Globalization, Crop Choice and Property Rights in Rural Peru, 1994-2004[†]

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Abstract

This paper describes the results of initial work analyzing a panel of rural households in Peru between 1994 and 2004 to determine household responses to changes in relative prices of traditional versus export-oriented products. Our principal interest was to better understand how household responses to external economic shocks influenced rural welfare, income distribution and poverty. Since a large percentage of Peruvians living in poverty are located in rural areas, learning more about how these households respond to a changing external environment provides insights into the factors that influence their ability to improve their absolute and relative economic position.

The results of our analysis indicate that changes in relative prices had a significant impact on the adoption of new agricultural products, and the magnitude of response was mitigated by households' degree of tenure security and access to regional and local markets. Analysis of household expenditures over the period indicate that those who adopted export crops experienced a significant growth in consumption proportional to the change in acreage devoted to exportable products, and were less likely to be classified as impoverished at the end of the period. Instrumental variables estimates suggest that this association is causal.

Key Words: agricultural households, microeconomic responses to international trade, structural adjustment, technology adoption, poverty, household decision making, property rights income distribution

JEL Classifications: I3, F1, O1, Q1

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INTRODUCTION

Global integration of the world economy in many dimensions has been taking place at a noteworthy pace for the past two decades. The policy changes that have accompanied and facilitated the increased flows of goods, services and resources have impacted economies at both the micro and macro levels. Investment and technology flows along with changes in relative prices both within and between sectors have resulted in changes in production structures and changes in the relative demand for factor inputs and accompanying factor payments. Any time that changes such as these take place at such rapid rates in a relatively short period of time there are winners and losers. In terms of the international trade aspect, changes in prices of import goods resulting from a decrease in protection directly benefit the consumers of those goods and indirectly those who consume goods that use imported inputs in their production. At the same time, factors used relatively intensively in import competitive industries tend to suffer with the fall in domestic prices as the trade policy price distortions are removed. On the positive side, trade liberalization which leads to an expansion of exports clearly has a positive effect on the owners of the factors of production used relatively intensively in its production. To the extent that factors lack internal mobility, these effects are clearly enhanced. Thus, while it is often suggested that less restricted world trade should lead to an increase in demand for unskilled labor and hence income and perhaps wages in the developing world, there is legitimate concern that poor and unskilled labor is, in fact, being made worse off, both relatively and absolutely.

A significant body of literature already exists on the many links between globalization and poverty. It has been effectively summarized in the recent surveys by Harrison (2005) and Winter, McCulloch and McKay (2004). In addition, the recent work by Bardhan (2005, 2006) which provides an overview on the links between globalization and rural poverty lays out the many direct and indirect ways that reducing barriers to international transactions and domestic market imperfections can influence rural output,

productivity and poverty through various consumption and production effects. It is obvious from these surveys that considerable work has been carried out at the aggregate level both across and within countries. However, to better gauge the effects of key factors such as changes in relative prices, changes in technology, and increased international mobility of capital, it is imperative that more empirical research be carried out at the household level in a variety of settings.

This paper describes the results of initial work analyzing a sample of rural households in Peru over the period from 1994 to 2004 to determine how these households responded to and were affected by globalization and the corresponding change in relative prices of traditional versus export-oriented products. Our principal interest was to identify the impact of opening the economy to international trade on rural household decision-making and better understand how household responses to globalization influence rural welfare and poverty dynamics. Since a large percentage of Peruvians living in poverty are located in rural areas, learning more about how these households responded to the changing external economic environment should provide insights into factors that affected their ability to improve their economic position, both absolutely and relatively.

In brief, the results of our analysis indicate that changes in relative prices between traditional and export oriented crops had a significant impact on the adoption of these new products, as did property ownership and access to regional and local markets. It also reaffirms the fact that geographical characteristics such as altitude, rainfall, and growing climate preclude the possibility of many households changing cropping patterns. Finally, by examining changes in household expenditures from the beginning to the end of the period, our analysis suggests that those households who did adopt the new export oriented crops experienced growth in consumption in proportion to the change in the fraction or amount of land devoted to exportable products, and were much less likely to be classified as impoverished at the end of the period.

BACKGROUND: THE PERUVIAN ECONOMY 1994-2004

Peru is the fourth largest country in Latin America with a current population of 27.2 million and a rural population of approximately 7.3 million. IFAD has classified Peru as a severely indebted, middle income country, with a per capita GDP of $2,806 in 2005. The rural areas are found in each of the three major zones of the country: the Pacific Coastal area (coast), the Andean Highlands (highlands) and the Amazon Basin (jungle). The largest segment of the rural poor are found in the highlands, consisting of approximately 5,500 peasant communities and accounting for approximately 4.9 million people. It has been estimated that in 2001, some 73 percent of the rural highland population were living below the poverty line and 27 percent were living in extreme poverty (Massler, 2004). The 2006 *World Development Report* indicates that in 1997, 49.0 percent of the total Peruvian population lived below the poverty line, including 64.7 percent of the rural population and some 40.4 percent of the urban population. In 2000, it was estimated that 18.1 percent of the total population received below $1/day (poverty gap = 9.1%) and 37.7 percent received less than $2/day (poverty gap =18.5%). Given our focus on the rural areas, it is useful to note that the importance of agriculture has increased over the recent decade, accounting for approximately 9.0 percent of GDP in 2000 as opposed to 7.0 percent in 1990, a trend which is presumably related in part to

structural adjustment measures over the period that included significant reductions in state-owned enterprises.

The 1990-2004 period is a particularly interesting and tumultuous period inasmuch as Peru undertook a number of policy reforms and also experienced several outside shocks that impacted the entire economy. A list of the most important events is provided in Table 1. One of the most significant changes was the freeing-up of capital markets and the enactment of a rather extensive trade reform in 1994, which remained essentially in place over the following ten-year period, through which the Peruvian economy became much more open and subject to changes in the global economy. Prior to the Trade Liberalization Reform in August 1990, Peruvian foreign trade policy was characterized by a system of high tariffs with considerable dispersion (56 different levels from 10-84%) between commodities and many quotas. The simple average tariff was 66% and the weighted average tariff was 44%, which jointly resulted in both negative and extremely high positive rates of effective protection. For example, the effective rates of protection were 261%, for clothing and 189% for dairy products (Webb, Camminati and Thorne 2005). Although significant changes occurred in 1990, reductions in trade barriers continued throughout the 1990s, with important reductions happening in 1997 and 2001. Reflecting Peru's increasingly broad based open trade regime, total merchandise trade grew at an annual rate of 7.2% from 1990 to 2004, and total merchandise exports grew at an annual rate of 7.9% over the same period (World Bank 1996, 2000, 2006).

Even in the presence of fairly major events such as El Nino and tumultuous political events, the data show a continuing growth in exports and a declining trade deficit in recent years. With respect to agriculture, exports grew more rapidly than total imports from 1991 to 1998, but less rapidly in the years following, in part due to the effects of El Nino. The volume response was somewhat different than the value response due to decreases in world prices of some grains, milk and meat products, which continued to be the major import groups. Regarding exports, the more traditional export products like coffee, sugar and cotton were accompanied by a rapid growth in non-traditional exports such as tomatoes and asparagus. Not surprisingly given the differences in the geographical characteristics, the nature of the rural production response differed between the coastal, highlands and jungle areas.

Recent IDB Country Indicators for Peru provide a useful overview of the performance of the economy from 1995 to 2005. Key measures of Peru’s economic and social development during this period show that while growth was erratic due in part to the effects of El Nino, the economy grew considerably. The inflation rate fell substantially over the period from well over 20 percent in the early 1990’s to 2 percent in 2003. The sizeable trade deficit of the early 1990s first increased (especially during the El Nino period) and then decreased. By 2004, the trade balance had become positive. Much of this turnaround can be traced to the increase in mineral and metals prices. Using the traditional measure of openness, the economy became more open over the ten-year period from 1994 to 2004 as exports plus imports as a share of GDP rose from 23 percent to nearly 39 percent. As a result of the improving trade balance, the external debt fell from 1996 to 2002. However, net foreign investment proved somewhat erratic falling through the late 1990s and then recovering slightly between 2000 and 2004.

Table 1. Factors Impacting the Peruvian Economy 1990-2002*

Economic Reforms

- Price subsidies eliminated
- Farm-Gate Pricing abolished
- New Central Bank Law
- Agrarian Bank abolished, replaced by commercial lenders and NGOs
- Adoption of a unified floating exchange rate
- Major reductions in tariff levels and tariff dispersion
- Import prohibitions, para-tariff measures and state import monoplies eliminated
- Capital flows and foreign currencies freed
- Major banking reforms undertaken
- Creation of private pension system
- Privatization promoted with establishment of several commissions and autonomous regulating entities
- National Institute for Competition and Intellectual Property Defense created
- State deregulation involving reduction in number of state workers
- Labor markets deregulated and Constitution altered to partially eliminate labor stability
- Payroll taxes eliminated
- Social programs created and focus on poverty initiated
- Highlands Rural Poverty Reduction Strategy initiated in 2002

External Factors

- El Nino climate shock to production 1997-1998
- Asian-led international financial crises of 1997-1998
- Growth in world demand and resulting increase in prices of mineral/metal products in late 1990s, which has continued up to present
- U.S. Andean Trade Preference and Drug Eradication Act (ATPDEA) which reduced or eliminated tariffs on more than 6000 agricultural products from Peru, Bolivia, Columbia and Ecuador

* *This information relied heavily on Webb, Camminai and Thorne (2005), Zorilla (1991), and USAID (2001).*

Because of the influence of many different domestic and external factors during this period, it is virtually impossible to isolate the unique effect of globalization on overall poverty in the rural sectors of Peru during the past decade. Thus, this research focuses on the nature of the rural household production response to the change in relative prices between exportable and traditional crops in the presence of other direct and indirect effects of globalization. We look specifically at the roles of property rights and market access in influencing household crop choice, and examine these and other barriers to production responses to price incentives. Furthermore, to the extent possible, we test the assumption that those who take advantage of the relative price regime shifts are more likely to increase their income by estimating the returns to switching to export-oriented production among households that were more able to do so as a result of quasi-exogenous

factors. This allows us to draw some inferences about the influence of globalization on poverty among our household sample over the period.

The ability to take advantage of changes in relative prices depends on the degree to which factors are appropriately mobile and/or production structures are flexible. This is indicated to some degree by observing which producers did in fact alter their production in response to the increased openness of the Peruvian economy over this period. More specifically, we focus on the household response to these relative price effects by examining the degree to which household production shifted towards greater relative production of export versus domestic crops driven by both the 1997 and 2001 reductions in tariff rates that reduced the relative price of commodities such as grains, and the preferential tax treatment for nearly all agricultural exports to the U.S. granted under the Andean Trade Preference and Drug Eradication Act (ATPDEA). The former led to an increase in grain imports and the latter led to increases in US demand for Peruvian exports of fruits and vegetables.

Table 2 gives the average changes in tariffs over the period of study for the primary crop categories in our sample. Although tariff reductions were nearly universal, differences in the elasticity of export demand to reductions in trade barriers generate important variation in the post-reform increases in returns to the cultivation of specific crops. Specifically, even though tariffs on nearly all fruits and (non-grain) vegetables fell from 25% to 20% between 1994 and 2004, increased export demand for specific fruit and vegetable products such as citrus rose (in great part due to the increase in U.S. imports) and more than offset the price effects of reduced protection. Meanwhile, grain products, which were highly protected prior to the reforms, experienced a fall in domestic price and consequently there was a dramatic rise in wheat imports. On account of these changes, by 2003 Peru was a net grain importer, and grains (specifically wheat, corn, dry peas, lentils, and rice) composed nearly half of U.S. agricultural exports to Peru. U.S. exports of grain accounted for $114 million in 2003, up 24 percent from the previous year; wheat accounted for 88 percent of the total.

Table 2: Tariff Rates on Peruvian Imports

	1994	1997-2001	2001-2004	Change 1994-2004
Wheat	25	20	17	-8
Potato	25	20	20	-5
Barley	18	12	12	-6
Rice	25	20	20	-5
Yuca	18	12	12	-6
Corn	18	12	12	-6
Maize	18	12	12	-6
Beans	25	20	20	-5
Fruit/vegetables	25	20	20	-5

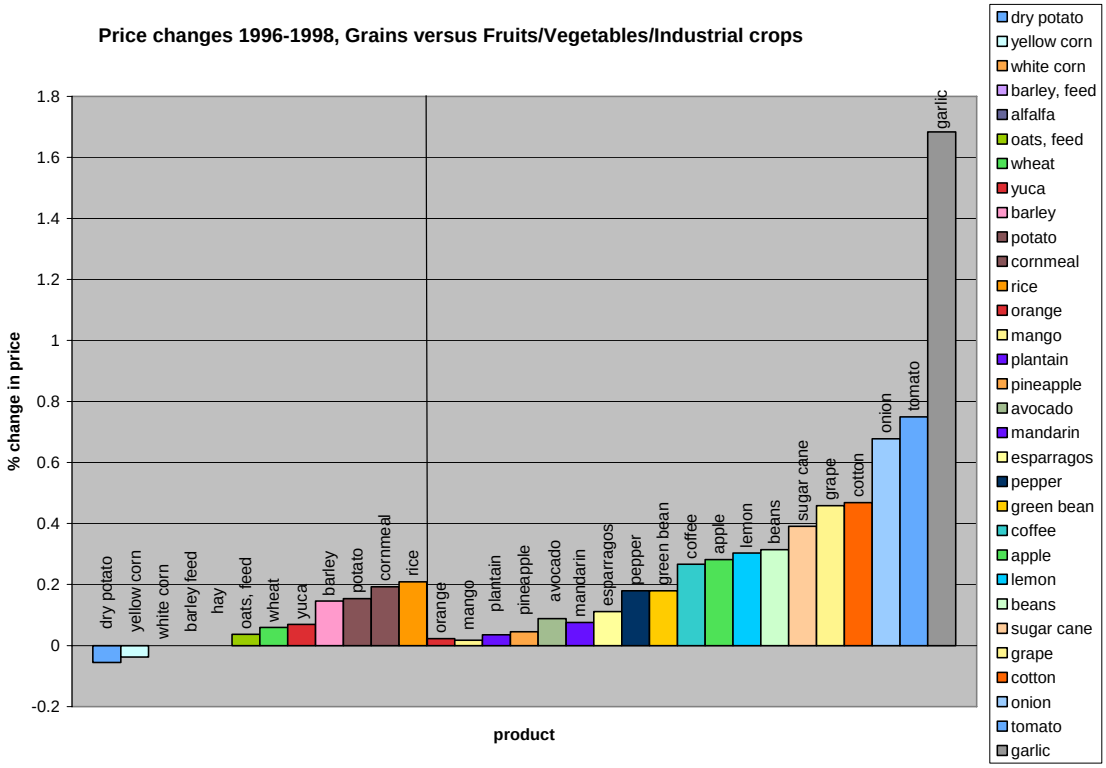
Notes: Tariffs in first three columns provided by the National Superintendence of Tax Administration (SUNAT) and the Ministry of Agriculture (General Direction of Agrarian Information).

At the same time, the price of export-oriented produce was rising over this period in response to increasing demand from abroad. Import penetration in the U.S. fruit and

vegetable market – Peru's most important export destination – has increased significantly in recent years, most of which is sourced from Western Hemisphere suppliers. Indeed, tropical fruit consumption rose significantly at the same time as domestic production was falling, such that Mexico and Peru now supply almost all of the mangos, papayas, and limes consumed in the U.S. Over the period 1994-2003, U.S. imports of horticultural products increased 121 percent (from $9.9 billion to $21.9 billion). Excluding bananas and melons, imports of fresh fruit rose from 11.6 to 19 percent of fresh domestic consumption during the same period, while imports of fresh vegetables rose from 7.5 to 13.5 percent between 1990 and 2002.

As seen in Figure 1, these market changes are reflected in the changing price of export-oriented agricultural products relative to import-competitive products in Peru during the period. This figure shows the difference in the average domestic price of the most common agricultural products, collected by the Ministry of Agriculture on a monthly basis beginning in 1996. The data show the difference in average annual prices before and after the first wave of tariff reductions in 1997. As can be seen by observing price changes to the right and left of the vertical line separating grains and traditional crops from fruits, vegetables and industrial crops, the former experienced very little price change over this period relative to the latter.

Figure 1.



Notes: Crop prices from the Peruvian Ministry of Agriculture monthly crop-specific price series from January 1996 to December 2004 (based on data from Regional Agricultural Directions).

DETERMINANTS OF CROP ADOPTION

Our empirical study tests specific hypotheses regarding factors influencing the adoption of export-oriented crops in place of grains. Household decisions to adopt new export products are dependent on household information regarding the product and its relative price, feasibility of growing the export crop in the household's geographical environment, adoption costs such as the availability and cost of inputs, and accessibility to product markets. All of these are functions of various characteristics of the household and its local environment.

With respect to price incentives, while little work has been done on rural household decisions to adopt export crops in the presence of trade opening, there has been considerable work examining the decision of rural households to switch from household or locally consumed traditional crops to commercial crops. Of notable interest is a study by Cadot, Dutoit and Olarreaga (2006) focusing on the cost of moving out of subsistence crops and that of Vakis, Sadoulet and DeJanvry (2003) focusing on transactions costs of shifting from traditional to commercial crops in Peru. While the adoption of export crops in response to globalization effects may involve a movement away from subsistence crops, it also is likely to involve the shifting from production of domestic commercial crops to export crops. Thus, household decision-making regarding the adoption of export crops is assumed to involve the same critical elements as decisions regarding switching from traditional to commercial crops. For instance, household production is influenced by land size and the percentage of land cropped. In addition, geographical factors such as climate, altitude and length of growing season determine the production possibilities in the area. Furthermore, willingness to adopt a new export product is more likely if the household has previous experience producing commercial crops in addition to the traditional crops of the region. Hence, the likelihood of adoption will be increasing in the fraction of initial total output that is commercial production.

Traditional household characteristics such as size of household, age and sex of the household head, education of the household head and farm experience are also assumed to play a role in household decisions to alter the mix of products. In addition, other institutional variables such as local producer organizations, labor opportunities for household members outside the household, and the availability and cost of hired labor can enter into the final decision. Consideration of risk also suggests that the closer the household is to the poverty level, the less willing they will be to risk undertaking a new production endeavor. Finally, the ability to carry out this change may also depend on access to credit needed to acquire inputs.

Lastly, production of exportable crops is influenced by market access, a function of household characteristics such as distance or time to hard surface roads and walking distance to local commercial markets and major centers of agricultural trade. Since products can be either marketed locally, at the farmgate to buyers who travel from farm to farm, or sold in distant, more major markets, the decision to produce new crops depends on the availability and prices of these marketing choices. Since, by definition, export crops are destined for shipments abroad, the accessibility to export marketing centers is more likely to be critical in the adoption decision. Thus, quality of road and distance to the markets should play a significant role in the decision process. Vakis, Sadoulet and deJanvry (2003) provide a comprehensive analysis of the role of information, search costs and bargaining in the selection of markets and quantities in Peru

with regard to the commercial sales of potatoes by rural households. Switching products also depends on the household knowledge of product alternatives, and expected prices and costs of necessary inputs, which are likely to increase with proximity to centers of trade. This information may also depend upon the technical assistance available or the past experience of other members of the community in adopting commercial crops.

Finally, land rights may be an important predictor of household price responses for a number of reasons. First, switching costs may require sufficient credit from institutions such as agricultural banks. Without property titles, households may lack the resources needed to pay for the fixed costs of adoption or to take on the risk involved in doing so. Second, household tenure insecurity may reduce the incentive to invest in agricultural products with longer investment time horizons, such as fruit trees which have a three to five year gestation period. Third, because property rights increase gains from trade in land, titled households may have greater opportunity to respond to relative prices of agricultural products by buying or selling land.

CHANGES IN RURAL OWNERSHIP RIGHTS 1994-2004[1]

Interestingly, the period of 1994 to 2004 was one in which rural households in Peru experienced dramatic changes in ownership rights through a large nation-wide land titling program. The map in Appendix A shows the distribution of households participating in the Special Rural Cadastre and Land Titling Project (PETT). Each point on the map corresponds to a rural community sampled in the 2004 Land Titling Special Project Survey, and the black dots indicate whether the titling program operated in the community while the blue dots show the rate of export crop adoption at the community level aggregated from the household survey data.

Prior to the reforms, possession of formal property titles in rural areas was limited, largely on account of lengthy and expensive registration procedures. In response to this concern, in 1991 the government implemented PETT through Legislative Decree 25902. PETT's field operations started in 1993 in the coastal region of the country. The program was initially aimed at issuing property titles and developing a cadastre for beneficiaries of the Agrarian Reform, owners of uncultivated land, and native communities. In 1996, the Government of Peru signed an agreement with the InterAmerican Development Bank (IDB) to speed the titling process and increase its coverage to all rural estates. The agreement included financing a 4-year project aimed at surveying 1.1 million parcels for rural cadastre and registering 1.1 million property titles in the coast and highlands. By 2000, the project had surveyed 1.9 million parcels for rural cadastre, registered 900 thousand new property titles, and moved into the jungle region.

Based on 1996-98 information from a sample of farms in the northern coastal provinces of Piura and Ica, the 1994 Agricultural Census, and the National Superintendency of Registry Offices (SUNARP), an IDB evaluation of PETT's performance found effects of the titling program on agricultural practices and credit markets. Production on titled and registered parcels in Ica was 67% higher than those that were titled but unregistered and 179% higher than those with no title at all. This fact may be related to farmers switching production from potatoes, beans, and corn to grapevines and asparagus. In the case of credit markets, the study found that rural areas that were titled through PETT experienced increases in the number of mortgages and sales of land.

[1] This section borrows heavily from Field and Torero (2005).

A decline in livestock herds – substituted with other means of saving and borrowing – was also documented in Ica. Antle et al (2003) analyze the impact of titling on investment in terraces in the province of Cajamarca (northern Peru). They find that the probability of investments in terraces increased by 6.6% with registration. Likewise, Aldana and Fort (2001) document that registry and titling have a significant impact on access to formal credit and a positive - albeit smaller - effect on informal credit. Nevertheless, they find that these effects tend to fall rapidly with land size, such that no significant effect is predicted for producers with less than one hectare. In this sense, titling does not necessarily imply a substantial increase in access to credit among farmers in our sample, 25% of which have less than 1 hectare of land in 1994. Furthermore, results from the last two studies should be interpreted with caution since in both cases possession of a title is not limited to cases reached by the government program, so endogeneity concerns are likely to be significant.

Because the sudden shift in ownership status brought about through PETT coincided with the opening of the economy to international trade, it is a prime opportunity to examine whether lack of ownership rights presents a significant barrier to the adoption of commercial crops or modern farming practices. To the extent that participation was quasi-exogenous to other household features influencing production choices, the titling program serves as a natural experiment in tenure status that enables us to compare the influence of price incentives across untitled and newly titled households.

TABLE 3

Panel Decomposition (# of households)

Initial panel		682
Non-agricultural households	31	
Only in agricultural activities in 1994 wave	55	
Only in agricultural activities in 2004 wave	23	
Households involved in agricultural activities		573
No information on crops in both waves	13	
Did not harvest crops in 1994 wave	6	
Did not harvest crops in 2004 wave	36	
Final panel		518

Notes: Numbers in table calculated by authors from bridge file linking the 1994 Peruvian Living Standard Measurement Survey (LSMS) and the 2004 Land Titling Special Project Survey (PETT).

DATA

To examine household responses to changes in relative agricultural prices, we use data from a nationwide panel of rural households linked across two large surveys: the 1994 Peruvian Living Standard Measurement Survey (LSMS) and 2004 Land Titling Special Project Survey (PETT). PETT was a nationally representative rural household survey conducted between April and July 2004, which drew its sample from the collection of rural households that participated in the 1994, 1997 and 2000 LSMS surveys. The sample was stratified by three regions in the country in order to maintain representative samples from each region. The survey collected detailed individual and

household information including members' characteristics (age, sex, education, health, labor, etc.); assets, income and expenses; ownership rights, including title status of the dwelling and participation in the government land-titling program (PETT); access to credit; and agricultural production, where survey questions were designed to match the LSMS survey instrument for comparison across years.[2] Additional geographic information was gathered through land coordinates identifying the exact location of each household, from which we constructed a village-level measure of altitude, average rainfall, and walking distance to the district capital.

The spatial distribution of households in our sample is shown on the map in Appendix B. As detailed in Table 3, the initial panel consisted of 682 households – or 51% of the 1994 rural LSMS sample –, 651 of which were at one or both periods involved in agriculture. Among these, 10% either entered or abandoned farming over the ten-year period. An additional 55 households did not harvest any crops in one or both waves during the preceding 12 months, which reduced the panel to 518. Six others had missing crop data. An important limitation of the data is the fact that the sub-sample of households in the 1994-2004 panel are subject to selection driven by all forms of sample attrition over the period. While this is that is potentially relevant to the interpretation of results, it implies no obvious selection bias. Furthermore, expanding the analysis to include the 81 households that stopped producing during the ten-year period has little effect on the results.

PATTERNS OF AGRICULTURAL PRODUCTION 1994 - 2004

Table 4 provides basic summary statistics on crop choice and demographic characteristics of households in our sample. As discussed previously, trade opening influenced the price of export-oriented crops (fruit, coffee and cacao) relative to import crops (grains) and therefore presumably altered household incentives to produce fruits and vegetables versus grains. Indeed, a cursory look at the data in Table 4 indicates that agricultural households have switched away from wheat and other grains towards export-oriented fruits, industrial crops and legumes. According to the summary statistics, the most significant changes in agriculture over this panel appear to happen in jungle and highlands regions. In highland villages, the total decrease in agricultural production swamps substitution across categories of products. In the jungle, we observe a significant reduction in the fraction of households cultivating cereals and a significant increase in the fraction cultivating fruits and legumes. In fact, over the period of study, fruits and industrial crops (bananas, coffee, mango, avocado, orange, cocoa) have become the main type of crops in the jungle, and legumes (kidney beans and peas) have significantly increased their incidence in the highlands and jungle. Figure 2 reveals that this change in farm activity is occurring primarily among wealthier households in the coast and highlands, while change in land devoted to export crops is independent of 1994 income in the jungle. This likely reflects higher fixed costs of switching to irrigated crops as well as the stronger relationship between climate and income in dryer regions.

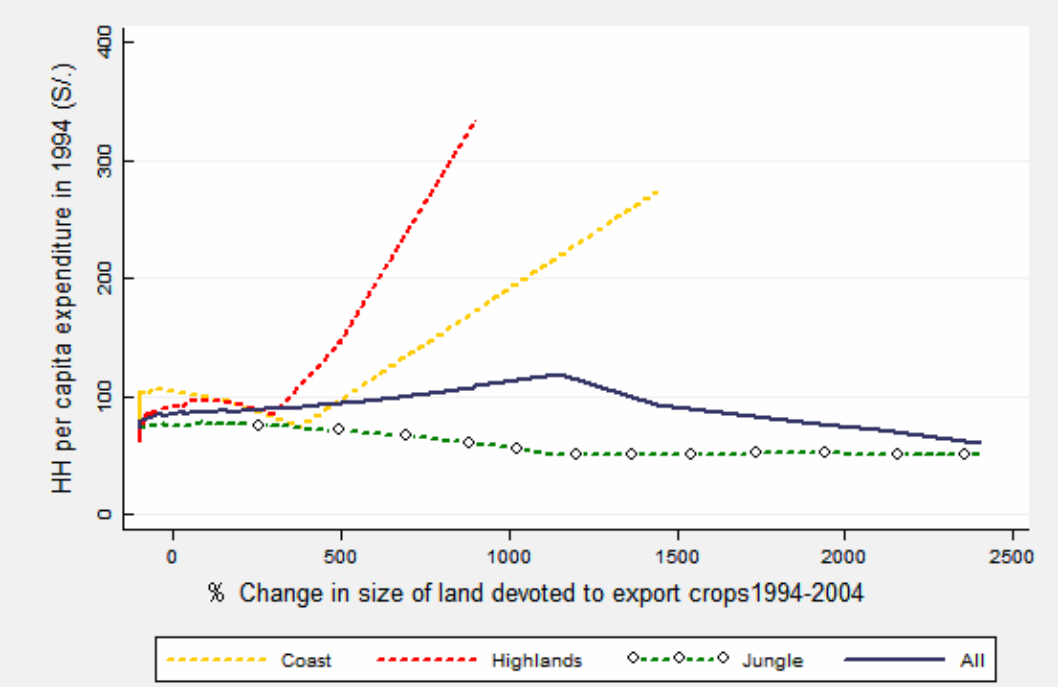
[2] Details on the construction of the total expenditure variable are provided in Appendix B.

TABLE 4: Summary Statistics from the LSMS/PETT Panel

	1994			2004		
	Coast	Highlands	Jungle	Coast	Highlands	Jungle
Land size						
Median size of land (m^2)	30000	12500	50000	25000	7568	60000
Median size of land with crops (m^2)	25000	10000	27500	20000	6666	50000
Mean size of land (m^2)	39386	19914	95204	42065	16690	93925
Mean size of land with crops (m^2)	33269	14739	30271	39599	13971	87847
Proportion of land with crops	0.89	0.85	0.63	0.95	0.90	0.94
Crops						
Number of crops	2.53	4.04	3.77	1.59	2.75	3.14
Fruits	0.15	0.01	0.36	0.14	0.06	0.66
Industrials	0.10	0.01	0.26	0.05	0.02	0.41
Cereals	0.75	0.89	0.72	0.78	0.85	0.67
Vegetables	0.22	0.05	0.06	0.11	0.04	0.03
Legumes	0.25	0.25	0.06	0.18	0.31	0.09
Tubers	0.08	0.61	0.43	0.07	0.60	0.46
Forages	0.04	0.11	0.01	0.04	0.03	0.02
Pastures	0.08	0.06	0.00	0.04	0.03	0.01
Adopted any crop				0.44	0.54	0.67
Adopted any export crop				0.21	0.12	0.50
Adopted any long term crop				0.14	0.07	0.48
Land Title and infrastructure						
PETT	0.45	0.33	0.37	0.12	0.22	0.19
Other title				0.41	0.33	0.36
No property title	0.55	0.67	0.63	0.47	0.44	0.45
Time to nearest paved highway (min)				28	79	87
Time to nearest market (min)				30	50	48
Access to a formal loan	0.01	0.00	0.01	0.27	0.05	0.06
Access to an informal loan	0.18	0.17	0.19	0.16	0.07	0.08
Demographics						
Household size	5.6	5.6	6.0	4.3	4.6	4.8
Same HH head in 2004	1.0	1.0	1.0	0.95	0.91	0.82
Age of HH head	50.1	46.4	45.2	59.3	56.0	54.0
Sex of HH head	0.92	0.91	0.92	0.93	0.90	0.84
Schooling years of HH head	4.5	4.7	4.6	4.5	5.1	4.5
Employment outside of HH						
Total weekly hours (all members)	44.7	33.2	33.8	27.0	36.1	37.6
Total weekly hours (males)	30.8	22.4	21.3	16.2	25.4	27.2
Total weekly hours (females)	13.9	10.8	12.5	10.8	10.7	10.5
Weekly hours per worker	37.1	30.9	34.4	38.2	38.3	37.4
Weekly hours per male worker	42.2	33.1	32.7	37.0	39.7	38.2
Weekly hours per female worker	30.2	27.7	37.5	42.9	37.0	38.9
Production						
Agricultural production (quantity)	19366	4266	9565	21479	3328	12421
Agricultural production (value)	12451	2748	5050	14397	1791	14863
Agricultural production (% sold)	0.85	0.37	0.59	0.87	0.36	0.77
Agricultural production (% consumed)	0.05	0.42	0.26	0.09	0.44	0.17
Agricultural subproducts (quantity)	-	387	2604	275	556	2013
Agricultural subproducts (value)	-	166	2586	170	348	1047
Agricultural subproducts (% sold)	-	0.44	0.84	0.40	0.08	0.51
Agricultural subproducts (% consumed)	-	0.55	0.12	0.60	0.82	0.49
Pecuarian production (quantity)	-11.7	-7.5	-20.8	-9.0	-10.5	-55.4
Pecuarian production (value)	958	651	574	929	1099	1017
Pecuarian production (% sold)	0.41	0.47	0.38	0.61	0.66	0.41
Pecuarian production (% consumed)	0.57	0.47	0.57	0.39	0.33	0.57
Expenditure and Poverty						
Monthly per capita expenditure (S/.)	125	74	77	174	79	97
Real per capita expenditure (S/.)				104	47	58
Negative shock in last 2 years				0.10	0.24	0.19
Change in expenditures (%)				64.9	40.9	68.8
Change in expenditures (% - medians)				23.2	9.9	24.6
N	73	315	124	73	315	124

Notes: Data from subsample of all households that can be linked to across the 1994 Peruvian Living Standard Measurement Survey (LSMS) and the 2004 Land Titling Special Project Survey (PETT). Mean values reported in cells.

Figure 2.



Notes: Authors' calculations. Data from subsample of all households that can be linked to across the 1994 Peruvian Living Standard Measurement Survey (LSMS) and the 2004 Land Titling Special Project Survey (PETT). Lowess regressions with bandwidth of 0.8. Analysis considered as a maximum a 2500% change in land devoted to exports, eliminating 9 observations with extreme right values. In addition, 12 households that produce export crops in 2004 but not 1994 are excluded since we cannot estimate a percentage change.

Table 5 provides additional information regarding the specific nature of crop adoption over the period. Unfortunately, the structure of the questionnaire in 1994 allows the respondent to specify a maximum of 11 crops while the 2004 survey only allows a maximum of six crops, which precludes us from recognizing as adopters those that produce only a minimal amount of the new export crop. As a result, we considered two possible definitions for an "adopter". The first scenario involves ranking all harvested crops according to the fraction of land size devoted to each one and then considering only changes in the top six crops.[3] The result was 347 adopter households (68% of the sample), 134 of which are adopters of export oriented crops. The second scenario considers all crops harvested in both years, such that any new crop introduced in the 2004 survey turns a household into an adopter, which yields 306 households (60%). Among these, 65% (115 households) are adopters of export oriented crops. The remainder of the analysis focuses on the second definition of adopter since it makes use of all possible information and is therefore more likely to pick up genuine crop adoption.

Based on this definition, there is a clear movement from traditional crops to both long term and short term export crops such as fruits and vegetables. For instance, the fraction of households producing wheat fell from 23% to 10%, and the fraction producing

[3] Maize has been simplified as a uniform crop category when possible to avoid greater variation in results.

barley fell from 16% to 6%. Among traditional crops, only yellow corn increased significantly in production, moving from 19% to 30% of households.

TABLE 5: Crop Choice, 1994 and 2004

LSMS 1994				PETT 2004			
Rank	**Crop Name**	**Number of HH**	**Percent**	**Rank**	**Crop Name**	**Number of HH**	**Percent**
1	Wheat	81	23.3	1	Yellow corn	105	30.3
2	Yellow corn	67	19.3	2	Potato	50	14.4
3	Potato	59	17.0	3	Lima beans	36	10.4
4	Barley	52	14.9	3	Wheat	36	10.4
5	Corn (chala)	33	9.5	5	Plantains	35	10.1
6	Green beans	28	8.0	6	Yuca	30	8.6
7	Rice	25	7.2	7	Beans	28	8.1
8	Yuca	24	6.9	8	Peas	22	6.3
9	Lima beans	20	5.7	9	Barley	20	5.8
10	Peas	18	5.2	10	Avocado	16	4.6
11	Alfalfa	15	4.3	11	Rice	13	3.7
11	Quinua	15	4.3	12	Cocoa	10	2.9
13	Oca	13	3.7	12	Coffee	10	2.9
14	Dry potato	10	2.9	12	Coca	10	2.9
15	Onion	7	2.0	12	Mango	10	2.9
15	Coca	7	2.0	12	Orange	10	2.9
15	Corn (choclo)	7	2.0	17	Corn (chala)	8	2.3
18	Cotton	6	1.7	17	Quinua	8	2.3
19	Peanut	5	1.4	19	Corn (choclo)	6	1.7
19	Tomato	5	1.4	19	Squash	6	1.7
19	Carrot	5	1.4				
N	348 observations			N	347 observations		

Notes: Data from subsample of all households that can be linked to across the 1994 Peruvian Living Standard Measurement Survey (LSMS) and the 2004 Land Titling Special Project Survey (PETT). There are slight differences in categories across years since different crop classifications were used in the two surveys. PETT uses ENAHO classification and LSMS uses a broader set of categories.

Table 6 provides a glimpse of the differences between household characteristics and crop choices of those who adopted new crops or export crops in 1994 and 2004. Both the mean and median land sizes of export adopters were larger than that of all adopters, and all adopters were larger than non-adopters. The proportion of land cropped increased for all categories over the period. In addition, the average number of crops produced fell for all categories, indicating a move towards greater specialization. A higher percentage of New Exporters had title to property (64%) in 2004, compared to 52% for those not classified as new exporters. On the positive side, monthly per capita expenditures were substantially higher for new exporters in both 1994 and 2004 than "Others" , while All Adopters' expenditures increased at the same time that "Others" expenditures declined slightly such that there was little difference between expenditures for "All Adopters" and "Others" in 2004 (87-86). Finally, adopters of new crops experienced more negative shocks in 2003-04 than did non-adopters, suggesting that there is a higher risk associated with undertaking a change in crop production structure.

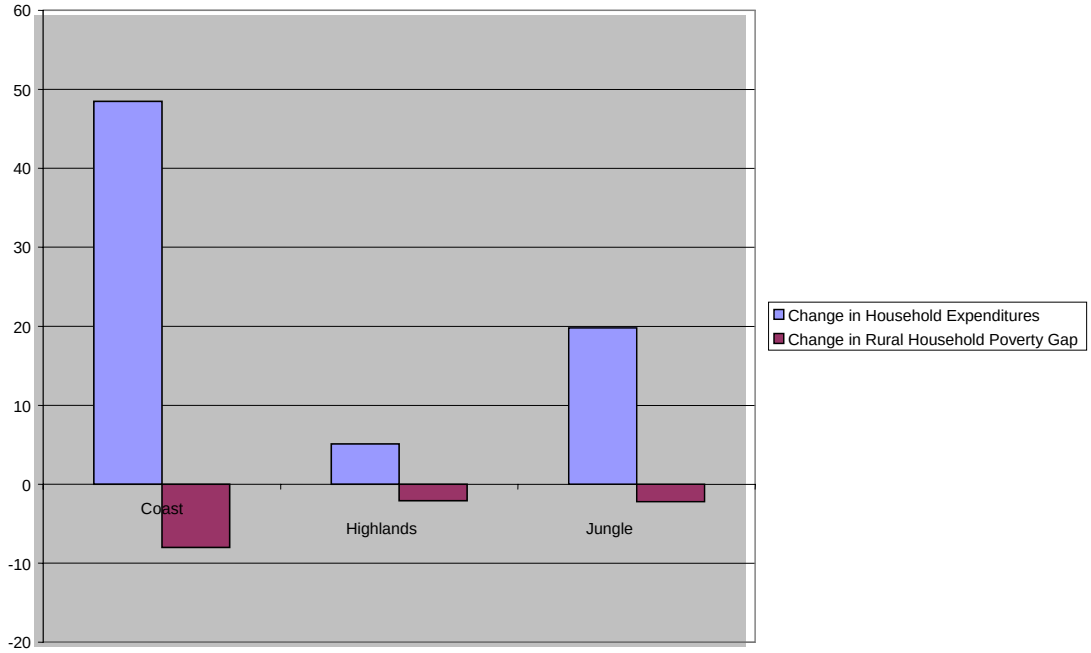
TABLE 6: Summary Statistics in 1994 and 2004, Adopters versus Non-adopters

	1994				2004			
	All adopters	Others	New Exporters	Others	All adopters	Others	New Exporters	Others
Land size								
Median size of land (m^2)	20000	19000	30000	15000	15000	10000	30000	10000
Median size of land with crops (m^2)	15000	15000	21000	12500	12450	10000	25000	10000
Mean size of land (m^2)	45590	31901	64516	33389	46063	24348	66609	30166
Mean size of land with crops (m^2)	21305	20745	28766	18624	41529	23162	60840	27375
Proportion of land with crops	0.78	0.85	0.74	0.82	0.91	0.92	0.91	0.92
Crops								
Number of crops	3.86	3.54	3.99	3.68	3.02	1.95	3.33	2.46
Fruits	0.12	0.10	0.17	0.09	0.29	0.06	0.68	0.06
Industrials	0.12	0.01	0.22	0.04	0.17	0.01	0.46	0.01
Cereals	0.76	0.96	0.68	0.88	0.76	0.87	0.54	0.88
Vegetables	0.09	0.04	0.16	0.05	0.07	0.01	0.18	0.01
Legumes	0.16	0.30	0.10	0.24	0.29	0.14	0.11	0.28
Tubers	0.47	0.53	0.44	0.51	0.52	0.42	0.40	0.52
Forages	0.10	0.03	0.02	0.10	0.04	0.00	0.02	0.03
Pastures	0.06	0.02	0.07	0.04	0.03	0.01	0.04	0.02
Land Title								
PETT	0.38	0.31	0.46	0.33	0.21	0.18	0.20	0.20
Other title					0.36	0.33	0.44	0.32
No property title	0.62	0.69	0.54	0.67	0.43	0.48	0.36	0.48
Time to nearest paved highway (min)					77	67	69	75
Time to nearest market (min)					47	46	36	50
Demographics								
Household size	5.75	5.63	5.80	5.68	4.60	4.63	4.43	4.67
Different HH head in 2004					0.13	0.06	0.18	0.08
Age of HH head	47.2	45.4	47.8	46.2	56.3	55.3	57.3	55.5
Sex of HH head	0.91	0.92	0.90	0.91	0.88	0.93	0.83	0.91
Schooling years of HH head	4.6	4.7	4.7	4.6	5.0	4.7	4.8	4.9
Monthly per capita expenditure (S/.)	79	88	100	76	87	86	107	80
Real per capita expenditure (S/.)					52	51	64	48
Negative shock in last 2 years					0.23	0.16	0.25	0.19
N	347	165	126	386	347	165	126	386

Notes: Authors' calculations. Data from subsample of all households that can be linked to across the 1994 Peruvian Living Standard Measurement Survey (LSMS) and the 2004 Land Titling Special Project Survey (PETT).

The second element of interest relates more directly to changes in poverty that took place during this period. We are interested in whether those households that experienced changes in product prices and were both able to and chose to respond experienced an increase in real income. For some this could mean a movement out of absolute poverty, while for others it implies moving further above the poverty line. Using monthly per capita expenditures as an indicator of household income, the summary statistics in Table 4 and Appendix C suggest that conditions improved for coastal households, and changed little for households the highlands, the most impoverished region. The relationships are also illustrated in Figure 3. The situation in the jungle is less clear. While the variance as well as the mean of household income increased in both the coast and the jungle, in the jungle – the poorer of the two regions – this rise in inequality resulted in a significant increase in the fraction of households below the poverty line, reflecting the general vulnerability of households in this part of the country. In the highlands, there is almost no noticeable change in poverty, either in terms of the poverty gap or fraction of households below the poverty line. The highlands result is not surprising inasmuch as this region is substantially more insulated from national markets, its altitude and climate preclude the adoption of the new export type crops, and the low level of income and assets prevent residents from being able to change.

Figure 3. Change in Household Expenditure and Poverty Gap by Region, 1994-2004



Notes: Authors' calculations. Data from subsample of all households that can be linked to across the 1994 Peruvian Living Standard Measurement Survey (LSMS) and the 2004 Land Titling Special Project Survey (PETT).

The fact that in the jungle region where export crop adoption was highest average expenditures increased at the same time as the fraction of households below the poverty line suggests one of two possibilities: Either high variance in the returns to crop adoption, or high returns to crop adoption along with a decline in the returns to traditional crops. The latter story implies that the degree of traditional crop subsidization was particularly high in the jungle region, which could arise from higher average marketing costs given the remoteness of households in this region. In particular, price distortions were likely to be higher in the jungle relative to the highlands and the coast on account of the government's traditional policy of farmgate pricing, or guaranteeing a price per unit independent of location, which was abolished in the 1990s (Table 1). Our empirical analysis of the returns to crop adoption will help distinguish between these two scenarios.

EMPIRICAL ANALYSIS OF CROP ADOPTION

To test hypotheses regarding determinants of crop adoption, we examine the interaction between specific household characteristics and price incentives to re-orient production to export industries. The first specific hypothesis we explored is whether changes in household crop cultivation were influenced by the presence of legal ownership rights of the household. To do so, we used variation in household ownership rights stemming from regional variation in program activity of the Peruvian rural land titling program, PETT. Between 1994 and 1998, PETT distributed property titles to over 1.1 million rural households, one of the largest formalization program targeted to rural areas in the developing world. As shown in Table 4 and Appendix D, approximately 20% of households in our sample received a land title through the PETT program in the late 1990s, the majority of which resided in the highlands where the bulk of program activity

took place. By 2004, 35% had acquired a title independently of the program and approximately 45% of households in our sample still had no legal ownership rights to their land. As indicated by the rate of non-PETT titles in 1994, virtually all new titles obtained between 1994 and 2004 resulted from the PETT program.

We examine more formally determinants of changes in amount of land devoted to crops destined for export markets by running the following fixed effects regression that controls for differences in production choices within each of eight climate zones (*c*) based on temperature and altitude:

$$crop\_adoption_{ic} = \alpha + \beta_0 (Pr_{pc}) + \beta_1 (T_{ic}) + \beta_2 (C_{ic}) + \beta_3 (M_{ic}) + \beta_4 (P_{ic}) + \beta_5 (X_{ic}) + \mu_c + \varepsilon_{ic}$$

The regression analysis considers four measures of change in crop choices for household *i* in climate zone *c* between 1994 and 2004 as outcome variables in the above equation: change in hectares of land devoted to export-oriented crops; change in fraction of land devoted to export crops; change in fraction of cultivated land devoted to export crops and whether the household introduced any export-oriented crop by the 2004 survey.[4] The right-hand-side variables of interest are agricultural product prices, property rights, access to product markets, climate, and household demographic characteristics. Hence, *Pr* is a vector of agricultural product prices in 1996 and 2004. We consider the role of changes in prices that occurred during the period as a result of general increased openness and tariff reductions using the 1996 and 2004 prices of the most widely grown traditional crop (destined primarily for domestic markets) in the province in 1994, which encompasses nine separate products. Crop status as import-competing or export-oriented was determined following criteria of volume and FOB amounts according to data provided by the National Superintendence of Tax Administration (SUNAT) and the Ministry of Agriculture (General Direction of Agrarian Information) for the period December 2004/2005. Import-competing (import) crops were defined as all crops that were not exported abroad at all or represented an insignificant amount of exports. The most common crop by province was determined by aggregating frequencies for each household crop at the province level from the 1994 LSMS. In case of a tie, the crop to which more land was devoted in the province was selected. Monthly crop prices were obtained from the Ministry of Agriculture based on price series between January 1996 and December 2004 constructed from data from Regional Agricultural Directions.[5] In total, real prices of the most common products fell over the period for about half of the sample and rose for the other half. *Pr* also contains the interaction of 2004 prices with acquisition of a PETT property title and distance to nearest paved road.

In addition, *T* is a vector of binary indicators of whether the household possessed formal title to its land in 1994 and whether it received a title through the government titling program between 1994 and 2004; *C* includes altitude and mean rain fall (mapped to climate data from GPS data collected by survey-takers); *M* includes distance to nearest paved road, distance to province capital, and urbanicity; and *X* includes number of household members in 1994 and 2004, age and education level of household head in 1994, and household expenditures per person in 1994. Finally, we control for the

[4] Considering only the fraction of cultivated land yields virtually identical results.

[5] For a few crops prices are only available since 1997. Hence, the earliest price available (in most cases January 1996) was used as a proxy for the 1996 price. Prices in 2004 are taken from May since this was the month of the PETT survey. All estimates are robust to using annual averages in place of monthly data.

following characteristics of household production (*P)*: land holdings in 1994 and 2004, fraction of farm produce sold in 1994, land devoted to export crop production in 1994, financial losses due to drought or weather conditions during the past year; whether household belonged to a local producers association; and binary indicators of the top two crops categories produced.[6] Although land and household size are both potentially endogenous, we include them to increase the precision of the estimates and run robustness checks excluding these variables.

The regressions include fixed effects for each of eight climatic zones. The results are presented in Table 7. In the first column, for the binary outcome of whether any export-oriented crop was adopted, a probit model is run with the same set of controls. The estimates in column 1 suggest that household production of export crops increased in response to falling prices of grains in the domestic market. A 10% reduction in the price of a province-level traditional crop is associated with a 12% increase in the likelihood that a producer begins growing fruits or vegetables. With respect to ownership status, we observe that possession of a property title is also a strong predictor of changes in production. Households that acquired a property title between 1994 and 2004 are an estimated 68% more likely to begin producing an export-oriented crop. Furthermore, households that received property titles through the government titling program appear to be more responsive to changes in price incentives. In particular, the coefficient on the interaction term between province-level import prices and participation in the titling program is positive and statistically significant. Finally, market access in terms of hours of traveling time to the district capital is a strong predictor of crop adoption: with each additional 10 hours of travel time, households are 16% less likely to switch from a traditional to an export-oriented crop.

With the continuous measure of intensity of adoption, the relationships are not as strong. For all four outcome measures, crop adoption falls with the price of the most common traditional crop produced in the province, as measured in either 2004 or 1996. However, the effect of a property title on the amount of land devoted to export crops only shows up as significant when the outcome is measured in absolute terms rather than percentage terms. Not surprisingly, climate characteristics including average rainfall and altitude are strong predictors of changes in production: Households that live in high altitudes and those with little rainfall are significantly less likely to begin producing fruits or vegetables or expand production of these crops. This relationship is clearly shown in Figure 4. Similarly, production choices in 1994 are strong predictors of production choices in 2004, reflecting both switching costs as well as unobservable determinants of relative returns to specific products.

[6] Categories are: vegetables, legumes, fruits, cereals, grasses, tubers, and industrial crops.

Table 7: Determinants of Export Crop Adoption, 1994-2004

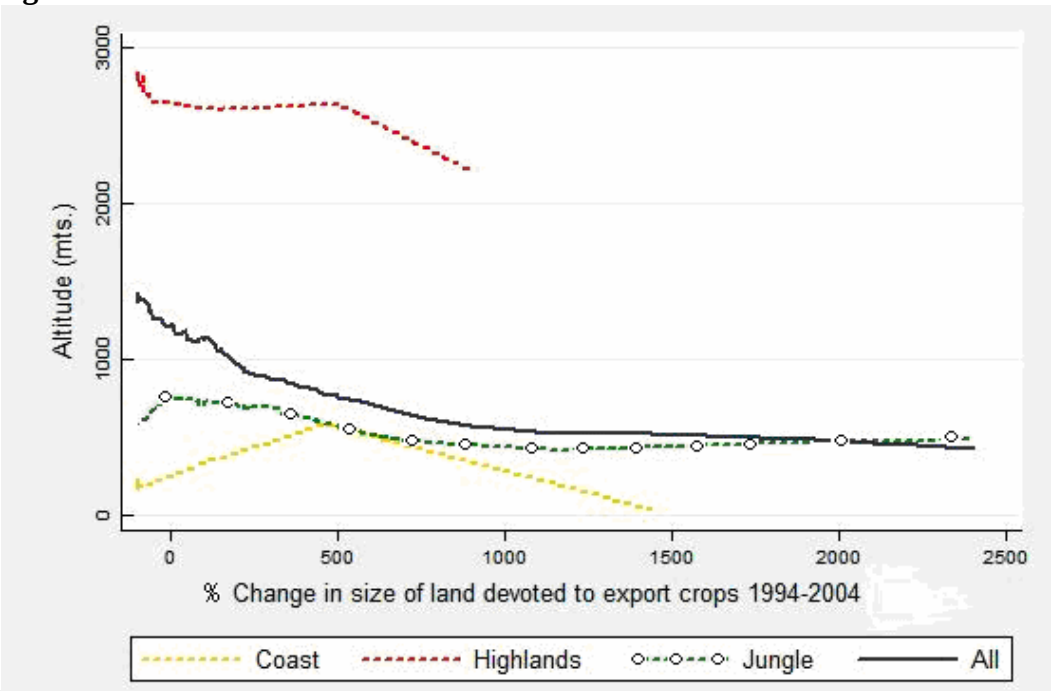
	Adopter of any export crop in 2004	Change in fraction of all land devoted to export crops, 1994-2004	Change in fraction of cultivated land devoted to export crops, 1994-2004	Change in hectares of land devoted to export crops, 1994-2004
PETT title in 2004	0.676	0.117	0.122	2.402
	[0.172]***	[0.094]	[0.084]	[1.189]**
Price of most common import crop by province (1994)	0.212	-0.015	-0.176	-2.788
	[0.139]	[0.095]	[0.086]**	[1.214]**
Price of most common import crop by province (2004)	-0.197	-0.148	-0.099	1.208
	[0.099]**	[0.066]**	[0.059]*	[0.840]
(Price of most common import crop by province (2004))*(PETT title in 2004)	-0.675	-0.080	-0.078	-2.139
	[0.188]***	[0.117]	[0.105]	[1.483]
(Price of most common import crop by province (2004))*(Distance to capital)	0.000	0.000	0.000	-0.007
	[0.001]	[0.000]	[0.000]	[0.006]
Mean altitude of CCPP	0.000	0.000	0.000	0.000
	[0.000]***	[0.000]***	[0.000]***	[0.000]
Mean precipitation level of CCPP	0.060	0.022	0.027	0.293
	[0.014]***	[0.008]***	[0.007]***	[0.103]***
Belongs to a producers' group	-0.017	0.091	0.065	1.249
	[0.063]	[0.047]*	[0.043]	[0.604]**
Time (minutes) to nearest paved highway	-0.001	0.000	0.000	0.007
	[0.000]	[0.000]	[0.000]	[0.004]*
Time to capital of CCPP (hours)	0.016	0.003	0.003	0.022
	[0.006]**	[0.005]	[0.004]	[0.061]
HH head age in 1994	-0.002	0.000	0.000	0.009
	[0.002]	[0.001]	[0.001]	[0.013]
Household size in 1994	-0.001	0.007	-0.005	-0.038
	[0.009]	[0.006]	[0.005]	[0.074]
Household size in 2004	0.000	-0.001	-0.006	-0.105
	[0.010]	[0.006]	[0.006]	[0.083]
Level of education attained by HH head in 1994	0.012	0.006	0.017	-0.110
	[0.021]	[0.015]	[0.013]	[0.188]
Log of per capita expenditure in 1994	0.023	0.060	0.005	-0.016
	[0.037]	[0.024]**	[0.021]	[0.300]
HH head is another person in 2004	0.029	0.042	0.071	1.134
	[0.053]	[0.036]	[0.032]**	[0.452]**
Size of land in 1994 (m2)	0.000	0.000	0.000	0.000
	[0.000]*	[0.000]	[0.000]*	[0.000]*
Size of land devoted to export crops in 1994	0.000	0.000	0.000	0.000
	[0.000]	[0.000]***	[0.000]***	[0.000]
Percent of agricultural value sold in 1994	-0.119	-0.088	-0.128	-1.046
	[0.074]	[0.048]*	[0.043]***	[0.606]*
Property title in 1994	0.066	0.001	0.011	0.447
	[0.046]	[0.028]	[0.025]	[0.360]
One of top 2 crops is industrial in 1994	0.038	-0.269	-0.324	-2.991
	[0.101]	[0.066]***	[0.059]***	[0.837]***
One of top 2 crops is cereal in 1994	-0.080	0.134	0.066	0.497
	[0.061]	[0.037]***	[0.033]**	[0.467]
One of top 2 crops is vegetable in 1994	0.236	-0.081	-0.053	-0.268
	[0.108]**	[0.052]	[0.046]	[0.657]
One of top 2 crops is legume in 1994	-0.016	0.023	0.018	-0.225
	[0.054]	[0.034]	[0.030]	[0.429]
One of top 2 crops is tuber in 1994	0.039	0.032	0.003	0.404
	[0.043]	[0.028]	[0.026]	[0.362]
One of top 2 crops is grass in 1994	0.111	0.058	-0.006	-0.560
	[0.120]	[0.062]	[0.055]	[0.786]
Drought lossses in HH in last 2 years	0.208	0.076	0.071	-0.418
	[0.113]*	[0.047]	[0.042]*	[0.596]
Constant		-0.317	0.173	1.093
		[0.178]*	[0.160]	[2.266]
Observations	502	512	512	512
R-squared		0.29	0.34	0.23

Robust standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Notes: Coefficient estimates from ordinary least squares regressions. Data from subsample of all households that can be linked to across the 1994 Peruvian Living Standard Measurement Survey (LSMS) and the 2004 Land Titling Special Project Survey (PETT). "CCPP" is geographic center of village (GPS measurements taken at time of PETT survey).

More surprisingly, agricultural losses due to drought significantly *increase* the likelihood that a household adopts a new crop. Although the loss in income from a shock to production presumably works against the household's ability to alter or expand production, response to risk and loss of long-term investments appear to encourage new crop choices such that the net effect is positive.

Figure 4:



Notes: Data from subsample of all households that can be linked to across the 1994 Peruvian Living Standard Measurement Survey (LSMS) and the 2004 Land Titling Special Project Survey (PETT). Lowess regressions with bandwidth of 0.8. Analysis considered as a maximum a 2500% change in land devoted to exports, eliminating 9 observations with extreme right values. In addition, 12 households that produce export crops in 2004 but not 1994 are excluded since we cannot estimate a percentage change.

While likely to matter, the influence of demographic characteristics such as education are swamped by the more fundamental influences of climate and prices such that their effect on crop adoption cannot be detected in the regression estimates. Meanwhile, membership in a local producer's association is also a significant determinant of increased in export-oriented production, which could reflect an important role of spillovers in technology adoption.

Because production choices are endogenous to many household characteristics, we instrumented for changes in the amount of land devoted to export crop production by making use of household participation in the PETT titling program and province-specific changes in the price of imported agricultural products. We estimated the following instrumental variables (IV) model, where $\hat{A}_{ic}$ is predicted crop adoption of household *i* based on the first-stage regression estimate detailed in the first equation:

$$crop\_adoption_{ic} = \alpha + \beta_0 (Z_{ic}) + \beta_1 (T_{ic}) + \beta_2 (C_{ic}) + \beta_3 (M_{ic}) + \beta_4 (P_{ic}) + \beta_5 (X_{ic}) + \mu_c + \varepsilon_{ic}$$

$$\ln(pc\_consumption)_{ic} = \gamma + \lambda_1 (\hat{A}_{ic}) + \lambda_2 (T_{ic}) + \lambda_3 (C_{ic}) + \lambda_4 (M_{ic}) + \lambda_5 (P_{ic}) + \lambda_6 (X_{ic}) + \mu_c + \varepsilon_{ic}$$

The following instruments are contained in *Z*: province-level agricultural product prices in 1996 and 2004, whether the household received a property title through the government titling program between 1994 and 2004, and 2004 prices interacted with receipt of a property title and distance to nearest paved road. The level effect of distance to nearest paved road and other indicators of market access, along with ownership rights prior to the government program are included in both regressions in the set of control variables. Hence, our identification strategy makes use of participation in the titling program and variation in product prices, which we argue are exogenous to other determinants of crop choice conditional on baseline property rights in 1994, and the differential impact of this variation on households based on distance to market and ownership of land.

The regression results in Table 7 reveal that the instruments have statistical power in predicting variation in crop adoption, the first requirement for instruments to be valid. However, since the first-stage F-statistic falls between 5.79 and 7.12, there is potential concern over "weak instruments" bias. In addition, identification of the causal effect of changes in agricultural production in the above set of regressions requires that the instruments (Z_{ic}) be uncorrelated with the household expenditures conditional on the observables contained in *T, C, M, P* and *X*. If differences in the likelihood of receiving a property title are positively related to other factors that encourage changes in production conditional on *T, C, M, P* and *X*, then the estimates will overstate the true effect of crop adoption on income and poverty. With respect to prices, this is unlikely to present a problem since product prices are measured at the national level and reflect changes in prices driven by global markets which is unaffected by local supply decisions. Variation across provinces in the modal crop is therefore likely to reflect region-specific comparative advantage in the production of certain plant types and possibly institutional infrastructure that favors specific products.

EFFECT OF CROP ADOPTION ON INCOME AND POVERTY

In the second stage of the analysis we study the returns to crop adoption by estimating the effect of changes in production on household income and poverty status. Our first outcome of interest is the natural log of per capita household expenditure in 2004 conditional on log expenditures in 1994.[7] Expenditure data collected in the 1994 and 2004 surveys were designed to include consumption from own production and income in kind. We also consider the effect of crop adoption on poverty status by classifying households as impoverished if per capita income falls below 100 soles per month, which corresponds to the international standard "absolute poverty line" of $1/day.

As far as the titling program is concerned, we treat receipt of a property title between 1994 and 2004 as exogenous to household production choices conditional on 1994 household income, tenure status in 1994 and geographic and production characteristics of the household. This assumption is supported by previous analyses of

[7] Data were converted to 2004 prices using the Consumer Price Index (CPI) estimated by the Peruvian National Statistical Institute (INEI) on a monthly basis.

program expansion and participation criteria, detailed in Field and Torero (2005). Although possession of a land title in 1994 is likely to be correlated with household wealth, assets and use of technology, conditional on climate zone and 1994 expenditures, participation in the PETT program appears to be independent of household production or other observables.

The instrumental variable (IV) regression results are presented in Table 8. Not surprisingly, household size, head's education level, and household expenditures in 1994 are the strongest predictors of expenditures and poverty status in 2004. Furthermore, households whose principal product in 1994 is a grain do significantly worse in terms of expenditures and poverty status, even conditional on climate zone and changes in production over the period. Negative shocks over the past ten years – particularly agricultural losses from weather shocks – are also likely to drive a household into poverty. These characteristics, along with climate zone fixed effects, soak up most of the variation in per capita expenditures and poverty classification in 2004.

However, results from the IV regressions also indicate high returns to expansion of production and adoption of new export-oriented crops. Based on all three continuous measures of expansion in production, our estimates indicate that switching towards export-oriented crops is a significant determinant of growth in expenditures over the period. According to the estimate in column 1, a ten percent expansion in the fraction of land devoted to export crops corresponds to a 14 percentage point increase in expenditures per capita. The same change is associated with an estimated 16% reduction in the likelihood of being classified as extremely poor in 2004 (column 2). These estimates are independent of whether changes in production are measured in terms of cultivated or total land holdings (column 3). Similarly column 4 suggests that each additional hectare of land devoted to export-oriented production is associated with an 11 percentage point increase in household consumption. These changes are illustrated graphically in Figure 5, which shows a steady improvement in estimated income with amount of land dedicated to export-oriented production marked by the blue line. The plotted lines also indicate a higher rate of return in coast and jungle areas, although the confidence bands are too large for interpretation in the regional graphs, particularly for changes in production greater than 500 square meters, of which there are very few.

It is important to note in all of these IV regression results the possible role of bias due to weak instruments in light of the fact that the first-stage F-statistic does not surpass the critical value believed to indicate sufficiently strong instruments (Staiger and Stock, 1994). Hence, the results on poverty and household expenditures should be taken as suggestive rather than solid evidence of the high returns to crop adoption in rural Peru over this period.

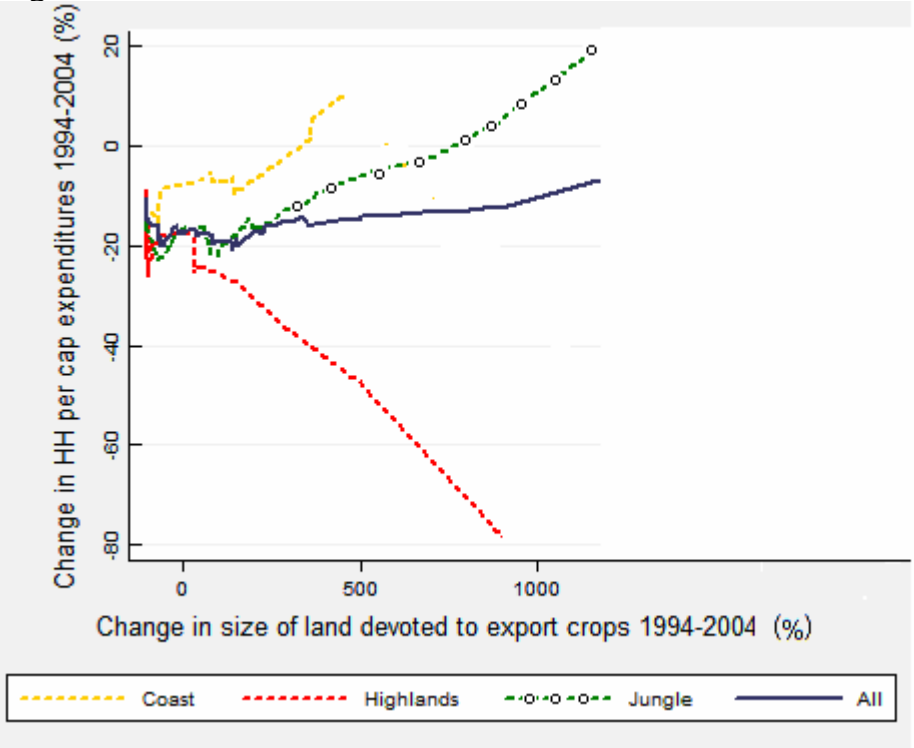
Table 8: Crop Adoption and Changes in Household Consumption, 1994-2004

	Log per capita expenditure 2004	Whether extremely poor 2004	Log per capita expenditure 2004	Log per capita expenditure 2004
Change in fraction of all land devoted to export crops, 1994-2004	1.441	-1.652		
	[0.752]*	[0.819]**		
Change in fraction of cultivated land devoted to export crops, 1994-2004			1.694	
			[0.778]**	
Change in hectares of land devoted to export crops, 1994-2004				0.106
				[0.059]*
Mean altitude of CCPP	0.000	0.000	0.000	0.000
	[0.000]	[0.000]**	[0.000]	[0.000]
Mean precipitation level of CCPP	-0.016	0.046	-0.028	-0.018
	[0.023]	[0.025]*	[0.026]	[0.024]
Belongs to a producers' group	-0.001	0.013	0.026	0.018
	[0.140]	[0.151]	[0.134]	[0.139]
Time to capital of CCPP (hours)	-0.021	0.039	-0.019	-0.013
	[0.012]*	[0.019]**	[0.012]	[0.012]
Time (minutes) to nearest paved highway	0.000	0.000	0.000	0.000
	[0.000]	[0.000]	[0.000]	[0.000]
HH head age in 1994	0.003	-0.002	0.002	0.001
	[0.003]	[0.003]	[0.003]	[0.003]
Household size in 1994	0.017	-0.008	0.035	0.027
	[0.015]	[0.016]	[0.016]**	[0.014]*
Household size in 2004	-0.154	0.111	-0.144	-0.142
	[0.016]***	[0.019]***	[0.018]***	[0.018]***
Level of education attained by HH head in 1994	0.088	-0.052	0.063	0.102
	[0.036]**	[0.039]	[0.041]	[0.037]***
Log of per capita expenditure in 1994	0.188	-0.050	0.264	0.268
	[0.072]***	[0.081]	[0.061]***	[0.059]***
HH head is another person in 2004	-0.139	0.081	-0.209	-0.192
	[0.097]	[0.093]	[0.115]*	[0.116]*
Size of land in 1994 (m2)	0.000	0.000	0.000	0.000
	[0.000]	[0.000]	[0.000]	[0.000]
Size of land devoted to export crops in 1994	0.000	0.000	0.000	0.000
	[0.000]**	[0.000]*	[0.000]**	[0.000]
Percent of agricultural value sold in 1994	0.236	-0.171	0.312	0.213
	[0.128]*	[0.138]	[0.148]**	[0.126]*
Property title in 1994	0.076	-0.025	0.057	0.036
	[0.070]	[0.076]	[0.074]	[0.076]
One of top 2 crops is industrial in 1994	-0.148	-0.220	-0.012	-0.222
	[0.252]	[0.303]	[0.288]	[0.233]
One of top 2 crops is cereal in 1994	-0.369	0.442	-0.268	-0.232
	[0.122]***	[0.131]***	[0.096]***	[0.090]**
One of top 2 crops is vegetable in 1994	-0.003	0.046	-0.019	-0.080
	[0.139]	[0.142]	[0.140]	[0.130]
One of top 2 crops is legume in 1994	-0.221	0.195	-0.223	-0.174
	[0.084]***	[0.071]***	[0.088]**	[0.085]**
One of top 2 crops is tuber in 1994	-0.053	0.075	-0.020	-0.049
	[0.076]	[0.084]	[0.073]	[0.077]
One of top 2 crops is grass in 1994	0.273	-0.230	0.326	0.456
	[0.170]	[0.206]	[0.155]**	[0.135]***
Drought lossses in HH in last 2 years	-0.289	0.291	-0.301	-0.142
	[0.127]**	[0.055]***	[0.132]**	[0.120]
Constant	4.558		4.019	3.956
	[0.497]***		[0.388]***	[0.375]***
Observations	511	508	511	511
R-squared	0.35		0.28	0.32

Robust standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Notes: Coefficient estimates from ordinary least squares regressions. Data from subsample of all households that can be linked to across the 1994 Peruvian Living Standard Measurement Survey (LSMS) and the 2004 Land Titling Special Project Survey (PETT). "CCPP" is geographic center of village (GPS measurements taken at time of PETT survey).

Figure 5.



Notes: Data from subsample of all households that can be linked to across the 1994 Peruvian Living Standard Measurement Survey (LSMS) and the 2004 Land Titling Special Project Survey (PETT). Lowess regressions with bandwidth of 0.8. Analysis considered as a maximum a 2500% change in land devoted to exports and a 300% change of expenditures, eliminating 18 observations with extreme right values. In addition, 12 households that produce export crops in 2004 but not 1994 are excluded since we cannot estimate a percentage change.

CONCLUSIONS

This paper examined rural household decision-making in Peru over the period of 1994-2004. It focused on how these households responded to changes in the economic environment accompanying economic reforms of the period which reduced domestic market distortions, opened up the economy and changed relative prices between traditional agricultural crops and those produced primarily for export. The econometric results confirmed that changes in these relative prices increased the likelihood that households would shift production towards these new export products. These tendencies appear to be strengthened if the household obtained title to their property over the period, which indicates that weak property institutions may inhibit the degree to which households can reap the benefits of a globalized market place. Additional work is needed to disentangle the possible channels through which ownership security could matter for crop adoption, which has relevance for the steps necessary to counter the negative influence of weak institutions on growth. Adoption of these crops was also found to be dependent upon geographical characteristics such as altitude and rainfall, initial cropping pattern and membership in a technical assistance group. Interestingly, these factors appeared to dominate the effects of head of household characteristics.

We then examined how changes in the cropping pattern related to changes in household expenditures and poverty. Our results indicated high returns to adoption of

export products and that households which began producing an export oriented crop over the period were much less likely to be classified as impoverished in 2004. The obvious implication is that those who were unable to alter production due to reasons such as geographical location, access to credit, or lacking title to their property continued to produce traditional crops and were not able to escape poverty. This finding reaffirms the idea that liberalizing markets must be accompanied by appropriate social programs or institutional reforms directed to the unique situational problems of different subgroups in poverty if the broader poverty issue is to be improved.

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Appendix A: Construction of Total Household Expenditures

The 1994 annual expenditure measure was built by "Instituto CUANTO", the institution in charge of developing the Peruvian LSMS. The final expenditure variable assesses the total annual expenditures of all members in the household. It is divided among nine categories according to recurrence or periodicity of expenditures and their incidence in the basket of goods. Monthly per capita expenditure is calculated by the simple division of annual household expenditure by 12 divided by household size. The nine categories considered are the following:

1. Food, beverages and tobacco: Includes all expenditures made in these categories during the last 15 days. Any self-produced or self-supplied item, and any payment in kind is included in the estimation. Results are multiplied by 26 to obtain annual figures.
2. Clothing and footwear: Includes all clothing and footwear bought, self-produced or self-supplied during the last 3 months. Payments in kind are also considered. Results are multiplied by 4 to obtain annual figures.
3. Rents, fuel and electricity: Includes nominal monthly payments for rent in case the dwelling is rented. For other property options (owned, by invasion, etc.) a hypothetical monthly rent is provided. Monthly payments for home taxes and utilities such as fuel, electricity or water are considered. Payments in kind are also included. Results are multiplied by 12 to obtain annual figures.
4. Pieces of furniture, belongings and maintenance of dwelling: Includes all personal care and cleaning products bought during the last 15 days. Also, accounts for home furniture and kitchen products and appliances bought in the last 3 months. Payments in kind and self-supplied items are also considered. Finally, this category includes payments for housecleaning services. Results are multiplied by 26 and 3 accordingly, in order to obtain annual figures.
5. Health and medicines: Includes all expenditures related to health services and medicines during the last 3 months. Results are multiplied by 4 to obtain annual figures.
6. Transport and communication: Includes all expenditures made in public transport, communication and gas during the last 15 days. Expenditures incurred during the last 3 months in car maintenance or repair, national or international trips, and purchase of motorized vehicles are also considered. Finally, monthly telephone bills (landlines or cellular phones) are also included. Results are multiplied by 26, 3 and 12 accordingly, in order to obtain annual figures.
7. Leisure, cultural and educational services: Includes all expenditures incurred in recreational activities during the last 3 months. Also, expenditures in books, newspapers, magazines, subscriptions to journals, or purchases of electronic items (camera, radio, TV, etc.) are considered. "Educational services" comprise tuition payments made to universities, schools or kindergartens, and any additional expenditure incurred in those institutions (transport, snacks, school supplies, etc.).

Results are multiplied by 4 and 9 (length of academic year) in order to obtain annual figures.

8. Other goods and services: Includes all additional purchases or consumptions incurred in the last 15 days, quarter or year. Some examples are food eaten in restaurants, purchase of a particular electronic item, insurance premiums, etc. Results are multiplied accordingly to obtain annual figures.
9. Transfers: Includes any monetary transfer incurred in the last year such as alimony, contributions to social security, donations, consignments, etc. Figures are already expressed in annual terms.

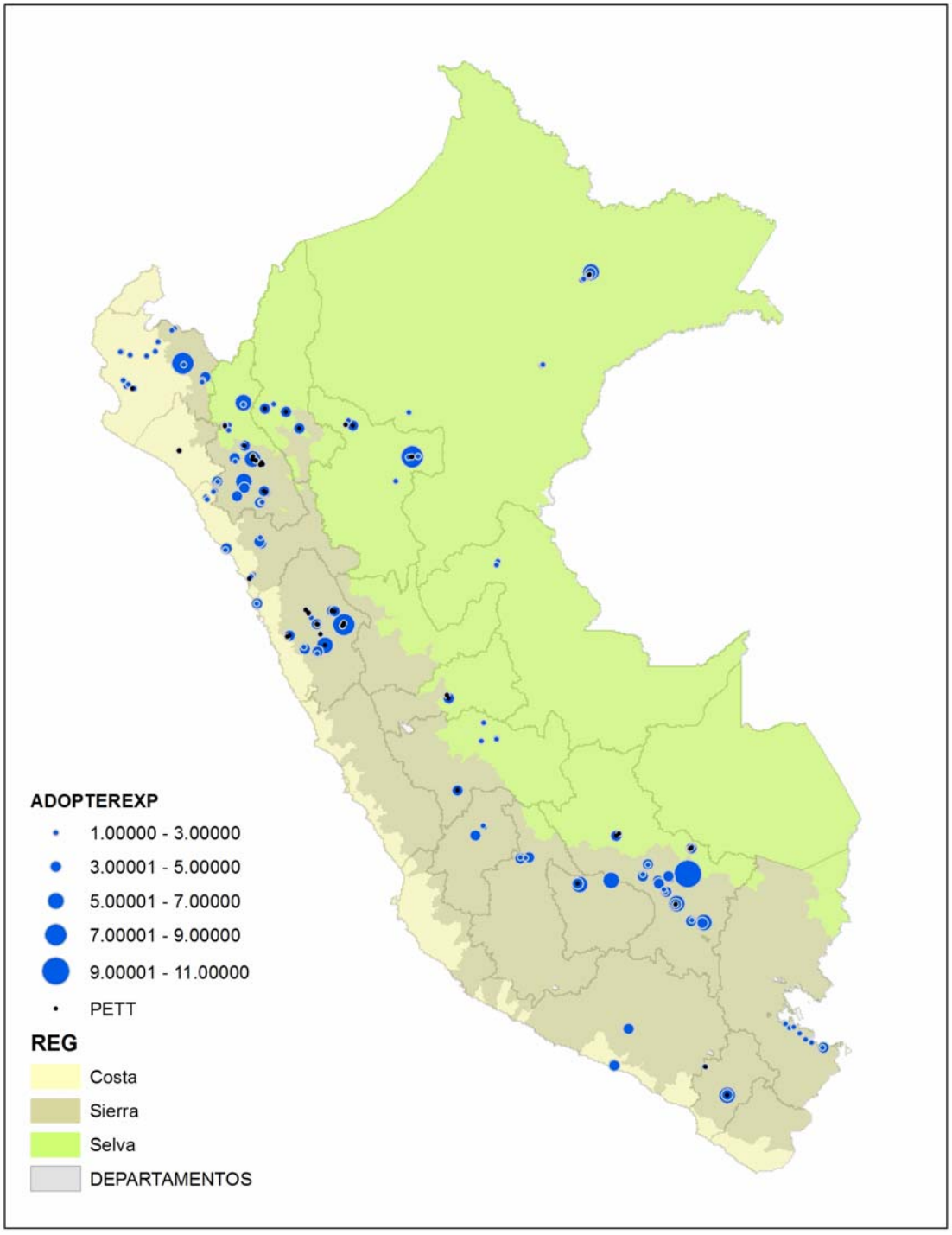
The 2004 expenditure measure was built following the same criteria used to construct the 1994 expenditure variable. However, the "Expenditure Module" in the 2004 survey was shorter than the one in 1994. For this reason, a typical expenditure category in 1994 includes a greater set of items compared to a category in 2004. Although there is no change in the wording between the two surveys, the data in 1994 presents more detailed information.

The "Expenditure Module" in 2004 is divided according to periodicity or recurrence of expenditures:

1. Last 15 days: Includes aggregates for "food and non-alcoholic beverages consumed in the household", "cigarettes and alcoholic beverages", "personal care and cleaning products", and "transport". Results are multiplied by 2 to obtain monthly figures.
2. Last month: Includes monthly bills or expenditures paid for telephone (landline), public telephone, cellular phone, electricity, water and internet. Information is already provided in monthly terms.
3. Last 3 months: Includes aggregates for "clothing and footwear" and "other goods and services" (such as newspapers, magazines, car repair, recreation, etc.). Result is divided by 3 to obtain monthly figures.
4. Last 12 months: Includes aggregates for "educational services" (tuitions, school supplies, registration fees, etc.) and "transfers" (alimony, child support, donations, any big electronic or furniture purchase, etc.). Result is divided by 12 in order to obtain monthly figures.
5. Health expenditures during last 12 months: Includes aggregates for "adults' health expenditures" (medicines, consultations, medical equipment, etc.), and "kids' health expenditures" (medicines, vaccines, consultations, etc.). Result is divided by 12 to obtain monthly figures.

Finally, a monthly hypothetical rent is included in the final estimation. Respondents are asked for a market rent value of their homes in case the dwelling is owned, partially owned, owned by invasion, etc. This value is upper-bounded in case the amount provided exceeds 30% of total expenditure.

Appendix B. Distribution of Sample, Property Titles and Change in Crop Adoption



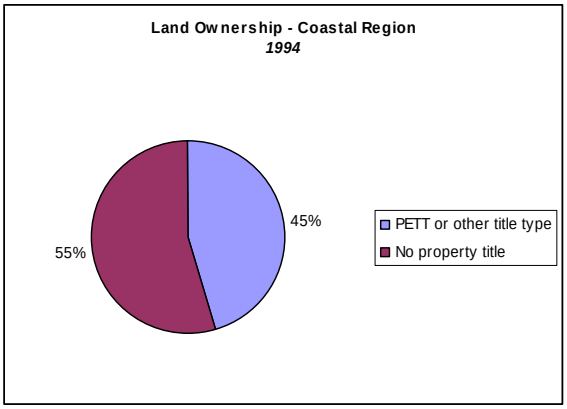
Notes: GIS coordinates and crop adoption data from the 1994 Peruvian Living Standard Measurement Survey (LSMS) and the 2004 Land Titling Special Project Survey (PETT). Authors' calculations.

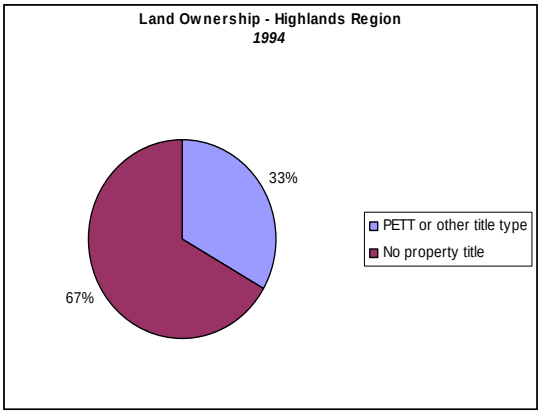
Appendix C. Regional Household Monthly Per Capita Expenditures and Poverty *

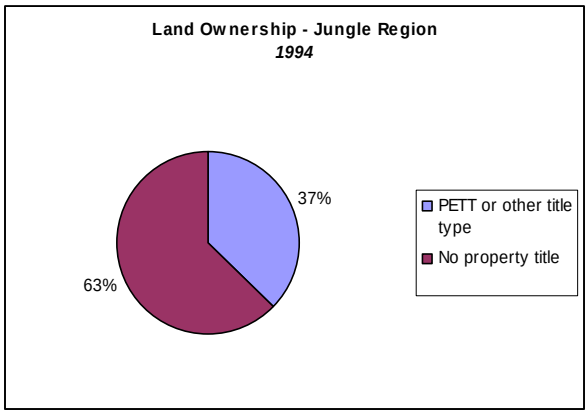
Region	1994	2004
COAST (n = 73)		
Per-Capita Mean HH Expenditures	125.2 S/.	173.7 S/.
Expenditure Range	21.7 – 1000.6 S/.	30.7 – 1170.0 S/.
Standard Deviation	134.3 S/.	195.1 S/.
% HH below poverty line**	56.2 %	45.2 %
Mean poverty gap ***	40.1 S/.	32.1 S/.
HIGHLANDS (n = 314)		
Per-Capita Mean HH Expenditures	73.8 S/.	78.9 S/.
Expenditure Range	10.2 -- 850.3 S/.	8.7 – 476.7 S/.
Standard Deviation	79.3 S/.	67.3 S/.
% HH below poverty line	80.3 %	83.4 %
Mean poverty gap	49.5 S/.	47.6 S/.
JUNGLE (n = 124)		
Per-Capita Mean HH Expenditures	76.9 S/.	96.7 S/.
Expenditure Range	9.9 – 448.8 S/.	12.1 – 343.5 S/.
Standard Deviation	55.1 S/.	67.8 S/.
% HH below poverty line	65.3 %	80.6 %
Mean poverty gap	43.3 S/.	41.1 S/.

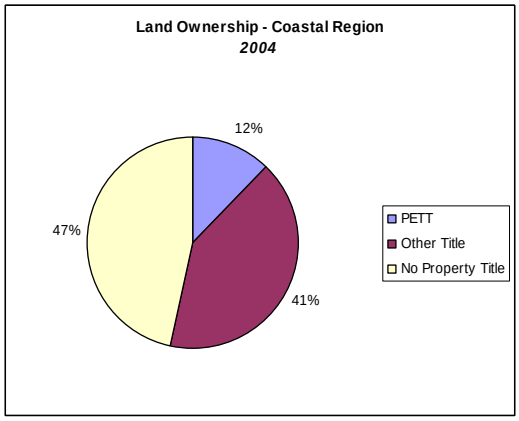
*Poverty line is estimated to be 100 S/. per capita per month, based on the UN poverty line of one dollar per day.
**households in poverty /regional sample size, n
*** S/100 minus mean per capita HH expenditures among households with income below S/100

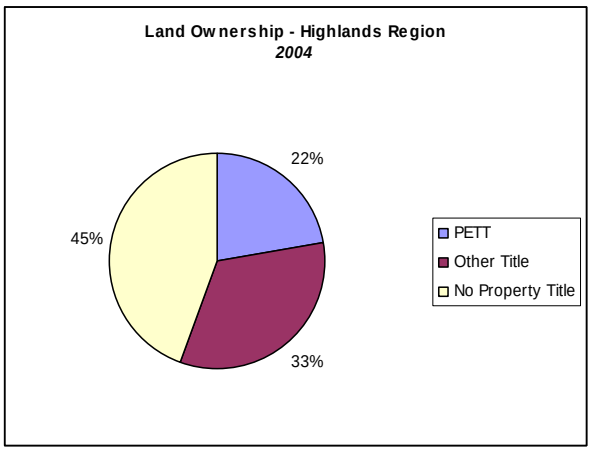
Appendix D: Land Ownership

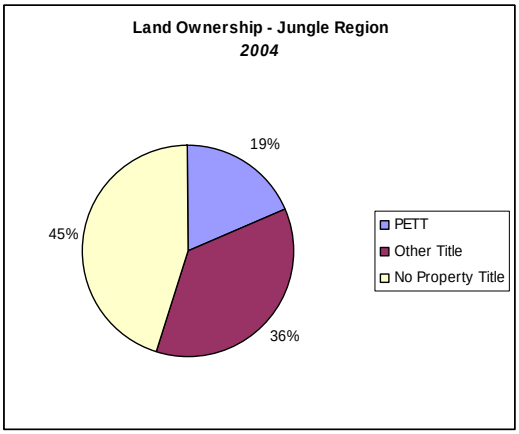












Notes: Land ownership data from the 2004 Land Titling Special Project Survey (PETT). Authors' calculations.