731	14,003	4,965	15,280	2,578	3,213	2,628
Chi2	25,798	53,609	16,284	50,149	5,689	7,229	6,048
Log-Likelihood	-4,544	-12,932	-4,567	-13,326	-1,454	-1,992	-2,075
Probability > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Notes: Standard errors in parentheses. * p < 0,10; **p < 0,05; ***p < 0,01

In the top part of Table 17, the estimated elasticities of all inputs exhibit the expected sign. The Sierra and Costa regions exhibit the highest elasticity in the value of production with respect to changes in the mix of intermediate inputs, implying that producers in those regions have greater flexibility to increase production by changing the mix of inputs. By contrast, in the Selva region the value of production is much less sensitive to changes in the mix of inputs. As expected, in all regions the value of production is most sensitive to changes in land: the elasticity of production with respect to land ranges from 0.67 to 0.70. Also as expected, elasticities of production with respect to input mix vary by producer type, with the contribution of different inputs to production varying across producer types. Among subsistence producers, production is most affected by changes in land, while among transitional farmers production is more sensitive to changes in labor. In the bottom part of Table 17, information appears relating to the model specifications for the SPF analysis, the numbers of observations by group, and the results of tests for statistical significance of different models across regions and producer types.

Figure 33 provides an indication of the degree of dispersion within each region in the technical efficiency of individual producers. The distributions are not directly comparable, however, because each model was estimated independently. In the Costa region, the distribution is consistent with most farmers operating at high levels of efficiency, with relatively less variance. In the Selva region, the distribution shows greater dispersion in levels of efficiency, and farmers appear to be much more heterogeneous with respect to efficiency. In the Sierra region, the distribution falls between those of the other two regions.

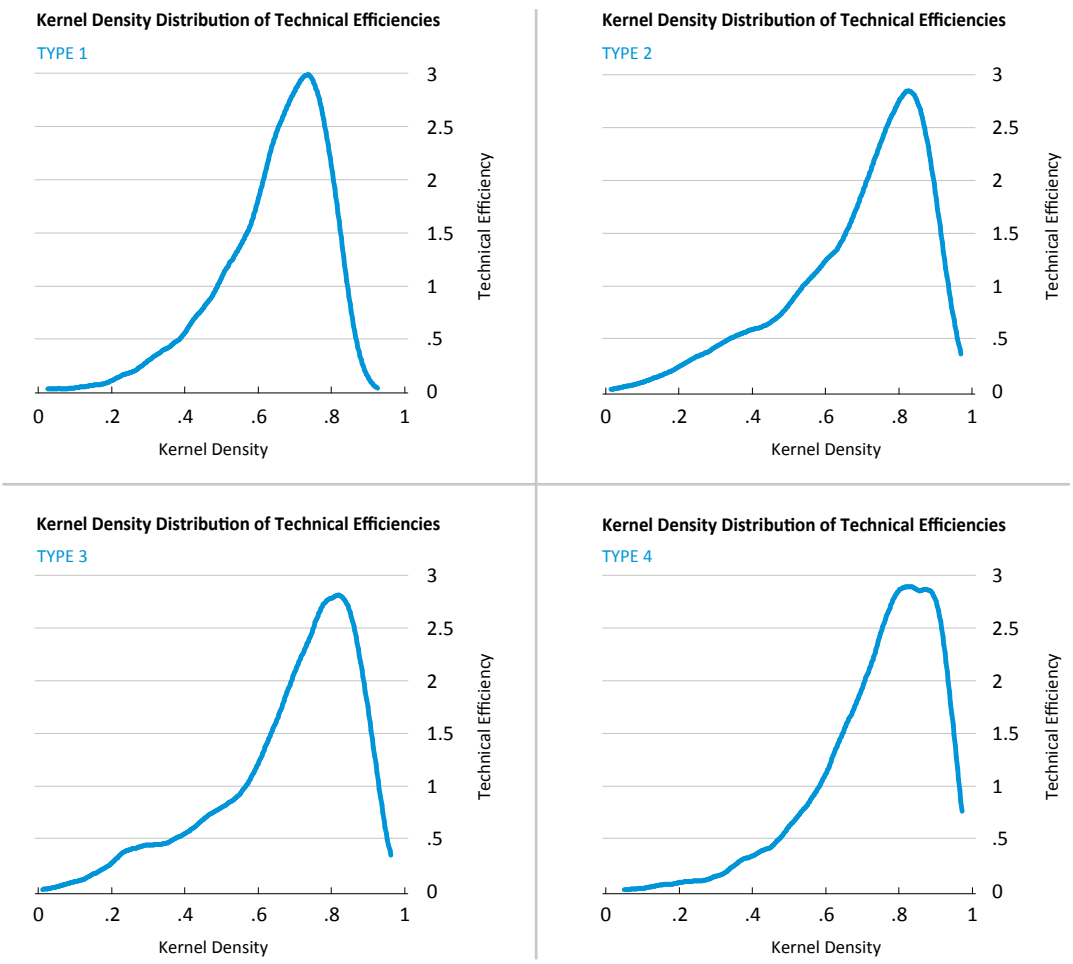
Figure 33. Kernel density distributions of technical efficiencies by regions



Source: Authors' calculations.

Figure 34 provides an indication of the degree of dispersion within groups of producers in technical efficiency. Among consolidated farmers (Type 1), the distribution is tighter and the peak of the distribution is located closer to the efficiency frontier, indicating that most consolidated farmers are already operating at relatively high levels of efficiency. For subsistence farmers (Type 4), the distribution is flatter and the peak of the distribution is located further away from the efficiency frontier, indicating that efficiency among subsistence farmers is more variable and that relatively large numbers of subsistence farmers are operating at some distance from the frontier. With respect to transition farmers (Types 2 and 3), the shapes of the distributions are similar to that observed among consolidated farmers, although among transition farmers the mean efficiencies are lower.

Figure 34. Kernel density distributions of technical efficiencies by type of farmer



Source: Authors' calculations.

Each model was estimated separately, so the results are not directly comparable (because each sample likely contained a different mix of production technologies). Nonetheless, it is clear that producers in the Selva region are likely to be operating at low levels of efficiency compared to producers in the other two regions. This difference could be related to the greater use in the Selva region of extensive farming practices. In addition, in the Selva region efficiency scores have higher variance and standard deviation on average, suggesting greater heterogeneity in farm efficiency levels compared to the other two regions.

Table 18 presents estimates of the marginal effects of exogenous determinants of efficiency, broken down by region and type of producer (for details of the modeling approach, see Appendix 4). Due to nonlinearities of the model, the estimated coefficients are not directly interpretable; only their direction and level of significance are meaningful. For this reason, Table 18 presents marginal effects calculated from the estimated coefficients following a method described by Kumbhakar, Wang, and Horncastle (2015).[32]

Table 18. Inefficiency components—Stochastic Production Frontier, by region and farmer type

Marginal effects of inefficiency drivers	By natural region			By producer type			
	Costa	Sierra	Selva	Type 1	Type 2	Type 3	Type 4
	Mg. Eff.	Mg. Eff.	Mg. Eff.	Mg. Eff.	Mg. Eff.	Mg. Eff.	Mg. Eff.
Association dummy (yes=1)	-0.0680	-0.0403	-0.0985 ***	-0.0406 *	-0.0193	-0.0257	-0.0258
Livestock dummy (yes=1)	0.0014	-0.0268 *	0.0444 **	-0.0186 *	0.3953 ***	0.4088 ***	0.4019 ***
District cell phone coverage (%)	-0.0005	0.0000	0.0002	0.0001	-0.0002	0.0007 *	0.0003
Share of households with electricity access (district level) (%)	-0.0007	-0.0011 ***	0.0006	-0.0014 ***	0.0003	-0.0018 ***	-0.0013 **
Distance to nearest city with population above 50 000	0.0005 **	0.0000	-0.0002 **	-0.0001	0.0003 **	0.0004 ***	0.0003 ***

32 Some authors include farm size in the inefficiency equation, while others have deemed it unnecessary. The SPF analysis was repeated including the land (farm size) variable in the inefficiency equation. Including farm size in the inefficiency equation does not alter the magnitude and significance of other coefficients.

Table 18. Inefficiency components—Stochastic Production Frontier, by region and farmer type *(continued)*

Marginal effects of inefficiency drivers	By natural region			By producer type			
	Costa	Sierra	Selva	Type 1	Type 2	Type 3	Type 4
	Mg. Eff.	Mg. Eff.	Mg. Eff.	Mg. Eff.	Mg. Eff.	Mg. Eff.	Mg. Eff.
Extension and advisory services dummy	-0.0852 *	-0.1429 ***	-0.1216 ***	-0.1173 ***	-0.0867 **	-0.0458	-0.0744 **
Access to information dummy (yes=1)	-0.1104 ***	-0.1277 ***	-0.0206	-0.1212 ***	-0.0837 ***	-0.0551 ***	-0.0257
Share of farmers with non-agricultural income (district level) (%)	0.0020 **	-0.0008 ***	0.0018 ***	-0.0003	0.0021 ***	0.0007	0.0021 ***
Average number of plots in the district	0.1835 ***	0.0121 ***	-0.0858 **	0.0067 *	0.0212 **	0.0669 ***	0.0417 ***
Average Herfindahl index in the district (0 to 1)	0.0005	0.0034 ***	-0.0017 *	0.0024 ***	0.0019 **	0.0027 ***	0.0014
Irrigation coverage in the district (%)	-0.0021 ***	-0.0011 ***	0.0005	-0.0003 **	-0.0004	-0.0003	-0.0012 ***
Credit access in the district (% of HH)	-0.0044 ***	-0.0018 **	-0.0044 ***	-0.0020 ***	-0.0076 ***	-0.0038 ***	-0.0023 ***
Land titling dummy (yes=1)	-0.0939 ***	-0.0258 *	0.0136	-0.0302 **	-0.0305	-0.0518 ***	-0.0109
Number of household members	0.0114 **	0.0031	-0.0032	-0.0178 ***	-0.0675 ***	-0.0771 ***	-0.0567 ***
Female producer (yes=1)	0.0570 ***	0.0375 ***	0.0224	0.0413 ***	0.0030	0.0029	0.0105
Age of producer	-0.0002	0.0010 ***	0.0009	0.0004	0.0023 ***	0.0019 ***	0.0002

Table 18. Inefficiency components—Stochastic Production Frontier, by region and farmer type *(continued)*

Marginal effects of inefficiency drivers	By natural region			By producer type			
	Costa	Sierra	Selva	Type 1	Type 2	Type 3	Type 4
	Mg. Eff.	Mg. Eff.	Mg. Eff.	Mg. Eff.	Mg. Eff.	Mg. Eff.	Mg. Eff.
% of farmers with secondary education or better in district	-0.0080 ***	-0.0016 ***	-0.0027 *	-0.0016 ***	-0.0027 ***	-0.0019 **	-0.0001
Number of observations	-0.0680	-0.0403	-0.0985 ***	-0.0406 *	-0.0193	-0.0257	-0.0258

Notes: *p < 0,10; **p < 0,05; ***p < 0,01.

Source: Authors' calculations.

Results by natural region

The results by natural region (Columns 1-3 in Table 18) show considerable heterogeneity in the contribution of different factors to inefficiency. This empirical evidence of the spatial variability and magnitude of inefficiency drivers can help policy makers identify the factors that matter the most in each natural region, which in some instances appear to go against conventional beliefs.

Regional results: Cross-cutting factors

Three factors are strongly and significantly associated with reduced levels of inefficiency in all three natural regions.

Access to technical assistance (extension and advisory services) has a significant impact on reducing inefficiency in all three regions. Access to technical assistance reduces inefficiency by 8 percent, 14 percent, and 12 percent in the Costa, Sierra, and Selva regions, respectively. This result suggests that ongoing efforts to strengthen agricultural extension services could have a major impact on productivity. Getting agents out to more remote parts of the Sierra and Selva regions, and targeting women producers in the Costa and Sierra regions, are likely to generate significant marginal gains in efficiency.

Access to credit also is significantly associated with reduced inefficiency in all three regions, although the effect is smaller. A 10 percent increase in the share of households with access to credit reduces inefficiency by nearly 4.5 percent in the Costa and Selva regions, and by 1.8 percent in the Sierra region. This result suggests that policies aimed at boosting the density of financial intermediaries and increasing the number of instruments offered to producers, financial literacy training, and provision of guarantees to financial institutions could play an important role in reducing production inefficiency.

Education is the third factor that is significantly associated with reduced inefficiency in all three regions. Education enables farmers to reduce inefficiency by taking better production decisions and achieving better integration into markets. A 10 percent increase in the share of farmers in the district with secondary education or better can reduce inefficiency by 8 percent, 1.6 percent, and 2.7 percent in the Costa, Sierra, and Selva regions, respectively. Moreover, education is shown to be significant for subsistence and transition farmers.

Regional results: Costa region

In addition to the three cross-cutting factors, other factors are associated with decreased inefficiency in the Costa region. Market integration, as measured by distance to a large city with 50,000 or more inhabitants, is associated with reduced inefficiency in the Costa region; a 100-km reduction in the distance to a large city (50,000 or more inhabitants) reduces inefficiency by 5 percent. Access to market information is associated with an 11 percent reduction in inefficiency in the Costa region.[33] Irrigation matters to some extent in the Costa region; a 10 percent increase in irrigation coverage is associated with a reduction in inefficiency of 2 percent. Finally, land titling affects inefficiency in the Costa region; farmers with titled land are 9 percent more efficient than farmers who lack titled land. The effect of titling is more pronounced in the Costa region compared to the other two regions, most likely because other restrictions in credit and land markets are not as important in the Costa region.

Interestingly, two factors were found to be associated with increased inefficiency in the Costa region. Land fragmentation, measured at the district level as the average number of plots worked by each household, is associated with increased inefficiency; one additional plot per household is associated with 18 percent more

33 A recent study by Nakasone (2014) carried out in the central highlands of Peru finds that access to market information increases prices received by producers by 13-14 percent and increases the likelihood that farmers participate in commercial activities. He also finds strong spillover effects to producers that did not receive information but were in the same communities.

inefficiency. The potential gains from reducing land fragmentation in the Costa region thus appear very large, consistent with the high land productivity in the region. Similarly, income diversification is associated with increased efficiency in the Costa region; a 10 percent increase in the share of farmers with non-agricultural income increases inefficiency by 2 percent, suggesting a diversion effect whereby rural households with non-agricultural income opportunities devote less attention to their farming activities.

Regional results: Sierra region

In addition to the three cross-cutting factors, several other factors are associated with decreased inefficiency in the Sierra region. Income diversification was found to be important in the Sierra region; a 10 percent increase in the share of farmers earning non-agricultural income is associated with an 0.8 percent reduction in inefficiency. This result could reflect the influence of regional characteristics, such as the prevalence in the Sierra region of small plots, along with limited access to land and capital. Non-agricultural income opportunities could also be contributing to increased productivity in the Sierra region by absorbing the oversupply of family labor engaged in agriculture. Land fragmentation, measured at the district level as the average number of plots worked by each household, is associated with increased inefficiency in the Sierra region; one additional plot per household increases inefficiency by 1.2 percent. Access to market information is associated with an 13 percent reduction in inefficiency in the Sierra region.

The results of the SPF analysis point to several opportunities to specifically target the region. Access to electricity appears particularly important in the Sierra region; a 10 percent increase in the share of households with access to electricity at the district level is associated with a 1.1 percent reduction in production inefficiency. Consistent with the finding on the importance in the Sierra region of income diversification, the results also indicate that owning livestock reduces inefficiency by 2.7 percent in the Sierra region. This finding supports the conventional wisdom that livestock provide a way for farmers in the Sierra region to hedge against risk. Extreme land fragmentation in this region—where limited access to land is one of the main constraints preventing farmers from improving their living conditions—and the lack of income-earning opportunities outside agriculture are forcing rural workers to remain on their family farms. These circumstances result in the high labor allocation to on-farm activities and impede an optimal spatial reallocation of labor away from agriculture.

Regional results: Selva region

In the Selva region as well, several factors other than the cross-cutting factors are associated with reductions in inefficiency. Land fragmentation appears to be an important determinant of production efficiency in the Selva region, as one additional plot per household reduces inefficiency by 9 percent. The latter result may be related to the low average number of plots in the Selva region, and to the extensification strategy that predominates there. Membership in a cooperative or producer association is also important in the Selva region, being associated with 10 percent less inefficiency. This result could be related to benefits derived from participating in the important commercial value chains found in this region, such as coffee and cocoa, because producers who participate in these value chains usually are members of a cooperative or producer association.

Similar to the Costa region, income diversification is associated with increased efficiency in the Selva region: a 10 percent increase in the share of farmers with non-agricultural income increases inefficiency by 1.8 percent. Again, this result may reflect a diversion effect whereby rural households with non-agricultural income opportunities devote less attention to their farming activities.

Results by producer type

The results by producer type (Columns 4-7 in Table 18) show that the role and magnitude of the different factors affecting inefficiency also differ among groups of producers.

Type 1: Subsistence-oriented producers

Among subsistence-oriented producers (Type 1), multiple factors are associated with reduced inefficiency, which is not unexpected, because subsistence-oriented producers face numerous binding constraints. Having access to information, and to technical and extension assistance services, appear to be more relevant and effective for this group of farmers than any other factors, as the impact on efficiency is larger. A 10 percent increase in the share of subsistence households with access to extension and advisory services reduces inefficiency by nearly 12 percent. Similarly, access to information reduces production inefficiency by 12 percent for this group. Risk-mitigation strategies (crop and income diversification) represent a particularly effective means of reducing inefficiency among subsistence-oriented producers—most likely because they are more vulnerable to exogenous shocks

than other types of farmers. Finally, subsistence-oriented producers can benefit from higher education, presumably due to the presence of barriers hindering access to education for this group. However, the marginal impact of education is larger among transitional producers (Types 2 and 3).

Types 2 and 3: Transitional producers

In the case of transitional producers (Types 2 and 3), the efficiency-enhancing effect of access to credit is bigger than it is for subsistence-oriented producers. For transitional farmers, the impact of market integration and land titling is larger as well. These results suggest that once farmers attain a higher resource base, they are in a better position to take advantage of financial services and productive market opportunities. Access to information and technical assistance are significant drivers of technical efficiency as well, although the impacts are largest among subsistence-oriented producers. Both land fragmentation and crop concentration increase inefficiency for producers across the board.

Type 4: Consolidated producers

For consolidated producers (Type 4), the key drivers of efficiency are better access to credit and market integration, likely because consolidated producers have already developed the ability to take advantage of these tools for reaching dynamic and more profitable markets.

5.4 Discussion

The productivity analysis is valuable for documenting what has happened in Peruvian agriculture during the last decade. The comparisons across regions, by farm size, and by producer type highlight the sharp increase in productivity growth that has occurred in the Costa region and show the lack of a similar increase in other regions, most notably the Sierra region, which is home to so many poor households.

Some interesting conclusions emerge from the TFP analysis. One of the most striking results appears in Table 12, which shows the levels and evolution of TFP by region from 2007 to 2015. A dramatic contrast can be seen between the Costa region, where TFP grew rapidly, and the other two regions, where TFP remained flat or declined. In the Costa region, output and TFP increased, driven in large part by substitution out of low-value staples into high-value fruit and horticultural crops destined for the export market. In the Sierra region, even though output increased, TFP fell by 0.2 percent per year, reflecting extremely rapid growth in the use of family labor. For the Sierra region, which is home to the highest proportion

of Peru's farming population, there is a clear need to raise technological efficiency in input use. This should be a major priority for the sector.

Differences in TFP detected between natural regions and across farm sizes are likely driven in part by climatic, topographical, and soil quality differences. Overall, results of the aggregate (national-level) and disaggregated (regional-level) analysis suggest that the relationship between farm size and TFP is positive in Peru. Larger farms use inputs more efficiently than smaller farms. In terms of variation through time, TFP difference are due as well to other variable factors, such as variation in the composition of production, uneven advances in adopting technology, the specificity of new technologies to different locations, and changes in transaction costs due to improvements over time in market accessibility. Less easily measured factors that might explain changes over time in TFP include improved farmer access to assets in a broader sense, pre-existing entrepreneurial ability in a region, and the attractiveness of a region to new entrepreneurs. Entrepreneurial ability is enhanced by schooling, so differences across regions in the level and quality of human capital might also have explanatory power. Finally, there are likely to be regional differences in access to finance and to the capital embodied in infrastructure investments. Taking together the differences in entrepreneurial abilities and access to capital, one would expect differences in the scale and the degree of specialization at the farm level.

In the Costa region, TFP growth appears to have been driven primarily by changes in the crop mix, especially by substitution out of low value crops such as maize and wheat and into high value crops such as asparagus, avocados, and grapes. Productivity growth within established crops appears to have been less important. Expansion of irrigation also played an important role. The Ministry of Agriculture recently announced plans to move ahead with several big new irrigation projects in the Costa region, which are expected to add 200,000 ha of irrigated land.[34] The results of the TFP analysis suggest that the best way to contribute to higher productivity growth in the Costa region will be to ensure that the newly irrigated land is used for the production of high-value crops, using improved technology. The results of the TFP analysis also suggest that the best way to stimulate rapid productivity growth will be to avoid imposing conditions on land allocation, for example through requirements that mixed schemes be introduced involving alliances between large and small farms.

The SPF analysis of the determinants of technical efficiency shows that while many factors can influence productive efficiency, the three cross-cutting factors

34 http://agraria.pe/noticias/peru-duplicara-tierras-para-produccion-agricola-exportable-13930

with the greatest potential to improve productive efficiency in all three natural regions and among all four producer types include: (i) access to extension and advisory services, (ii) access to credit, and (iii) education. Efforts are needed to build innovation capacity within the country, for the purpose of stimulating the uptake of improved technologies relevant for the geophysical and crop context of the Costa, Sierra, and Selva regions. Strengthened capacity to innovate will have to be complemented with improvements in the "last-mile delivery" of technical assistance, through the deployment of extension networks. It is also important through these networks to focus on improving access to quality information among women producers, who our results show are disadvantaged in the Costa and Sierra regions, particularly in the subsistence-oriented producer group. Of course, the availability of improved technologies will make little difference if they remain inaccessible to producers, and for that reason initiatives to strengthen the "last-mile delivery" system will need to be complemented with efforts to promote greater access to credit. On the supply side, it will be important to increase the number of financial intermediaries active in the rural space and expand the range of instruments on offer. One potential strategy for doing this would be for the government to provide credit guarantees to development banks that target agricultural producers, including subsistence producers in the Sierra and Selva regions. On the demand side, the introduction of new instruments will need to be accompanied by initiatives to increase financial literacy among producers, especially producers who have not previously participated in formal financial markets. Finally, producers will be in a better position to access productivity-enhancing innovations, including with the help of financing, if they are sufficiently well educated to be able to assimilate new information and put it to good use. Education plays a big role in reducing inefficiency in Peruvian agriculture, presumably because better-educated farmers make better decisions about their production and marketing activities and consequently achieve better agricultural outcomes. This emphasizes the importance of investments made outside the sector to improve the reach and quality of basic education services.

In the Costa region, higher levels of productive efficiency are associated with better market integration and easier access to market information. Irrigation matters to some extent in the Costa region. Finally, land titling affects inefficiency in the Costa region; farmers with titled land are more efficient than farmers who lack titled land. The effect of titling is more pronounced in the Costa region compared to the other two regions. This difference does not necessarily mean that land titling is unimportant elsewhere; it is possible that no relationship was detected between land titling and efficiency in the Sierra and Selva regions because land markets are still functioning poorly in those regions.

In the Sierra region, the region that poses the greatest development challenge, problems for the agricultural sector include the harsh geographical terrain, the difficulty of developing new agricultural land (especially irrigated land), underdeveloped land markets, and the high fragmentation of agricultural landholdings (the latter a result of continued intergenerational land transfer within families). The TFP analysis shows that agriculture practiced on very small plots, using family labor as the main input, results in very low levels of productivity. One important key to success in this area will be building human capacity. People coming from agricultural households need to be provided with opportunities to receive vocational training, for example through technical schools and other similar outlets. In addition, public and private entities must work to create financial instruments for more productive households to buy or rent land, from family, neighbors, and others. In the Sierra region traditional staples such as potatoes, maize, wheat, and barley, grown using traditional methods, continue to dominate the crop portfolio. Crops such as avocados, considered high value in the Costa region, which uses more technologically intensive production methods, are grown more traditionally in the Sierra region with family labor as the most intensive input. A challenge for the region is to promote the use of greater amounts of technological inputs, including intermediate inputs, capital, and hired labor. To achieve this objective, more technical training through better networks of extension services, as well as access to capital, should be high priorities. Only through a combination of factors described above, as well as better market integration of the region (secured through improved infrastructure, information, and value chain development), will the region see real and measurable transformation.

In most areas of the Sierra region, agricultural productivity growth can be accelerated by providing improved access to basic services such as water, electricity, and health care. A rural development strategy for the Sierra region calls for a differentiated multi-sectoral, articulated approach with a territorial focus, similar to what was suggested by the OECD country report. In 2004, the government funded the development of a National Strategy for Rural Development (Estrategia Nacional para Desarollo Rural – ENDER), but the strategy was never operationalized, and an implementation agency was never designated.[35] The National Public Investment System (Sistema Nacional de Inversion Publica – SNIP), in place since the late 1990s, has not lived up to expectations with respect to promoting more targeted investments based on territorial planning, as it evaluates investment projects one by one, without clear criteria for prioritization of investments to close important poverty or competitiveness gaps. Following the creation of MIDIS in 2011, an attempt was

35 Two years ago, a GRADE study analyzed ENDER to determine whether government investments in subsequent years followed a systematic approach to deal with poverty in rural areas. See Fort et al. 2015, http://www.grade.org.pe/ wp-content/uploads/LIBROGRADE_ENDER_.pdf

made to establish a new multi-sectoral national strategy to fight poverty (Incluir para Crecer), but the focus of this program has been on the expansion of conditional cash transfer programs (Juntos, Pension 65), and relatively little attention has been paid to the economic inclusion objective. Current recommendations that align with the results of this study, and ENDER (see footnote 33), include collaboration between MIDIS and MINAGRI to prioritize and create programs based on a typology of different rural territories and producer capacities.

In the Selva region, agricultural productivity levels have remained flat for a decade or more. Many of the factors contributing to inefficiency in the Selva region are similar to those found in the Sierra region. Production increases in the Selva region have come mainly from expansion of the land frontier, as reflected in the recent rapid increase in the area under cultivated pastures and tree crops including coffee, cocoa, and oil palm. This expansion has come in large part from opening up new areas to commercial agriculture, which suggests that agricultural growth in the Selva region is coming at a high environmental cost in terms of deforestation and is not a sustainable solution. Providing producers with greater access to markets via value chains could be one of the enablers of agricultural efficiency in the region. At the same time, there is a need for the authorities to develop a strategy for awarding forestry concessions the Selva region in a way that ensures sustainable use of forest resources, to promote the uptake of sustainable agroforestry practices in those parts of the Selva region that are considered suitable for agriculture, and to develop sustainable intensification practices appropriate for smallholder producers.[36]

Last but not least, the TFP and SPF analyses show—as expected—that commercial farms are more productive on average and more efficient than subsistence-oriented farms. The role and magnitude of the different drivers of efficiency differ across types of producers. For example, better market integration is associated with higher levels of efficiency among all types of producers except subsistence-oriented producers, who by definition do not participate actively in markets and face other binding constraints. Risk mitigation strategies and services (crop diversification) appear to be particularly effective for reducing inefficiency for this group, likely because they are more vulnerable to shocks than transitional and consolidated farmers. These results highlight the need for agricultural support strategies that are differentiated not only by natural region, but also by type of producer.

36 See GRADE (2105) for recommendations for development of oil palm in the Selva region via small producers, without deforestation: http://www.grade.org.pe/wp-content/uploads/LIBROGRADE _palma.pdf. In the case of oil palm production, government and private certifications can help achieve development and environmental goals simultaneously.

CHAPTER 6

Competitiveness of Peru's agriculture

Competitiveness of Peru's agriculture

How competitive are Peruvian agricultural products, in domestic and international markets? What key factors influence the competitiveness of Peruvian agriculture? What can be learned from the Peruvian value chains that have emerged as global success stories? Going forward, what are the key challenges that will have to be overcome to ensure the continuing successful development of Peruvian agriculture? And where are the most promising opportunities for future success?

These questions are crucial, as continued strong growth of Peru's agricultural sector will be possible only if Peruvian producers and value chain actors are able to compete effectively, both domestically and abroad. The productivity analysis presented in Chapter 5 of this report provides insights into factors operating at the farm level that influence competitiveness, primarily by influencing productivity, which determines the unit cost of primary production. Yet the unit cost of primary production is only one factor among many that determine the ability of Peruvian producers to compete in domestic and international markets. Any advantage conferred by efficiency in production can be lost through inefficiencies at other points in the value chain that drive up costs, reduce product quality, create uncertainty in supply, or otherwise make products less attractive to buyers and eventually consumers.

In this chapter, the focus is on factors operating throughout the value chain that affect the competitiveness of Peruvian agriculture and agribusiness. The analysis is not necessarily based on primary data; often it relies on the results of existing sectoral and value chain studies, supplemented by benchmarking based on secondary data.

6.1 Competitiveness of Peru: Evidence from global benchmarks

Insights about the competitiveness of Peruvian agriculture are provided by global benchmarking exercises that compare the performance of Peru to other countries with respect to key factors that determine competitiveness.

According to the Global Competitiveness Index (GCI), which is calculated based on 12 indicators considered influential in determining competitiveness, in 2016-17 Peru ranked 67th among 138 countries. Peru was the sixth best performer among Latin American countries, after Chile (the top regional performer), Panama, Mexico, Costa Rica, and Colombia. The GCI classifies the 12 indicators into three categories of competitiveness factors: (i) basic factors, (ii) enhancing factors, and (iii) innovation and sophistication factors. The largest gap between Peru's score and that of the top regional performer (Chile) relates to institutions, followed by level of innovation, higher education, technological readiness, and infrastructure (Table 19).

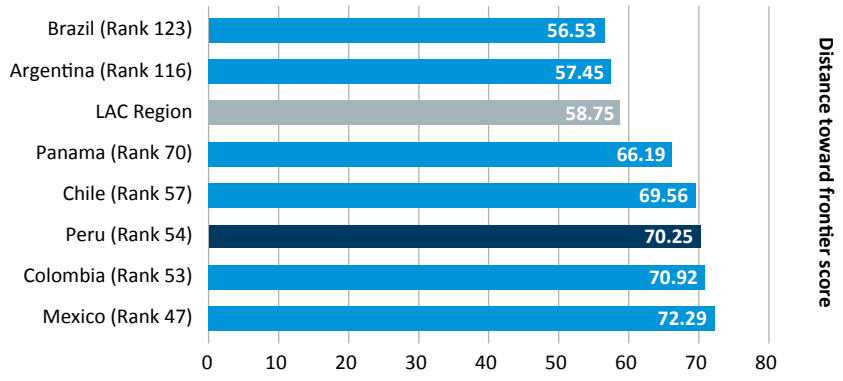
Table 19. Global Competitiveness Index 2016, selected results for Peru

1. Basic factors	Difference from highest ranked	2. Enhancing factors	Difference from highest ranked	3. Innovation and sophistication	Difference from highest ranked
Institutions	-71	Higher education	-52	Business sophistication	1
Infrastructure	-45	Goods and market efficiency	-21	Innovation	-56
Macroeconomics	-1	Labor and market efficiency	-9		
Health and Primary	-27	Financial and market development	-3		
		Technological readiness	-49		
		Market size	-4		

Source: Global Competitiveness Index 2017.

Other global benchmarking initiatives also suggest that the efforts of the Government of Peru to establish a business-friendly environment by reducing transaction costs and eliminating inefficiencies are bearing fruit. For example, in the 2016 Doing Business Indicators (DBI), which measure the impacts of regulations that enhance or constrain business activity, Peru ranked 54th among 190 countries, above the regional average and better than top regional economies, such as Chile (Figure 35). In the 2016 Logistic Performance Index (LPI), which measures progress against infrastructure, services, border procedures and time, and supply chain reliability, Peru scored above the average for its income group, yet still below Chile, the top regional performer (Table 20). Interestingly, Peru's LPI score in 2016 had improved from its score in 2007 (increasing from 2.77 to 2.89 out of possible 5), yet over the same period Peru's global ranking fell from 59th to 69th, showing that logistics systems in Peru are not being upgraded as rapidly as in many other countries. Still, Peru's performance improved in some areas, rising in the global ranking with respect to customs, tracking and tracing, and logistics quality and competence. Infrastructure and timeliness continue to constitute challenges, however.

Figure 35. Ease of Doing Business 2016-17, selected results



Source: World Bank.

Table 20. Logistics Performance Index 2016, selected results

	Customs	Infrastructure	International shipments	Logistics competence	Tracking and tracing	Timeliness
Chile	3.19	2.77	3.3	2.97	3.5	3.71
Peru	2.76	2.62	2.91	2.87	2.94	3.23
Upper middle income	2.52	2.6	2.76	2.68	2.68	3.12

To complement more general indexes that apply to entire economies, the World Bank has developed the Enabling the Business of Agriculture (EBA) indicators, which are designed to assess the ease of doing business specifically in agriculture and agribusiness. Similar to the DBI indicators, the EBA indicators measure the extent to which regulations and procedures facilitate or constrain firms operating in the agricultural sector, particularly with respect to input and output markets, as well as with respect to agricultural services. Box 4 highlights key insights derived from the most recent EBA indicators for Peru (the complete set of EBA scores can be found at EBA 2017).

BOX 4. ENABLING THE BUSINESS OF AGRICULTURE (EBA) – RESULTS FOR PERU

Results of the 2017 EBA exercise provide interesting insights into the enabling environment faced by agribusiness firms in Peru compared to other countries in the region and worldwide.

Agricultural inputs: Peru's regulatory framework seems to be relatively inefficient when it comes to regulating markets for agricultural inputs. Peru ranked 52nd out of 62 countries for regulations dealing with fertilizers and 58th for machinery. In the case of fertilizer, registration of a new fertilizer product is not required in Peru, and key quality control requirements are missing or underdeveloped. For instance, Peru only requires 6 out of 13 possible labeling requirements and does not forbid by law the sale of opened fertilizer bags. It also does not penalize the sale of mislabeled fertilizer bags. In the case of machinery, Peru does not require the registration of tractors for on-the-road-use; nor does it use national tractor standards or require any tractor type to be approved before being marketed. On the positive side, national legislation does address certain operator safety standards and does not require private companies to obtain pre-shipment import permits, which tend to increase regulatory inefficiency. Despite weak performance related to the above indicators, the country performs relatively well in comparison to peers with regard to regulations relating to seed, finance, and transport.

Table 21. EBA indicator scores, 2017, Peru vs regional comparators

Country	Seed	Fertilizer	Machinery	Finance	Markets	Transport	Water	ICT
Bolivia	25	45	52	13	22	15	43	30
Chile	29	54	28	46	9	46	28	15
Colombia	27	8	45	1	17	10	3	9

Table 21. EBA indicator scores, 2017, Peru vs regional comparators *(continued)*

Country	Seed	Fertilizer	Machinery	Finance	Markets	Transport	Water	ICT
Guatemala	26	10	57	24	14	58	58	21
Mexico	24	24	51	9	3	20	2	9
Nicaragua	44	11	48	36	20	36	23	43
Peru	10	52	58	2	27	5	11	15
Uruguay	9	25	56	19	15	11	25	37

Agricultural markets: Here Peru's performance is also mixed. While the regulatory framework in Peru is relatively streamlined—it neither establishes price regulations nor requires traders to obtain a trader-level license—it does exhibit key weaknesses regarding the export procedures for agricultural products. On average 11 days are needed in Peru to obtain a complete set of pre-shipment documents, in contrast to Colombia and Nicaragua, where only 4 and 2 days are needed, respectively. Viewed on a larger scale in comparison to other global coffee exporters, Peru still performs poorly relative to its peers. The costs as a percentage of GNI per capita, however, are comparatively low.

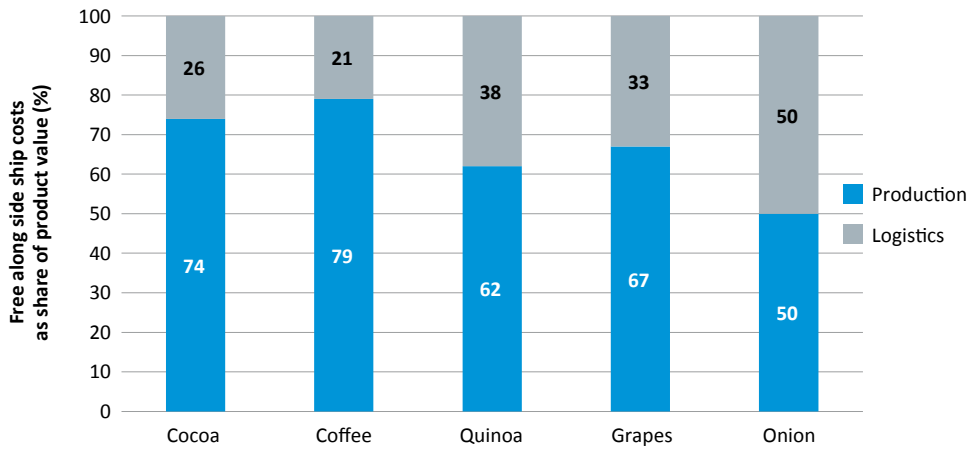
Transport: Peru performs relatively well with respect to transport regulation. Only three calendar days are needed to obtain a trucking license in Peru, compared to Colombia and Mexico, where 60 and 30 days are needed, respectively. Peru requires a cross-border transport license for foreign trucks, which is considered good practice. While the country requires a company-level license to transport goods in the domestic markets (good practice), it does not have legislation on the transport of perishable agricultural products or foodstuffs.

6.2 Efficiency of Peru's agricultural logistics systems

The different competitiveness indicators provide useful benchmarks for assessing the overall competitiveness of Peru compared to regional and global comparators. Additional insights into the performance of the logistics systems that support the production and post-harvest handling of agricultural and food products in Peru come from a recent World Bank study (2015). The study examined the supply chains for five export-oriented commodities (cocoa, coffee, quinoa, grapes, and

yellow onions) and found that logistics costs make up between 20 and 50 percent of the value for these five commodities (Figure 36). Expressed in a different way, logistics costs make up between 14 and 22 percent of the export price (FOB price), suggesting that they play a major role in determining the profitability—and hence the competitiveness—of these commodities. Compared with other countries, for products such as coffee and cocoa these shares seem to be relatively high. For example, logistics costs for coffee currently comprise 9-14 percent of the FOB price in Colombia and about 10 percent in Nicaragua. Similarly, logistics costs for cocoa recently were estimated at 12 percent for Ghana.

Figure 36. Production and logistics costs, selected products, Peru



Source: World Bank 2015.

Breaking down the logistics costs of the five agricultural products, it is evident that the characteristics of a given product, the organization of the value chain, and market requirements all play important roles in determining the structure of logistic costs (Table 22). For non-perishable products such as cocoa, coffee, and quinoa, transportation costs make up an important share of total logistics costs. Loading and uploading costs are particularly high for quinoa and onions, indicating in the case of quinoa the need for greater efficiencies and improved supply chain coordination, while in the case of onions the high loading and uploading costs reflect the care with which the product needs to be handled to avoid damage. In the case of highly perishable products, such as grapes, post-harvest treatment costs (representing the cleaning, packing, and inspections that are needed to prepare the product for export) weigh heavily in the logistics cost structure.

Table 22. Breakdown of logistic costs, selected products, Peru

Product category	Bulk			Refrigerated	
	Cocoa	Coffee	Quinoa	Grapes	Yellow onions
Transport	32.2	20.4	33.8	5.7	6.6
Product losses	20.3	19.2	18.4	18.8	9.8
Loading and uploading	10.4	9.6	20.7	6.9	32.3
Post-harvest treatment	13.7	11.2	7.1	41.6	15.1
Security	13.1	24.0	4.1	5.9	12.4
Procedures and certifications	4.4	3.9	5.1	11.8	14.9
Financial	3.9	8.3	5.3	1.4	6.2
Port costs	1.9	3.4	5.5	7.8	2.7
Total	100.0	100.0	100.0	100.0	100.0

Source: World Bank 2015.

Noteworthy among the numbers appearing in Table 22 is the relatively high cost incurred for transporting the three bulk commodities. The high transport costs stem from external and internal factors affecting the transport services provided to the agricultural sector in Peru. An example of the former is poor road quality, a problem which is particularly severe in rural areas. According to the same study, 70 percent of the rural roads that connect farms to collection centers in Peru are rated bad or very bad. The roads connecting collection centers to processing plants are in much better condition (about 87 percent are rated good). Internal factors affecting agricultural transport services in Peru include the high degree of fragmentation of the transport industry, as more than 60 percent of road transport providers own only one vehicle (this is particularly the case for service providers who convey products from farms to collection centers). Moreover, the transport industry is extremely informal; an estimated 80 percent of the more than 100,000 trucks in the country operate without a commercial license. The main obstacles to

formalization are the high cost and cumbersome procedures involved in acquiring a commercial license (insurance is particularly expensive). Finally, the average age of the transport fleet in Peru is 12.5 years, well above the 8 years accepted by international standards.

Noteworthy as well in the numbers presented in Table 22 is the high cost of product losses, which affect all five of the products. Losses result from poor post-harvest handling at various stages, inadequate packaging, and delays caused by bad conditions on secondary and tertiary roads.

One important factor contributing both to high transport costs and the high cost of product losses are delays. A large percentage of the trucks that transport agricultural products experience delays when moving products from the farm to collection centers and eventually to export ports. Those delays stem in part from infrastructure-related factors, such as bad road conditions and traffic congestion in the highly traveled central corridors (responsible for an estimated 50 percent of delays). Another source of delays is the excessive and often extremely inefficient procedures and controls to which commodity shipments are subject. Information about the time required to complete many of these procedures comes from the EBA; for example, obtaining obligatory pre-shipment export certificates takes on average 11 days for coffee, 10 days for quinoa, 4 days for grapes, 4 days for onions, and 3 days for cocoa. These delays may seem modest, but they result in significant costs.

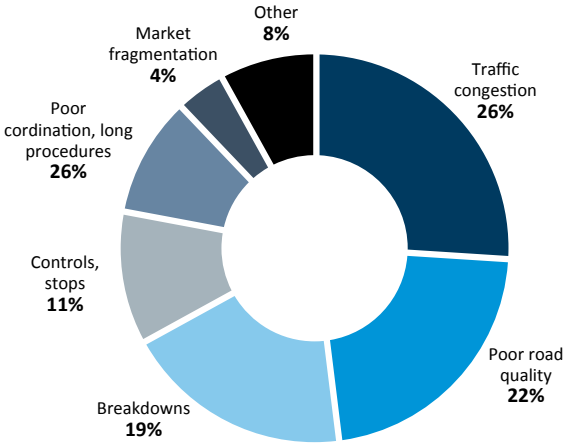
A final factor driving up logistics costs in Peru is security concerns. Payments to security personnel or police are typically made to protect loads from theft, and many intermediaries also purchase insurance policies to ensure compensation for losses.[37]

37 Interestingly, the length of the transport corridor is only weakly correlated with the logistics costs in Peru. While the two longest corridors also exhibit the highest logistics costs, other corridors show no clear correlation, with some short distances being linked to high costs and vice versa. When isolating post-harvest losses, on the other hand, the analysis did not find positive correlation between these losses and distance of the route.

Figure 37. Frequency and nature of transport delays, selected commodities, Peru

Corridor / Products	Frequency of delays
North: Coffee, cocoa	26.9 %
North: Grapes	25.2 %
Center: Coffee, cocoa, quinoa	51.9 %
South: Quinoa	50.4 %
South: Onions, grapes	4.8%

(a) Trips delayed per transport corridor (%)



(b) Reason for delays during transport

Source: World Bank 2015.

The World Bank report identifies areas in which increased attention is needed to improve the performance of logistics systems that handle agricultural products. The report also proposes a set of strategic interventions, including investments to strengthen enabling factors such as infrastructure (e.g., road networks, port facilities) and to build capacity within the institutions that provide services to the sector (e.g. customs, sanitary and phytosanitary services). Other proposed interventions are more supply-chain oriented, aiming at improving coordination mechanisms and reducing transaction costs.

Efforts to reduce logistics costs in Peru must confront the enormous disparity in connectivity between Lima on the one hand and most inland intermediate cities on the other hand. While Lima is relatively well served by transport infrastructure linking it to internal production zones as well as the export point in the nearby port of Callao, the same is not true of most intermediate cities in the Sierra and Selva regions (Table 23). Most inland intermediate cities are poorly linked to production zones and to export points located along the coast, and transportation charges frequently add a 65-70 percent cost premium to their commercial and social exchanges. Connectivity therefore poses a significant cost barrier for the many inland intermediate cities that are seeking to connect with domestic markets beyond the nearest hinterland and/or to trade with the rest of the world (Briceño and Moroz, 2016).

Table 23. Cost premium to mobilize goods and people, intermediate cities, Peru

Region	City	Cost premium (%)
Costa	Chimbote	41
	Chiclayo	50
	Trujillo	51
	Piura	62
	Tacna	64
Sierra	Huancayo	24
	Juliaca	64
	Arequipa	69
	Cusco	71
Selva	Pucallpa	67
	Iquitos	88

Source: Briceño and Moroz 2016.

6.3 Development of competitive agricultural value chains

6.3.1 Key features of the agricultural export boom

Over the past 25 years, Peru has claimed a significant share in global markets for a range of agricultural products. The first efforts to diversify exports away from the so-called "traditional commodities" (coffee, cocoa, sugar, and cotton) began in the mid-1980s with the successful promotion of asparagus exports. The expansion of this export subsector in the 1990s was accompanied by diversification into a wide range of other high-value products for export. Over time, Peru consolidated its position as a world leader in the production of horticultural products.

The development of value chains for high-value agricultural exports required substantial "hard" investments in irrigation infrastructure, processing and storage facilities, and logistics, along with an important cohort of "soft" investments—for example, to improve market coordination and strengthen value chain integration, to enhance compliance with quality and safety standards, and to meet a host of market entry requirements, including buyer-imposed private standards.

Peru is an enviable position: it already exports a wide range of horticultural products, yet it can diversify its export offerings even more. New opportunities to diversify are continuously being identified, thanks to the diversity of Peru's natural regions and to Peruvian firms' increasing capacity to access cutting-edge technology and innovative production and processing methods. For instance, expectations are high that blackberry and pomegranate exports will take off soon, and prospects for a number of other specialty and niche products are attracting attention.

In spite of the progress achieved to date and the attractive prospects for the future, the horticulture subsector has missed opportunities to create additional value added by strengthening backward and forward linkages and generating opportunities in related industries. Table grapes provide a good example. Table grape exports expanded considerably during the past two decades, and today Peru is the second-largest global supplier. Yet much of the value generated in the Peruvian table grape industry accrues to foreign actors. Fernandex-Stark, Bamber, and Gereffi (2016) estimate that in 2013, Peruvian producers and agribusiness firms captured only around 35 percent of the retail price in the importing country, and the net benefits for Peru as a whole were even lower, considering that a significant share of table grape production inputs is imported. These authors identify a number of opportunities to capture greater value from the chain, notably by relying more on locally procured production inputs and services. Areas in which the country is beginning to develop local capacity include packaging (including wooden crates and plastic bags) and the trellises used to support the vines. Procuring these inputs locally would provide new markets for Peru's emerging forestry and plastics industries.

One area that offers particularly attractive opportunities to generate additional value added in the horticultural export sector is human capital. Producing and processing horticultural exports demands skilled labor, which is still in short supply. Technical training and skill development programs for workers in the industry could have a large impact by improving productivity and efficiency all along the supply chain. The Ministry of Production (PRODUCE) has already identified horticulture and vegetable processing as clusters to be supported, which will present opportunities for upgrading these subsectors and generating new jobs.

6.3.2 Making agricultural value chains more inclusive

The development of Peru's agricultural sector—driven mainly by success with horticultural exports—has generated important benefits, but the news is not

uniformly positive. As described earlier, because agricultural development has been uneven, regional disparities have emerged in income levels and development outcomes.

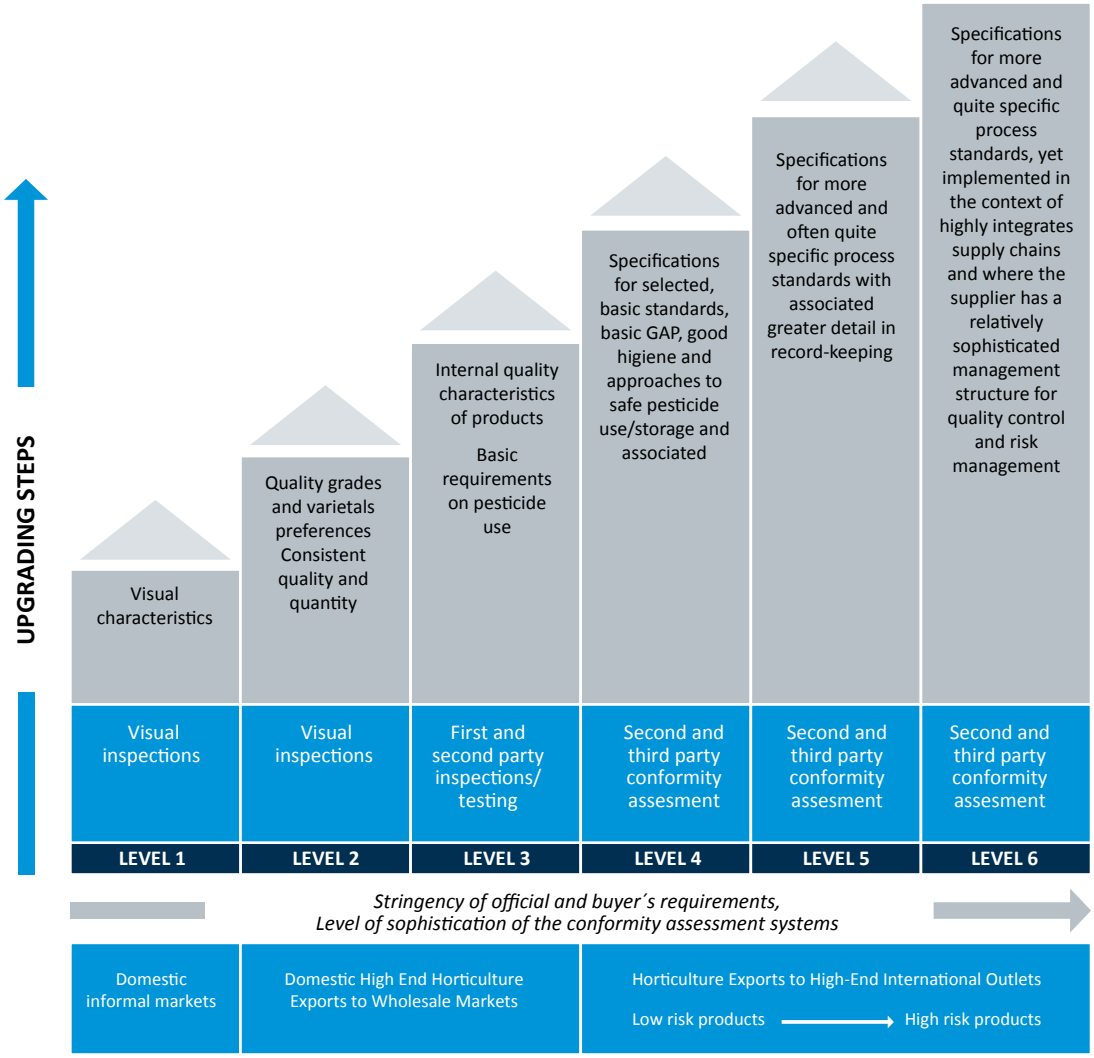
It is commonly asserted that Peru's agricultural export boom has generated large numbers of jobs, but in truth there is little consensus regarding the numbers of jobs that have been created. Some authors estimate that the roughly 400 firms that make up the horticultural export industry have generated in excess of 100,000 jobs. Under pressure to meet labor standards required by importing markets, many of these firms have been improving employment conditions for their workers. Some recent studies report positive impacts on worker empowerment and tangible employee wellbeing (see Schuster and Maertens 2015). Despite these gains, the uneven nature of development in the sub-sector has raised concern, particularly regarding the lack of opportunities for integrating small-scale farmers in value chains for horticultural exports.[38]

Where, then, are the opportunities to make agricultural value chains in Peru more inclusive, with the goal of spreading the benefits to a larger number of people, including the poor? To help answer this question, it is useful to think about the requirements of progressively more sophisticated markets for horticultural export products and to consider the numbers and types of jobs needed to meet the requirements associated with different markets. Figure 38 presents in stylized form the requirements associated with a series of progressively more sophisticated markets, ranked in increasing order of sophistication from Level 1 (value products being sold into informal domestic bulk markets) to Level 6 (highly perishable, high-value products being sold into sophisticated international markets).

At one end of the spectrum, Levels 5 and 6 represent markets with very demanding standards, implying the need for strong value chain coordination and hence large investments in infrastructure, logistics, and coordination mechanisms. For the most part, Peru's agricultural exporters have targeted these markets, which has encouraged strong vertical integration from production to exports to achieve economies of scale, assure compliance with market requirements, and achieve higher levels of competitiveness.

38 This concern stems in part from the experience in neighboring countries. For example, in Chile in the early 1990s, despite a large, targeted government program subsidizing extension and credit for small farmers (INDAP), there was little integration of small farms into the export agriculture sector, except for a few products, such as labor-intensive berries (Alberto Valdes, personal communication).

Figure 38. Requirements associated with increasingly sophisticated agri-food markets



Source: Adapted from World Bank 2011.

Peru, like many other export-oriented countries, aspires to incorporate small-scale producers into Level 5 and Level 6 markets, because they tend to involve extremely high-value products and appear to offer the best opportunities for farmers to capture added value. Yet there are relatively few documented instances in Peru or elsewhere in which large numbers of small-scale producers have successfully integrated into Level 5 and 6 markets. This lack of success can be attributed to the fact that the barriers to entering these markets are very high—in terms of the investment costs as well as the required level of knowledge and skills.

More promising opportunities may be associated with markets located toward the middle of the spectrum—Levels 3 and 4. When large numbers of small-scale producers have succeeded in penetrating international markets, usually they have focused on commodities with more modest market requirements, such as cocoa, coffee, and bananas. In Peru, the main strategy to increase competitiveness and generate value for farmers and other actors has been to "de-commodify" these products through quality differentiation. Details of how the differentiated organic cocoa, coffee, and banana value chains developed in Peru appear in Boxes 5, 6, and 7.

BOX 5. THE DE-COMMODIFICATION OF COFFEE IN PERU

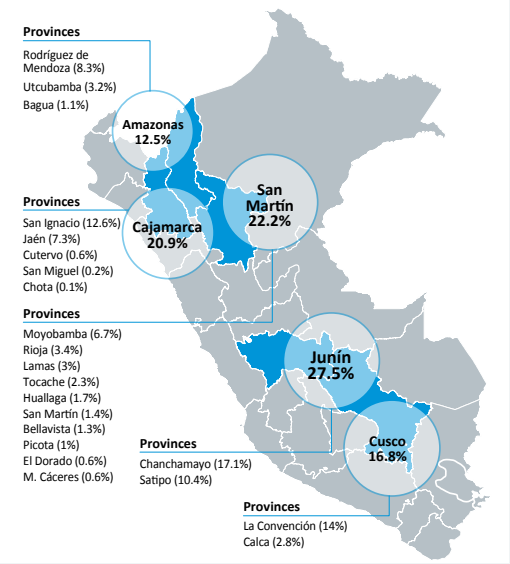
The development of Peru's coffee sector has been nothing short of astounding. In 2015, the area planted to coffee stood at about 380,000 ha (MINAGRI 2017), having more than doubled over the previous 25 years. Small-scale producers with less than 5 ha under production represent about 80 percent of the farmers involved in the activity. Coffee production generates about 1.5 million jobs and involves approximately 223,000 families. During the past two decades, Peru has emerged as a major producer of organic coffee (with about 90,000 ha certified organic, Peru is the world's second-leading exporter of organic coffee), and it is increasing its participation in this specialty market. The shift from the conventional to the organic and differentiated coffee market did not result from a deliberate national strategy to shift-farmers from high-input production systems to organic production; rather, it emerged to take advantage of the fact that most producers used low levels of chemical fertilizers and pesticides because they could not afford them.

Rise of the specialty coffee industry

The state institutions that dominated the coffee industry came apart in the 1980s for many reasons, including the Shining Path insurgency, which hit farmer-based organizations particularly hard. In 1993, a few of the surviving coffee cooperatives founded the Junta Nacional del Café. Over the years, producer cooperatives—many associated with the Junta Nacional—have retained a significant share of the export market, growing from 4 percent in 1990 to more than 20 percent in 2014. The largest producer associations or cooperatives have more than 2,000 members.

As the State's presence in the industry ebbed in the 1980s and 1990s, NGOs and international agencies encouraged the industry to align itself with the growing global demand for organic and specialty coffee. Since the late 1990s, efforts by NGOs, international agencies, and government

Main coffee production regions of Peru



Source. Apoyo Consultoría, 2016.

entities to support the competitiveness of small-scale coffee producers have focused on improving the early stages of coffee processing (harvesting, milling, drying, sorting), pursuing collective action at the level of aggregation, and achieving organic and other certifications (Fair Trade, Rainforest Alliance). Associated marketing campaigns and investments in infrastructure to assess quality (cupping capabilities, for instance) helped to increase domestic consumption and draw international attention to the new quality attributes of Peruvian coffee.

The shift in market orientation brought better export prices, community empowerment, and other benefits to small-scale producers, but coffee is still a risky business, characterized by volatile pricing, climatic, disease, and pest conditions. For example, since 2014 an outbreak of coffee rust disease has affected 40–60 percent of plantations nationwide. The premium paid for organic and specialty coffee has not been enough to compensate for lost productivity. Organic producers have been particularly vulnerable, because their use of fungicides to suppress the disease is restricted.

The sector is recovering, but aside from severely de-capitalizing thousands of farmers, the outbreak has highlighted profound institutional weaknesses and uneven improvement along the value chain. Limited support for critical services (research and extension, climate information, early warning programs, plant renovation programs) limited the industry's capacity to foresee and effectively react to emerging risks and increased its exposure to them.

Environmental challenges

Coffee production in Peru is concentrated in three main growing areas. Gradually production has shifted from Chanchamayo (Junín Region) in Peru's central highlands to the northern highlands of the Amazonas and San Martín Regions. Although Chanchamayo still accounts for a significant share of production, Amazonas and San Martín are now the leading producers. This shift, reinforced by waves of migration, has brought important environmental challenges in its wake, especially deforestation to expand production of coffee (in addition to cocoa, oil palm, and other crops).

Recalibrating the value chain

Initiatives to increase Peru's participation in the quality-differentiated market for coffee have widened opportunities for thousands of farmers, and quality improvements have helped to buffer the low prices and other shocks that inevitably affect the industry. Support for the coffee sub-sector is expected to intensify, as the three coffee-producing clusters have been prioritized for government support. At this juncture, the competitiveness of this critical value chain will depend on striking a better balance between improvements on and off of the farm, to strengthen the capacity of all participants in the value chain to respond in concert to a broad set of competitiveness challenges, from production to marketing.

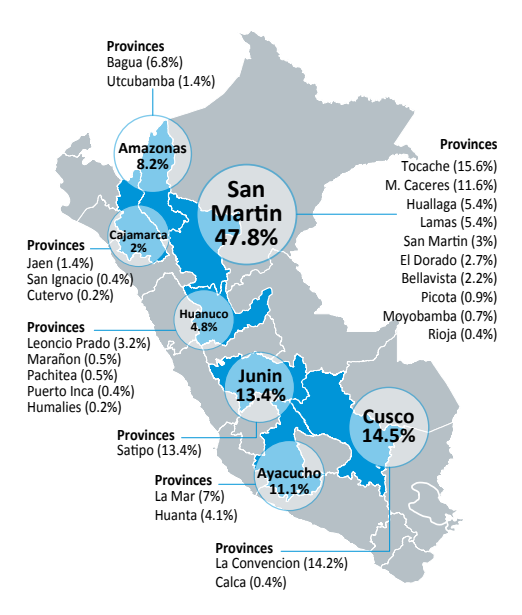
BOX 6. THE DE-COMMODIFICATION OF COCOA IN PERU

For cocoa exports, like coffee exports, market differentiation proved to be a valuable strategy. After decades of stagnation, in the early 2000s the area planted to cocoa in Peru started to rise steadily and then dramatically—increasing from 50,000 ha in 2005 to 121,000 ha in 2015. The sector involves nearly 50,000 farmers, about 20 percent of whom belong to a producer association or cooperative, in a number of regions.

IIntroduction of cocoa

Interest in cocoa was fomented by development projects launched to replace coca. The projects took the form of public-private alliances that brought together Peruvian public institutions, international buyers, and producers; examples include the Economic Development Alliance and the Cocoa Alliance of Peru (Alianza Cacao Peru), funded by USAID. Although some of the partnerships with large international buyers never materialized, the projects provided an essential platform for innovation and coordination in the value chain.

Main cocoa production regions of Peru



Source. Apoyo Consultoría, 2016.

Entry into market for conventional cocoa

Initially the highly productive and disease-resistant cocoa hybrid CCN51 was promoted and planted on a large area, but it proved to have a significant disadvantage: the quality of the bean is unexceptional, forcing Peru to compete in the market for conventional cocoa. Dominated by large West African players, the market is highly competitive and extremely price sensitive. Profit margins are tiny and highly vulnerable to price fluctuations. Currently cocoa prices are experiencing a significant decline owing to global overproduction.

Efforts to enter organic cocoa and other differentiated markets

Peru's cocoa industry managed to move away from the conventional cocoa market by pursuing organic certification. Although a small player in terms of overall cocoa production, Peru is the world's second-largest producer of organic cocoa. The industry has recently scaled up efforts to break into the "fine/flavor" cocoa market by promoting the unique qualities of Peru's indigenous cocoa varieties. Compliance with certification and traceability requirements is costly but essentially mandatory, given that most large international chocolate manufacturers are committed to achieving 100 percent certification of their supply. Producer organizations in Peru will need to seek technical assistance to improve productivity, focus on consolidation to achieve economies of scale and gain market power, strengthen their links to international markets, and develop their links with local buyers in the national market.

BOX 7. THE DE-COMMODIFICATION OF BANANA IN PERU

The rise of the Peruvian banana industry is one more example of the successful development of a competitive, export-oriented value chain, although the factors that propelled its development differ from those that made the coffee and cocoa industries competitive. Peru entered the global banana market thanks to the increased demand for organic products, although other key factors came into play.

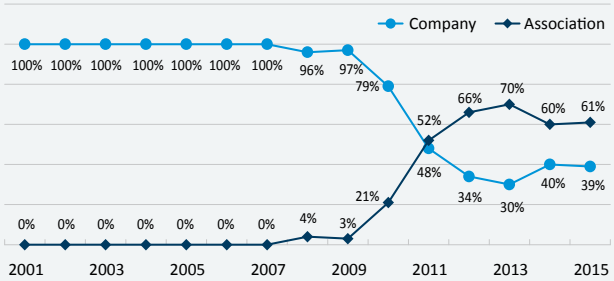
A unique market opportunity

The European Union (EU) is the leading importer of organic bananas. Changes in EU regulations in the 2000s significantly reduced tariffs on banana imports and invited expansion in the sector. At the same time, large multinationals were shifting out of direct production and relying more on suppliers, which provided an opportunity for new players to enter at the production level. Retailers (mainly in the EU) started to explore direct procurement agreements with local producers in exporting countries, which encouraged arrangements with producer organizations that had Fair Trade and organic certification.

Response of Peruvian banana producers

Along with these market-related factors, production factors played a critical role in the expansion of organic banana production. The Costa region proved to be unusually favorable for growing bananas. Its low rainfall meant that producers did not have to invest in drainage, which reduced production costs, and Black Sigatoka disease, which had decimated banana production elsewhere, was not present. Prior to 2001, Peru exported only very small quantities of organic bananas (see the figure), almost entirely through two large multinationals that sent teams of workers, trained and directed by a supervisor, to buy production from nearby farmers whose practices were ascertained to be organic (MINAGRI 2014).

PERUVIAN EXPORTS OF ORGANIC BANANA BY TYPE OF EXPORTER



Source. Solidaridad, 2017.

Even so, because the integrity of the organic production methods could not be ensured, the Ministry of Agriculture and Irrigation (MINAGRI), in partnership with nongovernment organizations aligned with the Fair Trade movement, decided to organize farmers, formally introduce organic production methods, and promote certification. Since the early 2000s, growth in Peru's banana exports has been remarkable, increasing by 45 percent per year between 2000 and 2014 (see the figure). In 2014, the total value of exports was approximately US$89 million, generated on 8,500 ha by 7,500 small-scale producers and 46 producer-based associations. Today, Peru is the second-largest producer of organic bananas worldwide.

Emerging challenges

The organic banana industry must address several emerging challenges if it is to continue to expand and flourish. Smallholders' productivity is low, mainly because underdeveloped input markets make it difficult to obtain good planting material and nitrogen-rich organic fertilizers. Securing sufficient irrigation water is becoming more challenging, because water supplies are limited in the prime production areas. The industry has recognized the need for collective action to resolve problems that limit competitiveness along the value chain, and it has developed platforms to do so.

6.3.3 Lessons from the case studies

Each of the value chains in the case studies is different, but four common features shaped their development. First, in all three instances, the value chain emerged when the industry responded proactively to a clear market opportunity, either existing or potential. Each industry shifted its market orientation and significantly expanded its presence in global markets, because it had insight into how global demand was evolving (especially for differentiated products) and introduced changes on the supply side to meet that demand. Producers of all three commodities were encouraged to take collective action to become certified producers of organic and specialty products. Quality improvements during harvesting and processing were important for cocoa and coffee: for example, cocoa producers undertook more selective harvesting and closer monitoring of de-pulping, fermentation, and drying, whereas coffee producers gained greater control over quality by using cupping practices. Downstream in the value chain, the focus was on strengthening the ability of industry players to control for quality and on supporting marketing promotion domestically and abroad. Second, development of each value chain involved complementary efforts by multiple actors, including producer organizations, agribusiness firms, public agencies, NGOs, and international development agencies, whether closely coordinated or acting in parallel. Third, in every case an entity (or set of entities) provided strategic direction for others to follow in pursuit of a shared goal. Fourth, the value chains took years to materialize, which required participants to have a strong commitment and persistence—often in the face of tremendous uncertainty—and buy-in to a long-term vision.

Are these strategies sufficient to ensure success going forward? Global markets are certain to remain highly competitive. Even if Peruvian producers of coffee, cocoa, and bananas compete successfully today, profit margins remain thin, and risks such as fluctuating prices, climatic factors, and disease will continue to threaten profits. The stakes are significant: the coffee, cocoa, and banana industries combined employ nearly 300,000 farmers—about 15 percent of all farmers in Peru. Efforts to improve market positioning will need to be complemented by on-farm improvements to drive down production costs, increase efficiency, and reduce vulnerability. Peru has scope for progress, because yields are low by international standards and most likely can be improved.

Other value chains that could benefit from these lessons include quinoa, which has traditionally been grown by smallholders, mostly in the Sierra region. Peru focused on expanding production (especially through efforts in the Costa region) to capture a larger share of the conventional market, but it did not complement those

efforts with coordinated measures to differentiate the Peruvian product in quality-conscious markets. Production of quinoa in Peru has increased significantly, but the increase in supply has outstripped growth in global demand for conventional quinoa, and prices in the international market have fallen precipitously.

6.3.4 Beyond high-value exports: Inclusive value chains for dynamic domestic markets

While a few small-scale export-oriented value chains have been successful, given the need to improve the welfare of rural households, it is legitimate to ask whether a concerted effort should be made to support a more inclusive pattern of agricultural growth. The answer to that question depends in part on the opportunities that exist to link small-scale producers to dynamic domestic markets (Level 2 to Level 3 in Figure 38), as opposed to high-value export markets.

Possibilities for involving small-scale producers in export-oriented value chains are shaped by a complex set of factors including the characteristics of the product, the structure of production, the organization of the value chain, the nature of demand, and the motives of the participants, among others. Within this constellation of factors, one actor plays a particularly important role in determining the scope for smallholder participation—namely, the buyers that purchase the commodity from producers (in this case the term "buyers" includes assemblers, processors, and exporters). Decisions taken by buyers about whether and how to involve smallholder producers include a consideration of the costs, product quality, reliability of supply, and risk of non-compliance, among other factors. Many interventions by governments, often with support from the development community, are designed to tilt (or at least level) the playing field so that prominent buyers will be induced to procure from smallholder farmers (World Bank 2011). Their decisions may be based entirely on commercial interests or on a combination of commercial interests and social responsibility objectives.

Looking ahead, clear opportunities exist to capitalize on lessons from experience in developing new value chains that are competitive as well as inclusive, including experience in developing value chains in domestic markets. The native potato value chain (Box 8) is perhaps the country's most emblematic case of a successful, inclusive (pro-poor) value chain developed for domestic markets (Levels 2 and 3 in Figure 38). Many lessons from the export-oriented case studies apply to this value chain. A particularly relevant feature is the range of institutional innovations that emerged to support small-scale farmers and bridge gaps in capacity.

BOX 8. THE EMERGENCE OF THE NATIVE POTATO VALUE CHAIN IN PERU

Potatoes have been a staple of Peruvian diets since ancient times, and many Peruvian farmers continue to grow potatoes today to meet household needs, rather than as a commercial crop. Since the 2000s, however, Peru's native potatoes, promoted for their gastronomic sophistication and nutritional value, have become emblematic of a remarkable experience in market development.

Innovative platforms for building and consolidating a value chain

The effort to develop a value chain for native potatoes was led by the International Potato Center (CIP) via the regional Papa Andina Project and the associated INCOPA project in Peru, which was implemented in Peru for about eight years. Although CIP played a key coordinating role, value chain developments were anchored on innovation platforms involving a broader set of public and private actors and NGOs.

Three stages have been identified by CIP in the development of the native potato value chain. An exploration phase (2001–03) focused on the creation of instruments and participatory methodologies as well as the establishment of partnerships with NGOS. A second phase (2004–07) focused on the development of commercial innovations, market penetration, and strengthening innovation platforms. Key milestones during this phase were the penetration of native potatoes into supermarkets and wholesale markets, as well as the establishment of National Potato Day, which was key to pushing demand from an estimated 70 kg per capita per year in the early 2000s to 80 kg at present. A third phase (2007–10) focused on strengthening technological innovations in production and marketing (for instance, market innovations included processed products such as Lays Andina, Mr. Chips, Pures Villa Andina) and alliances with the gastronomy and restaurant sectors.

Most recently, this value chain has enhanced links with export markets, particularly for processed products. The value of total native potato exports (snacks, frozen, dehydrated, and fresh) increased from US$821,000 in 2010 to US$2.5 million in 2015. Nearly 70 percent of this value comes from the snacks category.

Areas that required attention to achieve broader impacts

A specific characteristic of the development of this value chain has been the role played by NGOs, both as market actors—bridging the capacity of producers to strengthen their links to market players (buyers), negotiating contracts, serving as aggregators, and so on—and as development actors, providing technical support to improve quality and consistency in production and achieve economies of aggregation. Some authors argue that although the role of NGOs as market actors has been critical, more efforts should be made to strengthen the capacity of producer organizations to participate in markets. Studies suggest that there is some social stratification in this value chain (farmers with higher capacities integrate better). For that reason, some authors argue that to mitigate social stratification, the commodity and informal market outlets that households typically access must also receive support.

Source: Proexpansion (2011), Tobin (2014).

The transformation of the food system, driven by demographic trends such as income growth and urbanization, will continue to offer great potential for

differentiating products in the domestic market. The penetration of supermarkets, although proceeding more slowly in Peru than in many other countries at similar stages of development, offers opportunities to link farmers to markets, assuming that they can adjust their products to meet rapidly evolving demand. The expansion of local agro-industry, including smaller firms, might create opportunities for small-scale producers to ally with processors and manufacturers of fruit juices, dairy products, snack foods, and nutritional supplements, among others. The development of the gastronomy value chain presents still other options to small-scale producers. High-end restaurants now source ingredients directly from local farmers and maintain traceability as a way of adding value to their offerings for socially conscious consumers.

Ensuring the participation of smallholders is not easy. Even in value chains regarded as highly "inclusive," including those discussed in this report, there are always concerns that efforts to ensure broad participation will come up short, with the result that the lion's share of the benefits is captured by better-off farmers with the resources, knowledge, and skills to leverage better outcomes from support provided by the government or development community. Native potatoes are a good case in point: most efforts to develop this value chain targeted marginal producers, yet some studies suggest that participants in native potato promotion schemes generally have higher economic status in comparison with other members of their communities (Escobal and Cavero 2012). This finding argues that a step-wise approach might be preferable for ensuring market inclusion. Such an approach would first introduce small changes, followed by continual upgrades, beginning with the farmers who can take small steps; it would not seek to begin by bridging large capacity gaps. The key to success lies in putting tailored strategies into place to target the farmers who have lower prospects of being integrated into these value chain developments.

In summary, although a strategy of product differentiation offers opportunities for many small-scale producers to enter specialized domestic markets, it has limits. Producers who have the resources, knowledge, and skills to take up such opportunities can realize important benefits, yet for most farmers, traditional markets will remain the major outlet. To improve competitiveness and enhance economic opportunities for those farmers, it is critical to reduce their costs, increase their production and productivity, and enhance their resilience in the face of what is likely to become an increasingly variable environment. Going forward, policy makers may need to put more flexible programs into place—programs that are capable of being tailored to the needs of individual farmers or groups of farmers, recognizing that individuals with different sets of resources and capacities will not transition at the same speed.

CHAPTER 7

Evolution of agricultural policies in Peru

Evolution of agricultural policies in Peru

Up to this point, the report has focused primarily on investments needed to increase productivity and enhance competitiveness in Peruvian agriculture. The role of policies—both sectoral policies directed specifically at the agricultural sector and more general policies aimed at the entire economy—has not been discussed in detail. This does not mean that policies are unimportant. Quite the opposite: by determining the quantity and quality of public spending on agriculture, and by shaping the incentives that determine private investment in the sector, policies can play a critical role in affecting performance.

The focus of agricultural policy in Peru has evolved considerably over time. During the 1990s and early 2000s, the primary focus of policy makers was to support development of the agro-export sector, mainly in the Costa region and to some extent in the Selva region. Sectoral policies and investment programs during this period largely ignored family agriculture. A few initiatives were launched in the Sierra region to improve productivity in the small-scale farming sector and enhance management of natural resources, but these initiatives paid limited attention to promoting competitiveness and increasing market integration. More recently, efforts have been made to reverse the historical policy neglect of family farming via a set of legislative actions and investments designed to promote modernization and commercialization of the small-scale farming sector. These efforts appear to be paying off, and important progress has been made in recent years with respect to integrating producers in the Sierra and Selva regions into markets.

To provide a sense of how policy support to agriculture has shifted over time, the evolution of agricultural policy making in Peru since the early 1990s is briefly summarized below.

7.1 Past: Supporting agro-export growth

It is well known that the engine driving Peru's successful agricultural export growth and diversification strategy has been the private sector. Less appreciated is the fact that the emergence in Peru of a thriving agro-export sector was made possible by policies that created a favorable business environment to stimulate private investment while at the same time exposing agribusiness firms to the winds of competition. Using a coordinated set of policy reforms and economic incentives, the government put together an enticing value proposition that facilitated access to productive resources, allowed private firms to share investment risks via tax concessions and other incentives, and demonstrated strong commitment to trade openness. Particularly significant policy interventions occurred in five areas: (i) labor markets, (ii) land markets, (iii) taxation, (iv) trade, and (v) sanitary and phytosanitary compliance.

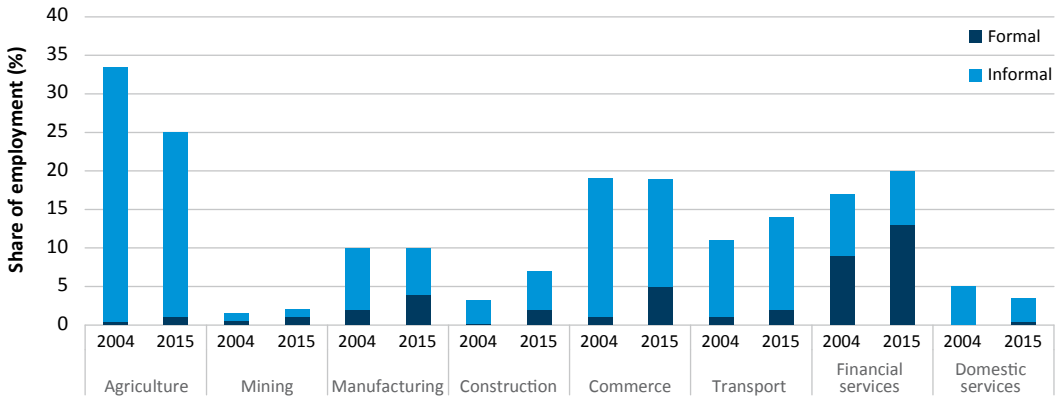
7.1.1 Labor markets

Informality remains extremely high in the agricultural sector of Peru (Figure 39). Because informality has a pervasive impact on economic efficiency and productivity, tax collection, firm development, and job conditions, a core feature of the government's campaign to support agribusiness development has been the regulation of labor markers to promote formality, including in the agricultural sector (Box 9).

Despite the overall policy to promote formalization, the Government of Peru has recognized the unusual characteristics of certain sectors that at times justify special treatment. Nowhere has this been more evident than in the agro-export sector. Special labor regimes covering non-traditional exports (NTEs) date from the late 1970s, when the passage of Decree Law 22342 allowed employers to employ workers indefinitely using consecutive short-term contracts.[39] In 2000, the Peruvian Congress launched the Agricultural Sector Promotion Law 27360. Conceived as a temporary measure to foster the growth of new exports, the law allowed special treatment of agro-export workers, exempting agro-exporters from otherwise mandatory compensation provisions relating to wage scales, vacation time, protections from arbitrary dismissal, and working conditions.

39 In sectors other than NTEs, the use of consecutive short-term contracts is limited to five years. Decree Law 22342 provided an exception for NTE workers by removing the limit on the use of consecutive short-term contracts.

Figure 39. Sectoral employment and level of informality, Peru, 2004-2014



Source: World Bank 2016.

Agro-exporters argue that thanks to the special labor regime applying to the agro-export sector, thousands of formal jobs have been created, and many more will be created as export agriculture continues to expand. Supporters of Law 27360 argue that it has not only increased the number of formal jobs but also improved the quality of those jobs by raising salaries and bringing positive social welfare impacts. Meanwhile, the special labor regime has come under increasing scrutiny from critics who assert that Law 27360 has become, in effect, a permanent mandate and a major obstacle to improving the standard of living for hundreds of thousands of rural Peruvians. These critics argue that the law codifies substandard protections for agro-export workers; commonly cited examples include limitations on the right to association, the lower share of health insurance contributions that employers are required to pay (4.5 percent, compared to 9 percent in other sectors), and the perceived inappropriate use of temporary contracts.

The provisions of Law 27360 are scheduled to expire in December 2021. Representatives of the agro-export industry have proposed that coverage of the law be extended until 2032 or even longer. These proposals have generated a heated debate about whether an extension is really needed, given that the agro-export sector has expanded greatly and become highly profitable since the law was enacted. In parallel, proposals to extend selected provisions of the law to other sectors, to promote job creation and formalization, are generating even more debate, especially the provision that allows firms to reduce the employer health contribution from 9 percent to 4.5 percent of the total compensation package. Given the tremendous challenge faced by the government in seeking to increase formal

employment in the economy as a whole and in the agricultural sector in particular, as the debate intensifies, there is a need to better understand the extent to which Law 27360 has succeeded in promoting job formalization and job creation, as well as the associated impacts on the welfare of workers, the profitability of firms, the fiscal revenues flowing to the government, and the competitiveness of the sector as a whole.

BOX 9. AGRICULTURE AND LABOR FORMALIZATION IN PERU

In Peru, almost 90 percent of firms are informal (meaning they are not registered with the tax authorities), and approximately 70 percent of workers are informal (meaning they are not covered by social security—this includes both workers employed by informal firms and workers who are self-employed). Several factors have been identified as contributing to the high levels of informality found in Peru, including the weak institutional framework, the significant costs associated with formalization, the large size of low-productivity sectors, and cultural and socioeconomic behaviors found among certain economic agents (OECD 2016).

Formalization trends in the overall economy

Because smaller firms have fewer incentives to formalize, the fact that there are so many small and medium enterprises (SMEs) in Peru makes formalization a particularly daunting challenge. On the positive side, progress has been made on reducing informality. The share of employment that is formal grew from 20.1 percent in 2007 to 26.3 percent in 2012. In addition, the median monthly wage for informal workers almost doubled during the period 2004-2014, leading to a reduction in the wage gap between formal and informal employment (World Bank, 2016). The wage gap remains extremely large, however; in 2014, the median monthly income for formal workers was PEN 1,576, compared to only PEN 647 for informal workers, well below the minimum wage (World Bank, 2016). Among the factors that have contributed to increased formalization, the introduction in August 2007 of the e-payroll system stands out; the e-payroll system requires employers having three or more workers to send monthly reports to the National Tax Authority (SUNAT) regarding various aspects of their labor force. Less encouraging, special tax regimes applying to SMEs appear to have been relatively ineffective in reducing informality among SMEs and promoting compliance, although some would argue this is because they have not been implemented fully (OECD, 2016).

Formalization trends in the agricultural sector

Consistent with trends in the overall economy, formalization has increased in the agricultural sector, thanks mainly to the expansion of the agro-export sector. Still, progress has been modest in relation to the high levels of informality that characterize the sector. Access to health insurance, a commonly-used proxy for formalization, has been growing among agricultural workers, whether employed by a firm or self-employed. Many health insurance policies covering agricultural dependent workers (i.e., employees of firms involved in the agricultural sector) were established in 1996 under the Fujimori government, while the regime governing agricultural independent workers (i.e., self-employed workers involved in agricultural activities) has been in place since 1987. According to the International Labour Organization (2015), in 2012 about 9.7 million Peruvians enjoyed health insurance coverage; of these, about 0.5 million had access to coverage through their involvement in agriculture and related sectors (including agribusiness and aquaculture). This meant that roughly 18.7 percent of the approximately 2.7 million people employed in agriculture had health insurance. The vast majority of agricultural workers with access to health insurance (91 percent) were dependent workers. Among the much larger number of independent workers, access to health insurance was and is still very low.

Large agribusiness firms have been the leading contributors to formal job creation in the agricultural sector. Between 2006 and 2012, total employment among large companies grew at an annual rate of 8.4 percent, significantly faster than the rate of formal employment growth among medium-sized companies having 10-100 employees (3.7 percent) and among small companies having less than 10 employees (1.3 percent). In 2012, of the nearly 3,000 companies involved in agriculture/agribusiness activities, the 261 companies (8.7 percent) that employed more than 100 workers accounted for 88 percent of all formal agricultural employment in the country.

7.1.2 Land markets

Land reforms undertaken during the late 1960s radically transformed the ownership structure of agricultural land in Peru, leading during the following three decades to high levels of fragmentation. During the mid-1960s, nearly 30 percent of farms were larger than 500 ha; by 1994, this share had fallen to only 4 percent (Table 24). Fragmentation of landholdings continues in the Sierra region, but it has been reversed in the Costa region and to some extend also in the Selva region. Land and irrigation policies promoted beginning in the early 1990s have encouraged consolidation of landholdings, including the measures embodied in Agrarian Law 27360, which gave a strong push to large investments in irrigation via public and private partnerships (see Box 3, chapter 3). These initiatives are expected to bring 140,000 ha under irrigation and generate more than 300,000 jobs, for a total cost approaching US$500 million.

Table 24. Size distribution of farms in Peru, 1960 to 2012

	1960	1994	2012
Farm size:		% of farms	
0 - 20 ha	50	70	45
20 - 500 ha	21	26	23
500 - 2,500 ha	9	2	8
> 2,500 ha	20	2	24
Total	100	100	100

Source: Based on CENAGRO 2012.

7.1.3 Tax policy

The Government of Peru has passed numerous laws and fiscal regulations designed to make Peru's agricultural sector competitive in global markets. Agrarian Law 27360 established a series of tax incentives favorable to the agricultural sector, including reductions in income tax (agricultural income is taxed at a rate of 15 percent, one-half of the rate applied to other sectors), exemptions from valued added tax (VAT), and a VAT drawback mechanism (applied only to exports) relating to input costs and customs duties. In addition, investments related to irrigation benefit from additional tax exemptions. Aside from these measures, which target the entire sector, other measures have focused on specific regions and products. For example, during the late 1990s measures were introduced under Law 27037 to promote agribusiness development in the Amazon region, which included additional tax reductions on income derived from the production of oil palm, coffee, cocoa, and various native and alternative crops. It is estimated that during the past 10 years, the various tax concession schemes have generated savings for the agribusiness sector on the order of US$6.1 billion (equivalent to about 20 percent of total earnings). Although reliable numbers are not available, back-of-the envelope calculations suggest that the impacts of the VAT drawback mechanism have also been significant.

7.1.4 Trade policy

Trade policy reforms introduced beginning in the 1990s, along with additional reforms implemented during the early 2000s, resulted in a significant opening of the Peruvian economy. The first wave of reforms was designed to jump-start growth after decades of stagnation, while the second wave was introduced during a period of rapid economic growth (Baldarrago and Salinas, 2017). The first wave of reforms, which included unilateral reduction of many non-tariff and tariff barriers, largely dismantled the highly protectionist regime that had been set up two decades earlier as part of an import substitution industrialization strategy. The reforms undertaken during the 2000s were implemented mainly through a series of bilateral and regional trade liberalization agreements. Sensitive sectors such as agriculture, which had not been affected by the earlier reforms, were specifically targeted during the 2000s. Significant tariff reductions on agricultural products took place between 2008 and 2010, following the entrance into force of free-trade agreements with the USA (2009) and China (2010). As a result, the average level of protection given to agricultural products, which stood at 12.9 percent in 2007, fell sharply to 3.9 percent in 2013 (WTO, 2013) (Table 25).

Currently, Peru has free-trade agreements with Chile, the European Union, the European Free Trade Association (which includes Iceland, Liechtenstein, Norway,

and Switzerland), Honduras, Japan, Mexico, Panama, Singapore, South Korea, and Thailand. Peru also has framework agreements in place with MERCOSUR countries (Argentina, Brazil, Uruguay, and Paraguay) and the Andean Community of Nations (Bolivia, Ecuador, and Colombia), as well as a partial preferential agreement with Cuba. Additional trade liberalization agreements have been signed with Costa Rica, Guatemala, and Venezuela and are awaiting implementation. While the USA, China, and the European Union remain Peru's leading trading partners, China's share has grown substantially.

Table 25. Changes in tariff regime, Peru, 2000 vs. 2014

	2000	2014	Change
Animal	13.1	1.5	-11.6
Vegetable	12.7	1.9	-10.8
Food products	13.7	2.0	-11.7
Minerals	8.5	0.8	-7.7
Fuels	6.4	1.2	-5.2
Chemicals	7.2	1.6	-5.6
Plastic or rubber	11.1	2.8	-8.2
Hides and skins	9.3	2.4	-6.9
Wood	16.0	6.3	-9.7
Textiles and clothing	15.6	5.6	-9.9
Footwear	8.3	1.5	-6.8
Stone and glass	7.8	0.8	-7.0
Metals	7.4	0.6	-6.8
Machinery and electricity	8.1	1.0	-7.0
Transportation	9.8	1.7	-8.2

Note: Tariffs weighted by countries' shares of Peru's total imports

Source: Baldarrago and Salinas, 2017.

Not all agricultural products have been exempted from preferential treatment, however. The government has maintained some protection for four products classified as "sensitive" (rice, maize, sugar, and whole milk powder), using a price band mechanism that operates within the Andean community. Under the price band mechanism, tariffs may include an ad valorem component and

another, specific component, which can result in an increase or a reduction in the ad valorem rate. The specific component is calculated based on the level of the international price relative to a band composed of floor and ceiling prices determined on the basis of historical prices prevailing in international reference markets. When the international price falls below the floor, a tariff surcharge is imposed, and when it rises above the ceiling, a tariff reduction is applied. If the international price lies within the band, the corresponding Most Favored Nation (MFN) ad valorem tariff applies, with no surcharges or reductions. The preferential treatment of sensitive products, for which imports make up about 40 percent of total consumption, represents a transfer from consumers (who pay higher prices) to domestic producers (who receive higher prices). Most studies suggest the size of the transfer has decreased over time as production costs in Peru have come down and the difference between international and domestic prices has narrowed.

7.1.5 Sanitary and phytosanitary compliance

Institutional reforms implemented by the Fujimori government led to the creation of SENASA in 1992. Since its creation, SENASA has been able to maintain its technical role outside of political bargains and instabilities; this has been possible because the institution is headed by a steering committee whose members come from the public and private sectors. The agency has played a key role in consolidating market opportunities for the Peruvian agro-export sector by facilitating access through compliance with sanitary and phytosanitary requirements. SENASA also plays a leading role in ensuring the reliability of the framework for organic production. SENASA currently certifies shipments to 174 countries, and it supports private efforts to introduce Peruvian products into new markets by performing pest risk analysis, developing and implementing protocols for quarantine treatments, etc. These functions are increasingly important, given the high share of Peru's agro-exports that go to the demanding United States and European Union markets, whose import requirements evolve continuously, as well as the increasing vulnerability of Peruvian agricultural products to pest and disease risks.

7.2 Present: Addressing regional disparities

Supporting the agro-export sector has been a consistent policy priority for the Government of Peru, but the level of attention paid to other policy objectives has varied over the years. Following several decades of relatively generous support to the agriculture and rural development agenda, the 1990s brought a dramatic decline in government spending on rural areas, which fell from about US$970 million per year in the early and mid-1990s to only US$367 million in 1999 (MINAGRI, 2002). Of the latter amount, about 35 percent supported irrigation investments (mainly in the Costa region), 9.1 percent supported road infrastructure, 47

percent basic sanitation and services, and less than 1 percent went to productive support. The productive support often had a poverty focus, so it was highly concentrated in the Sierra region and was frequently oriented toward enhancing production performance and preserving the natural resource base for agricultural production.[40]

The picture changed beginning in the early 2000s, when the government stepped up its effort to fight poverty and undertook a series of policy actions targeting the Sierra and Selva regions. In some respects, these policy actions mirrored the policies that had given rise to the agricultural export boom in the Costa region: they included tax incentives for private investors, measures designed to facilitate access to productive resources, and co-financing agreements with productive actors.

7.2.1 Tax incentives for private investors

In December 1998, the government enacted Law 27037 to promote investment in the Amazon region. Law 27037, which created a special fund to support infrastructure development and established a set of tax concessions that specifically favored firms dedicated to the production and processing of oil palm, coffee, cocoa, and a number of native and alternative crops, had a noticeable impact in terms of attracting investment into the Amazon region. Based on the success of Law 27037, similar incentives were introduced in 2010 to promote investment in the Sierra region; these incentives were reinforced in 2012 by the approval of a special fiscal regime applicable to agrarian cooperatives as the main "private" actors in the Sierra region. Because the policies targeting the Sierra region are still relatively new, their impacts in terms of stimulating agribusiness developments are not yet known. Some critics have argued, however, that since the tax exemptions relating to the Sierra region have not been introduced as part of a broader program including coordinated investments in productive capacity and infrastructure, their impact is likely to be limited.

7.2.2 Measures to facilitate access to productive resources

Land. Efforts made in the past to expand the agricultural frontier in the Costa region by facilitating transfers of public land to private investors were usually accompanied by initiatives to formalize land registration and strengthen titling. While such initiatives were quite common in the Costa region, they were not always matched by similar initiatives in other regions, leaving a legacy of uneven territorial coverage when it comes to land registration and titling. As discussed

40 Flagship programs to support poor rural households included: Strengthening Extension Systems in the Sierra (FEAS); the National Program for Watershed Management and Soil Conservation (PRONAMACHCs); and the Natural Resources Management Project in the Southern Highlands (MARENASS).

earlier, in 2015, 48 percent of farmers in the Costa region held formal titles to the land that they were cultivating, compared to only 17 percent of farmers in the Sierra region and 23 percent of farmers in the Selva region (ENA 2015).

Efforts to address land registration and land titling issues began in the early 1990s with the launch of the PETT land titling project, which focused on the Costa region, consistent with the policy priorities at the time. PETT was followed by the Rural Land Titling and Registration Project, which started in 1996 and has been implemented in three phases (PTRT1: 1996-2001 costing US$36.5 million; PTRT2: 2001-2006 costing US$46.7 million; and PTRT3: 2015-2019 costing US$80 million). During the nearly 10-year gap between the closing of PTRT2 and the initiation of PTRT3, land registration was pursued at a lower level of activity by COFOPRI. Institutional reforms enacted in the mid-2000s led to the merging of PETT/PTRT with COFOPRI, which brought under one initiative the responsibility for all property rights formalization activities in the country. The same institutional reforms also led to the decentralization of responsibility for land registration and titling processes, as these functions were delegated to the regions.[41] Unfortunately, decentralization gave rise to inefficiencies in rural land registration and titling, and the gains achieved during the past decade have been very modest. In 2013, a new wave of institutional reforms transferred to MINAGRI responsibility for the registration and titling of rural land.[42] Under PTRT3, which started implementing in 2015, land registration and titling efforts have focused particularly on the Selva region and selected parts of the Sierra region. At the same time, the emphasis has been not only on formalizing land ownership but also on strengthening institutional capacity within MINAGRI and within regional governments, so that they can more effectively perform the functions for which they now hold responsibility.

Water. As far back as the mid-1980s, large investments were being made in the Costa region in irrigation infrastructure, as irrigation was considered the key to success for the agro-export sector. As a result, the area under irrigation expanded much more rapidly in the Costa region than in other regions. The regional disparities in the area under irrigation today are being addressed under Law 28585, launched in 2005, which created the National Program for Modernized Irrigation (Programa Nacional de Riego Tecnificado - PNRT) and established the Subsectoral Irrigation Program (Programa Subsectorial de Irrigacion - PSI) as a specialized agency within MINAGRI responsible for modernization of irrigation. While PNRT and PSI have existed for more than a decade, only recently have programs targeting small-scale irrigation investments in the Sierra region started

41 Supreme Decree 088-2008-PCM/DS 056-2010-PCM transferred the responsibilities for rural property regularization to the regional governments, while COFOPRI continued to be responsible for managing the rural cadastral platform.

42 Supreme Decree 0012013-AG, establishing MINAGRI as the lead agency for setting national agrarian policy. In 2014, the Agricultural Property Title Clearance and Rural Cadastre Division (DISPACR) was created within MINAGRI. One of MINAGRI's key national responsibilities is to design and implement projects with the regional governments aimed at improving rural titling and cadastre services.

to gain prominence. The irrigation promotion fund for the Sierra region "Mi Riego" and the PSI-Sierra Project both are targeting vulnerable farmers located in the highlands (originally farmers located above 1,500 masl, later expanded to include farmers located above 1,000 masl). In 2016, MINAGRI launched the "Programa Sierra Azul," with the objective of increasing water security and enhancing the productivity of agriculture throughout the national territory. The rationale for scaling up irrigation investments beyond the Costa region is solid, given recent experiences in the Sierra and Selva regions, which have suffered more frequent and more intense episodes of floods and droughts that are widely attributed to deterioration of watersheds and climate change impacts, including glacial retreat and variability in precipitation patterns.

Beyond the focus on addressing regional disparities in irrigation infrastructure, policy efforts have focused on improving the management of water resources. In many of Peru's river basins, water quantity and water quality are major issues. This is particularly the case in the Costa region, which holds only 1.8 percent of the country's endowment of water resources but which contains nearly one-half of all irrigated land. The continuous expansion of groundwater-dependent farmland in the Costa region has led to water scarcity, causing serious problems and sparking conflicts between users. In addition, uncontrolled use of agrochemicals has negatively affected the quality of water in many intensively farmed zones, affecting people's health, increasing the cost of treating potable water supplies, and reducing prospects for agricultural exports.

Mid- and long-term solutions to the water scarcity problem are being pursued via the construction of large-scale infrastructure designed to exploit the large volumes of water found in the Amazon region (e.g., the Majes-Siguas and Olmos projects). For these ambitious schemes to succeed, however, construction of irrigation infrastructure will have to be accompanied by the introduction of integrated water resource management strategies at the river basin level and the formalization of water rights. The establishment in 2008 of the National Water Authority (Autoridad Nacional del Agua - ANA) has been a key step in creating the institutional framework needed to support integrated water management approaches, but the ANA requires continued strengthening at the national and local levels. Another important regulatory action to promote increased water use efficiency is Law 29736 for the Productive Reconversion in the Agricultural Sector (Ley de Reconversion Productiva Agropecuaria). Enacted in 2014, Law 29736 provides support to help farmers in water-scarce zones transition away from growing crops with high water requirements or crops having negative environmental impacts. Three crops are initially being targeted: cotton in Ica; rice in Tumbes, Piura, Lambayeque, and Libertad; and coca in VRAEM (Valle de los Ríos Apurímac, Ene y Mantaro). The reconversion initiative is being implemented under the AGROIDEAS program.

7.2.3 Co-investments with productive actors

During the 2000s, a series of institutional reforms and legislative actions were undertaken to improve the competitiveness of small-scale producers. Examples of institutional reforms included the creation within MINAGRI of the National Directorate of Agricultural Competitiveness and the launching of two major programs designed to strengthen agricultural policies: Programa de Desarrollo Productivo Agrario Rural (AGRORURAL), created in 2008 as an executing agency within MINAGRI and charged with implementing activities around rural agricultural development in economically underdeveloped regions; and (2) Programa de Compensaciones para la Competitividad Agraria) (PROIDEAS), created to strengthen producer organizations and promote technology adoption among small-scale producers to help them address the impacts of the free-trade agreement signed with the USA. The Sierra Program Export (Sierra Exportadora) was created in 2006 under the Office of the Presidency; rather than supporting direct investments, it focused more strategically on "soft" activities in the areas of institutional coordination and technical support. Also in 2006, Law 28846 on Strengthening Productive Value Chains and Conglomerates (Ley para el Fortalecimiento de las Cadenas Productivas y Conglomerados) provided a mechanism through which the government could co-finance business plans put forward by agricultural entrepreneurs in the Sierra region and more recently also the Selva region.

Many of the initiatives designed to support productive investments in the agricultural sector in Peru have used competitive grant funding mechanisms, under which public funds are used to leverage matching investments from private beneficiaries. Typically, such initiatives have multiple objectives: (i) strengthening the ability of producers to engage in collective action; (ii) encouraging the participation of producer organizations in the identification and implementation of their agro-productive priorities; (iii) promoting links between producers and producer organizations with other economic agents in the value chain; and (iv) encouraging regional and local governments to promote production in their territories. The investments are embedded in business plans and supported with grants, with co-financing provided by producer organizations and in some cases also local governments. Technical assistance and extension support is often linked to investments in infrastructure and machinery.

The co-financing approach has been widely used not only by MINAGRI, but also by other government agencies. For example, the program PROCOMPITE (created in 2009 under Law 29337) allows regional and local governments to allocate up to 10 percent of their resources to support initiatives that use competitive funds to raise productivity and improve competitiveness. PROCOMPITE, which is managed

by the Ministry of Economy and Finance (MEF) working in collaboration with regional and local governments, has seen a large proportion of investments focus on agri-food value chains. Similarly, the Fondo de Cooperación para el Desarrollo Social – FONCODES) managed by MIDIS uses a competitive funding mechanism to strengthen market integration by poor and extremely poor rural populations, with a clear focus on agricultural investments.[43] Competitive funds managed by PRODUCE include the Support to Clusters Program and Start-up Peru, both of which support producer organizations engaged in the production and marketing of agricultural products such as cocoa and coffee. Variations on the competitive funds approach are also used by the Instituto Nacional de Innovación Agraria (INIA) to support investments in agricultural innovation.

7.3 Future: Keys to success

After a long period during which sectoral policies focused mainly on promoting the development of export agriculture in the Costa region, more recently attention has shifted to other regions of the country. Policy actions taken in recent years are designed to address constraints and generate opportunities for small-scale producers in the Sierra and Selva regions. While similar policy actions were successful in the past in attracting private investment into the Costa region, the results were not achieved quickly, and since the focus on the Sierra and Selva regions is still fairly recent, the impacts in these two regions remain to be seen.

The objective of this report is not to recommend specific policy reforms; if policy reforms are to attract political support, they will have to originate within the line ministries responsible for agriculture and agribusiness development, which will in turn have to convince legislators to enact them into law. Nonetheless, some broad lessons can be identified that are relevant as policy makers explore new approaches to support small-scale producers, particularly in the Sierra and Selva regions:

- ***Anchor farm-level investments in a broader strategy.*** In Peru as in other countries, the most successful examples of value chain development highlight the need to provide support not only at the level of primary production, but also at multiple stages in the value chain, as well as in the larger enabling environment. Much of the support provided for productive improvements via competitive funding mechanisms has focused narrowly on the farm level; relatively little support

43 Programs implemented by MIDIS through FONCODES of relevance for rural agricultural families include Haku Wiñay/Noa Jayatai (Vamos a Crecer), Chacra emprendedora, and Compras mi Peru.

has been directed to downstream stages in the value chain. Programs such as AGROIDEAS, PROCOMPITE, and AGRORURAL have demonstrated the impacts that can be achieved when farm-level investments are linked to downstream investments in value chain development, such as the establishment of multi-stakeholder platforms for the prioritization and coordination of investments.

- ***Build capacity among producer organizations.*** Many government programs in Peru channel support through producer organizations. Significant gains could be generated by sharing experiences of working through producer organizations and building consensus on the most effective ways to enhance the capacity of these organizations. Some of the co-financing programs combine strategies around market integration of producer groups/associations and food security objectives via rural communities. Lessons emerging from those experiences are rarely consolidated, shared in a systematic way, and incorporated into broader programs.

- ***Pay attention to the quality of service providers.*** Competitive grant programs typically involve large numbers of service providers, who support producer organizations in the identification, preparation, and implementation of business plans. It is often assumed that good and timely service providers will always be available, but often they are not. Training and capacity building of service providers thus may be needed as part of an integrated approach.

- ***Seize opportunities to develop input markets.*** In many cases, approaches to support productivity and competitiveness focus narrowly on opportunities to develop markets for products. Much less attention is paid to opportunities to develop markets for inputs. The case of organic production provides a good example. More than 90,000 producers are involved in organic production for exports, yet markets for specialized inputs needed to support organic production (e.g., biological fertilizer, organic pesticides) are practically non-existent.

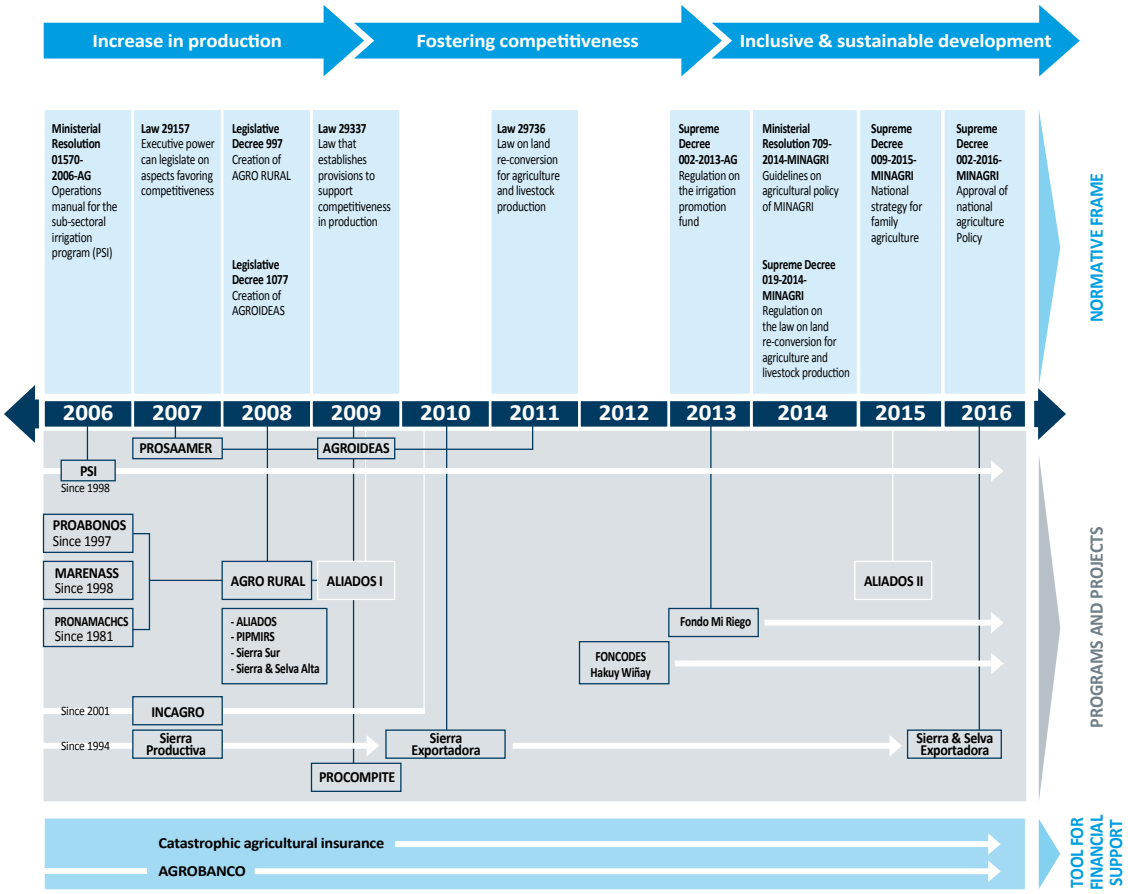
- ***Seek the convergence of programs and investments.*** Initiatives to promote the development of small-scale agriculture often target specific populations. As a result, they sometimes end up operating in silos, oblivious to other ongoing programs and projects that offer potential synergies. Policy makers and program administrators need to better understand the "big picture" and pursue complementarities with other initiatives. Furthermore, the setting of robust and integrated monitoring systems around these co-financing investments is a critical area requiring government attention.

- ***Go beyond the "grant" mechanism.*** An additional opportunity to explore is to improve the complementarity of grant funds with credit schemes to expand the mid- and long-term impacts of these programs. Furthermore, strengthening the

links of these investments with other programs such as land titling, irrigation investments, improved road infrastructure, and others could strongly contribute to enhance their impacts.

- ***Align national programs with local priorities.*** Within the context of the move toward decentralization, there is an emergent tension between the national and regional/local levels, in terms of the ways programs/investments are designed. These tensions could be addressed through better understanding and planning of regional and local agricultural investment opportunities, so that incentives and support can be tailored properly. It will be necessary to strengthen capacities for better planning, including methodologies to identify the areas that offer the greatest potential for agriculture with low environmental impacts, and where agriculture could make an important contribution to growth and poverty reduction.

FIGURE 40. PUBLIC POLICIES AND PROGRAMS SUPPORTING SMALL-SCALE AGRICULTURE COMPETITINENESS



Source of the graph: Agrorural 2017 (unpublished).

CHAPTER 8

Summary and conclusions

Summary and conclusions

8.1 Agriculture in Peru: High-level overview

Agriculture has been and remains a critical sector in Peru. Information and analysis presented in this report make it clear that the importance of agriculture stems from multiple characteristics, summarized in the following stylized facts:

- Value added in agriculture is growing at a robust pace, averaging 3.3 percent per year over the past 15 years
- Agriculture comprises a significant share of GDP—around 11 percent when forward and backward linkages are taken into account
- Because other sectors—notably services—have grown even more rapidly than agriculture, the share of agriculture in the overall economy has declined, but it remains high compared to many other countries at similar stages of development
- Agriculture accounts for a significant share of employment, providing approximately one in every four jobs in the country
- Agriculture is the principal livelihood source for many Peruvians, including a disproportionate share of poor Peruvians
- Agriculture provides an effective pathway out of poverty, in the sense that growth coming from agriculture has a larger impact on reducing poverty than growth coming from other sectors
- Agricultural growth helps to diversify the economy and reduce reliance on non-renewable extractive industries (oil, gas, and minerals)
- In the future, agriculture could play a critical role in mitigating climate change by helping to control GHG emissions and sequester carbon

As these stylized facts indicate, Peru's agriculture has performed well on aggregate. Over the longer term, growth in the sector has been robust, and because agriculture constitutes a significant share of the economy and is the principal livelihood source for many of the country's poorest households, agricultural growth has played a disproportionately large role in helping to reduce poverty. Agricultural growth has been driven to a considerable extent by an impressive expansion of the agro-export sector, with production expanding dramatically in a variety of non-traditional products, and as a result the agricultural sector has been an important generator of export earnings. Income growth, combined with rapid urbanization, has sparked sweeping changes in the larger food system, offering many consumers a wider range of food products at lower prices. The emergence of a Peruvian food culture has helped launch "gastronomic tourism" and sparked the birth of a tourism sub-sector that is providing high-quality jobs for thousands. Finally, thanks to significant gains in the production of domestic staples, growth in the amount of domestically consumed food that is imported has slowed, contributing to enhanced national food security.

8.2 Performance of agriculture: The view from ground level

Viewed from very high up, the performance of Peru's agricultural sector has in many ways been impressive. But viewed from ground level, it is clear that there is considerable room for improvement. Challenges remain to be addressed in a number of areas. Income levels among farming households are stagnating, and poverty rates in rural areas remain stubbornly high. Pronounced territorial imbalances are evident in the pattern of development, with some regions flourishing and others languishing. Many agricultural productions systems remain extremely vulnerable to shocks, especially extreme weather events associated with the El Niño effect and longer-term climate change. Beyond the farm, post-harvest infrastructure has failed to keep up with rapidly growing cities, adversely affecting the quality and safety of food and contributing to enormous losses. And while the national food system has broadened and deepened, malnutrition remains widespread, indicating that too many Peruvians still lack the resources and/or knowledge needed to ensure adequate and healthy diets.

Traveling across the country, it soon becomes evident that agriculture in Peru consists of three vastly different worlds. Because of spatial differences in resource endowments, climate, location, demographics, and policies, among other factors, the Costa, Sierra, and Selva regions offer widely divergent experiences and pose very different challenges.

8.2.1 Costa region: Experience to date and emerging challenges

Without a doubt, the Costa region is home to Peru's greatest agricultural development success story. Recent decades have witnessed the emergence in the Costa region of a dynamic and highly productive commercial agriculture oriented mainly around the production of high-value export crops. The development of agriculture in the Costa region was greatly stimulated by an array of government policies designed to boost productivity and promote competitiveness. Through a series of policy reforms implemented over many years, the government created a favorable enabling environment for agribusiness by removing distortionary price policies, improving the functioning of factor markets (especially land, water, and labor), liberalizing trade regimes to provide easier access to global markets, and directing public investment to critical infrastructure in the irrigation, transport, and energy sectors. Private agribusiness firms, both local and foreign, responded to the favorable enabling environment, bringing in not only resources but equally important improved production technology and knowledge of international markets. The result has been explosive growth in the agro-export sector, which has established Peru as a global leader in the production of many high-value crops.

While the rise of agro-exports in the Costa region has been a clear success, concerns have been raised that the traditional growth engine may soon run out of steam if three major emerging challenges are not addressed. The first challenge will be to maintain productivity growth in primary production. As this report has made clear, the impressive productivity gains recorded in the Costa region derived mainly from growth in the production of high-value export crops, either through conversion of land formerly planted to lower-value crops or through expansion of the area under cultivation. Once all agricultural land has been converted to high-value crops, it will be much more difficult to maintain the same rate of productivity growth. Further diversification into new higher-value crops, yet to be identified, will to some extent be possible, but it will become increasingly important to generate productivity growth in crops that are already being grown—which will give increasing importance to the innovation agenda. A second major challenge emerging in the Costa region will be to respond effectively to the increasing scarcity of productive factors. Demographic growth combined with rapid urbanization is leading to the concentration of the population in the large coastal cities, increasing competition for land and water. Meanwhile, the allure of easier and better-paying jobs in urban areas is precipitating an exodus from the countryside, leaving farm labor in short supply in many areas. Agribusiness firms in the Costa region will have to be very agile in responding to the sharp increases in factor prices that these developments portend. The third major emerging challenge facing agribusiness in

Costa region will be to maintain competitiveness in increasingly demanding global markets. International trade in agri-food products faces increasingly stringent requirements with respect not only to the quality and safety of food products but also to production practices, whose social and environmental impacts are of concern to consumers. Peruvian agribusiness firms therefore will have to develop expertise in recognizing trends in global demand, engaging effectively with international buyers, and adapting production and handling systems to meet their requirements with respect to quantity, quality, and price.

8.2.2 Sierra region: Experience to date and emerging challenges

In stark contrast to the Costa region, vast areas in the Sierra region continue to be dominated by unproductive and non-dynamic subsistence-oriented farming systems. Production methods have changed little over time. With the goal of meeting their own consumption requirements, the majority of households continue to grow low-value staples such as potato, wheat, barley, and quinoa using traditional production methods that involve limited use of purchased inputs and little or no mechanization. Connectivity is a major problem; many producers in the Sierra region lack ready access to markets, so they have little incentive to produce marketable surpluses and few opportunities to generate cash income that can be reinvested in agricultural enterprise.

The challenges facing the Sierra region cannot be characterized as emerging, because they are essentially the challenges that have always existed. Four principal challenges stand out. The first challenge will be to boost productivity in the staples that are currently being grown, so that poor rural households can more easily meet their consumption requirements while freeing up resources for other activities. The second challenge will be to enable diversification into alternative, high-value crops. Given the small farm sizes and the generally unfavorable agro-climatic conditions that characterize much of the Sierra region, no household will ever be able to escape from poverty by growing staples, so there is a need to find alternative, higher-value crops. The third challenge facing agriculture in the Sierra region is to make farming systems more resilient in the face of agro-climatic conditions that are likely to become increasingly unfavorable as a result of climate change and to improve natural resource management. Changes in temperature and precipitation patterns in the Sierra region that are affecting agriculture are already becoming evident; going forward, farmers will need help in adjusting to these changes. The fourth major challenge will be to improve access to markets and connectivity. Agricultural productivity and access to markets are positively related, not only because markets provide an outlet for selling surplus

production and generating income, but also because markets provide a source of inputs and technical know-how. Extending the coverage and improving the quality of the secondary and tertiary road network in the Sierra region, while potentially costly, could play a critical role in improving market access in the Sierra region and driving productivity growth. These infrastructure investments combined with programs to foster market linkages could generate important economic impacts for producers in the Sierra region with the highest agriculture potential.

8.2.3 Selva region: Experience to date and emerging challenges

In the Selva region, the agricultural development story has been mixed. Agriculture was never a major activity in the Selva region, as the indigenous people who inhabit the region traditionally subsisted from hunting and gathering. What little agriculture took place consisted mainly of the cultivation of small kitchen gardens to produce vegetables, roots, and tubers for home consumption, supplemented by keeping a few birds, pigs, or guinea pigs. Beginning about 50 years ago, commercial agriculture began to make inroads into the Selva region, through two distinct avenues. Some parts of the Selva region were colonized by people from the Sierra and Costa regions, who arrived in search of better opportunities. The new arrivals cleared forest land and started raising cattle and/or planting crops, initially mainly annuals but more recently also perennials, including coffee, cocoa, and tropical fruits. In many cases this activity created conflicts with local peoples whose livelihoods depended on resources harvested sustainably from the Selva region's many biomes. The productivity of the newly established agricultural systems has been variable, with productivity often being very low in the early stages after land is brought under cultivation through deforestation. More recently, commercial agribusiness firms have been moving into the Selva region, attracted by the abundant land and favorable agro-climatic conditions that lend themselves to the large-scale production of industrial crops, including oil palm, rubber, coffee, and cocoa.

Precisely because of these vast areas of arable land, abundant water resources, and a climate that is favorable for agriculture, the Selva region has enormous potential. Realizing that potential will not be possible, however, unless three major challenges can be overcome. The first major challenge, as in other regions, is to find sources of productivity growth. Average yields for many of the crops grown in the Selva region are still relatively low, suggesting that there is considerable scope for raising productivity, but doing so will require successful uptake of improved technologies and increased use of modern inputs in a region in which agricultural extension and input distribution systems are largely absent. The second major challenge facing agriculture in the Selva region will be to improve connectivity. Because the Selva

region lies to the east of the Andes, significant costs are involved in transporting products to urban consumption centers to the west and export points along the coast. If agriculture in the Selva region is to become competitive, domestically and globally, these costs will have to come down. The third major challenge facing agriculture in the Selva region is to ensure that agriculture develops in ways that are environmentally friendly and sustainable. The natural biomes found in the Selva region generate important environmental services and harbor an enormous amount of biodiversity whose value is still being assessed; to protect and preserve these biomes, agricultural growth will have to be based on sustainable intensification, rather than through expansion of the land frontier driven by deforestation.

8.3 Key opportunities and entry points

Over the next 10–20 years, the contribution of agriculture to the economy of Peru will remain significant. Projected steady growth in the direct contribution of agriculture through primary production activities, which accounts for 7.3 percent of Peru's value added, will be complemented by even stronger growth in the indirect contribution of agriculture through forward and backward linkages within the broader food system, which is projected to contribute an additional 54 percent over the direct contribution. Directly and indirectly, the sector will contribute to growth and diversification, provide a significant source of employment, and serve as a major driver of poverty reduction.

Unlocking the power of agriculture to perform these vital functions will require a comprehensive and multi-faceted approach to improve the productivity of subsistence-oriented traditional farming systems (particularly in the Sierra region), stimulate the expansion of high-value commercial agriculture, promote growth in non-farm economic activities in rural areas, and help people to move out of agriculture. This calls for a multi-sectoral territorial development strategy, similar to the one proposed under the ENDER, which was formulated in 2004 but never implemented. The key feature of a territorial approach is that it calls for proposed public investments in rural areas to be analyzed holistically, taking into account synergies between complementary interventions. This approach would be quite different from what has been done in the past, for example under the SNIP system, which calls for separate analysis of proposed investments in each sector.

8.3.1 Entry points for boosting productivity and competitiveness

This report has presented evidence on factors affecting the productivity and competitiveness of Peruvian farmers, distinguishing between the particular

circumstances prevailing in each of the three regions. After considering the factors that are constraining productivity and competitiveness, and after considering interventions that could help to overcome those constraints, six entry points emerge as priorities.

(1) Innovation

Maintaining productivity growth in Peru's agricultural sector and ensuring the competitiveness of Peruvian farmers and livestock keepers will depend critically on the ability of participants throughout the food system to innovate. Innovation will be needed in primary production to increase TFP and reduce costs. In traditional crops such as potatoes, maize, and wheat, improved technology is particularly needed to help reduce the current heavy dependence on family and hired labor. In non-traditional crops, including many high-value export crops, improved technology is needed to reduce the use of increasingly scare land and water resources (an urgent priority, particularly in the Costa region) and more importantly to allow commercial producers to continue diversifying into new products and new markets. Innovation will also be needed further along the value chain to reduce logistics costs, improve product quality and safety, and ensure traceability. To date, a lot of innovation in the agricultural sector has come through imported technology, especially in the export sector, where private firms brought in technology and know-how from other parts of the world and adapted it effectively to Peruvian conditions. With the yield gap now narrowing, future innovation will have to be "home grown" to a much greater extent. Home-grown innovation will place a heavier burden on Peruvian institutions, especially the public agencies that will be called upon to produce the public goods and services that profit-oriented private firms are unlikely to finance, such as basic research, conservation of genetic resources, production and generation of information, and applied research targeting the needs of subsistence farmers who have little ability to pay. INIA, in association with MINAGRI, could play an especially influential role in serving as the hub of the national innovation system. With support from the World Bank Group and the Inter-American Development Bank (IDB), MINAGRI has committed to modernizing and strengthening INIA.

(2) Production inputs and advisory services

Maintaining productivity growth and ensuring competitiveness in Peru's agricultural sector will depend as well on the ability of producers and value chain participants to access production inputs and advisory services. Information presented in Chapter 2 of this report shows how the use of purchased inputs—seed of improved varieties, fertilizer, crop chemicals, machinery—is still low in many parts of the country, especially the Sierra and Selva regions. Demand-side factors

are certainly a constraint, including the fact that many small-scale farmers lack resources to purchase inputs or pay for technical assistance, but a more general problem is that input distribution systems are underdeveloped and extension services largely non-existent. Input distribution being fundamentally a private sector activity, opportunities for public participation are limited; global experience makes clear that direct participation by public agencies in the procurement and distribution of seed and fertilizer, which is often undertaken with the help of subsidies, is unlikely to strengthen the private input distribution sector. Instead, the government should focus on creating an environment that encourages private firms to make high-quality inputs available to more farmers at affordable prices. This means eliminating unnecessary regulations regarding the trade in seed, fertilizer, crop chemicals, and agricultural machinery; reducing the tax burden on importing, manufacturing, and selling inputs; and most important of all helping to reduce transport costs by ensuring that the targeting of investments in secondary and tertiary roads takes into account the likely impact on agriculture.

With respect to advisory services, the collapse of the former public extension service due to its high cost and limited effectiveness has left a vacuum. This vacuum provides an opportunity to build new types of advisory service delivery systems, publicly funded but implemented by private service providers on a fee-for service basis and driven by the power of the rapidly evolving information and communication (ICT) sector, which has dramatically lowered the cost of accessing and delivering information. Contrary to the conventional wisdom that long held that farmers—especially subsistence-oriented smallholders—are unwilling or unable to pay for extension advice, experience in Peru and globally makes clear that farmers of all types are willing to pay for extension advice when the advice is relevant and profit-enhancing. Recognizing that this creates a market opportunity, entrepreneurs are targeting agriculture, and recent years have seen a proliferation of advisory service start-ups. The government can help to promote this activity by providing support at early stages of development—for example, by underwriting the cost of subsidized advisory services targeted at small farmers, with beneficiaries expected to make a matching contribution. This approach is already being used on a limited scale through INIA via the National Program for Agricultural Innovation (PNIA), which has awarded numerous small grants for sub-projects promoting innovative methods for delivering extension advisory services.

(3) Skills and capacity development

Innovative technologies, improved production inputs, and relevant advisory services will contribute to productivity growth and enhanced competitiveness only if farmers and livestock keepers have the knowledge and skills to take

advantage of them. In Peru, often they do not. Overall, educational achievement levels are low in rural areas, and relatively few farmers have received technical training related to agriculture. The results of the productivity analysis presented in Chapter 5 of this report are consistent with the results of studies carried out in many other countries in concluding that farmers with more education tend to be more responsive to new opportunities: they adopt improved technologies at a higher rate, use greater amounts of purchased inputs, and achieve higher levels of efficiency and productivity. Capacity development thus offers a clear avenue for enhancing productivity in agriculture over the longer term, particularly among subsistence farmers, whose levels of educational achievement are generally low compared to other groups of farmers.

One area that offers particularly attractive opportunities to generate additional value added from capacity development is the export sector. Production and processing of horticulture exports demands considerable amounts of skilled labor, which is often in short supply. Technical training and skills development programs for workers in the horticulture industry could have a large impact in terms of improving productivity and realizing efficiencies all along the supply chain. PRODUCE has already identified the horticulture cluster and the vegetable processing sectors as clusters to be supported, so there will be certainly opportunities for upgrading these sectors and generating new job opportunities.

(4) Connectivity and market access

In Peru as in other countries, critical factors driving productivity and competitiveness in agriculture are connectivity and market access. In addition to transmitting price signals that can help to direct resources to their most productive and profitable uses, markets provide a conduit for channeling technology and knowledge to farmers and other actors throughout the value chain. This activity has a real impact on productivity. Information presented in Chapter 5 of this report shows that in all three regions, farmers who participate actively in markets (in the sense of selling part of their production) achieve higher levels of productivity. The impacts of improved connectivity and market access are significant: in the Costa region, a reduction of one hour in the travel time to the district capital reduces inefficiency by 5 percent, and in the Costa and the Sierra regions, having access to market information reduces inefficiency by 12 to 13 percent. Better integration into productive markets is also important for reducing inefficiency: the analysis presented in Chapter 5 shows that within individual districts, an increase of 10 percent in the number of farmers engaging in commercial sales (indicating the presence of a market) reduces mean inefficiency by 5, 1, and 1 percent in the Selva, Costa, and Sierra regions, respectively.

Competitiveness could be boosted in the future through investments in the transport networks and associated logistics systems that connect food system participants to markets. For many farmers, the most obvious opportunity for improving connectivity and enhancing market access lies in expanding the reach and improving the condition of secondary and tertiary roads. Rural road construction tends to be expensive, however, so there is a need to ensure that scarce public resources are directed to areas where the potential to stimulate agricultural growth is highest. While there is a tendency to think that priority should be given to connecting the most remote rural communities, in many instances this approach will not be cost effective, and often a better strategy will be to service areas having high agricultural potential that are located closer to urban centers.

Reductions in transport costs are often necessary to stimulate productivity and increase competitiveness, but they are rarely sufficient. Investments in transport infrastructure will usually have to be accompanied by reductions in other post-harvest logistics costs. Many of Peru's food handling and distribution systems have failed to keep up with the country's robust demographic growth and today are ill-equipped to deal with the needs of an increasingly sophisticated population whose consumption preferences are changing rapidly. Market infrastructure and logistics systems are in many instances inadequate, making it difficult to match demand and supply, undermining the quality and safety of many food products by the time they reach consumers, and contributing to wasteful losses that according to some estimates come to one-third of production. Many of the investments needed to reduce logistics costs can be made by profit-oriented private firms, but since the costs are often very high, these activities could become dominated by a small number of extremely large players. To ensure the participation of smaller firms and individuals, public investment will be needed in certain critical areas, for example, in rural assembly points, regional wholesale distribution centers, and urban retail markets.

Investments in infrastructure and post-harvest logistics systems designed to improve connectivity and enhance market access are critically important for increasing connectivity and balancing agribusiness development across regions, but they need to be complemented by investments that help producers integrate into markets by allowing them to raise productivity, achieve economies of scale, reduce costs, and/or improve product quality. In Peru, efforts to better integrate farmers into markets have generated a number of valuable lessons in this regard, such as the importance of strengthening the ability of producers to engage in collective action, the importance of enhancing the role of the private sector in promoting value chain improvements, the need to identify and exploit emerging

opportunities in specific cropping sectors and value chains, and the need to scale up pilots quickly when they show promising results.

(5) Land administration

Land administration reform, to the extent that it could facilitate transfers of land ownership and allow consolidation of landholdings, could provide an important impetus to productivity and competitiveness in the agricultural sector. The extreme fragmentation of agricultural landholdings that characterizes large parts of the country, particularly in the Sierra region, poses a constraint to productivity growth. Because there is a fixed cost involved in adopting many improved production technologies, and because some inputs are lumpy (for example, it is not easy for a farmer to purchase one-half of a tractor), producers will have limited incentives to make the investments needed to improve productivity and enhance competitiveness.

Can land administration reform facilitate access to credit for the many rural households that lack other resources that can be used as collateral? Based on a comprehensive review of evidence from the 1990s and 2000s on the effects of land titling in rural areas of Peru, Fort (2008) concludes that use of titled land as collateral has been limited. Banks and other formal financial institutions, mostly located in the Costa region, have been reluctant to accept agricultural land as collateral for loans, because the land in question often consists of small plots with low value, located in areas where land markets are not well developed. Given these circumstances, it is usually difficult to sell land in case of default. Banks have required that other types of assets be used as collateral, or bigger land parcels. Historically, the Sierra and Selva regions have been particularly disadvantaged, due to the relatively weaker land markets in these regions and the lower presence of financial institutions. More recently, however, the agriculture export boom in the Costa region has led to the development of new financial institutions targeting the agricultural sector, some of which (for example, Cajas Rurales, Microfinance, Agrobanco) have shown a willingness to accept land as collateral. Land sales and rental markets are now more developed, and land values are increasing. The development of land markets remains concentrated mainly in the Costa region, however; land markets remain moribund throughout much of the Sierra and Selva regions, with the exception of a few areas such as Huancayo and Tarapoto.

Aside from the potential value of land titling as a means to secure collateral for credit, land titling can affect agriculture in other ways. While the risk of expropriation of untitled land is generally low in rural areas of Peru, due to the strength of traditional land tenure systems, titling helps reduce conflicts over

boundaries and is appreciated by farmers. There is some evidence that farmers who receive formal titles are more likely to make improvements to their land, but most of these investments are labor intensive and do not require much capital.

The results presented in Chapter 5 of this report show that land titling is associated with higher levels of productive efficiency in the Costa region (access to a land title reduces inefficiency by 10 percent), but not in the other two regions. This finding suggests that efforts to reform land administration systems in the Sierra and Selva regions—with the specific goal of promoting land titling—could be instrumental over the longer term in boosting productivity in those regions. That said, it should be noted that land titling is necessary for developing land markets, but it is not sufficient—other factors must be present as well.

(6) Risk management

Prospects for achieving sustained productivity growth and competitiveness in Peruvian agriculture are threatened by the risk of extreme weather events. Surveys consistently show that farmers and livestock keepers perceive climate events as the single most important risk determining their incomes. And whenever climate events disrupt primary production, other actors along the value chain are also affected. The TFP and SPF analysis described above also shows that the use of agricultural insurance is significantly associated with higher productivity (access to agricultural insurance boosts efficiency among producers in the Selva region by 22 percent, and among subsistence farmers in Peru by 26 percent). Production risk stemming from extreme weather events could be mitigated through various types of insurance products. Coverage of agricultural insurance in Peru is still very limited, however. Numerous attempts have been made to establish commercial insurance in Peru, but none of the instruments that have been introduced has been sustainable, for a combination of reasons: (i) the presence of high basis risk; (ii) the large variety of crops being cultivated, which poses technical difficulties for risk modeling; (iii) the presence of large numbers of widely dispersed small-scale producers; (iv) the absence of reliable data needed for designing insurance contracts; and (v) a general lack of interest on the part of private insurers. Given the lack of success, a clear opportunity exists to make agricultural insurance available to low-income segments of the rural population. Admittedly, this will not be easy; it will require the development of insurance instruments that are cost-effective, affordable, easy to administer, free from moral hazard, and financially sustainable. The government at one stage discussed with the World Bank Group the possibility of mobilizing World Bank assistance to design a market-based risk management mechanism that could overcome the challenges and meet the criteria mentioned above, but the activity never materialized.

8.3.2 Summarizing across the entry points: Building markets for agricultural services

The six entry points described in the previous section are quite diverse, but they have something in common: all depend on services that currently are in very short supply in Peru. In that respect, the primary challenge facing agricultural policy makers, as well as the agencies charged with implementing policies and programs in the sector, is how to build dynamic, efficient, and cost-effective markets for services. Such markets will depend critically on the ability of three principal actors to carry out their respective functions: (i) producers, producer organizations, and agribusiness firms will need to express effective demand for services; (ii) private firms, civil society organizations, and public institutes will need to provide adequate supplies of services; and (iii) government agencies and regulatory bodies will need to establish and enforce rules of the game that ensure that markets for agricultural services function efficiently, i.e., by ensuring that demand for services is expressed effectively and that adequate incentives are in place to encourage service providers to respond.

8.3.3 Boosting productivity and competitiveness: Regional priorities

The relative importance of the six entry points varies by region, consistent with the inter-regional differences in agricultural systems and producer types (Table 26).

Table 26. Regional priorities for public interventions

Entry points	Costa region	Sierra region	Selva region
Innovation	X	X	X
Inputs and advisory services		X	X
Skills and capacity development		X	X
Market access and integration	X	X	X
Land administration		X	X
Risk management	X	X	X

In the Costa region, the policy agenda for agriculture relates mainly to ensuring that the necessary conditions are in place to facilitate private investment. Direct public provision of goods and services is arguably less important in this region, because given the right incentives, agribusiness firms have demonstrated their ability to bring in the technology and mobilize the financial resources needed to respond

effectively in a rapidly evolving marketplace. In the Costa region, public and private investments in logistics networks have been able to bring about significant cost efficiencies, leading to important gains in productivity and competitiveness. Going forward, further upgrades to the quality of roads, improvements in transportation services, and upgrading of port facilities will be important for sustaining export growth. In parallel, institutional strengthening activities to improve the quality of advisory services, for example those provided by SENASA, will help ensure producers have access to the newest technology.

In the Sierra and the Selva regions, the policy agenda for agriculture is more complex, and the public sector will be called upon to play a more proactive role. A major priority in the Sierra and the Selva regions is to improve connectivity. Improvements in the transport network will be needed to help connect farmers in these two regions not only to export markets, but also to opportunities emerging in increasingly differentiated domestic markets, which already include distinct sub-markets such as restaurants, supermarkets, and processing industries. For the time being, Lima remains the largest market, but over the longer term the biggest payoff is likely to come from linking producers and other actors to consumers in more easily accessible intermediate cities, which are projected to experience explosive growth in the coming years. Important gains will come from better market integration, but market integration does not depend simply on the existence of good quality roads and reliable transport services. To participate effectively in markets, producers and food system actors will have to be able to achieve cost efficiencies by capturing economies of scale in production, assembly, processing, storage, and distribution, as well as by upgrading logistics systems to ensure that products can be delivered to consumers at the appropriate time, to the desired standard of quality, and at the right price. Larger private firms will be able to develop this capacity through self-financing, but smaller firms and individuals are likely to require support, including through targeted programs to improve access to credit services. These policies and programs include not only those directly related to the financial services sector, but also those related to land markets, since land is often the only resource that small-scale producers can offer as collateral to secure agricultural credit. One of the most promising opportunities to impact large number of small-scale farmers in the Sierra and Selva regions will be to de-commodify production so that differentiated products can be sold at higher prices into domestic markets. For this strategy to be successful, investments will be needed to upgrade the capacity of producers and other supply chain actors, many of whom still lack the knowledge, skills, and capacities to participate effectively in increasingly sophisticated and increasingly demanding markets. This means that policies and programs must be targeted

specifically at strengthening the capacity of smallholders, as in the extension sub-projects currently being implemented through PNIA.

8.4 Vision for the future

What is a reasonable vision for the future of Peru's agriculture and food system? An ambitious but achievable vision is for the agricultural sector to provide employment and generate incomes for rural households, ensure food and nutrition security for rural and urban households alike, supply domestic as well as export markets with a diversified range of high-quality and nutritious commodities, and be resilient to internal and external economic shocks. In addition, the agriculture and food system will have to be resilient in the face of climatic shocks, environmentally sustainable, and climate smart in the sense of contributing to global reductions in carbon emissions and greenhouse gasses.

More specifically, agriculture has the potential to play five important roles in Peru.

First, **agriculture can remain a major contributor to growth**. With policy reforms, institutional changes, and stepped-up levels of investment, growth in agricultural GDP in Peru could reach 4-5 percent per year. Because the agricultural sector accounts for a significant share of the economy, this level of growth would provide a significant boost to overall GDP growth.

Second, **agriculture can make an important contribution to poverty reduction**. Sustained agricultural growth would create employment for hundreds of thousands of rural households, so the fruits of agricultural growth would be widely shared. Research has shown that agricultural growth is twice as effective in reducing poverty as other types of growth (World Bank, 2007). Consistent with global experience, in Peru the substantial poverty reduction achieved in recent years was led by increases in real labor income, including from agriculture (World Bank, 2016).

Third, **agriculture could become an even larger source of export earnings**. Since 2000, agricultural exports have grown at an average annual rate of 17 percent, and they now account for 13 percent of the country's total exports. This impressive performance was due in part to growth in exports of traditional products such as coffee and sugar, but a more important factor was the growth in exports of non-traditional products including fruits (grapes, avocados, mangos, and bananas), vegetables (asparagus), and even cereals (quinoa). Peru has become a leading supplier to global markets of high-value, healthy agri-food products.

Fourth, **agriculture can provide the basis for improved food security**, both at the national level as well as at the household level. In recent years, food staples have been abundantly available in global markets, and international prices have remained low and relatively stable, but extreme volatility could return at any time. While it is impossible to know whether food crises will recur, development of the agricultural sector will reduce Peru's vulnerability to fluctuations in global food supplies. To the extent that the majority of rural households continue to engage in agricultural activities, the vulnerability of individual households to variability in the availability and cost of food will be reduced as well.

Fifth, **agriculture can make an important contribution to the sustainable management of natural resources**. As a major user of natural resources, agriculture has multiple impacts on the natural resource base. Many of these impacts are negative. For example, agriculture is by far the largest user of water in Peru, contributing to the water shortages experienced in many areas. It has also been implicated as a leading contributor to soil fertility declines, chemical pollution of soil and water, deforestation, and loss of biodiversity. But agriculture can also have positive impacts on the natural resource base. It is often a major provider of environmental services, generally unrecognized and unremunerated: maintaining soil fertility, sequestering carbon, protecting watersheds, capturing carbon, and preserving biodiversity.

8.5 Operationalizing the vision through regional strategies

Achieving this vision will not be easy. In a world in which natural resources will become increasingly scarce and more challenging to manage, agricultural development objectives will become even more closely intertwined with environmental protection objectives. Pressure will mount to reduce agriculture's large environmental footprint, make farming systems less vulnerable to climate change, and harness agriculture to deliver more environmental services. Innovative policy initiatives and strong political commitment will be needed to achieve these objectives, which will require active participation by many sectors in addition to agriculture.

One important message emerging from the information and analysis presented in this report is that the agricultural sector in Peru consists of several different worlds operating at very different stages of development. These circumstances suggest that a territorially focused, graduated strategy designed to provide support in a step-wise fashion could be very effective in helping farmers and other food-system actors climb the development ladder. Subsistence farmers facing

multiple constraints are likely to benefit most from basic productive tools (i.e., productive knowledge through education and technical assistance services, as well as information) and income-smoothing mechanisms (i.e., income and crop diversification strategies) to increase their levels of technical efficiency. Once the initial set of constraints has been lifted, farmers in transition agriculture are likely to benefit most from the improved availability of credit and improved access to markets as they improve their production methods and add value to their outputs through quality enhancements. Finally, consolidated farmers are likely to benefit most from improved availability of credit, better market integration, and improved telecommunication services, factors that will help them reach the scale and achieve the level of efficiency needed to compete effectively in rapidly evolving domestic and foreign markets.

The road ahead: Vision for the Costa region

The policy aspiration for agriculture in the Costa region is to maintain high rates of growth by keeping up with growing demand in domestic markets while at the same time scaling up exports and conquering new international markets. Agriculture in the Costa region being highly commercialized, the main focus of policy makers should be to ensure that private firms have incentives to continue investing to expand and diversify the productive base while also strengthening forward and backward linkages with other industries. In this context, a key consideration—not discussed in this report—will be exchange rate policy, as episodes of rising or falling real exchange rates can overwhelm the effect of most other variables on farm returns and private investment in the sector. Maintaining incentives for private investment should be the main focus of policy makers, but at the same time public agencies including SENASA will increasingly be called upon to help farmers and agribusiness firms more generally comply with food safety and quality standards. If Peruvian producers are to maintain and expand their presence in the OECD countries, North America, and Asia, they will have to meet the rigorous standards required by these demanding markets. Last but not least, over the longer term the productivity and competitiveness of agriculture in the Costa region will depend critically on the ability of farmers, livestock keepers, and other actors throughout the value chain to manage resources efficiently and sustainably.

The road ahead: Vision for the Sierra and Selva regions

The policy aspiration for agriculture in the Sierra and Selva regions is to transform these regions into dynamic sources of diversified export growth. Although some

progress has been made, until now exports from these regions have consisted mainly of bulk commodities with relatively low levels of export requirements, such as regular grade coffee, cocoa, and quinoa. Differentiating certain grades so that they can be sold as specialty products into high-value export markets has yet to happen on a large scale. If a product differentiation strategy is to succeed, however, investments will be needed to transform primary production practices and upgrade existing value chains. Previous experience in de-commodifying coffee, cocoa, bananas, native potatoes, and other products provides valuable lessons about how to go about supporting the upgrading of value chains, especially the importance of paying attention not only to improving primary production practices, but also many other activities downstream in the value chain.

The agricultural development challenge in the Sierra and Selva regions is broad and complex. This breadth and complexity are reflected in the government's strategy for these regions, which proposes actions in 12 strategic areas to improve competitiveness and productivity while enhancing resilience and improving natural resource management. One of the key factors that contributed to the successful development of a dynamic agro-export industry in the Costa region was the fact that policy makers were able to develop a holistic approach that included land and labor market reforms, public investments in critical infrastructure (irrigation, roads, port facilities), tax incentives for agribusiness, and market liberalization measure. These efforts were highly coordinated and geographically focused. A similar approach involving high levels of policy and program coordination combined with geographic prioritization is needed for the Sierra and Selva regions. Admittedly, achieving such coordination may be more challenging today, given recent moves by the government to encourage decentralization of policy and investment decision-making. Yet recent experiences—the development of the Puno-Cusco corridor is one instance—show that important economic territorial dynamics can be developed by building upon investments in connectivity through complementary interventions specific to the agricultural sector, applied in a consistent, sustained manner and linked with local and regional priorities (Briceno and Moroz, 2016). That said, it is important that territorial development strategies in the Sierra and the Selva regions accommodate the heterogeneity of these regions, recognizing the diverse needs of producers with very different sets of capacities who also have very different sets of opportunities. In this respect, there is a need to better understand the characteristics of different types of farmers, so that interventions can be designed to support their transition to more sustained income-generating opportunities within and outside the agricultural sector.

8.6 Roles and responsibilities

The results summarized in this report emerged from work undertaken to describe Peru's agricultural sector, diagnose constraints that are negatively affecting the performance of Peruvian agriculture, and identify opportunities to improve productivity and enhance competitiveness in major agricultural value chains. The work was not intended to be prescriptive, however, and for that reason no operational guidelines are presented or specific actions recommended. Still, it is important to recognize that to be successful, future initiatives to improve productivity and enhance competitiveness in Peru's agricultural sector will have to be designed and implemented taking into account the different roles of the three tiers of government: national, regional, and local. Consistent with the government's desire to empower citizens by decentralizing decision-making authority away from Lima and conferring responsibility for program design and execution to the regional and local levels, each tier of government will logically have to play a different role in operationalizing the agricultural development agenda going forward. National bodies—not only line ministries such as MINAGRI, PRODUCE, and MIDIS, but also regulatory agencies such as SENASA and ANA—will have to play a strong coordination role in establishing the rules of the game through policy measures and regulatory actions. Regional bodies, especially the regional governments, will be called upon to adapt national policies and regulations according to regional priorities and incorporate them in regional development plans and programs. Local bodies, including municipal governments, will be expected to help mobilize the resources needed to implement the regional development plans and programs at local level. Achieving effective coordination among the three tiers will not be easy, as opinions will always differ about what should be the overall policy priorities and what is the best strategy for pursuing them. Successful outcomes are within reach, but they will require a strong commitment to collaboration, along with mutual respect and a considerable level of trust.

CHAPTER 9

References

References

- Aigner, D., C. A. K. Lovell, and P. Schmidt. 1977. Formulation and Estimation of Stochastic Frontier Production Function Models. Journal of Econometrics, Vol 6, no, 1, 21–37, https://doi.org/10.1016/0304-4076(77)90052-5
- Alvarez, A., and C. Arias. 2004. Technical efficiency and farm size: A Conditional analysis. Agricultural Economics, Vol 30, No 3, 241-250.
- Agrorural. 2017. Sistematización de la experiencia del Proyecto Aliados II. Documento en preparación por Apoyo Consultoría. Sin publicar.
- Apoyo Consultoría. 2015. Presentaciones cadena del cacao y cadena del café. Documentos comisionados por el Banco Mundial.
- Aragon, F., F. Oteiza, and J.P. Rud. 2017. "Climate Change and Agriculture in a Developing Country: Farm Level Responses to Extreme Heat," Working Paper, Simon Fraser University.
- Arnade, C. 1998. Using a programming approach to measure international agricultural efficiency and productivity. Journal of Agricultural Economics, Vol 49, No 1, 67-84.
- Asensio, R. H., and C. Trivelli. 2012. Crecimiento económico, cohesión social y trayectorias divergentes Valle Sur – Ocongate (Cuzco – Perú)". Documento de Trabajo N° 65, Programa de Dinámicas Territoriales. Rimisp – Centro Latinoamericano para el Desarrollo Rural, Santiago, Chile.
- Baldarrago, E., Salinas, G. 2017. Trade Liberalization in Peru: Adjustment Costs Amidst High Labor Mobility. IMF Working Papers, WP/17/47. International Monetary Fund, March 2017. Washington, DC. USA
- Barrett, C. B. 1996. On Price Risk and the Inverse Farm Size–Productivity Relationship. Journal of Development Economics, Vol 51, No 2, 193–215.

- Barrett. C., M.F. Bellemare, and J.Y. Hou. 2010. Reconsidering Conventional Explanations of the Inverse Productivity–Size Relationship. World Development, Vol 38, No 1, 88–97.
- Battese, G. E., and T.J. Coelli. 1988. Prediction of firm-level technical efficiencies with a generalized frontier production function and panel data. Journal of Econometrics, Vol 38, No 3, 387–399.
- Battese, G. E., and T.J. Coelli. 1992. Frontier production functions, technical efficiency and panel data: with application to paddy farmers in India. In International applications of productivity and efficiency analysis, 149-165, Springer Netherlands.
- Berdegué, J.A., and F. Modrego (Eds.). 2012. De Yucatán a Chiloé. Dinámicas territoriales en América Latina. Buenos Aires: Editorial Teseo.
- Berdegué J. A. and Proctor F. J. with Cazzuffi C., 2014. Inclusive Rural–Urban Linkages. Working Paper Series N° 123. Working Group: Development with Territorial Cohesion. Territorial Cohesion for Development Program. Rimisp, Santiago, Chile.
- BID and CEPAL. 2014. "La economía del cambio climático en el Perú." Banco Interamericano de Desarrollo (BID), Comisión Económica para América Latina y el Caribe (CEPAL). Monografía del BID 222.
- Binswanger, H. P., K. Deininger, and G. Feder. 1995. Power, distortions, revolt and reform in agricultural land relations. Handbook of Development Economics, Vol 3, 2659-2772.
- Bourliaud, J., and Eresue, Michel. 2015. La (re)concentración de las tierras costeñas. Revista Agraria, Año 15, N0169, enero 2015. Centro Peruano de Estudios Sociales. Lima, Perú.
- Bravo-Ortega, C., and D. Lederman. 2005. Agriculture and national welfare around the world: causality and international heterogeneity since 1960. World Bank Policy Research Working Paper, No 3499.
- Briceño-Garmendia, C. and Moroz, H. 2016. Geography, Economic Activity and Infrastructure Networks in Peru. Background paper. The World Bank.
- Carletto, C., S. Savastano, and A. Zezza, A. 2013. Fact or artifact: The impact of measurement errors on the farm size–productivity relationship. Journal of Development Economics, Vol 103, 254-261.
- Carter, M.R. 1984. Identification of the inverse relationship between farm size and productivity: an empirical analysis of peasant agricultural production. Oxford Economic Papers, 131-145.
- Caves, D. W., L.R. Christensen, and W.E. Diewert. 1982. The economic theory of index numbers and the measurement of input, output, and productivity. Econometrica: Journal of the Econometric Society, 1393-1414.

- Coelli, T. J., D.S.P. Rao, C.J. O'Donnell, and G.E. Battese. 2005. An introduction to efficiency and productivity analysis. Biometrics, Vol 41.
- De Ferranti, D., G.E. Perry, W. Foster, D. Lederman, and A. Valdés. 2006. Beyond the City: The Rural Contribution to Development. Latin American and Caribbean Studies. Washington, DC: World Bank.
- De Los Rios, C. 2013. La eficiencia técnica en la agricultura peruana (El caso del algodón Tanguis en los valles de Huaral, Cañete y Chincha). Debate Agrario, Vol 40/41, 141-168.
- Dixon, J., Omwega, M., Burns, C., Donati, Kelly., and Carlisle, R. 2007. The Health Equity Dimensions of Urban Food Systems. Journal of Urban Health. 2007 May; 84(Suppl 1): 118–129.
- Eastwood, R., M. Lipton, and A. Newell. 2010. Farm size. Handbook of agricultural economics, Vol 4, 3323-3397.
- Escobal, J, A., and Cavero, D. 2012. Transaction Costs, Institutional Arrangements and Inequality Outcomes: Potato Marketing by Small Producers in Rural Peru. World Development Vol. 40, No. 2, pp. 329–341, 2012.
- Escobal, J., R. Forte, E. Zegarra. 2015. Agricultura Peruana: Nuevas Miradas desde el Censo Agropecuario. Grupo de Análisis para el Desarrollo, GRADE. Lima, Perú.
- Escobal, J., and C. Armas. 2015. El uso de encuestas y censos agropecuarios para desarrollar una tipología de la pequeña y mediana agricultura familiar en el Perú. Capitulos de Libros, 123-165.
- Escobal, J. and C. Armas (2016). " Documentos de Investigación dt79, Grupo de Análisis para el Desarrollo (GRADE).
- Eswaran, M., and A. Kotwal. 1985. A Theory of Contractual Structure in Agriculture. American Economic Review, Vol 75, 352-67.
- Eswaran, M., and A. Kotwal. 1986. Access to Capital and Agrarian Production Organization. Economic Journal, Vol 96, 482-98.
- FAO. 2016. The Structural Transformation of Latin American Economies: A Sectoral Long-Term Review. Rural Transformation Conference - 19-20 September 2016, FAO Headquarters, Rome, Italy. Food and Agriculture Organization of the United Nations.
- Fernandex-Stark, K., Bamber, P., and Gereffi, G. 2016. Peru in the Table Grape Global Value Chain OPPORTUNITIES FOR UPGRADING. January, 2016. Duke University. Report commissioned by the World Bank.
- Fort, R. 2007. Property rights after market liberalization reforms: Land Titling and investments in rural Peru. Wageningen Academic Publisher: Wageningen, The Netherlands.

- Fort, R. 2008. Assessing the Impact of Rural Land Titling in Peru: The Case of the PETT program. World Bank Conference on New Challenges for Land Policy and Administration.
- Fort, R., M.I. Remy, H. Paredes. 2015. ¿Es necesaria una Estrategia Nacional de Desarrollo Rural en el Perú?: aportes para el debate y propuesta de implementación. Lima: GRADE.
- Foster, A. D., and M.R. Rosenzweig. 2017. Input Transaction Costs, Mechanization, and the Misallocation of Land: The irrelevance of the IR. Working paper, Yale University.
- Foster, W. and A. Valdes. 2015. Measuring the Size of the Renewable Resource Sector: The Case of Chile. World Food Policy, Vol 2, No 1.
- Fulginiti, L., and R.K. Perrin. 1993. The theory and measurement of producer response under quotas. The Review of Economics and Statistics, 97-106.
- Fulginiti, L. E., and R.K. Perrin. 1997. LDC agriculture: Nonparametric Malmquist productivity indexes. Journal of Development Economics, Vol 53, No 2, 373-390.
- Fulginiti, L. E., and R.K. Perrin. 1998. Agricultural productivity in developing countries. Agricultural economics, Vol 19, No 1, 45-51.
- Fulginiti, L. E., and R.K. Perrin. 1999. Have price policies damaged LDC agricultural productivity? Contemporary Economic Policy, Vol 17, No 4, 469-475.
- GAIN 2014a. Peruvian Supermarket Expansion Boosts U.S. Export Opportunities. Global Agriculture Information Network. GAIN Report, December 2014. USDA Foreign Agriculture Service (FAS).
- GAIN. 2014b. Peru. Food Service - Hotel Restaurant Institutional: Peru, a Gastronomic Powerhouse. Global Agriculture Information Network. GAIN Report, December 2014. USDA Foreign Agriculture Service (FAS).
- Galarza, F. B., and J. Guillermo - Díaz. 2015. Productividad total de factores en la agricultura peruana: estimación y determinantes. Economía, Vol 38, No 76, 77–116.
- Gestion (Peru). FMI mantiene proyección de crecimiento del Perú en 3,7% para el 2016. http://gestion.pe/economia/fmi-mantiene-proyeccion-crecimiento-peru-37-2016-2165903.
- Gollin, D., D. Lakatos, and M.E. Waugh. 2014. The Agricultural Productivity Gap. The Quarterly Journal of Economics. pp 939–993.
- Greene, W. H. 1980. On the estimation of a flexible frontier production model. Journal of Econometrics, Vol 13, No 1, 101–15.
- Greene, W. H. 2003. Simulated likelihood estimation of the normal-gamma stochastic frontier function. Journal of Productivity Analysis, Vol 19, No 2, 179-190.

- Gutiérrez, L. H. 2013. Red de mercados de abastos competitivos y la cadena de la gastronomía [PPT].
- Helfand, S.M., and M.P.H. Taylor. 2017. The Inverse Relationship between Farm Size and Productivity: Refocusing the Debate. Working Paper, University of California Riverside.
- Iacovone, L., L.F. Sanchez-Bayardo, and S. Sharma. 2015. Regional Productivity Convergence in Peru. World Bank Policy Research Working Paper 7499, Washington D.C.
- Imedia (Peru). http://prensa.imedia.pe/custm/notas.php?cod=7556889&pass=734ab742c72
- Instituto Nacional de Estadística e Informática INEI, Ministerio de Agricultura y Riego. 2013. IV Censo nacional Agropecuario 2012 (IV CENAGRO). Lima. Peru.
- Jondrow, J., C.A. Knox Lovell, I.S. Materov, and P. Schmidt. 1982. On the estimation of technical inefficiency in the stochastic frontier production function model. Journal of Econometrics, Vol 19, No. 2–3, 233–238.
- Kagin, J., J.E. Taylor, and A. Yunez-Naude. 2015. Inverse Productivity or Inverse Efficiency? Evidence from Mexico. The Journal of Development Studies, 1-16.
- Kevane, M. 1996. Agrarian Structure and Agricultural Practice. Typology and Application to Western Sudan. American Journal of Agricultural Economics, Vol 78, No 1, 236–245.
- Key, N. 2017. Farm size and Productivity Growth in the United States Corn Belt. Presented at the USDA Farm Size and Productivity Conference.
- Kumbhakar, S., H.-J., Wang, and A. Horncastle. 2015. A Practitioner's Guide to Stochastic Frontier Analysis Using Stata.
- La Republica (Peru). 2017. "1.5 millones de agricultores afectados por Niño costero y 90 mil hectáreas perdidas". Perú 2017. http://larepublica.pe/impresa/economia/862248-15-millones-de-agricultores-afectados-por-nino-costero-y-90-mil-hectareas-perdidas
- Lopez-Calva, Luis F.; Ortiz-Juarez, Eduardo. 2011. A Vulnerability Approach to the Definition of the Middle Class. Policy Research working paper; no. WPS 5902. World Bank. Available in: <https://openknowledge.worldbank.org/handle/10986/3669>.
- Ludena, C. E. 2010. Agricultural productivity growth, efficiency change and technical progress in Latin America and the Caribbean.
- Matsuura, K., and C. Willmott. 2007. Terrestrial Air Temperature and Precipitation: 1900-2006 Gridded Monthly Time Series, Version 1.01. University of Delaware. http://climate. geog. udel. edu/climate.

- McCullough, E. 2015. Labor Productivity and Employment Gaps in Sub-Saharan Africa, World Bank Policy Research Working Paper 7234, Washington D.C.
- Meeusen, W., and J. van Den Broeck. 1977. Efficiency estimation from Cobb-Douglas production functions with composed error. International economic review, 435-444.
- Ministerio de Agricultura, 2012-FAO. Plan de Gestión de Riesgos y Adaptación al Cambio Climático para el Sector Agrario PLANGRACC 2012-2021. Available in: <http://minagri.gob.pe/portal/download/pdf/especiales/plangracc/plangracc.pdf>
- Ministerio de Agricultura y Riego. El Banano Peruano "Producto Estrella de Exportación". Tendencias de la producción y e l comercio del banano en e l mercado internacional y nacional. Lima. Ministerio de Agricultura y Riego. Noviembre 2014.
- Molina, O., and V. Saldarriaga. 2017. The perils of climate change: In utero exposure to temperature variability and birth outcomes in the Andean region. Economics & Human Biology, Vol 24, 111-124.
- Muyanga, M., and T.S. Jayne. 2016. Is Small Still Beautiful? The Farm-Size Productivity Relationship Revisited, presentation at the conference on Land Policy in Africa, Addis Ababa, Ethiopia.
- Nakasone, E. 2013. The role of price information in agricultural markets: Experimental evidence from rural Peru. In Annual Meeting of the Agricultural and Applied Economics Association.
- OECD. 2016. OECD Territorial Reviews: Peru 2016. Paris: OECD. http://dx.doi.org/10.1787/9789264262904-en
- Gutierrez, L. H. 2013. Red de Mercados de Abastos Competitivos y la Cadena de la Gastronomía. Power Point Presentation.
- Proexpansion. 2011. Cambios del sector papa en el Perú en la última década: Los aportes del proyecto Innovación y Competitividad de la Papa (INCOPA). November 2011.
- ProInversión. 2010. Peru: Establishing a framework for transferring public land. Power Point Presentation. 2010.
- ProInversión. 2016. Desarrollo de las APP de Irrigación en el Perú. Power Point Presentation. Noviembre 2016.
- Reardon, M., Berdegué, J. 2002. The Rapid Rise of Supermarkets in Latin America: Challenges and Opportunities for Development. Development Policy Review, 2002, 20 (4): 317-334
- Republic of Peru. 2015. Contribución prevista y determinada a nivel nacional (INDC1) de la Republica del Perú. Country Paper for the Paris 21st Conference of the Parties (COP).

- Rocha, R., and R.R. Soares. 2015. Water scarcity and birth outcomes in the Brazilian semiarid. Journal of Development Economics, Vol 112, 72-91.
- Sen, A. K. 1962. An Aspect of Indian Agriculture. Economic Weekly, Vol 14, 243–266.
- Sen, A. K. 1966. Peasants and Dualism with or Without Surplus Labor. Journal of Political Economy, Vol 74, No 5, 425–450.
- Sheng, Y., and W. Chancellor. 2017. Exploring the Relationship between Farm Size and Productivity: Evidence from the Australian Grain Industry. Presented at the USDA Farm Size and Productivity Conference.
- Schuster, M., and Maertens, M. 2015. Worker Empowerment through Private Standards. Evidence from the Peruvian Horticultural Export Sector. Bioeconomics Working Paper Series. Working 2015/7. University of Leuven, Belgium.
- Solidaridad, 2017. Cadena del Banano Orgánico en Perú. Power Point Presentation. January 2017.
- Stevenson, R. E. 1980. Likelihood Functions for Generalized Stochastic Frontier Estimation. Journal of Econometrics, Vol 13, 57–66.
- Tobin, D. 2014. Interactions between livelihoods and pro-poor value chains: A case study of native potatoes in the central highlands of Peru. PhD Thesis. The Pennsylvania State University, 2014.
- Trindade, F. J., and L.E. Fulginiti. 2015. Is there a slowdown in agricultural productivity growth in South America? Agricultural Economics, Vol 46, No S1, 69-81.
- United States Department of Agriculture. 2016. International Agricultural Productivity. Washington, DC. https://www.ers.usda.gov/data-products/international-agricultural-productivity
- Wang, S.L., F. Tuan, F. Gale, A. Somwaru, and J. Hansen. 2013. China's regional agricultural productivity growth in 1985–2007: A multilateral comparison. Agricultural Economics, Vol 44, No 2, 241-251.
- World Bank. 2007. World Development Report 2008: Agriculture for Development. Washington, DC.
- World Bank. 2011. Making the Grade: Smallholder Farmers, Emerging Standards, and Development Assistance Programs in Africa. A Research Program Synthesis. The World Bank.
- World Bank. 2012. Public Expenditure Review for Peru: Spending for Results, Report No 62586-PE.
- World Bank. 2013. El Futuro del Riego en el Perú. Volumen 1. Informe de Síntesis. Washington DC: World Bank.

- World Bank. 2015. Agriculture in Nicaragua: Performance, Challenges, and Options.
- World Bank. 2015. Perú – Hacia un Sistema integrado de ciudades. Una nueva visión para crecer. Lima: World Bank.
- World Bank; CIAT; CATIE. 2015. Climate Smart Agriculture in Peru. CSA Country profiles for Latin American Series. 2nd ed. Washington D.C.: World Bank Group.
- World Bank. 2016. Peru Systematic Country Diagnosis. Available in: <http://documents.worldbank.org/curated/en/919181490109288624/pdf/Peru-SCD-final-3-16-17-03162017.pdf>.
- World Bank. 2017. Enabling the Business of Agriculture. Country Profile: Peru. 2017 International Bank for Reconstruction and Development, The World Bank.
- World Trade Organization (WTO). 2013. Trade Policy Review 2013. Geneva: WTO.
- Zaibet, L. T., and E.G. Dunn. 1998. Land Tenure, Farm Size, and Rural Market Participation in Developing Countries: The Case of the Tunisian Olive Sector. Economic Development and Cultural Change, Vol. 46.
- Zegarra, E. and J.P. Gayoso. 2015. Cambios en la agricultura y deforestación en la selva peruana: análisis basado en el IV Censo Agropecuario. In J. Escobal, R. Fort, and E. Zegarra (eds.). Agricultura peruana: nuevas miradas desde el censo agropecuario. Lima: GRADE.
- Zegarra, E. 2010. Seguridad alimentaria: una propuesta de política para el próximo gobierno. Opciones de política económica en el Perú 2011-2015. Lima: GRADE.

Annexes

ANNEX 1

Measuring the importance of agriculture: methodology

To create an expanded agricultural VA measure, we consider two types of linkages as per Foster and Valdes (2015): forward linkages are measured through the value of input delivery to downstream uses of other sectors, and backward linkages are the value of purchases of a given sector from upstream sector input markets. For Peru input-output matrices show important linkages through the agro-food industry in the provision of unprocessed milk for dairy products, animals including chicken and cattle for processed meat, rough rice, wheat and sugar cane for processed pastas and sugar, and anchovies for the production of fish meal and oil, among others.

We use Peru's 2007 Production and Input-Output (I-O) matrices from the Cuentas Nacionales produced by the Instituto Nacional de Estadística e Informática (INEI) to generate our estimates. For each product, these tables include information disaggregated into intermediate inputs used by activities, production, and final demand split into domestic and foreign consumption (exports). The 2007 Peru I-O table of utilization, at current prices, consists of 365 products aggregated into 111 activities. Of these, 69 products and 5 activities pertain to renewable primary production encompassing agricultural, agroforestry, and fisheries and aquaculture.

To illustrate the difference between activities that are not typically considered as part of primary production but are heavily dependent on inputs from this sector—and may be considered as being accounted for in primary production

among economists and policy makers unfamiliar with the details of national accounting—we present examples in Table A1.1 and Table A1.2. For the processing and preservation of meat, counting only the contribution of primary production for the activity through the supply of live animals as an intermediate input accounts for 80 percent of the VA of these activities. However, including actual animal meat, animal feed, and yellow corn primary production contributes roughly 90 percent of the total cost. Similarly, for wine manufacturing in Peru, grapes as a raw material accounts for 31 percent of the cost of production. With many cases of similarly strong linkages in which production within the agro-food industry is not included in the VA of primary production, the knock-on policy implications of agricultural protectionism may not be fully accounted for, if the sector is viewed from the traditional accounting perspective.

Table A1.1: Dependence of the meat sector on primary agriculture, 2007

Product	Participation
Chicken	40.85
Cattle	16.11
Other live birds	7.75
Pig	7.65
Sheep and goats	5.01
Pork meat	4.37
Prepared animal feed	3.61
Other live animals	2.74
Hard yellow corn	2.59
Chicken meat and offal	1.67
Fats of vegetable and animal origin	0.82
Meat from other mammals	0.74
Articles and plastic materials	0.71
Mammals and slaughter by-products	0.51
Other products	4.88

Source: Instituto Nacional de Estadística e Informática (INEI), Cuentas Nacionales, 2007.

Table A1.2: Dependence of wine manufacture on primary agriculture, 2007

Product	Participation
Grapes	30.82
Bottles and glass jars	21.23
Advertising services	10.62
Services of protection, research, private security, systems and security consultancy	5.14
White sugar	4.79
Accounting, auditing and consulting services on management and business management	4.45
Articles and plastic materials	2.40
Corrugated paper and paperboard	2.05
Synthetic organic and prepared coloring matter and other basic chemical substances	2.05
Other products	16.44

Source: Instituto Nacional de Estadística e Informática (INEI), Cuentas Nacionales, 2007.

In estimating an expanded measure of the value of agriculture, merely taking a sum of the VA of activities closely related to agriculture would overestimate the role of agriculture. Taking into account 29 activities closely related to the primary renewable resource sector, Table A1.3 demonstrates this point.

Table A1.3: Activities closely related to the renewable primary resource sector, 2007

Activity	Intermediate demand from primary sector by activity (millions of soles, 2007 prices)	Participation (% total VA)
Processing and preserving of meat	6,203	0.46
Milling, noodles and other pasta	3,702	0.50
Manufacture of fish meal and oil	2,669	0.56
Manufacture of other food products	1,409	0.23
Restaurants	1,384	2.64

Table A1.3: Activities closely related to the renewable primary resource sector, 2007 *(continued)*

Activity	Intermediate demand from primary sector by activity (millions of soles, 2007 prices)	Participation (% total VA)
Manufacture of dairy products	1,372	0.30
Processing and preservation of fish	1,038	0.34
Sawmills, planing and veneer sheets	997	0.41
Processing and conservation of fruits and vegetables	952	0.26
Preparation and spinning of textile fibers	824	0.27
Other Manufacturing	755	1.47
Manufacture of prepared animal feed	690	0.11
Processing and refining of sugar	471	0.16
Brewing malt and beer	216	0.33
Bakery and confectionery	180	0.40
Textile weaving and finishing	173	0.37
Manufacture of vegetable and animal oils and fats	166	0.24
Manufacture of cocoa, chocolate and confectionery	163	0.06
Manufacture of wines, other alcoholic beverages and tobacco	90	0.06
Public administration and defense	80	4.68
Accommodation	72	0.48
Manufacture of rubber products	69	0.11
Manufacture of clothing	68	1.30
Manufacture of pharmaceuticals and pharmaceuticals	61	0.32
Social services, associations or non-merchant organizations	57	0.25
Manufacture of starches and starch products	48	0.01

Table A1.3: Activities closely related to the renewable primary resource sector, 2007 *(continued)*

Activity	Intermediate demand from primary sector by activity (millions of soles, 2007 prices)	Participation (% total VA)
Manufacture of pesticides and other chemical products	31	0.39
Manufacture of basic chemicals, plastics and rubber	16	0.21
Manufacture of soft drinks	14	0.19
Total (a)	23,970	17.08
Primary sector of renewable resources (b)		7.31
(a) + (b)		24.39

Source: Instituto Nacional de Estadística e Informática (INEI), Cuentas Nacionales, 2007.

With the goal of providing a more meaningful estimate of the contribution of agriculture to growth and poverty reduction in Peru, an expanded measure was calculated of agriculture's contribution to GDP, taking into account forward and backward linkages. Following the approach used by Foster and Valdes (2005), adapted to meet the particularities of Peru's production and I-O matrices, an expanded measure of agriculture can be denoted:

VA Primary Expanded = VA Primary + F. VA Other + B. VA Other (1)

Where $0 \leq F \leq 1$ and $0 \leq B \leq 1$ represent the strength of forward and backward linkages between agriculture and other sectors.

To capture the strength of forward linkages (F) through VA of other sectors, suppose we consider an economy with j sectors $X^T_{Pj} = \sum_1^n X^T_{nPj} = X^T_{1Pj} + \cdots + X^T_{nPj}$ denotes the use of primary sector products 1 to n in sector *j*. Similarly, X^T_{kj} $k \neq j$ represents the use of products from sector *k* in sector *j*.

The proportion of intermediate input costs in sector *j* that is due to the primary production sector, both local and imports, is:

$$Share^T_{Pj} = \frac{X^T_{1Pj} + \cdots + X^T_{nPj}}{X^T_{1Pj} + \cdots + X^T_{nPj} + X^T_{n+1k+1j} + \cdots + X^T_{NKj}} = \frac{\sum_1^n X^T_{nPj}}{\sum_k \sum_1^N X^T_{nkj}} = \frac{X^T_{Pj}}{\sum_k X^T_{kj}}$$

The proportion of total intermediate input costs in in sector *j* that is due to the national primary sector would be:

$$Share_{Pj}^{N} = \frac{X_{Pj}^{N}}{\sum_k X_{kj}^{T}} = \frac{X_{Pj}^{T}}{\sum_k X_{kj}^{T}} * \frac{X_{Pj}^{N}}{X_{Pj}^{T}}$$

Then the forward linkage from VA from sector *j* that can be attributed to primary production is:

$$F_{Pj} = Share_{Pj}^{N} * VA_j = \frac{X_{Pj}^{N}}{\sum_k X_{kj}^{T}} * VA_j \qquad (2)$$

Similarly, to estimate the strength of backward linkages (B) through the VA in agriculture, we estimate the following:

$$B_{jP} = \left(\frac{X_{jP}^{N}}{\sum_k X_{jk}^{T}}\right) * \left(\frac{\sum_k X_{jk}^{N}}{TVO_j^{N}}\right) * VA_j \qquad (3)$$

Where X_{jP}^{N} is the value of products sold by sector j for use by the domestic primary production sector and TVO_j^{N} represents the total value of output of the domestic sector *j*.

While the I-O matrices available record the share of a product that is exported, the share of the product that is exported is not disaggregated into the shares exported to be used as inputs relative to consumption overseas. Therefore, in creating these estimates of backward linkages, we: (i) assume none of the input supplied by the product is exported (i.e., only the domestic market uses the product as an input) – UPPER BOUND; (ii) assume the share of the product exported is used as input in activity j, where the share=total export of product*(share input domestic/total output for domestic) – MIDPOINT; and (iii) assume all export of product is used as input in foreign market – LOWER BOUND. We do not find drastic differences between the upper, midpoint, and lower bounds of the backward linkages.

ANNEX 2

Data sources for productivity analysis: ENAHO and ENA

ENAHO database

The National Household Survey (Encuesta National de Hogares – ENAHO) is designed to assess changing living conditions in urban and rural households across Peru. The survey is designed and administered by INEI. The ENAHO database used in this report covers the years 2004-2015.

ENAHO has national and regional (department) representation, but only if both rural and urban households are considered. For rural households, it also has representation based on geographic domains.[44] It includes about 25,000 observations (households) per year, of which about 9,000 are rural. It also includes an unbalanced panel sample of households for different periods (one for the period 2007-2011 and the other for the period 2012-2016). Households are mostly followed for two or three years. The representativeness of such a sample is quite limited, however, since the number of observations is small. This problem is exacerbated if only rural households are considered, or households with at least one agricultural producer. For instance, the balanced panel sample for the years 2007-2011 includes around 1,200 households, of which fewer than 500 households contain at least one agricultural producer.

44 The seven geographic domains in Peru are the following: North Costa, Central Costa, South Costa, North Sierra, Central Sierra, South Sierra, and Selva.

The ENAHO database includes detailed information on agricultural output. Quantities, prices, and value added by crop in each plot of the agricultural unit are included. With respect to inputs, the ENAHO database includes farm-level aggregate expenditures for the following agricultural inputs: land rental, seeds, fertilizer, organic manure, pesticides, labor, machinery and equipment, transport, storage, water, technical assistance, cattle feed, cattle vaccines and other expenses. The survey collects no information on prices or quantities of these inputs, however. Finally, the ENAHO database also includes detailed information on farm and household characteristics.

Although ENAHO was not designed for analyzing agricultural issues, it is possible to make some adjustments to the expansion factors of the survey so that the information available represents the majority of farmers at the national level (all farmers with less than 50 ha) and by geographical region (Costa, Sierra, Selva). This adjustment can be made based on the agricultural area and number of farmers reported in the Agricultural Census 2012. The procedure involves projecting the data for all the years covered by this report using the inter-census growth rates of these two key variables (agricultural area and number of farmers). Using this adjustment, information from ENAHO can be extrapolated to reflect the universe of farmers and agricultural units in the entire country and in individual regions.

ENA database

The National Agricultural Survey (Encuesta Nacional Agropecuaria – ENA) is a recently released database specifically designed to cover agricultural units. It was designed by agricultural specialists, with help from MINAGRI, MEF, and INEI. ENA uses the 2012 National Agricultural Census (CENAGRO) as a sampling frame. Currently, information is available for the years 2014 and 2015. The survey will continue to be implemented in the coming years, however, and it is intended to become the official source for calculating agricultural variables and estimating the effects of different public programs.

ENA has national and departmental representation of agricultural units, which means that information about producers can be aggregated by region and by domain. It includes about 30,000 observations per year (at farm level). ENA considers two types of producers: (i) small-scale and medium producers, and (ii) large producers, for which it uses a different (although quite similar) questionnaire.

The ENA database includes detailed information about agricultural output. Quantities, prices, and value added by crop in each plot of the agricultural unit

are recorded. With respect to inputs, ENA collects detailed information about quantities and expenditures by crop for a set of inputs (which allows calculation of implicit prices), including seeds and organic manure. For another set of inputs, including fertilizer and pesticide, it reports only the expenditure by crop. ENA also collects information about farm-level aggregate expenditures for the following inputs (separated here into agricultural and livestock activities): land rental, permanent and temporary workers (number of workers, not number of hours worked), water, technical assistance, purchase and rental of agricultural equipment and machinery, fuel purchase, others. Finally, the survey collects information about agricultural practices that involve expenses (cattle vaccines, artificial insemination, cattle feed), as well as information about productive infrastructure and agricultural equipment.

ENA also includes detailed information about farm and household characteristics. With respect to the first group, it includes demographic characteristics of the farmer and family members (gender, age, education, mother tongue). With respect to the second group, it includes information on the number of plots, sown area, irrigation, number of crops, and livestock, among other variables.

ANNEX 3

Total Factor Productivity (TFP) analysis: Methodological note

Methods used to measure TFP can be characterized as non-parametric and parametric. The former include Data Envelope Analysis (DEA) and index numbers, while the latter includes production function models and stochastic frontiers. Non-parametric methods such as DEA and index numbers can be used to calculate TFP measures at multiple levels of aggregation, since they do not assume a functional form for the production frontier. They do not allow for measurement errors, however, and they lack statistical inference. Despite these shortcomings, non-parametric methods are widely used in the economic literature for mapping productivity levels across countries or regions. The choice between DEA-based methods and index number methods is usually based on data availability, as index number methods require input prices, while DEA-based methods do not. Parametric methods such as production function models can also be used for estimating TFP, but the identification and econometric estimation of such models can be challenging. This is because a firm's productivity is transmitted to the firm's optimal choice of inputs, resulting in an endogeneity issue known in the literature as "transmission bias" (Griliches and Mairesse, 1995; De Loecker, 2007; Gandhi et al., 2011). Most econometric specifications that can be used to deal with this problem require panel data. Since available panel datasets usually cover short periods and often have limited coverage, parametric methods often cannot be used to map TFP at high levels of aggregation (e.g., national level).

Multilateral Tornqvist-Theil TFP Index

A normalized multilateral TFP index can be constructed using any region as the base region. The expression of the TFP index between region k and the base region l can be expressed as follows:

$$\ln\left(\frac{TFP_k}{TFP_l}\right) = \frac{1}{2} * \sum_i (R_i^k + R_l) * \ln\left(\frac{Y_i^k}{\widetilde{Y_i}}\right) - \frac{1}{2} * \sum_i (R_i^l + R_l) * \ln\left(\frac{Y_i^k}{\widetilde{Y_i}}\right) - \frac{1}{2} * \sum_n (W_n^k + W_n) * \ln\left(\frac{X_n^k}{\widetilde{X_n}}\right) + \frac{1}{2} * \sum_n (W_n^l + W_n) * \ln\left(\frac{X_n^l}{\widetilde{X_n}}\right)$$

where a bar indicates the arithmetic mean and a tilde indicates the geometric mean, Ri is the revenue share for output i, Wn is the cost share for input n. As we can see, the index subtracts inputs (of region k) of output (of region k), and do the same for region L. Then, the TFP level measure of L is subtracted from the TFP level of region k (in this case, region L is being used as the base region). A similar procedure can be performed by a region "X", other than k using region L as the base region and will satisfy transitivity property (Wang et al., 2013).

The Peru Systematic Country Diagnostic and the 2015 Peru flagship report use an alternative index number approach (growth accounting) to estimate TFP in the manufacturing and services sectors. That particular approach is difficult to reproduce for the agricultural sector, however, due to differences between firms and farms. As described by Saikia (2014), "In the Growth Accounting Method, TFP is measured as a residual factor, which attributes to that part of growth in the output that is not accounted for by the growth in the basic factor inputs. This approach approximates the technological change by the computation of factor productivity indices, mainly the rate of change of TFP indices (Christensen, 1975). The TFP index is measured as the ratio of the index of net output and the index of total factor inputs. The index of total factor inputs is derived as weighted average of indices of labor inputs, capital inputs and land inputs, with relative income shares of the three factors as respective weights."

Output

The aggregate quantities of each crop and livestock output were obtained from the ENAHO and ENA databases by applying the expansion factors and summing up the quantities of each crop and livestock product at a given level of aggregation (natural region, domain, department, or farm-size group). The estimation of output indices and, thus, TFP indices, requires the revenue share for each of the output

products used in the analysis. Farm-level output prices reported by each farmer in the survey were used (ENAHO and ENA collect this information in the same way), and the value of each crop and livestock product (which is the quantity times the price) was aggregated across a given geographic area or at a given group level (again using the expansion factors included in the surveys). With that information, the revenue shares for all outputs can be calculated for each level of analysis. Once aggregate information has been obtained on quantities and revenue shares of each crop and livestock product, the aggregate output indices can be calculated.

Input

Estimation of input indices requires information on the quantities and cost shares for each of the inputs included in the analysis. The procedure followed for estimating the input indices for the ENAHO and ENA analysis was the same, but the inputs included in the analysis differed to some extent due to data availability. In what follows, the input products included in each analysis are detailed, along with the procedure used to make the calculations.

ENAHO does not collect information about input quantities and prices, but it collects farm-level expenditures for the following input categories: land rental, seeds, fertilizers, pesticides, hired labor, transportation, storage and distribution logistics, irrigation water, technical assistance, animal feed, veterinary products and services, and other expenses (which includes machinery rental and repair, tractor rental, and agricultural tool purchases, among others). ENA does collect information about input quantities and prices, but only for a small set of inputs including seed, manure, and hired labor. ENA collects only farm-level expenditures for the other input categories, namely land rental, technical assistance, irrigation water, byproducts and derivatives production inputs, reproduction, animal feed, livestock services (veterinary services, vaccines, veterinary medicines, other veterinary products) and capital (expenditure on purchase and maintenance of agricultural equipment and machinery, fuel purchase). This information is aggregated at each level of analysis (natural region, domain, department, or farm-size group) using the expansion factors from the surveys, and then the cost share for each input category is obtained (which is the ratio of each input category value by the total cost).

To calculate input indices, it is necessary to have a quantity measure for each input category. For all input categories for which price information is unavailable but for which there are expenditure values, implicit quantities were obtained by deflating each input category value by a set of department-level input prices produced by MINAGRI and reported in the Complementary Agricultural Statistics Yearbooks

2005-2015. In the case of inputs for which no price data are available, regional deflators were used to approximate real quantities. This procedure was used for both surveys.

Using the approaches described above, it was possible to estimate the cost shares and the implicit quantities for each input category. The input categories were further aggregated into: land rental, hired labor, seeds, pesticides, fertilizers, livestock services (veterinary products and services), animal feed, capital, and other crop and livestock costs.

Two additional input categories were included in the analysis:

1. Family Labor: Since family labor is a key input used in Peruvian agriculture, a quantity measure was constructed for this input. The procedure was as follows: using the ENAHO pooled dataset 2007-2015, the average number was calculated of days worked by a family worker in agriculture for each month and department of the country.[45] This information was used to construct a departmental measure of the number days worked by family labor in agriculture. This measure was then applied to the number of family members that report working on the farm (same procedure and information collected in both surveys).[46] To obtain the cost share of this input category, the value of family labor was calculated by multiplying this measure with the labor price obtained from the Complementary Agricultural Statistics Yearbooks 2005-2015 (same price used to calculate the quantities of hired labor).

2. Agricultural Land: To incorporate agricultural land into the input index, a land value measure was obtained by using land rental expenditure and data on rented area (obtained from ENA 2015 and ENAHO 2007-2015). As data are available on irrigated and non-irrigated agricultural land at the plot level, a rental price can be calculated for irrigated and non-irrigated land. The rental price was then used to derive a value of irrigation-adjusted agricultural land. Based on the estimates of the quantity of land (in irrigated-equivalent hectares) and the price of land, it was possible to calculate the cost share of land for each level of analysis.

45 The ENAHO survey is collected throughout the year, and its information is representative on a monthly basis. This feature captures seasonal variations in the days worked in each of the departments of the country, allowing us to get a more accurate measure of annual family labor.

46 For family workers who are less than 18 years old, we assumed that they work half the time.

Output and Input Decomposition

We start from the Tornqvist Multilateral Index equation between region k and base region l:

$$\ln\left(\frac{TFP_k}{TFP_l}\right) = \frac{1}{2} * \sum_i \left(R_i^k + R_i\right) * \ln\left(\frac{Y_i^k}{\widetilde{Y_i}}\right) - \frac{1}{2} * \sum_i \left(R_i^k + R_i\right) * \ln\left(\frac{Y_i^l}{\widetilde{Y_i}}\right) \tag{1}$$

$$-\frac{1}{2} * \sum_n (W_n^k + W_n) * \ln\left(\frac{X_n^k}{\widetilde{X_n}}\right) + \frac{1}{2} * \sum_n (W_n^l + W_n) * \ln\left(\frac{X_n^l}{\widetilde{X_n}}\right)$$

Applying the exponential to both sides yields the following equation:

$$\frac{TFP_k}{TFP_l} = exp\left[\begin{array}{c} \frac{1}{2} * \sum_i \left(R_i^k + R_l\right) * \ln\left(\frac{Y_i^k}{\widetilde{Y_i}}\right) - \frac{1}{2} * \sum_i \left(R_i^k + R_i\right) * \ln\left(\frac{Y_i^l}{\widetilde{Y_i}}\right) \\ -\frac{1}{2} * \sum_n (W_n^k + W_n) * \ln\left(\frac{X_n^k}{\widetilde{X_n}}\right) + \frac{1}{2} * \sum_n (W_n^l + W_n) * \ln\left(\frac{X_n^l}{\widetilde{X_n}}\right) \end{array}\right]$$

Rearranging this equation results in the following expression:

$$\frac{TFP_k}{TFP_l} = \frac{exp\left[\frac{1}{2} * \sum_i \left(R_i^k + R_i\right) * \ln\left(\frac{Y_i^k}{\widetilde{Y_i}}\right) - \frac{1}{2} * \sum_i \left(R_i^l + R_i\right) * \ln\left(\frac{Y_i^l}{\widetilde{Y_i}}\right)\right]}{exp\left[-\frac{1}{2} * \sum_n (W_n^k + W_n) * \ln\left(\frac{X_n^k}{\widetilde{X_n}}\right) + \frac{1}{2} * \sum_n (W_n^k + W_n) * \ln\left(\frac{X_n^l}{\widetilde{X_n}}\right)\right]} \tag{2}$$

The first term in (2) is the multilateral output index ($MOI_{k,l}$) of region k with respect to region l, while the second term is the multilateral input index ($MII_{k,l}$) of region k with respect to region l. Therefore, both indices can be defined as follows:

$$MOI_{k,l} = \exp(Out_{k,l}) = exp\left[\frac{1}{2} * \sum_i \left(R_i^k + R_i\right) * \ln\left(\frac{Y_i^k}{\widetilde{Y_i}}\right) - \frac{1}{2} * \sum_i \left(R_i^l + R_i\right) * \ln\left(\frac{Y_i^l}{\widetilde{Y_i}}\right)\right] \tag{3}$$

$$MII_{k,l} = \exp(Inp_{k,l}) = exp\left[\frac{1}{2} * \sum_i \left(W_n^k + W_n\right) * \ln\left(\frac{X_n^k}{\widetilde{X_n}}\right) - \frac{1}{2} * \sum_i \left(W_n^l + W_n\right) * \ln\left(\frac{X_n^l}{\widetilde{X_n}}\right)\right] \tag{4}$$

The left side term can be defined as follows:

$$TFP_{k,l} = \frac{TFP_k}{TFP_l} \tag{5}$$

Then, equation (2) becomes:

$$TFP_{k,l} = \frac{\exp(Out_{k,l})}{\exp(Inp_{k,l})} \tag{6}$$

Equation (6) indicates that the multilateral *TFP* index of region *k* with respect to base region *l* is equal to the ratio between the multilateral output and input index of region *k* with respect to base region *l*.

Similarly, when working with more than one period, say period t and period *t*+1, the growth rate of the multilateral *TFP* index can be derived from the ratio between the growth rates of the output and input multilateral indices.

First define the growth rate of two consecutive periods, say period t and period *t*+1, as follows:

$$\Delta_{t,t+1}(Z) = \frac{Z^{t+1}}{Z^{t}} = \Delta Z$$

Then, expressing equation (6) in terms of growth rates:

$$\Delta TFP_{k,l} = \frac{TFP_{k,l}^{t+1}}{TFP_{k,l}^{t}} = \frac{\dfrac{\exp(Out_{k,l}^{t+1})}{\exp(Inp_{k,l}^{t+1})}}{\dfrac{\exp(Out_{k,l}^{t})}{\exp(Inp_{k,l}^{t})}} = \frac{\dfrac{\exp(Out_{k,l}^{t+1})}{\exp(Out_{k,l}^{t})}}{\dfrac{\exp(Inp_{k,l}^{t+1})}{\exp(Inp_{k,l}^{t})}} = \frac{\Delta \exp(Out_{k,l})}{\Delta \exp(Inp_{k,l})} \tag{7}$$

Consider now the input decomposition. Start from equation (4):

$$MII_{k,l} = \exp(Inp_{k,l}) = exp\left[\frac{1}{2} * \sum_i \left(W_n^k + W_i\right) * \ln\left(\frac{X_n^k}{\widetilde{X_n}}\right) - \frac{1}{2} * \sum_i \left(W_n^l + W_n\right) * \ln\left(\frac{X_i^l}{\widetilde{X_i}}\right)\right]$$

Suppose we are working with two inputs, let say input 1 (x_1) and input 2(x_2). Equation (4) then becomes:

$$\begin{aligned}
&\exp(Inp_{k,l}) \\
&= exp\left[\frac{1}{2} * \left(W_1^k + W_1\right) * \ln\left(\frac{X_1^k}{\widetilde{X_1}}\right) + \frac{1}{2} * \left(W_2^k + W_2\right. * \ln\left(\frac{X_2^k}{\widetilde{X_2}}\right)\right. \\
&\left. -\frac{1}{2} * \left(W_1^l + W_1\right) * \ln\left(\frac{X_1^l}{\widetilde{X_1}}\right) - \frac{1}{2} * \left(W_2^l + W_2\right) * \ln\left(\frac{X_2^l}{\widetilde{X_2}}\right)\right]
\end{aligned}$$

Rearranging the terms of the previous equation yields to the following expression:

$$\exp(Inp_{k,l})$$
$$= exp\left[\frac{1}{2} * (W_1^k + W_1) * \text{In}(\frac{X_1^k}{\widetilde{X_1}}) - \frac{1}{2} * (W_1^k + W_1) * \text{In}(\frac{X_1^k}{\widetilde{X_1}})\right.$$
$$\left. + \frac{1}{2} * (W_2^k + W_2) * \text{In}(\frac{X_2^k}{\widetilde{X_2}}) - \frac{1}{2} * (W_2^l + W_2) * \text{In}(\frac{X_2^l}{\widetilde{X_2}})\right]$$

This last expression can be further rearranged as follows:

$$\exp(Inp_{k,l}) = exp\left[\frac{1}{2} * (W_1^k + W_1) * \text{In}(\frac{X_1^k}{\widetilde{X_1}}) - \frac{1}{2} * (W_1^l + W_1) * \text{In}(\frac{X_1^l}{\widetilde{X_1}})\right]$$
$$\text{x } exp\left[\frac{1}{2} * (W_2^k + W_2) * \text{In}(\frac{X_2^k}{\widetilde{X_2}}) - \frac{1}{2} * (W_2^l + W_2) * \text{In}(\frac{X_2^l}{\widetilde{X_2}})\right]$$

Expressed in simple terms, this is equal to the equation shown below:

$$\exp(Inp_{k,l}) = exp\left(Inp_{k,l}^{x_1}\right) \text{ x } exp(Inp_{k,l}^{x_2}) \qquad (8)$$

Which simply indicates that the multilateral input index for region k with respect to region l is equal to the product of all individual inputs indices.

Likewise, when working with more than one period, say period *t* and period *t+1*, the growth rate of the input index is equal to the product of the growth rates of all individual input indices, as shown below:

$$\triangle \exp(Inp_{k,l}) = \frac{\exp(Inp_{k,l})_{t+1}}{\exp(Inp_{k,l})_t} = \frac{exp\left(Inp_{k,l}^{x_1}\right)_{t+1} \text{ x } exp\left(Inp_{k,l}^{x_2}\right)_{t+1}}{exp\left(Inp_{k,l}^{x_1}\right)_t \text{ x } exp\left(Inp_{k,l}^{x_2}\right)_{t+1}}$$
$$= \frac{exp\left(Inp_{k,l}^{x_1}\right)_{t+1}}{exp\left(Inp_{k,l}^{x_1}\right)_t} \text{ x } \frac{exp\left(Inp_{k,l}^{x_2}\right)_{t+1}}{exp\left(Inp_{k,l}^{x_2}\right)_t} = \triangle \exp(\text{Inp}_{k,l}^{x_1}) \text{ x} \triangle \exp(\text{Inp}_{k,l}^{x_2})$$

$$\triangle \exp(Inp_{k,l}) = \triangle \exp(\text{Inp}_{k,l}^{x_1}) \text{ x} \triangle \exp(\text{Inp}_{k,l}^{x_2})$$

Therefore, the results shown in Table 7 and Figure 7 are simply the annual average of the output, TFP, and input indices growth rates.

Levels of analysis

The TFP estimation using the ENAHO data was done by natural region. The sample size and the expanded number of farms for each year and region are described below.

Table A3.1: ENAHO 2007-2015: Observations (sample and expanded population) by region

	Sample				Expanded population			
Year	Costa	Sierra	Selva	Total	Costa	Sierra	Selva	Total
2007	1,329	5,567	2,178	9,074	371,818	1,361,296	418,982	2,152,096
2008	1,221	5,500	2,186	8,907	368,115	1,391,039	429,607	2,188,761
2009	1,269	5,702	2,290	9,261	357,775	1,438,828	440,804	2,237,408
2010	1,277	5,644	2,245	9,166	382,591	1,444,358	439,270	2,266,219
2011	1,448	6,459	2,571	10,478	358,974	1,494,680	467,527	2,321,180
2012	1,462	6,353	2,552	10,367	366,256	1,519,667	474,453	2,360,376
2013	1,820	7,514	3,059	12,393	377,856	1,518,130	477,109	2,373,096
2014	1,746	7,619	3,064	12,429	381,769	1,576,389	468,913	2,427,072
2015	1,820	7,752	3,366	12,938	359,921	1,604,286	467,344	2,431,551

Typology of producers

The TFP calculations based on the ENA 2015 dataset were done by region, department, farm size group, and according to a typology of producers developed by Escobal and Armas (2015) combining information from the ENA with the CENAGRO database. To characterize small and medium-sized agriculture in Peru, Escobal and Armas (2015) constructed a typology based on an operational definition suggested by Soto-Baquero et al. (2007) and Maletta (2011). The typology includes four categories:

1. Subsistence agriculture: agricultural net income below the extreme poverty line (Type 1).
2. Agriculture in transition I: agricultural net income between the extreme poverty line and the poverty line (Type 2).
3. Agriculture in transition II: agricultural net income between the poverty line and a line defined by a cut-off point equal to 2.4 the poverty line (Type 3).
4. Consolidated agriculture: agricultural net income between the poverty above the line defined by a cut-off point equal to 2.4 the poverty line (Type 4).

This typology aims to reflect differences in structural characteristics of farmers / farm households, their farms, and the context in which they operate. Since there are many aspects related to these dimensions, Escobal and Armas opted to construct an operational typology based on the information embodied in the net agricultural income of each farm unit. They argue that net agricultural income captures important differences in farmers' characteristics, farms conditions, contexts, and productive endowments.

Escobal and Armas define subsistence farming as the segment whose members lack sufficient land, cattle, or productive infrastructure to generate the income needed to cover the household's food requirements (approximated by the extreme poverty line). Farms are classified into this group when net agricultural income per household member is below the extreme poverty line defined by the INEI (this poverty line differs by region).

Escobal and Armas define farms in the transition agriculture segment as those that are able to cover their food requirements but that are also considered vulnerable. The authors divide this group into two categories: (i) farms whose net income exceeds the total poverty line but that are still vulnerable to fall into poverty, and (ii) farms for which agricultural incomes are below the poverty line, but above the extreme poverty line. The label "transition" is not intended to suggest mobility; it simply acknowledges that the net income generated allows basic needs to be met, but the base of productive assets is not high enough for households in this group to live a comfortable life if they choose to dedicate themselves exclusively to agricultural activities. What is relevant here is to assess the ability or not to accumulate and generate surpluses from the agricultural activity on their own, regardless of whether complementary economic activities are carried out.

Escobal and Armas define consolidated agriculture as the segment of farms whose members have agricultural incomes high enough to have a low probability—less than 10 percent—of falling into poverty at any time. This cut-off point is used in the international literature to distinguish those farms that are neither poor, nor vulnerable (López-Calva and Ortiz-Juárez 2011). In the case of Peru, Escobal (2014) shows, using information from the ENAHO, that the cut-off point associated with a probability equal to or less than 10 percent of falling into poverty equals 2.4 times the poverty line. Therefore, this cut-off point is used to define the consolidated farmers.

To confirm that the Escobal and Armas typology indeed reflects differences in structural characteristics of the farmers and households, their farms, and the

context in which they operate, it is important to describe the four groups in terms of these aspects. The following table presents mean differences between farm typology groups along a range of farm and household characteristics.

Table A3.2: Means of farm and farm household characteristics by producer type

Typology	Subsistence agriculture	Transition agriculture I	Transition agriculture II	Consolidated agriculture	Total
Mean net income (annual)	1,818	7,773	13,574	48,568	7,951
Farm characteristics					
Mean harvested area (ha)	0.7	1.7	2.9	7.2	1.6
Mean total area (ha)	2.7	7.5	9.7	16.1	5.3
Mean number of plots	3.1	3.0	2.8	2.5	3.0
Area in public records (%)	15%	19%	23%	33%	18%
Farmers and household characteristics					
Farming experience (years)	25.6	25.8	26.3	26.8	25.8
Years of education (household head)	12.5	13.1	13.5	14.0	12.8
Female household head (%)	31.9%	23.2%	22.6%	18.7%	29%
Native language (%)	48.4%	41.8%	35.4%	24.7%	44%
Number of family workers	3.3	2.9	2.6	2.2	3.1
Market access					
Membership in cooperative or association (%)	4%	8%	10%	13%	6%
Credit access (%)	11%	15%	18%	24%	14%
Sell to market (%)	55%	73%	76%	80%	62%

The statistics show, for example, that consolidated farms have, on average, 1.5 years of education more than subsistence farms in the household, which could

be associated with differences in productive skills. They also show higher levels of farming experience, and a lower use of family labor. In addition, consolidated farms have, on average, larger farms, a smaller number of plots, and a higher level of land titling. The typology also reflects differences in terms of market access: consolidated farms have higher access to credit, are more linked to productive networks, and are more connected to dynamic markets.

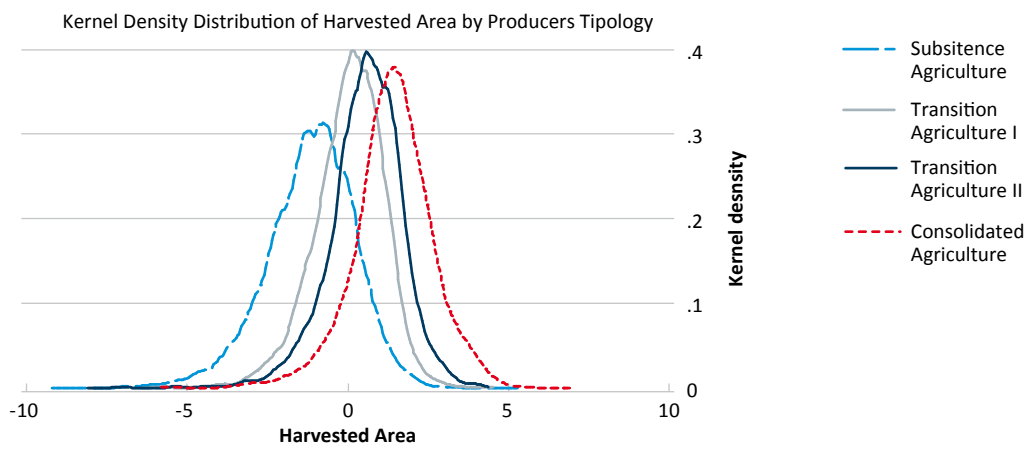
In terms of spatial differences, Table A3.3 presents the distribution of farms by region across the four categories.

Table A3.3: Distribution of farms by region and producer typology

Typology	Costa	Sierra	Selva	National
Subsistence agriculture	51.10	75.07	47.52	64.56
	9.75	76.11	14.14	100
Transition agriculture I	12.07	9.26	14.42	10.90
	14.14	57.80	28.06	100
Transition agriculture II	16.59	9.78	21.43	13.58
Consolidated agriculture	17.72	48.51	33.76	100
	20.24	5.89	16.63	10.97
	32.04	37.73	30.23	100
Regional total	**100**	**100**	**100**	**100**
National total	**13.13**	**67.44**	**19.43**	**100**

The data show that the subsistence agriculture group consists mainly of farms that belong to the Sierra region. In the case of transition agriculture, farms that are below the poverty line tend to be located in the Selva region, while those that generate income above the poverty line tend to be located along the central Costa and south Costa, as well as in the High Selva areas. Finally, consolidated family agriculture is concentrated mainly in the central Costa, the Andean valleys of Arequipa, the coffee zone of San Martín, and some provinces of the department of Huánuco and Madre de Dios.

Figure A3.1: Distribution of farm size by producer typology



Source: Authors' calculations.

Finally, Figure A3.1 depicts the distribution of farm sizes by typology category, in the form of a kernel density plot of the log of harvest area by typology.

The plot clearly shows that the typology of farms in fact reflects differences in farm sizes. While subsistence farms are smaller, farms categorized as consolidated agriculture are made up of larger plots.

The sample size and the expanded number of farms for each year and region are described in Table A3.2.

Table A3.2: ENA 2015: Number of observations (sample and expanded population) by geographic domains, typology of producers, and farm-size groups

	With Firms		Without Firms	
	Total sample	Total expanded population	Total sample	Total expanded population
Total	27,374	2,149,674	26,316	2,146,183
Domains				
Costa Norte	2,789	183,338	2,622	182,738
Costa Centro	2,090	85,438	1,683	84,228

Table A3.2: ENA 2015: Number of observations (sample and expanded population) by geographic domains, typology of producers, and farm-size groups *(continued)*

	With Firms		Without Firms	
	Total sample	Total expanded population	Total sample	Total expanded population
Costa Sur	983	27,322	931	27,081
Sierra Norte	3,371	430,691	3,347	430,594
Sierra Centro	6,697	524,578	6,575	524,250
Sierra Sur	5,781	490,598	5,725	490,341
Selva	5,663	407,710	5,433	406,952
Typology of producers				
Type 1: Subsistence	18,849	1,521,268	17,791	1,517,778
Type 2: Transition 1	2,580	204,554	2,580	204,554
Type 3: Transition 2	3,272	248,759	3,272	248,759
Type 4: Consolidated	2,673	175,093	2,673	175,093
Farm-size groups				
Less than 1 ha	14,981	1,279,368	14,912	1,279,124
1 to 3 ha	5,957	471,364	5,894	471,147
3 to 5 ha	1,826	133,963	1,780	133,839
5 to 10 ha	1,291	86,791	1,225	86,526
10 to 50 ha	866	41,674	728	41,026
More than 50 ha	319	1,083	0	0

ANNEX 4

Stochastic Production Frontier analysis: Methodological note

In microeconomic theory, a production function is defined in terms of the maximum output that can be produced from a specified set of inputs, given the existing technology available to the firms involved. Stochastic Frontier Analysis (SFA) is a method to estimate a production frontier that reflects the current state of technology in the industry. The frontier also defines the potential maximum or optimal level of production of the industry. Firms operate either on that frontier if they are technically efficient, or beneath the frontier if they are not technically efficient.

In the stochastic frontier approach developed in Battese and Coelli (1992), the frontier is viewed as stochastic and the problem is about estimating efficiency and inefficiency relative to this frontier. This becomes more complex when we can estimate only the "deterministic" part of the frontier. SFA deals with this issue first by estimating the stochastic frontier and then by estimating efficiency relative to this frontier.

A linear model of stochastic production frontiers can be expressed as follows:

$$Y_i = X_i\beta + V_i - U_i$$

where Y_i denotes the production of the i-th farm. X_i is a vector of inputs of production function and other explanatory variables related with the i-th farm. β is the vector of production function parameters to be estimated. V_i and U_i are the two components of the residuals and are assumed to be independently distributed. V_i is

the stochastic component of the residuals and is assumed to be i.i.d $N(0,\sigma^2)$. U_i is a non-negative random variable and represents technical inefficiency of production and is also assumed to be independently distributed.

The technical inefficiency effect can be expressed as function of a set of exogenous explanatory variables (z_i) and specified as:

$$U_i = z_i\delta + \varepsilon_i$$

In this equation, ε_i is a random errors variable and is defined by the truncation of the normal distribution with zero mean and variance σ^2.

The estimation of the model involves estimating the parameters of the frontier function, and estimating inefficiency. The distribution choice for the random error variable V_i is often not an issue, since a zero-mean normal distribution is widely accepted by the literature. For the random variable (stochastic term) U_i, however, there is no consensus. Within the most used distributions, we find the following: the half-normal distribution, the truncated-normal distribution, the truncated-normal distribution with scaling properties, the exponential distribution, and the gamma distribution (Aigner et al., 1977; Meeuseb and van den Broeck, 1977; Stevenson 1980; Greene, 1980, 2003).

Once the distributional assumptions are made, the log-likelihood function of the model is derived and numerical maximization procedures are used to obtain the maximum likelihood (ML) estimates of the model parameters. This derivation is based on the independence assumption between U_i and V_i. A second estimation step is necessary to disentangle the unobserverd component (the technical efficiency) from de compounded error (ε). The most well-known solutions were proposed by Jondrow et al. (1982) and Battese and Coelli (1988) through the use of the conditional distribution of U given ε.

An important characteristic of this method is the inclusion in the model of exogenous variables that affect inefficiency (z_i). It is possible that these inefficiency explanatory variables are correlated with input variables of the production (X_i), in which case the first step will be biased. Even when both terms are not correlated, ignoring the dependence of the inefficiency on zi also biases the estimation. Given these issues, the approach commonly used to estimate the exogenous determinants on efficiency is the single-step procedure. This method estimates the parameters of the inefficiency equation with the other parameters of the production frontier simultaneously through ML estimation (Kumbhakar, Wang and Horncastle, 2015).

The advantage of this method is that it allows the estimation of farms' efficiency scores and at the same time enables us to explore the effects of exogenous variables on such efficiency. Thus, the sources of technical efficiency can be identified using this method. It permits us to identify what type of intervention and corrective measures are needed to improve the level of farm productivity and efficiency.

In this study, we follow the single-step approach, based in a linear production function model with a half-normal distribution on the inefficiency term (half-normal model). The SFA model was estimated using an ML procedure.

It is important to remember that one of the strongest assumptions of the SFA models is the existence of the same production technology among firms. Therefore its application in contexts of high productive heterogeneity and at higher levels of aggregation is not recommended.

Level of analysis

Two sets of variables are used in the Stochastic Production Frontier (SPF) analysis: the set of variables included in the SPF model, and the set of exogenous variables that explain the (in) efficiency component. The two groups of variables are described in Tables A4.1 and A4.2, where we present the source of information and some descriptive statistics.

The dependent variable of the model is the log of the value of crop output per hectare of cultivated land. The explanatory variables include inputs like land, intermediate inputs, capital, and labor. In addition, we included a district-level soil quality proxy variable that came from the agricultural census 2012; as well as two precipitation and temperature indicators at district level that were constructed from information from the Terrestrial Air Temperature: 1900-2014 Gridded Monthly Time Series (1900 - 2014) (V 4.01 added 5/1/15) (Matsuura and Willmott, 2009).[47]

Table A4.1: Descriptive statistics of the variables used in the SFA estimation

Variable	Source	Mean	SD	Min	Max
Log (Value of Crop Output per Ha of cultivated land)	ENA 2015	8.51	0.84	2.91	14.32
Log (Plot Size in ha)	ENA 2015	-0.53	1.62	-9.21	6.88
Log (Intermediate Input costs per ha)	ENA 2015	5.41	2.28	-6.88	13.15

47 Some papers that have used this information include Molina and Saldarriaga (2016) "The perils of climate change: In utero exposure to temperature variability and birth outcomes in the Andean region," and Rocha and Soares (2012) "Water scarcity and birth outcomes in the Brazilian semiarid."

Table A4.1: Descriptive statistics of the variables used in the SFA estimation *(continued)*

Variable	Source	Mean	SD	Min	Max
Capital use Dummy (yes=1)	ENA 2015	0.20	0.40	0.00	1.00
Log (Labor costs per ha)	ENA 2015	9.22	1.53	3.35	18.29
Hired labor cost ratio in total labor cost	ENA 2015	0.14	0.20	0.00	1.00
Irrigated land ratio in total cultivated land	ENA 2015	0.45	0.48	0.00	1.00
Share of non-cultivated agricultural land by soil quality factors (at district level)	CENAGRO 2012	0.00	0.01	0.00	0.26
Log (rainfall (mm) in last 5 years) (district level)	TAT&P*	4.26	1.04	-0.35	6.52
Deviation of Log Rainfall with respect of district mean (1980-2010) (district level)	TAT&P	0.02	0.14	-0.62	0.67
Log (temperature (celsius) in last 5 years) (district level)	TAT&P	2.59	0.69	-4.23	3.57
Deviation of Log Temperature with respect of district mean (1980-2010) (district level)	TAT&P	0.09	0.27	-2.52	2.41

* Terrestrial Air Temperature and Precipitation: 1900-2008 Gridded Monthly Time Series, Version 1.02 (Matsuura and Willmott (2009).

The variables used to explain the inefficiency component are presented in Table A4.2.

Table A4.2: Variables used for inefficiency components of Stochastic Production Frontier estimation

Sources of technical (in) efficiency		Costa		Sierra		Selva	
	Source	Mean	SD	Mean	SD	Mean	SD
Association dummy (yes=1)	ENA 2015	9%	29%	4%	20%	14%	35%
Livestock dummy (yes=1)	ENA 2015	51%	50%	85%	36%	78%	41%
District cell phone coverage (%)	MINTRA 2012	92%	13%	65%	25%	57%	27%
Share of households with electricity access (district level) (%)	SISFOH 2012	46%	23%	35%	25%	17%	15%
Distance to nearest city with population above 50k	CENAGRO 2012	47.6	44.0	144.5	83.0	148.8	102.5

Table A4.2: Variables used for inefficiency components of Stochastic Production Frontier estimation *(continued)*

Sources of technical (in) efficiency		Costa		Sierra		Selva	
	Source	Mean	SD	Mean	SD	Mean	SD
Extension and advisory services dummy	ENA 2015	12%	33%	5%	21%	15%	35%
Access to information dummy (yes=1)	ENA 2015	43%	50%	40%	49%	60%	49%
Share of farmers with non-agricultural income (district level) (%)	CENAGRO 2012	22%	13%	23%	18%	18%	18%
Average number of plots in the district	ENA 2015	1.49	0.27	2.95	1.36	1.37	0.24
Average Herfindahl index in the district (0 to 1)	CENAGRO 2012	0.83	0.09	0.66	0.11	0.69	0.10
Irrigation coverage in the subdistrict (%)	CENAGRO 2012	93%	14%	51%	39%	4%	13%
Credit access in the subdistrict (% of HH)	CENAGRO 2012	24%	17%	6%	8%	10%	10%
Land titling dummy (yes=1)	ENA 2015	49%	50%	17%	38%	23%	42%
Number of household members	ENA 2015	3.45	1.89	3.62	2.01	4.09	2.19
Female producer (yes=1)	ENA 2015	24%	43%	31%	46%	19%	39%
Age of producer	ENA 2015	56.42	14.49	52.62	15.52	46.59	14.19
% of farmers with secondary education or better in district	ENA 2015	37%	14%	22%	12%	21%	8%
Observations		4,731		14,003		4,965	

These variables include some connectivity (cell phone coverage, distances), credit access, and electricity access indicators. There are also variables related to technical assistance and access to information, productive structure (secondary income source), and the agricultural sector (land title, average number of plots in district, crop concentration) of the district are included. Finally, some variables of household socioeconomic characteristics (age, gender, education level of the household head and household size) were added to our list.

The SFA analysis is performed by natural region and Escobal and Armas' typology of producers.

ANNEX 5

Disaggregating the Total Factor Productivity (TFP)–farm-size relationship by region

As a robustness check for the results of the TFP–farm-size relationship presented at the national level, results at the regional level are presented to confirm that the relationship does not change notably even when disaggregated. To explore this issue and assess balance, first the numbers and percentage distributions of farms by farm-size category in each region are presented in Table A5.1.

Table A5.1: Distribution of farms by farm-size group and region, ENA survey (number)

Farm size	Costa	Sierra	Selva	Total
< 1 ha	2,214	11,151	1,548	14,913
1 to 3 ha	1,345	2,496	2,053	5,894
3 to 5 ha	619	451	710	1,780
5 to10 ha	440	276	509	1,225
10 to 50 ha	177	114	438	729
Total	**4,795**	**14,488**	**5,258**	**24,541**

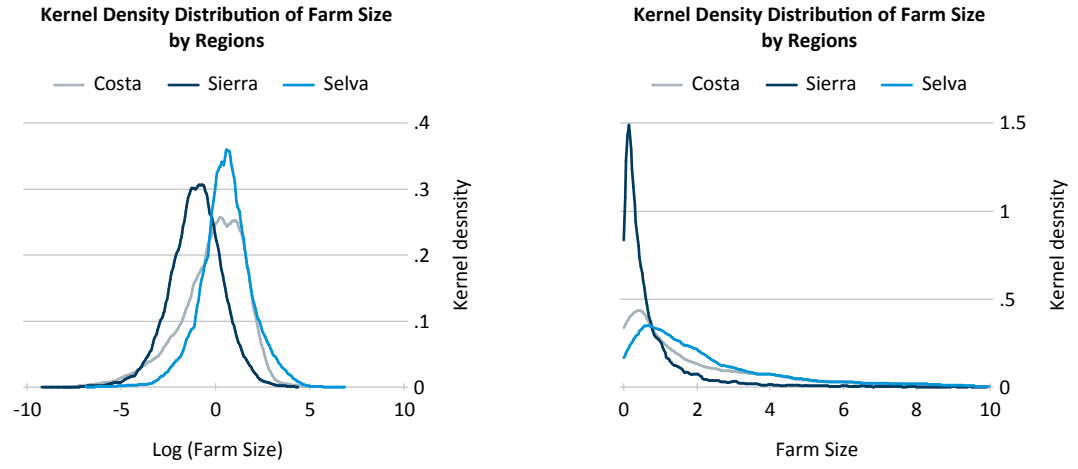
Given the important difference in the number of farms in each region, in Table A5.2 the shares of farms both across farm-size groups within and regions is presented.

Table A5.2: Distribution of farms by farm-size group and region, ENA survey (percent)

Distribution of farms by farm-size groups					Distribution of farmers by region				
Farm size	Costa	Sierra	Selva	Total	Farm size	Costa	Sierra	Selva	Total
< 1 ha	15%	75%	10%	**100%**	< 1 ha	46%	77%	29%	**61%**
1 to 3 ha	23%	42%	35%	**100%**	1 to 3 ha	28%	17%	39%	**24%**
3 to 5 ha	35%	25%	40%	**100%**	3 to 5 ha	13%	3%	14%	**7%**
5 to 10 ha	36%	23%	42%	**100%**	5 to 10 ha	9%	2%	10%	**5%**
10 to 50 ha	24%	16%	60%	**100%**	10 to 50 ha	4%	1%	8%	**3%**
Total	20%	59%	21%	**100%**	Total	100%	100%	100%	**100%**

Tables A5.1 and A5.2 taken together suggest that there is a sufficiently large sample size by farm-size and region to assess TFP by individual region, except for the 10 to 50 ha category. Nonetheless, the data reveal some imbalances across regions in the farm-size distribution. For example, the farm-size group of less than 1 ha is mostly composed of Sierra region farmers. In the farm-size groups of 3 to 5 ha, and 5 to 10 ha, most farmers belong to the Selva and Costa regions. Finally, the farm-size category of 10 to 50 ha mainly includes Selva farmers. Another way to illustrate these regional differences in farm size is to look at the kernel distribution of farm size, presented below in Figure A5.1.

Figure A5.1: Kernel density distribution of farm sizes by region from ENA survey



Source: Authors' calculations.

Despite the observed differences in farm-size between regions, we present the TFP results considering the same farm-size cut-off points we used to calculate the TFP by farm size at the national level.[48]

Farm-size groups	National	Costa	Sierra	Selva
Less than 1 ha	100	100	100	100
1 to 3 ha	208	140	205	197
3 to 5 ha	297	163	294	269
5 to 10 ha	346	192	357	311
10 to 50 ha	338	151	467	338

The results by region follow the same increasing relationship between farm-size and TFP as the results obtained at the national level. However, we only observe a decreasing relationship beyond 10 ha in the Costa region, not in the Selva and Sierra regions. The factors that explain these results are unclear. It is likely that this result is somewhat explained by the limited number of farmers observed in the last farm-size category in the Costa region (only 177 farmers).

An alternative and better approach to analyze the farm-size–TFP relationship at the regional level is to select farm-size groups that ensure a balanced distribution of farmers across these groups. One approach is to use farm-size quintiles rather than the arbitrarily chosen farm-size cut-off points.

Below in Table A5.3 we present the upper and lower farm-size in each quintile for each region. It is important to observe farm sizes by quintile prior to estimating the TFP–farm-size relationship using quintiles.

Table A5.3: Upper and lower farm sizes by land quintiles for each region

Quintiles - Costa	Mean	Min	Max	Obs
Quintile 1	0.09	0.00	0.25	1,041
Quintile 2	0.50	0.25	0.82	1,006
Quintile 3	1.35	0.82	2.00	1,117
Quintile 4	3.13	2.00	4.44	919
Quintile 5	8.61	4.45	47.93	712

48 It may not be appropriate to calculate TFP measures using the same farm-size cut-off points used in the estimation at the national level. These cut-off points were chosen taking into account the national distribution of farm sizes, not the regional distributions..

Table A5.3: Upper and lower farm sizes by land quintiles for each region *(continued)*

Quintiles - Sierra	Mean	Min	Max	Obs
Quintile 1	0.06	0.00	0.12	2,949
Quintile 2	0.20	0.12	0.28	2,909
Quintile 3	0.39	0.28	0.52	2,926
Quintile 4	0.78	0.52	1.14	2,925
Quintile 5	3.26	1.14	50.00	2,780
Quintiles - Selva	**Mean**	**Min**	**Max**	**Obs**
Quintile 1	0.32	0.00	0.60	1,082
Quintile 2	0.94	0.60	1.26	1,080
Quintile 3	1.76	1.26	2.25	1,100
Quintile 4	3.42	2.25	5.00	1,105
Quintile 5	13.24	5.01	50.00	892
Quintiles - National	**Mean**	**Min**	**Max**	**Obs**
Quintile 1	0.08	0.00	0.17	5,068
Quintile 2	0.29	0.17	0.45	5,060
Quintile 3	0.70	0.45	1.00	5,414
Quintile 4	1.62	1.00	2.50	4,849
Quintile 5	7.50	2.50	50.00	4,538

Table A5.4 presents the TFP farm-size relationship by quintiles for each region. The results confirm that the relationship between TFP and farm size is positive in all regions at all quintile levels. Using the quintiles approach, a decreasing or flat relationship beyond 10 ha is not observed.

Table A5.4: Upper and lower farm-sizes by land quintiles for each region

Farm-size Quantiles	National	Costa	Sierra	Selva
Quintile 1	100	100	100	100
Quintile 2	172	84	168	181
Quintile 3	237	122	196	234
Quintile 4	301	131	275	301
Quintile 5	416	149	493	389

ANNEX 6

Returns to scale and TFP by using a production function approach

The following derivation is adopted from Helfand and Taylor (2017), pp. 9-10.

Returns to scale in a production model in which output and input values are divided by land

Starting with the returns to scale definition:

$$f(\lambda K, \lambda L, \lambda A) = \lambda^t f\,(K, L, A) \qquad (1)$$

when the following equation holds, where K, L and A denote capital, labor and land respectively, then we can say that the production function is homogeneous of degree *t*. If *t*>1 the production function exhibits Increasing Returns to Scale (IRS), when *t*=1 Constant Returns to Scale (CRS), and when *t*<1 IRS.

If we define λ = 1/A, then by (1), we get the following equation:

$$f\left(\frac{1}{A}K, \frac{1}{A}L, \frac{1}{A}A\right) = A^{-t} f\,(K, L, A)$$

$$f\,(k, l, 1) = A^{-t} f\,(K, L, A)$$

$$A^t f\,(k, l, 1) = f\,(K, L, A) \qquad (2)$$

On the other hand, dividing output by land yields the following expression:

$$\frac{Y}{A} = \frac{f(K,L,A)}{A} \qquad (3)$$

Using (2) and (3) results in the following equation:

$$\frac{Y}{A} = y = \frac{f(K,L,A)}{A} = \frac{A^t f(k,l,1)}{A} = A^{t-1} f(k, l, 1) \qquad (4)$$

Assuming a Cobb-Douglas, where T represents the unobserved measure of TFP:

$$f(K, L, A) = TK^{\alpha} L^{\beta} A^{\gamma}$$

We can express equation 4 as follows:

$$y = \frac{f(K,L,A)}{A} = A^{t-1} f(k, l, 1) = A^{t-1} Tk^{\alpha} l^{\beta} 1^{\gamma} \qquad (5)$$

Taking logs:

$$ln(y) = \theta ln(A) + \alpha ln(k) + \beta ln(l) + ln(T) \qquad (6)$$

Donde $\theta = t - 1$

Therefore, the coefficient of the land variable (θ) is equal to t-1. When $\theta>0$ the production function exhibits IRS, when $\theta=0$ the production function exhibits CRS, and when when $\theta<0$ the production function exhibits DRS.

To control for weather, soil quality, and other factors associated with farmers' ability, we can incorporate in (6) additional control variables, as well as geographic fixed effects.

Calculating TFP by farm-size groups: Empirical strategy

Starting with equation (6) and assuming CRS (θ=0), we get the following empirical expression:

$$ln(y_i) = \beta_0 + \beta_1 ln(k_i) + \beta_2 ln(l_i) + \varepsilon_i \qquad (7)$$

This specification excludes the term $\ln(T)$ since it is an unobservable variable that is captured by the error term.

Helfand and Taylor claim that a way to calculate the TFP for each farm-size class is to include farm-size dummy variables (δ_s where s=1,2,...n represent each farm-size category). Incorporating this suggestion, equation (8) becomes:

$$ln(y_i) = \beta_0 + \beta_1\, ln(k_i) + \beta_2\, ln(l_i) + \delta_s + \varepsilon_i \qquad (8)$$

With the above approach the TFP of a farm size bin in a given period is calculated by:

$$TFP_s = e^{\beta_0 + \delta_s} \qquad (9)$$

Equation (9) enables us to calculate TFP indices by farm-size groups using a production function approach. However, two main limitations of this approach prevent us from applying this method for the Peruvian case (using the ENA survey):

i) The SFA results reject the null hypothesis of constant returns to scale (they suggest DRS). Since this approach is based in CRS, it is not appropriate to apply this framework if CRS does not hold.

ii) An important body of literature highlights the transmission bias that arises due to the endogeneity problem between productivity and input use. Two main approaches have been suggested to deal with this problem: the instrumental variables approach, and the panel data fixed effects approach. Both approaches require additional data that unfortunately are not available in our case.

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