

The Welfare Impacts of Rising Quinoa Prices: Evidence from Peru^{*}

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Abstract

Riding on a wave of Western interest in “superfoods,” quinoa – a grain that has been grown for centuries in the Andes – has gone from largely unknown outside of Latin America to an upper-class staple in the US and Western Europe in less than a decade. Concurrent with this increased demand for quinoa, there has been a sharp rise in the price of quinoa over the last 10 years. We study the impacts of rising quinoa prices on the welfare of households in Peru. Using 10 years of a nationally representative, large-scale household survey, we combine pseudo-panel and difference-in-differences methods to estimate the relationship between quinoa production and household consumption. We find that conditional on baseline values, quinoa production is associated with higher consumption and lower variance of consumption expenditures, indicating that the production of quinoa has both first- and second-order effects on household welfare.

Keywords: Quinoa, Food Prices, Household Welfare, Peru

JEL Classification Codes: O12, Q12

^{*} The authors would like to thank Mercedes Callenes for help with the ENAHO data and Towson University College of Business for Research Funding. All remaining errors are ours.

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1. Introduction

Riding on a wave of interest in gluten-free “superfoods” in the United States and other rich countries, quinoa – an Andean grain that has been grown for centuries in Bolivia, Ecuador, and Peru – has gone from largely unknown outside the Andes to a Whole Foods staple in less than a decade, and US consumers can now find quinoa at 7-Eleven convenience stores. As a consequence of this increasing demand for quinoa, its price has tripled since 2007, and shows no sign of falling. Exports of quinoa to the United States totaled \$80 million in 2013 up from \$5 million in 2008 (AgroVision, 2014).

Yet some consumers have questioned the ethics of this increased quinoa consumption in rich countries, i.e., the influence of this new, international demand for quinoa on Andean quinoa-consuming households. In January 2013, an article on the website of the United Kingdom’s *Guardian* newspaper made the following claim (Blythman, 2013):

[T]here is an unpalatable truth to face for those of us with a bag of quinoa in the larder. The appetite of countries such as ours for this grain has pushed up prices to such an extent that poorer people in Peru and Bolivia, for whom it was once a nourishing staple food, can no longer afford to eat it.

Three days later, an article on the website of Canada’s *Globe and Mail* newspaper made the following counterclaim (Saunders, 2013):

The people of the Altiplano are indeed among the poorest in the Americas. But their economy is almost entirely agrarian. They are sellers – farmers or farm workers seeking the highest price and wage. The quinoa price rise is the greatest thing that has happened to them.

Similarly, numerous US news outlets (e.g., the *NY Times*, the *Washington Post*, and NPR) have covered the influence of the international demand for quinoa on the welfare of households in countries where quinoa has traditionally been produced and consumed. These stories demonstrate an interest in whether rising quinoa prices have had an impact on the welfare of rural households in the Andes. Yet

beyond media anecdotes and limited market-level data, there is little to no evidence on the welfare impacts of rising quinoa prices on the welfare of households in Bolivia, Ecuador, or Peru.

In this paper, we compare trends in household welfare of quinoa-cultivating with non-cultivating regions in Peru from the start of the quinoa price boom of the last decade. A long literature in agricultural and development economics suggests positive welfare impacts for net sellers and negative for net buyers. In a seminal article, Deaton (1989) defined the concept of net benefit ratio, which can be used to determine the impact of an increase in the price of a good on household welfare. Predictably, whether a household's welfare rises or falls in response to an increase in the price of a good depends on whether the household is a net buyer (i.e., it consumes more than it produces) or a net seller (i.e., it produces more than it consumes) of that good: A net buyer's welfare decreases as a result of a price increase, whereas a net seller's welfare increases.¹ But even this requires having data on the prices of the goods one is interested in studying as well as on whether households are net buyers or net sellers of the same goods. Deaton's theoretical result has been confirmed empirically on more than one occasion (cf. Budd, 1993; Barrett and Dorosh, 1996; Lasco et al., 2008). More broadly, there is an important literature in agricultural economics studying the causes and consequences of the market participation behavior of agricultural households, i.e., whether they are net buyers or net sellers of various goods, and what this entails for their welfare (Goetz, 1992; Key et al., 2001; Bellemare and Barrett, 2006; Bellemare et al., 2013).

We compare the value of annual consumption – a proxy for welfare (Deaton, 1997) – of quinoa-producing households with that of other Peruvian households to test whether producer households have seen faster consumption growth as the price of quinoa rose. The analysis uses 10 years (2004-

¹ An autarkic household – that is, a household which neither produces nor consumes of a given good or a household whose consumption exactly equals its production of a given good – is left neither better nor worse off by an increase in the price of that good.

2013) of the National Household Survey (*Encuesta Nacional de Hogares*, hereafter ENAHO), a nationally representative survey of Peruvian households with roughly 227,000 observations. Because the ENAHO does not sample the same households every year, it is impossible to use standard panel techniques (e.g., household fixed effects). Instead we construct a pseudo-panel by comparing annual average household consumption and the annual proportion of households that grow quinoa at three geographic levels (McKenzie, 2004; Antman and McKenzie, 2007), and we use difference-in-differences methods in an effort to identify the potential causal relationship flowing from quinoa production to welfare, which compare household consumption trends between households that produce quinoa to other households over the decade during which quinoa prices sharply rose.

We find that the two groups' consumption grew at similar rates until 2012 and 2013, at which point quinoa revenues rose sharply, as did the consumption of quinoa producers. Moreover, we find that in recent years, quinoa cultivation has been associated with decreases in the variance of consumption expenditures. Our results thus suggest that the rising price of quinoa has had both first- and second-order effects on the welfare of those households by respectively increasing the level and reducing the variance of household consumption on average.

The remainder of this paper is organized as follows. In section 2, we present the data and discuss descriptive statistics. Section 3 presents the empirical framework we develop to study the relationship between quinoa cultivation and welfare, with particular emphasis on our identification strategy. In section 4, we present and discuss our estimation results. Section 5 concludes with some policy recommendations and directions for future research.

2. Data and Descriptive Statistics

For our empirical analysis we use the Peruvian ENAHO, an annual household survey conducted by the Peruvian government's National Institute of Statistics and Information (*Instituto Nacional de Estadística*

e Informática). The ENAHO sample is selected every year so as to be nationally representative, and the data include sampling weights, which we use throughout our analysis. We use the repeated cross section from 2004 to 2013 inclusively, which encompasses 227,400 household-year observations. Over this period, roughly 3.5% of households produced quinoa, resulting in a sample of 8,216 quinoa-producing household-year observations. We discuss how the repeated cross-sectional nature of the data allows us to construct a pseudo-panel in section 3.

Nearly all quinoa producing households use some quinoa for household consumption, but few producers buy quinoa (less than 0.5%). In other words nearly all quinoa producers are either autarkic (i.e., they neither buy nor sell quinoa) or net sellers (i.e., their sales exceed their purchases). The percentage of quinoa growers remained relatively constant around 3.5% from 2004 to 2011, as shown in table 1. For 2012 and 2013, the proportion of producers in the sample fell to 2.8 and 2.6%, respectively. The volume of production has been U-shaped over time, with the highest output levels per farm at the beginning and end of our sample. In the sample over 98% of households that produced quinoa used at least some of it for their own consumption, however the percentage of production used for own consumption has fallen dramatically from around two-thirds in 2004 to about one-third toward in 2013. The percentage of production used as seeds for the next harvest has remained relatively constant at around 6%.

More interestingly for our purposes, the percentage of quinoa-producing households that sold some of their production doubled between 2010 and 2011. The net seller households have seen the real price of quinoa experience a more than threefold increase over the past decade. Real revenue has grown five-fold over the same period, although that increase has not been steady. There are also two jumps in revenue: the first occurring between 2008 and 2009, when revenue more than doubled, and the second one occurring between 2011 and 2012, when revenue increased by 75%.

Our outcome of interest is household consumption.² All monetary values are in real 2004 Soles (3.4 Soles = \$1 USD). In developing economies such as that of Peru, where many households produce food for their own subsistence, it is important to include the value of all consumption, and not just purchases. For all households, purchased goods represented roughly 75% of the value of total consumption (which includes household food production), whereas for quinoa-producing households that number was closer to 60%.³ In other words, for quinoa-producing households, 40% of total household consumption is from non-purchased goods, including household food production, i.e., quinoa-producing households tend to be less integrated in markets. A comparison of mean household consumption between households that produce quinoa and those that do not is shown in table 2 and the distribution of consumption in figure 1. The most notable difference is that quinoa-producing households consumed roughly 40% of what non-quinoa producing households did at the beginning of the sample period. However, households that consumed but did not produce quinoa, had total household consumption 30% higher than non-consuming households. In other words net buyers of quinoa were substantially better off than the rest of the population.

Household consumption of quinoa producers has grown faster than that of non-producers: the consumption of quinoa producers grew by 71% versus a 29% growth for non-producers. This difference in household consumption growth rates between quinoa producers and non-producers has been especially pronounced from 2010 to 2013, a period during which the household consumption of those households that did not grow quinoa only saw minimal growth.

² We remove quinoa that is produced and consumed by the household from this measure to avoid quinoa prices direct effect on consumption.

³ Annual total consumption is computed by INEI as the sum of (i) purchases of food, clothing, housing, fuel, electricity, furniture, housewares, health, transportation, communications, and entertainment. Individuals reported information in past month or past three months depending on expenditure group; (ii) expenditures on appliances, transport and others, (iii) expenditures on food consumed outside the household; (iv) expenditures on food to be consumed inside and outside the household, and (v) the reported value of own consumption, gifts, social programs, and payments in kind in the same expenditure groups.

Over the sample period, about 28% of households reported consuming quinoa in the previous 15-day period, as shown in table 3. Back-of-the-envelope calculations based on table 3 suggest that the total effect of price rises on consumer was small. At the beginning of the sample period households purchased roughly 22.6 kg per year (or 0.87 kg every two weeks) the real cost of the basket rose roughly 100 soles over the sample frame, or only 0.5% of 2013 consumption (about 20,000 soles) for non-producing households.

Similar to the production data, the proportion of quinoa consumers over time has been U-shaped, with the highest percentages of quinoa consumption in 2005 and 2013. Over the sample period, quinoa purchases have fallen in relation to the rising price of quinoa. Real prices have increased for buyers almost threefold from 2004 to 2013. This rate is less than the growth in the sales price and the ratio of farm-gate to consumer price has increased from 43% to 60% from 2004 to 2013, which suggests that quinoa producers have captured some of the gains from rising quinoa prices.

3. Empirical Framework

The ENAHO is a repeated cross-sectional household survey, which means that the usual panel methods used in agricultural and development economics (e.g., household fixed effects) are not available to us. A standard strategy to overcome this issue is to create a pseudo-panel—a method developed by Deaton (1985) to overcome the type of data limitations one faces with repeated cross-sections. Pseudo-panels have also been effective in estimating economic mobility (McKenzie, 2004; Cuesta et al. 2013; Fields et al. 2014) and poverty in developing countries (Antman and McKenzie 2007; Christiaensen and Subbarao, 2005; Cruces et al. 2014).

With pseudo-panel methods, the outcome variable (here, household consumption) and the treatment variable (here, whether a household grows quinoa) are averaged across identifiable cohorts such as birth year, gender, or geographic region, and estimation occurs using the level of that cohort

(instead of the level of the units within cohort; here, those units within cohorts would be households) as the unit of analysis. For our purposes, we average consumption expenditures and whether a household grows quinoa over geographic units, using geographic units as our units of observation instead of households. Because households are chosen at random within each geographic region, the average of observed households should track the regional average over time.

For each geographic region g we estimate the regional consumption mean \bar{c}_{gt} as the average of consumption c_{ght} over the set H_{gt} of all observed households in geographic region g for each year t as shown in equation 1:

$$\bar{c}_{gt} = \frac{1}{H_{gt}} \sum_{i=1}^{H_{gt}} (c_{hgt}) \quad (1)$$

The use of a pseudo-panel has two clear benefits. First, because it includes over 20,000 households per year, the ENAHO is rich at both national and regional levels. Second, as the number of household averaged over grows when computing the geographical unit-level mean, the effect of potential error in the measurement of a particular household's consumption is reduced given that that error becomes spread out over more households. If they were available to us, individual household fixed effects would allow correcting for time-invariant measurement error; however, time-variant measurement errors would still be present, and the use of fixed effects tends to compound measurement error problems (Wooldridge, 2002). This would especially be an issue regarding food consumption, where yearly data is extrapolated from two weeks' worth of food consumption. Our use of pseudo-panel methods reduces this problem. Finally, as a consistency check we obtain similar results for our main model with regional and year fixed effects that uses households as the unit of observation (these results are available upon request).

We use three distinct geographical levels which we average over in order to treat those particular geographical units as units of observation. The largest is a department, of which Peru has 25. These

departments are subdivided into 195 provinces, and there are on average seven provinces per department, ranging from one to eight provinces (the Lima department has only one province, i.e., the province of Lima). Provinces are further subdivided into 1,838 total districts. The ENAHO has data on all departments, all but one of the provinces, and 1,401 of the 1,838 districts. Given the random selection of communities and the nationally representative nature of the ENAHO, those missing districts should not lessen the external validity of our results. Our results, however, would be representative of those 1,401 out of 1,838 districts, and of each of the provinces and departments.

As with all choices, using the largest (department) or smallest (district) geographic unit involve a tradeoff. As the geographic unit gets larger, there are more observations that go into the average of each unit, which minimizes measurement error but also presents the least amount of statistical power in this context. Conversely, as the geographic unit gets smaller, there are more units of observations in the regression analysis, which improves statistical power, but which also amplifies measurement error problems. In order to examine this tradeoff – and to ensure that our results are robust across geographical units – we estimate all of our specifications for each of the three levels of geographic analysis and find our core results to be robust to the choice of geographical unit.

Our independent variable of interest is quinoa production. We allow quinoa production to vary over time as households choose which crops to grow each year. As a robustness check we use baseline quinoa production in 2004 for each geographical unit as a time invariant measure of production, similarly to the pseudo panel method above, and use that measure across all years, much like one would define whether an observation has been treated in a difference-in-differences context. In our case, however, instead of looking at a binary treatment, treatment intensity is in the $[0,1]$ interval, depending on the percentage of households that farm quinoa.

3.1. Estimation Strategy

Our outcome of interest is the natural logarithm of consumption, $\ln c$, for household h in region g in year t , or $\ln c_{hgt}$. We look at the logarithm of consumption given that consumption only takes on non-negative values, and the logarithmic transformation yields a dependent variable that is approximately normally distributed (see figure 1).

Recall that the ENAHO is a repeated cross section, so household fixed effects are not available here. Instead we rely on the pseudo-panel methods described above, and we perform our estimations on the (weighted) mean of all households in a geographic unit g (i.e., district, province, or department) in year t . The explanatory variables shown in equation 2 and explained below include quinoa production, time controls, their interaction, and geographic unit fixed effects. Our equation of interest is thus

$$\ln c_{gt} = \alpha_0 + \beta_0 D_{gt} + \sum_{t=2005}^{2013} \alpha_t T_t + \sum_{t=2005}^{2013} \beta_t D_{gt} \times T_t + \sum_{g=2}^{g=G} \gamma_g X_g + e_{gt}, \quad (2)$$

where, in a slight abuse of notation, $\ln c_{gt}$ is the mean of $\ln c_{hgt}$ in geographical unit g , D_{gt} is the proportion of households who produce quinoa in geographical unit g , and X_g is a vector of geographical unit fixed effects.

Our variable of interest – our treatment variable, as it were – is the proportion of quinoa producers in geographical unit g in year t , which we denote as D_{gt} . Like our dependent variable, this is a weighted mean for the geographical unit of interest, where $D_{hgt} = 1$ if household h produces quinoa, so that $D_{gt} \in [0,1]$, with $D_{gt} = 0$ indicating that no household in geographical unit g produce quinoa and $D_{gt} = 1$ indicating that all households in geographical unit g produce quinoa. We also include a series of dummy variables for each year, where $T_t = 1$ if $T = t$. Our data set covers the period 2004-2013, so the dummy for the year 2004 is omitted in order to allow identifying the intercept. In order to obtain difference-in-differences estimates, these two variables are interacted ($D_{gt} \times T_t$) to estimate the

difference in trends in household consumption over time between quinoa producers and non-producers. Finally, we cluster the standard errors at the level of the relevant geographical unit (i.e., district, province, or department).

Consumption will vary by time-invariant characteristics. To control for the time-invariant region characteristics we use geographical unit fixed effects. Recall that we have use three geographical unit levels: department, province, and district, respectively with 25, 194, and 1401 units in the sample. Over the ten-year period we have all (n=250) department-years, 99% (n=1,919) of all province-years, and about 70% of all possible district-year observations (n=9,613). As a first check on the consistency of our results, we report estimates at all three levels.

We perform four robustness checks in addition to the specification shown in equation 2, or model 1. In model 2 we drop $\beta_0 D_{gt}$, as the regional fixed effects control for any time invariant influences on quinoa production such as geography. In model 3 we limit the sample only to only quinoa-producing regions in order to test the effects of quinoa intensity on the results. In model 4 we replace the measure of D_{gt} with baseline (i.e., 2004) quinoa production, D_{g04} , to create a time invariant measure of quinoa production. We drop $\beta_0 D_{gt}$ and replace the time variant quinoa measure with a time invariant measure for the interaction of quinoa with year fixed effects (*i. e.* $\sum_{t=2005}^{2013} \beta_t D_{04}$) The final analysis includes quinoa consumption in total household consumption. The robustness checks show the main results generally hold.

Lastly, in addition to looking at whether quinoa production is associated with increases in household consumption, we also look at whether quinoa production is associated with decreases in the variance of household consumption within each geographical unit. Taking consumption expenditures as a proxy for income, any reduction in the variance of household consumption means that quinoa production is

associated with reductions in the risk and uncertainty faced by the households in our sample, which suggests that the households in our sample might be producing quinoa as a means of coping with risk.

3.2. Identification Strategy

The error term e_{gt} in equation 2 represents the sum of our ignorance. As such, it contains all that is unobserved in equation 2 and reflects things that vary across observations (i.e., department-year, province-year, and district-year, depending on the geographical unit we look at). If those unobservable factors are correlated with the variables on the RHS of equation 2, our estimate of the impact of quinoa production on household consumption is biased because of statistical endogeneity issues.

In order to discuss how we identify the relationship between quinoa production and household welfare, we discuss in turn the three potential sources of statistical endogeneity, viz. (i) reverse causality or simultaneity, (ii) unobserved heterogeneity or omitted variables, and (iii) measurement error.

Reverse causality or simultaneity issues might arise in this context if the prospect of a higher welfare (as proxied by household consumption) induces some households who did not previously grow quinoa to do so, or if it induces quinoa producers to grow more quinoa within a given year. We perform a consistency check which uses a baseline time-invariant measure of quinoa production eliminating the potential for time-variant reverse causality. The results are consistent across the variant and invariant quinoa measures.

Unobserved heterogeneity or omitted variables issues might arise in this context if some unobservable factor is correlated with the variables on the right-hand side of equation 2. For example, it could be that households whose primary decision maker is more risk averse are more likely to grow quinoa, or that they grow more of it. In applied microeconomic investigations such as this one, unobserved heterogeneity is generally the most important problem plaguing the identification of causal relationships. We argue that this is greatly lessened by our use of pseudo-panel techniques. Indeed,

recall that each round of our data consists of randomly selected households. Because the households selected at random in each geographic unit in each year are representative of that geographic unit, our use of geographic unit fixed effects should control for everything – observable *as well as unobservable* – which does not vary over time within that geographic unit. Of course, this does not control for those factors that are time-variant within a geographic unit, which are unobserved and correlated with the variables on the right-hand side of equation 2. But our use of year dummies and year dummies interacted with the treatment should largely obviate that issue.

Finally, measurement error issues can bias our estimate of the impact of quinoa production on household welfare in two ways. With measurement error at random, our estimate of the impact of quinoa production on household welfare would be biased toward zero. With systematic measurement error, our estimate would be biased in a systematic direction, which would depend on the direction of measurement error. Time invariant measurement error that is systematic at regional level would be controlled for by the regional fixed effects. Here, the measurement error we should be most preoccupied with is measurement error at random and time variant in our variable of interest, i.e., average quinoa cultivation, and we have discussed above how the extent of measurement error is dependent upon the geographic unit we use as an observation. Moreover, there is no reason to believe that there is any systematic measurement error in this context, as there is really no incentive for respondents to systematically over- or under-report whether they grow quinoa or not. Furthermore, by using the baseline quinoa production as a consistency check we can control for time variant errors reports on quinoa production.

In other words, for an unobserved factor to bias the estimate of the impact of the extent of quinoa production within a geographic unit on household welfare, it has to be the case that that unobserved factor is neither controlled for by the geographical unit fixed effects (X_g), the year fixed effects (T_t), the

extent of quinoa production in a given geographical unit in a given year (D_{gt}), or the extent of quinoa production-year interaction terms ($D_{gt} \times T_t$), and that that unobserved factor is correlated with the variables on the right-hand side of equation 2.

4. Estimation Results and Discussion

The core result from the empirical analysis shows that higher levels of quinoa production were associated with faster growth in regional means of household consumption, but not until 2012 and 2013, i.e., the last two years of the study period. This result is based on the interaction terms between the between year fixed effects and quinoa production. In other words, our result implies that the value of consumption of quinoa producing households grew at a rate similar to other households in Peru from 2005-2011, but that it grew significantly faster in 2012 and 2013.

The results from the core model shown in table 4 are robust across at all three geographic units of analysis (district, province, and department) for the 2013 results, but the 2012 point estimates are statistically significant at 10% level at the district and provincial but not the departmental level. The interpretation of the district level coefficient is that compared to baseline consumption, a district with 100% quinoa farmers would have seen 46% more growth in consumption than a district with no quinoa producers over the timeframe of the sample.⁴ This result is consistent with the household data descriptive statistics showing consumption at the household level increased 71% for quinoa growing households versus a 29% for non-quinoa growers over the 10 years of the sample. On the one hand, we find that the size of the point estimate on the 2013 interaction with quinoa production increases as the geographic unit of observation increases (i.e., from district to province, and from province to

⁴ We calculate marginal effects for the interaction as specified in Halvorsen and Palmquist (1981), where the coefficient β_t has to be transformed by computing $\frac{\partial c}{\partial Q} = 100(e^{\beta_t} - 1)$ to recover the marginal effect of quinoa production on household consumption.

department), which is consistent on there being less measurement error, since measurement error tends to bias our estimate toward zero. On the other hand, the precision of that estimate declines as the geographic size increases, which is consistent with there being less statistical power as the number of observations falls.

In some sense it may be surprising that quinoa producers' consumption finally grew faster than average Peruvian households only in the last two years despite rising quinoa prices over the whole period. A closer look at the quinoa revenue data in table 2 shows stagnant revenue around 200 soles from quinoa sales for the period 2005-2008. The period 2009-2011 saw average revenues of around 400 soles. In 2012 revenue jumped to 833 soles, and it jumped to 912 soles in 2013 due to increased production per household. The change in quinoa revenue of 739 soles between 2004 and 2013 would be roughly be 11% of baseline household consumption. In other words the direct effect of quinoa revenue represents roughly one quarter of the total change of household consumption during the time period.

Finally, we test for effects of quinoa production on the within-region variance of consumption. Specifically, we examine the mean sum of squared differences between household and mean household consumption at the geographic unit level. In general quinoa production is associated with decreased variance over time. At the district level, in 2007 and 2012, the variance of household consumption was 15% and 16% lower for a community where everyone produced quinoa compared to baseline non-quinoa growing community. The 2012 results are robust across region size, although the 2007 results are not.

4.1. Robustness Checks

In order to gauge the robustness of our findings. As consistency checks, we estimate three additional models, shown in table 6. The first model removes the quinoa production term, the second uses only regions where quinoa is produced, and the third incorporates baseline quinoa production. At the district level the main interaction (i.e., *Year 2013*Quinoa*) remains relatively stable, ranging from

0.30 to 0.43, well within one standard error of the original estimate. As the size of the region increases from district to provinces the estimates are robust in the first and third consistency checks. At the provincial level, the coefficient on *Year 2013*Quinoa* is no longer statistically significant. This may be due to a drop in statistical power, given that our sample is cut almost in half as the second model only includes 115 of 195 provinces that had any quinoa growing households.

We estimated additional specifications in which we include quinoa consumption in our core consumption aggregate. The results in table 7 reproduce our core specifications, viz. those controlling for the amount of quinoa produced in 2004 (columns 1, 3, 4, 6, 7, and 9) and those that do not (columns 2, 5, and 8), controlling for district fixed effects (columns 1 to 3), province fixed effects (columns 4 to 6), and province fixed effects (columns 7 to 9), including either all geographical units at a given level (columns) or just those in which quinoa is produced (554 of 1,401 districts in column 3; 115 out of 194 provinces in column 6; and 18 of 25 departments in column 9). Those nine permutations of our difference-in-differences estimate largely support our core results: the consumption of quinoa producer households grew faster than that of average Peruvian households in 2013 – the year in our study period when quinoa prices were highest as a result of a spike in the international demand of quinoa. The fact that our results tend to be weaker when focusing only on geographical units where quinoa is produced (i.e., columns 6 and 9) appears to be the result of a drop in statistical power (as indicated by the loss of statistical significance of the difference-in-differences coefficients for 2013) as well as of the identification provided by those households in regions where no quinoa is produced (as indicated by the drop in magnitude of the difference-in-differences coefficients for 2013).

5. Concluding Remarks

This paper looked at whether the sharp rise in the price of quinoa over the last 10 years has had any impact on the welfare of quinoa-producing Peruvian households. We find results consistent with the

rising price of quinoa positively affecting the level of household consumption and reducing the variance of household consumption—in other words, the production of quinoa has beneficial first- and second-order effects on household welfare. Particularly, in 2012 and 2013, higher levels of quinoa production were associated with faster growth in the means of household consumption across districts, provinces and departments. The rising price of quinoa also appears to have second order effects as regions with more quinoa had reduced variance in household consumption.

Quinoa growers are particularly poor, with an average consumption still only about half of non-quinoa growing households. For net buyers we show using descriptive statistics that the direct negative effect of rising prices has been relatively small. Furthermore, consistent with the luxury-good nature of quinoa nowadays, net buyers are generally better off than average Peruvian households, so they are likely able to absorb rising quinoa prices with little to no negative effect on their welfare.

The analysis in the paper raises two questions for future research. First, what are the indirect effects of rising quinoa prices? This could include agricultural wages, technology adoption, or investment in productive capital. Second, though show quinoa producers tend to be poorer, our analysis does not show whether there are distributional effects of rising quinoa prices as well as changes in poverty rates.

Quinoa prices are unlikely to keep on growing forever, and at some point, demand might stabilize or supply will increase to meet a rising demand. Examining demand and supply responses of households to price changes would give us a sense of these factors at a local level. At this point rising quinoa prices have benefited growers in the short term, but whether there will be any long-term effects remains to be seen. If the gains from rising quinoa prices are to improve the permanent income of quinoa producers, there would likely need to be associated increased investment in human or household capital. By better understanding the long-term market response and investment strategies, future research can provide a more comprehensive analysis of household welfare dynamics. But our core empirical finding, which

suggests a faster growth in consumption for quinoa producers, should assuage rich-country consumers' concerns about whether their growing demand for quinoa is having a negative influence on Andean households.

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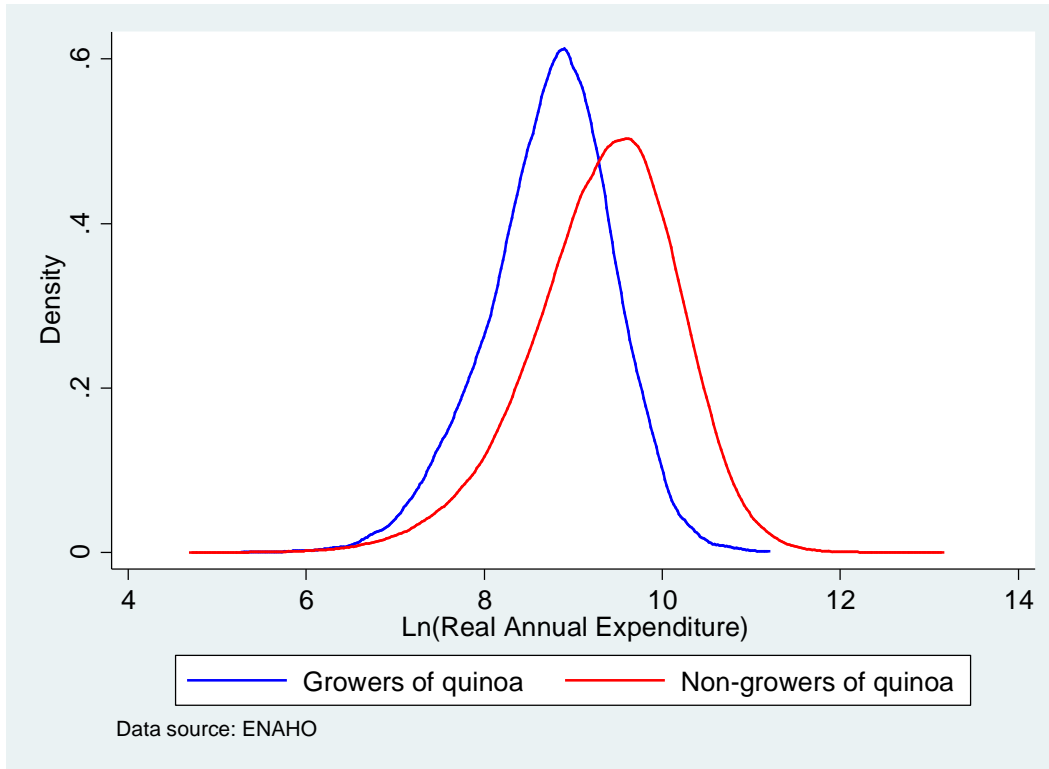


Figure 1. Kernel Density Estimates of Annual Household Consumption for Quinoa Producers and Non-Producers.

Table 1. Household Production of Quinoa.

	Proportion of producers (%)	Proportion of producers who purchase (%)	Proportion of producers who sell (%)	Production in kg, past 12 months	Production for self-consumption in kg, past 12 months	Seeds production in kg, past 12 months	Sale price per kg in real 2004 Soles	Revenue in real 2004 Soles
2004	3.69	0.29	8.12	69.0	50.4	4.85	1.34	173.4
2005	3.92	0.25	10.8	63.2	39.5	4.70	1.61	208.5
2006	3.90	0.41	9.47	70.5	46.7	5.01	1.68	202.5
2007	3.69	0.31	8.27	56.4	30.6	4.17	1.55	105.1
2008	3.06	0.25	6.57	39.6	22.0	2.40	2.23	200.1
2009	3.38	0.34	8.92	49.1	23.9	3.23	3.95	429.4
2010	3.56	0.18	8.16	51.8	26.9	3.22	3.64	312.9
2011	3.38	0.30	14.8	70.6	28.3	3.84	3.83	478.5
2012	2.81	0.16	16.3	86.5	28.9	4.14	4.44	833.3
2013	2.63	0.19	17.4	75.9	25.6	4.23	6.17	912.5

Source: ENAHO. Sampling weights used.

Table 2. Average Annual Household Consumption by Treatment Status.

	<u>Non-producing Households</u>			<u>Producing Households</u>		
	All	No Quinoa Consumers	Quinoa Consumers	All	No Quinoa Consumers	Quinoa Consumers
2004	15594.7	14474.8	19029.7	6281.5	6281.5	5505.6
2005	15397.2	14221.3	19225.2	5995.5	5995.5	5832.6
2006	16774.3	15859.8	21221.6	6442.3	6442.3	5524.5
2007	17889.5	17144.6	23440.3	7115.6	7115.6	6840.8
2008	18126.5	18732.7	24984.6	7720.2	7720.2	7023.7
2009	18724.9	19786.3	27411.9	7920.7	7920.7	7234.8
2010	19161.8	20643.0	27749.8	8481.1	8481.1	7726.6
2011	19524.0	21656.1	28879.5	9671.6	9671.6	8603.9
2012	19955.7	22918.0	30326.1	9440.4	9440.4	6524.5
2013	20097.7	23241.3	32091.5	10716.3	10716.3	12063.7

Source: ENAHO. Sampling weights used.

Table 3. Annual Household Consumption.

	Proportion of households who consume quinoa (%)	kg purchased of whole quinoa, past 15 days ⁵	Purchase price per kg of whole quinoa in real 2004 soles	kg purchased of ground quinoa, past 15 days	Purchase price per kg of ground quinoa in real 2004 soles	Budget share of annual total consumption of quinoa (%)
2004	26.8	0.87	3.15	0.57	3.51	0.096
2005	30.7	0.79	3.28	0.60	3.68	0.12
2006	30.6	0.83	3.14	0.61	3.53	0.11
2007	29.6	0.82	3.25	0.61	3.70	0.11
2008	25.7	0.74	4.36	0.61	4.46	0.53
2009	24.6	0.67	6.25	0.55	5.48	0.56
2010	25.8	0.72	6.44	0.53	5.89	0.54
2011	27.9	0.74	6.36	0.56	6.21	0.56
2012	29.4	0.70	6.31	0.55	6.01	0.57
2013	30.8	0.68	7.83	0.53	7.51	0.63

Source: ENAHO. Sampling weights used.

⁵ This is the average purchase amount for households who purchased quinoa (i.e. it does not include zeros for those who did not purchase).

Table 4. OLS Estimation Results for Household Consumption

VARIABLES	District	Province	Department
Quinoa	0.066 (0.079)	-0.184 (0.161)	-0.705 (0.858)
Year 2005 Dummy	-0.021* (0.011)	-0.023 (0.016)	-0.016 (0.016)
Year 2006 Dummy	0.028** (0.012)	0.020 (0.017)	0.028* (0.016)
Year 2007 Dummy	0.094*** (0.016)	0.097*** (0.026)	0.118*** (0.019)
Year 2008 Dummy	0.154*** (0.016)	0.189*** (0.025)	0.184*** (0.023)
Year 2009 Dummy	0.174*** (0.017)	0.185*** (0.028)	0.204*** (0.024)
Year 2010 Dummy	0.254*** (0.016)	0.262*** (0.026)	0.272*** (0.025)
Year 2011 Dummy	0.308*** (0.016)	0.337*** (0.025)	0.314*** (0.030)
Year 2012 Dummy	0.316*** (0.016)	0.328*** (0.026)	0.331*** (0.034)
Year 2013 Dummy	0.353*** (0.015)	0.349*** (0.025)	0.318*** (0.033)
Year 2005*Quinoa	-0.155* (0.084)	-0.093 (0.127)	-0.091 (0.141)
Year 2006*Quinoa	-0.004 (0.085)	0.092 (0.106)	0.191 (0.223)
Year 2007*Quinoa	0.005 (0.093)	0.098 (0.163)	0.207 (0.308)
Year 2008*Quinoa	0.060 (0.098)	0.033 (0.195)	0.107 (0.413)
Year 2009*Quinoa	0.079 (0.084)	0.129 (0.161)	0.228 (0.378)
Year 2010*Quinoa	0.061 (0.090)	0.082 (0.157)	0.369 (0.233)
Year 2011*Quinoa	0.022 (0.090)	0.029 (0.144)	0.278 (0.292)
Year 2012*Quinoa	0.161* (0.085)	0.257* (0.146)	0.474 (0.336)
Year 2013*Quinoa	0.377*** (0.092)	0.562*** (0.164)	1.050** (0.502)
Intercept	8.787*** (0.012)	8.830*** (0.020)	9.129*** (0.043)
N	9,613	1,919	250
R ²	0.217	0.426	0.778
Number of district	1,401		
Number of provinces		194	
Number of departments			25

Robust standard errors in parentheses clustered at regional level

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

Table 5. OLS Estimation Results for the Variance of Household Consumption

Variables	District	Province	Department
Dependent Variable: Variance of Consumption Expenditures			
Quinoa	-0.012 (0.068)	0.032 (0.122)	-0.190 (0.420)
Year 2005 Dummy	0.009 (0.009)	0.003 (0.014)	-0.005 (0.013)
Year 2006 Dummy	0.016* (0.010)	0.013 (0.015)	0.009 (0.019)
Year 2007 Dummy	0.026** (0.011)	0.057*** (0.018)	0.028 (0.020)
Year 2008 Dummy	0.044*** (0.011)	0.054*** (0.016)	0.017 (0.019)
Year 2009 Dummy	0.039*** (0.011)	0.050*** (0.016)	0.012 (0.023)
Year 2010 Dummy	0.031*** (0.011)	0.032** (0.016)	-0.009 (0.021)
Year 2011 Dummy	0.045*** (0.011)	0.046*** (0.016)	-0.033 (0.020)
Year 2012 Dummy	0.039*** (0.010)	0.041** (0.016)	-0.029 (0.024)
Year 2013 Dummy	0.030*** (0.010)	0.019 (0.016)	-0.043* (0.021)
Year 2005*Quinoa	0.021 (0.075)	0.081 (0.122)	0.314 (0.190)
Year 2006*Quinoa	0.015 (0.065)	0.014 (0.130)	0.138 (0.217)
Year 2007*Quinoa	-0.159** (0.072)	-0.143 (0.115)	-0.198 (0.197)
Year 2008*Quinoa	-0.125 (0.080)	-0.151 (0.124)	-0.083 (0.250)
Year 2009*Quinoa	-0.064 (0.084)	-0.061 (0.125)	-0.120 (0.162)
Year 2010*Quinoa	-0.072 (0.082)	0.083 (0.142)	-0.099 (0.156)
Year 2011*Quinoa	-0.106 (0.082)	-0.033 (0.115)	0.032 (0.254)
Year 2012*Quinoa	-0.183** (0.079)	-0.264** (0.121)	-0.363** (0.155)
Year 2013*Quinoa	-0.079 (0.082)	-0.198 (0.121)	-0.356** (0.149)
Intercept	0.368*** (0.008)	0.460*** (0.013)	0.563*** (0.017)
N	9,613	1,919	250
R ²	0.008	0.032	0.239
Number of district	1,401		
Number of provinces		194	
Number of departments			25

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 6. OLS Estimation Results for Household Consumption – Consistency Checks

VARIABLES	No Quinoa			Only Quinoa-Growing Regions			Baseline Quinoa Production		
	District	Province	Department	District	Province	Department	District	Province	Department
Quinoa				0.040 (0.105)	-0.138 (0.176)	-0.615 (0.905)			
Year 2005 Dummy	-0.024** (0.011)	-0.015 (0.017)	-0.009 (0.019)	0.078 (0.048)	0.009 (0.035)	0.003 (0.028)	-0.021* (0.011)	-0.018 (0.016)	-0.014 (0.016)
Year 2006 Dummy	0.025** (0.012)	0.029* (0.017)	0.036* (0.018)	0.016 (0.047)	0.020 (0.038)	0.035 (0.027)	0.032*** (0.012)	0.024 (0.017)	0.033* (0.016)
Year 2007 Dummy	0.090*** (0.016)	0.105*** (0.025)	0.125*** (0.020)	0.062 (0.051)	0.107*** (0.039)	0.140*** (0.028)	0.104*** (0.017)	0.096*** (0.026)	0.118*** (0.019)
Year 2008 Dummy	0.151*** (0.016)	0.197*** (0.024)	0.190*** (0.024)	0.085 (0.054)	0.207*** (0.043)	0.206*** (0.024)	0.162*** (0.017)	0.184*** (0.024)	0.179*** (0.023)
Year 2009 Dummy	0.170*** (0.016)	0.193*** (0.027)	0.209*** (0.023)	0.162*** (0.053)	0.277*** (0.041)	0.242*** (0.037)	0.183*** (0.017)	0.176*** (0.028)	0.202*** (0.024)
Year 2010 Dummy	0.251*** (0.016)	0.269*** (0.025)	0.278*** (0.024)	0.265*** (0.053)	0.333*** (0.041)	0.320*** (0.043)	0.270*** (0.017)	0.256*** (0.027)	0.273*** (0.026)
Year 2011 Dummy	0.305*** (0.016)	0.345*** (0.023)	0.320*** (0.027)	0.295*** (0.052)	0.374*** (0.045)	0.352*** (0.047)	0.308*** (0.017)	0.339*** (0.025)	0.314*** (0.030)
Year 2012 Dummy	0.313*** (0.016)	0.336*** (0.024)	0.338*** (0.032)	0.371*** (0.049)	0.401*** (0.043)	0.364*** (0.056)	0.315*** (0.017)	0.327*** (0.026)	0.331*** (0.034)
Year 2013 Dummy	0.350*** (0.015)	0.357*** (0.024)	0.323*** (0.031)	0.380*** (0.050)	0.429*** (0.040)	0.355*** (0.045)	0.337*** (0.016)	0.352*** (0.025)	0.320*** (0.034)
Year 2005*Quinoa	-0.105 (0.073)	-0.226* (0.127)	-0.294 (0.307)	-0.36*** (0.129)	-0.208 (0.157)	-0.195 (0.193)	-0.142* (0.085)	-0.214* (0.123)	-0.154 (0.133)
Year 2006*Quinoa	0.047 (0.067)	-0.043 (0.107)	-0.031 (0.285)	0.019 (0.124)	0.074 (0.141)	0.143 (0.273)	-0.053 (0.095)	0.030 (0.117)	0.055 (0.229)
Year 2007*Quinoa	0.061 (0.065)	-0.036 (0.112)	-0.005 (0.438)	0.082 (0.129)	0.049 (0.191)	0.085 (0.390)	-0.067 (0.118)	0.080 (0.178)	0.188 (0.349)
Year 2008*Quinoa	0.115 (0.077)	-0.093 (0.176)	0.005 (0.598)	0.213 (0.137)	-0.038 (0.246)	-0.016 (0.474)	0.053 (0.100)	0.120 (0.165)	0.288 (0.366)
Year 2009*Quinoa	0.134**	0.000	0.095	0.111	-0.183	0.011	0.039	0.284*	0.271

	(0.060)	(0.132)	(0.518)	(0.121)	(0.191)	(0.453)	(0.091)	(0.158)	(0.346)
Year 2010*Quinoa	0.117*	-0.048	0.195	0.046	-0.133	0.115	-0.019	0.172	0.344
	(0.065)	(0.128)	(0.402)	(0.127)	(0.188)	(0.329)	(0.117)	(0.166)	(0.255)
Year 2011*Quinoa	0.077	-0.102	0.136	0.063	-0.101	0.066	-0.052	-0.026	0.283
	(0.067)	(0.098)	(0.428)	(0.125)	(0.182)	(0.378)	(0.092)	(0.137)	(0.297)
Year 2012*Quinoa	0.215***	0.133	0.403	0.054	-0.019	0.283	0.099	0.258*	0.503*
	(0.063)	(0.120)	(0.475)	(0.117)	(0.177)	(0.373)	(0.092)	(0.147)	(0.284)
Year 2013*Quinoa	0.430***	0.440***	1.074*	0.303**	0.253	0.811	0.409***	0.472***	0.931***
	(0.070)	(0.135)	(0.603)	(0.128)	(0.194)	(0.488)	(0.097)	(0.158)	(0.301)
Intercept	8.791***	8.818***	9.102***	8.452***	8.612***	8.948***	8.853***	8.817***	9.102***
	(0.011)	(0.016)	(0.018)	(0.041)	(0.033)	(0.075)	(0.010)	(0.016)	(0.017)
N	9,613	1,919	250	2,360	851	145	7,061	1,890	250
R ²	0.217	0.425	0.776	0.238	0.500	0.793	0.234	0.433	0.776
Number of district	1,401			554			880		
Number of provinces		194			115			189	
Number of departments			25			18			25

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

robust standard errors clustered at regional level

Table 7. OLS Estimation Results for Consumption Including Quinoa Consumption

Variables	(1)	(2)	(3)	(4)	(5)
Dependent Variable: Log of Total Consumption Expenditures, Including Quinoa Consumption					
Quinoa Producer	0.079 (0.080)		0.058 (0.105)	-0.176 (0.161)	
Year 2005 Dummy	-0.021* (0.011)	-0.024** (0.011)	0.077 (0.048)	-0.023 (0.016)	-0.015 (0.017)
Year 2006 Dummy	0.028** (0.012)	0.025** (0.012)	0.015 (0.047)	0.021 (0.017)	0.029* (0.017)
Year 2007 Dummy	0.094*** (0.016)	0.090*** (0.016)	0.063 (0.051)	0.097*** (0.026)	0.105*** (0.025)
Year 2008 Dummy	0.155*** (0.016)	0.151*** (0.016)	0.090* (0.054)	0.190*** (0.025)	0.198*** (0.024)
Year 2009 Dummy	0.174*** (0.017)	0.170*** (0.016)	0.168*** (0.053)	0.186*** (0.028)	0.194*** (0.027)
Year 2010 Dummy	0.255*** (0.016)	0.250*** (0.016)	0.269*** (0.053)	0.263*** (0.026)	0.270*** (0.025)
Year 2011 Dummy	0.309*** (0.016)	0.305*** (0.016)	0.301*** (0.052)	0.338*** (0.025)	0.345*** (0.023)
Year 2012 Dummy	0.317*** (0.016)	0.313*** (0.016)	0.378*** (0.050)	0.329*** (0.026)	0.336*** (0.024)
Year 2013 Dummy	0.353*** (0.015)	0.349*** (0.015)	0.382*** (0.050)	0.350*** (0.025)	0.358*** (0.024)
Year 2005*Quinoa	-0.158* (0.084)	-0.098 (0.073)	-0.356*** (0.129)	-0.100 (0.128)	-0.228* (0.127)
Year 2006*Quinoa	-0.009 (0.084)	0.051 (0.067)	0.013 (0.124)	0.088 (0.106)	-0.041 (0.107)
Year 2007*Quinoa	-0.009 (0.093)	0.058 (0.066)	0.065 (0.130)	0.087 (0.162)	-0.041 (0.112)
Year 2008*Quinoa	0.030 (0.098)	0.096 (0.077)	0.175 (0.137)	0.004 (0.194)	-0.117 (0.177)
Year 2009*Quinoa	0.028 (0.084)	0.094 (0.060)	0.047 (0.121)	0.074 (0.160)	-0.049 (0.132)
Year 2010*Quinoa	0.022 (0.090)	0.090 (0.065)	-0.001 (0.127)	0.046 (0.158)	-0.079 (0.130)
Year 2011*Quinoa	-0.019 (0.090)	0.046 (0.067)	0.009 (0.126)	-0.002 (0.141)	-0.127 (0.096)
Year 2012*Quinoa	0.117 (0.086)	0.182*** (0.063)	-0.004 (0.118)	0.220 (0.146)	0.102 (0.121)
Year 2013*Quinoa	0.350*** (0.091)	0.414*** (0.070)	0.271** (0.127)	0.532*** (0.163)	0.415*** (0.135)
Constant	8.785*** (0.012)	8.790*** (0.011)	8.444*** (0.041)	8.828*** (0.020)	8.817*** (0.016)
Observations	9,613	9,613	2,360	1,919	1,919
R-squared	0.215	0.215	0.231	0.424	0.423
Number of districts	1,401	1,401	554	-	-
Number of departments	-	-	-	-	-
Number of provinces	-	-	-	194	194

Robust standard errors in parentheses

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

Table 7. OLS Estimation Results for Consumption Including Quinoa Consumption (cont.)

Variables	(6)	(7)	(8)	(9)
Dependent Variable: Log of Total Consumption Expenditures, Including Quinoa Consumption				
Quinoa Producer	-0.123 (0.175)	-0.672 (0.857)		-0.578 (0.901)
Year 2005 Dummy	0.010 (0.035)	-0.016 (0.016)	-0.009 (0.019)	0.004 (0.028)
Year 2006 Dummy	0.021 (0.038)	0.029* (0.016)	0.036* (0.018)	0.036 (0.027)
Year 2007 Dummy	0.110*** (0.039)	0.118*** (0.019)	0.125*** (0.020)	0.142*** (0.028)
Year 2008 Dummy	0.211*** (0.043)	0.185*** (0.023)	0.190*** (0.024)	0.207*** (0.023)
Year 2009 Dummy	0.282*** (0.041)	0.205*** (0.024)	0.210*** (0.023)	0.245*** (0.037)
Year 2010 Dummy	0.338*** (0.041)	0.273*** (0.025)	0.278*** (0.024)	0.322*** (0.043)
Year 2011 Dummy	0.378*** (0.045)	0.315*** (0.030)	0.321*** (0.027)	0.354*** (0.047)
Year 2012 Dummy	0.405*** (0.043)	0.332*** (0.034)	0.338*** (0.032)	0.365*** (0.056)
Year 2013 Dummy	0.432*** (0.040)	0.318*** (0.033)	0.323*** (0.031)	0.356*** (0.045)
Year 2005*Quinoa	-0.218 (0.159)	-0.100 (0.137)	-0.293 (0.304)	-0.207 (0.189)
Year 2006*Quinoa	0.068 (0.141)	0.182 (0.218)	-0.030 (0.283)	0.132 (0.267)
Year 2007*Quinoa	0.031 (0.189)	0.192 (0.305)	-0.010 (0.435)	0.065 (0.388)
Year 2008*Quinoa	-0.079 (0.243)	0.079 (0.406)	-0.018 (0.586)	-0.048 (0.467)
Year 2009*Quinoa	-0.254 (0.187)	0.164 (0.364)	0.038 (0.503)	-0.062 (0.436)
Year 2010*Quinoa	-0.181 (0.188)	0.326 (0.223)	0.161 (0.392)	0.065 (0.317)
Year 2011*Quinoa	-0.142 (0.177)	0.237 (0.281)	0.102 (0.416)	0.018 (0.366)
Year 2012*Quinoa	-0.066 (0.175)	0.436 (0.328)	0.368 (0.461)	0.238 (0.362)
Year 2013*Quinoa	0.214 (0.191)	1.026* (0.500)	1.048* (0.594)	0.784 (0.486)
Constant	8.607*** (0.033)	9.127*** (0.043)	9.101*** (0.017)	8.944*** (0.075)
Observations	851	250	250	145
R-squared	0.497	0.778	0.776	0.792
Number of districts	-	-	-	-
Number of departments	-	25	25	18
Number of provinces	115	-	-	-

Robust standard errors in parentheses

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