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Foods and fads: The welfare impacts of rising quinoa prices in Peru ☆

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ABSTRACT

Riding on a wave of interest in "superfoods" in rich countries, quinoa went in less than a decade from being largely unknown outside of South America to being an upper-class staple in the United States, the United Kingdom, and elsewhere. As a result, concerned commentators suggested that the rising international demand for quinoa, which tripled prices, might have substantially harmed Peruvian quinoa consumers. We study the impacts of rising quinoa prices on the welfare of Peruvian households. Our analysis suggests these fears are unwarranted. A descriptive analysis shows that quinoa is a small part (<1%) of the average household's budget share for the roughly 30% of households that consume quinoa. Our econometric analysis generally finds that as quinoa prices rose, welfare increased in regions with higher concentrations of quinoa consumers. Specifically, we use 11 years of a large-scale, nationally representative household survey to construct pseudo-panels at three geographic (district, province, and department) levels to look at the relationship between the international price of quinoa and the value of real household consumption, our proxy for household welfare. We find for the two smaller geographic regions (i.e., districts and provinces) higher concentrations of quinoa consumption or production are associated with a small and statistically significant increase in household welfare in response to quinoa price increases; in the largest regions (i.e., departments), higher concentrations of quinoa consumption or production are associated with small declines in welfare of less than 1% of total household consumption. Our findings that the international trade of quinoa has not been harmful to household welfare in Peru thus run counter to some of the myths surrounding quinoa.

1. Introduction

Riding on a wave of interest in so-called superfoods[1] in the United States and other rich countries, quinoa—a relatively high-protein grain grown for millennia in the Andean regions of Bolivia, Colombia, Ecuador, and Peru—went in less than a decade from being a largely unknown commodity outside of South America to being an upper-class staple in those same rich countries.[2] As quinoa imports to the US increased more than tenfold from about 5 million pounds per year in 2004 to almost 65 million pounds per year in 2013 (DePillis, 2013), the price of quinoa tripled (Blythman, 2013).

Some have questioned the consequences of this increase in the international popularity of quinoa, citing concerns about the effects of rising quinoa prices on the welfare of individuals and households in places where quinoa had traditionally been produced and consumed. A January 2013 article in the *Guardian* (Manchester) made the following claim (Blythman, 2013):

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[1] The Oxford English Dictionary defines superfoods as foods "considered especially nutritious or otherwise beneficial to health and well-being" (OED, 2015).

[2] With 50% of Peruvian quinoa going to the United States, the United States is the commodity's largest export market (Andina, 2016). It is followed by Canada (8%), Australia (7%), Germany (6%), the United Kingdom (6%), the Netherlands (4%), France (3%) and Israel (3%).

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> [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.

A few days later, an article in the *Globe and Mail* (Toronto) made the opposite claim (Saunders, 2013):

> The people of the [Andean plateau] 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.

As one might expect from media accounts, neither claim was based in serious empirical analysis.

That net buyers of a commodity are made worse off and net sellers better off, at least in the short run, by an increase in the price of that commodity is well-understood by economists (Deaton, 1989a). But what are the longer-term,[3] general equilibrium effects of that price increase for consumers? And what is the effect of an international, positive price shock on the welfare of producers-cum-consumers of that commodity?.

We study the welfare impacts of rising quinoa prices on those households that have traditionally consumed and produced it. To do so, we use 11 years of the Peruvian Encuesta Nacional de Hogares (ENAHO), a large-scale, nationally representative household survey, to look at whether there is a systematic relationship between (i) the value of household consumption (which we use here as a proxy for household welfare; see Deaton, 1997) and the price of quinoa for those households that report consuming quinoa; and (ii) household welfare and the price of quinoa for those households that report producing quinoa.

Our study period (i.e., 2004–2014) covers years both before and after the price of quinoa rose sharply. Because the ENAHO is a repeated cross-section and is thus not longitudinal, we use pseudo-panel techniques (Antman & McKenzie, 2007a, 2007b; Christiaensen & Subbarao, 2005; Cuesta, Ñopo, & Pizzolitto, 2011; Deaton, 1985; McKenzie, 2004), wherein we average over household-level measures within each geographical unit and then treat those geographical units as our primary units of observation.[4] To study the relationship between the international price of quinoa and household consumption, we rely in turn on geographical unit (i.e., district, region, and department) fixed effects and time trends with (i) year fixed effects and (ii) higher-order geographical unit-time trends.[5]

Our work is most closely related to the literature on the effects of commodity price shocks. This is a sizeable literature wherein scholars look at the effects of commodity price shocks on a host of outcome variables, from child outcomes (Cogneau & Jedwab, 2012) to conflict (Dube & Vargas, 2013) and almost everything in between. Specifically, our work relates to the literature on the effects of commodity price shocks—usually, food price shocks—on welfare. In a seminal contribution, Deaton (1989b) studies the effects of higher rice prices on welfare and inequality in Thailand. He finds that higher prices redistribute income towards households in the middle of the rural income distribution, with marked regional variations. More recently, Ivanic and Martin (2008) study the effects of higher global food prices on poverty in low-income countries. Using household surveys from nine low-income countries, they find that the effects of higher food prices on poverty vary by country, but also by commodity. Wodon and Zaman (2010) review the evidence looking specifically at sub-Saharan Africa, and they find that higher food prices tend to increase the extent of poverty given that net consumers tend to outnumber net producers of food. The study that is perhaps closest in spirit to our work is a study by Zezza et al. (2008), who rely on household surveys in 11 countries to look at how different groups of households are affected differently when food prices increase to look at the distributional impacts of food price changes. One notable difference between our work and most studies in the commodity price shocks literature, however, is that while that literature typically focuses on major food staples (e.g., maize, rice, wheat, etc.), we focus on a nonstaple. Additionally, the production of quinoa is concentrated in a specific region of the world, and little quinoa is produced in the United States or Europe. This makes quinoa like other regionally produced commodities, such as teff in Ethiopia and millet in Central Africa or India. The only other economic study of the effect of rising quinoa prices has been by Stevens (2017), who finds that cultural preference for quinoa in certain areas of Peru has not led to a worsening of nutritional outcomes.

The analysis uses districts, provinces and departments which are Peru's three types of geographic regions ranging in size from smallest to largest. Our results using the smallest geographic units (districts and provinces) suggest that the increased international demand for quinoa and the resulting quinoa price boom may have had beneficial effects for consumers as well as for producers of quinoa in Peru. In districts and provinces we find a positive relationship between the international price of quinoa and household welfare for regions with higher concentrations of quinoa consumption. This result suggests that the sharp increase in the price of quinoa has had positive general equilibrium effects on the welfare of the average household in those geographical unit-year observations.[6] Specifically, we find that for a 25% increase in the price of quinoa—a change that is commensurate to the change in the purchase price of quinoa between 2013 and 2014, when international demand spiked—total household consumption for quinoa consuming households increases on average by about 1.25%. At the departmental level we find negative relationships between the variables when we include individual department trends or only quinoa producing areas. At most these negative effects are estimated at a 1% decrease in total consumption when prices double.

Second, and in line with theoretical expectations (Deaton, 1989a), we find a positive relationship between household welfare and household quinoa production at the district level of analysis. More specifically, the 25% increase in the price of quinoa between 2013 and 2014 would be associated with a 3.5% to 4% increase in consumption of quinoa producing households. At the province and department level the results are not statistically significant.

The remainder of this article is organized as follows. In Section 2, we present the data and some descriptive statistics. Section 3 presents the empirical framework we develop to study the impacts of rising quinoa prices on welfare, with particular emphasis on our identification strategy. In Section 4, we present and discuss our

[3] By "longer-term," we are referring to a time horizon that is longer (i.e., up to one year, given the frequency of our data) than Deaton's (1989a) short-term measure of welfare, and not to the long-term as it is typically understood in economics, i.e., the length of time required for all factors of production to be variable.

[4] Peru is divided in 1838 districts in 195 provinces in 25 departments. As a first check on the robustness of our results, we estimate each set of results three times, respectively treating districts, provinces, and departments as our units of observation. We discuss our estimation strategy in more detail in Section 3. It is worth noting that Peru changed the designation of the largest sub-national units from departments to regions in 2002. However, the INEI still uses the term department in their data description, and we believe the term "department" avoids confusion with the more generic term "region." We thus use the term "department" throughout this article.

[5] At the district level, this means province-time trends. At the province level, this means department-time trends.

[6] We focus on quinoa-consuming districts, households, and departments because those are the geographical units for which quinoa prices are available.

estimation results. Section 5 concludes with some policy recommendations and directions for future research.

2. Data and descriptive statistics

We use data from the ENAHO, an annual household survey conducted by the Peruvian government's Instituto Nacional de Estadística e Informática (INEI). Because of their high quality and nationally representative character, ENAHO data have been used frequently in economics. Among others, Dell (2010) has used the ENAHO to study the long-term consequences of an extractive institution operating during colonial times in Peru, Aragon and Juan (2013) have used the ENAHO to study the effects of a gold mine on local incomes, and Galdo (2013) has used the ENAHO to study the long-run labor-market impacts of civil war.

The ENAHO sample is selected every year to be nationally representative. The data include household-level sampling weights, which we use throughout our analysis. We use repeated cross sections from 2004 to 2014 inclusively, which encompass 277,759 household-year observations. We discuss in Section 3 how the repeated cross-sectional nature of the data allows constructing a pseudo-panel. Additionally, a subset of the repeated cross-section was surveyed multiple times to create a household panel; we use this household panel of 74,729 household-year observations to conduct a robustness check, which yields results consistent with our pseudo-panel results.

Our outcome of interest is the total value of household consumption, which we use here as a proxy for household welfare.[7,8] 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 (reported in past month or past three months depending on the expenditure group);[9] (ii) expenditures on appliances, transport and others; (iii) expenditures on food consumed outside the household; (iv) expenditures on food to be consumed inside the household; and (v) the reported value of own consumption, gifts, social programs, and payments in kind in the same expenditure groups. As we discuss further, food consumption is reported via a two-week recall in a specific module of the ENAHO.[10] In developing countries such as Peru, where many rural households produce food for their own subsistence, it is important to include the value of all food consumption, and not just food purchases, to paint a more accurate portrait of welfare.

The ENAHO includes a battery of questions on agricultural production activities over the previous 12 months. Households report the quantity produced for about 200 commodities as well as the proportion of such production used for their own consumption, selling, bartering, seeding, and by-products. There is also information on the selling unit price and the value of sales.

We break our sample up into two non-mutually exclusive categories. "Quinoa producers" refers to households that report producing quinoa over the previous year, whether those households consume quinoa or not; "quinoa consumers" refers to households that report consuming quinoa over the last two weeks, whether those households produce quinoa or not. Although it is common in literature to split households between net buyers and net sellers of a commodity (see, for example, Bellemare, Barrett, & Just, 2013), the different recall periods for production (i.e., past year) and consumption data (i.e., past two weeks) make this difficult in this article. However, fewer than 2% of producers reported purchasing quinoa in the last two weeks, and fewer than 1% of quinoa buyers reported producing quinoa in the past year.

For all households, purchased goods represented roughly 75% of the value of total consumption, which also includes household food production. For quinoa-producing households, that number was closer to 60%. In other words, approximately 40% of the total household consumption of quinoa-producing households is from non-purchased goods, including household food production. Quinoa-producing households thus appear less integrated in markets than non-producing households.

A comparison of mean household consumption among households that produce quinoa (about 4% over the sample period) and those that consumed quinoa but did not produce it (about 20% over the sample period) is shown in Table 1. The most notable difference in Table 1 is that quinoa-producing households (fifth column of Table 1) consumed roughly 40% of what quinoa-consuming households did at the beginning of the sample period.[11] Households that consumed but did not produce quinoa (seventh column of Table 1), however, had total household consumption about 30% higher than that of households that neither consumed quinoa nor produced it (third column of Table 1). In other words, pure consumers of quinoa look like they were substantially better off than the rest of the population.

A visual comparison (Fig. 1) shows that as quinoa prices doubled between 2012 and 2014, households that consumed quinoa saw a 5% increase in consumption, while consumption for those that neither consumed nor produced declined by 2%. Specifically, Fig. 1 shows time series of the international price of quinoa and the consumption levels of quinoa producers, quinoa consumers, and those that neither produced nor consumed quinoa (about 75% of households in the sample) wherein, for ease of comparison, baseline consumption is set equal to 1 for each group.[12] Up until 2009, the total consumption (excluding quinoa consumption) of quinoa consumers increased at a faster rate than that of quinoa producers. Starting in 2010, however, quinoa producers saw their total household consumption increase faster than quinoa consumers. In fact, the welfare of quinoa producers increased much faster than that of quinoa consumers at the peak of the quinoa price boom in 2013 and 2014. Comparing quinoa-producing households on the one hand with quinoa-consuming and households that neither consumed nor produced quinoa on the other hand, the welfare of quinoa producers increased by over 50% over the period 2004–2014, whereas it increased by only about 25% for the other two groups of households.

In Table 2, we take a closer look at quinoa consumers. Three relationships of note emerge. First, the percentage of quinoa-consuming households has fluctuated in a way that appears unrelated to the price of quinoa over the sample period. Second, there has been a slight decline in the quantity of quinoa purchased over the sample period. Third, quinoa represents a small portion of the household budget (<1%) though there has been a doubling of the budget share of quinoa over the sample period. From 2004 to

[7] We remove the value of quinoa produced and consumed by the household from our measure of household welfare to avoid biasing the relationship between quinoa prices and consumption by way of reverse causality. We explain our identification strategy further in Section 3.

[8] We also examine per capita household consumption. The differences in results between the two measures are minor. The results of per capita consumption are discussed in the robustness checks section at the end of the results.

[9] The value of each expenditure group is rescaled to represent an annual value. For instance, monthly expenditures are multiplied by 12, quarterly expenditures are multiplied by three, and so on. In preliminary work, we controlled for the date of survey to eliminate seasonality, but doing so did not qualitatively change any of the results.

[10] ENAHO is a continuous, monthly survey. Every year, INEI visits the same primary sampling units (conglomerados) during the same survey month, but selects a different sample of dwellings to conduct the survey.

[11] All monetary values are expressed in real terms in 2004 Peruvian Soles (PEN). The 2004 PPP adjusted exchange rate was 1.3 PEN = $1 USD.

[12] Yearly departmental-level deflators are used to control for price changes.

Table 1
Household welfare trends, 2004–2014.

Year	Non-consumers and non-producers of quinoa		Producers of quinoa		Non-producer consumers of quinoa	
	% Households	Value	% Households	Value	% Households	Value
Household consumption (excluding quinoa consumption)						
2004	75.96%	14,474.84	3.58%	6,183.24	20.46%	18,952.50
2005	74.11%	14,014.12	3.59%	5,854.97	22.30%	18,851.58
2006	73.53%	15,450.09	3.71%	6,334.94	22.75%	20,582.52
2007	74.18%	15,841.39	4.04%	6,694.45	21.77%	21,599.44
2008	77.11%	16,100.50	3.62%	7,062.81	19.27%	21,394.45
2009	78.23%	17,007.19	3.91%	7,385.91	17.86%	23,441.23
2010	76.73%	17,304.01	4.26%	7,791.07	19.01%	23,146.46
2011	75.86%	17,236.37	3.64%	8,677.71	20.50%	22,861.67
2012	74.85%	17,777.42	3.19%	8,382.39	21.96%	23,363.85
2013	73.05%	17,498.58	2.92%	9,498.24	24.03%	23,968.07
2014	74.38%	17,340.45	3.76%	9,759.65	21.85%	24,417.73

Note: Figures measured in 2004 PEN and exclude consumption of cultivated and purchased quinoa. All descriptive statistics are weighted using the sampling weights provided in the ENAHO. In addition to being expressed in constant (i.e., 2004) terms, all prices are deflated using departmental-level deflators.

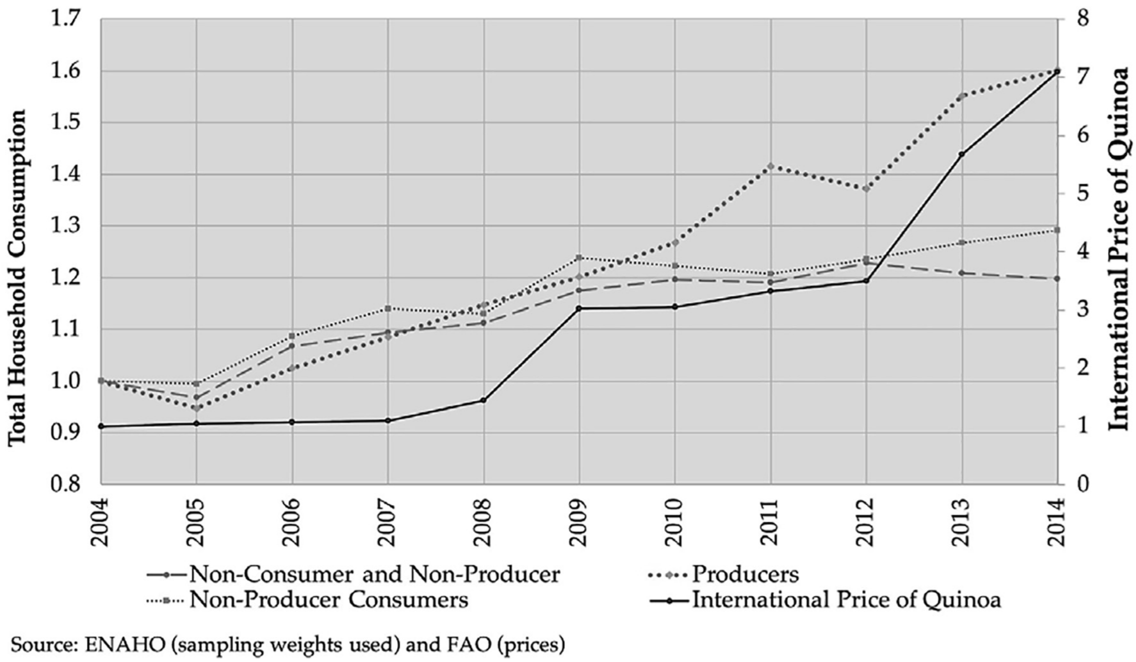

Fig. 1. Evolution of Total Household Consumption for Quinoa Consumer and Producer as well as Autarkic Households (Left; 2004 = 1.00) as well as the International Price of Quinoa (Right).

Table 2
Descriptive statistics for quinoa consumers, 2004–2014.

Year	Quinoa-consuming households (%)	kg of whole quinoa purchased, past two weeks	Purchase price of whole quinoa per kg, 2004 PEN	Budget share of annual total consumption of quinoa conditional on consumption (%)
2004	26.84%	0.87	3.15	0.10%
2005	30.70%	0.80	3.28	0.12%
2006	30.56%	0.84	3.17	0.12%
2007	29.60%	0.83	3.17	0.12%
2008	25.66%	0.75	4.18	0.62%
2009	24.64%	0.68	6.17	0.66%
2010	25.80%	0.73	6.29	0.65%
2011	27.90%	0.75	6.09	0.71%
2012	29.37%	0.71	6.10	0.74%
2013	30.83%	0.69	7.56	0.85%
2014	29.71%	0.64	11.27	1.01%

Note: Average purchase amount for households who purchased quinoa. In addition to being expressed in constant (i.e., 2004) terms, all prices are deflated using annual departmental-level deflators. Budget shares are imputed by multiplying the value of purchases in the previous two weeks by 26 and dividing by total household consumption.

2014, one fourth to one third of the households in our sample reported consuming quinoa in the two weeks before they were surveyed, as shown in the second column of Table 2.[13] Over these same two weeks, conditional on purchasing, the average household in the data purchased less than one kilogram of quinoa. Back-of-the-envelope calculations based on Table 2 suggest that the total effect of price rises on consumers was small: At the beginning of the sample period, households purchased roughly 22.6 kg per year (or 0.87 kg every two weeks), but the real cost of this amount of quinoa rose roughly 200 Peruvian Soles (PEN) over the sample period, which is about 0.8% of the overall consumption for those households that do not produce quinoa in 2014.

Over the sample period, quinoa purchases have fallen. Indeed, Table 2 shows that the quantity of quinoa purchased over the two weeks before the survey fell by about one third. Using the two-week purchase data, we estimated annual purchases by multiplying by 26 to create an annual budget share. The budget share of quinoa rose as the real price of quinoa paid by buyers more than tripled from 2004 to 2014. As noted above, quinoa represents a very small share (i.e., less than 1%) of the budget of the average household in the data, and the change in budget share between 2004 and 2014 is roughly 0.9 percentage points. Compared to the budget share of staples in low-income countries, which often average over 50% and can even attain 85% (see, for example, Barrett & Dorosh, 1996), quinoa does not seem to be a staple for households in Peru, though Stevens (2017, Tables 1 and 3) notes that there is a substantial amount of heterogeneity; in particular, averages in traditional quinoa-consuming areas such as Puno are higher than national averages, with a food budget share of quinoa of 3.6% compared to the national food budget share of quinoa of 0.5% in 2012.

Table 3 shows descriptive statistics for quinoa producers which highlight three relationships. First, as with the consumers, the share of producers seems unrelated to price over time. Second, total production declined at first but it has been rising in recent years and doubled between 2013–2014. Given that the number of producers was relatively constant, this suggest that producers increased their production through either higher yields or cultivating larger areas. A USDA report relying on FAO data suggests that rising yields due to better cultivation and insect control are responsible for this (USDA, 2014). Third, own consumption has been falling over time and recently there have been increases in revenue, the percentage of sellers and ratio of revenue to total consumption. Over the period 2004–2014, roughly 3.6% of all households in the data grew any quinoa. Counter to what one might expect given the quinoa price boom of 2012–2013, the percentage of producers in the data dropped from 3.4% in 2011 to 2.8% in 2012, and then to 2.6% in 2013. In 2014, with the international quinoa price still at its peak, the proportion of producers when back to the 2011 levels. Given that poorer quinoa farmers faced no incentive to exit the market as well as how stable the proportion of the sample that produces quinoa is, we do not believe that the decision to produce quinoa is endogenously related to household income or wealth.

The second and third column of Table 3 shows that in 2014, about 20% (0.66% divided by 3.34%) of the households who produce quinoa reported selling it. Most of the households who grow quinoa consume it all. More interestingly for our purposes, the percentage of households that sold some of their quinoa production (column 2 of Table 3) almost doubled from 8% to 15% between 2010 and 2011 and continuing to rise until 2014. When looking only at the sub-sample of quinoa producers, the average household produced less than 90 kg of quinoa in the last 12 months, and over time, the volume of quinoa production has been U-shaped, with the highest output levels per household at the beginning and at the end of our sample.

In our sample, over 98% of households that produced any quinoa used at least some of it for their own consumption. As shown in the fifth column of Table 3, however, the percentage of production used for a household's own consumption fell over the study period, from around 85% in 2004 to about 65% in 2014.

We mentioned earlier that the international price of quinoa had more than tripled over the period 2004–2014. Even more impressively, quinoa sellers have seen the real price of quinoa experience a more than fourfold increase during that period. The rate at which the purchase price of quinoa rose (column 4 of Table 2) was less than the growth in the sales price (column 6 of Table 3), and the farm-to-consumer price ratio has increased from 43% to 55% between 2004 and 2014.[14] This suggests that quinoa producers have captured some of the gains from rising quinoa prices, though this is obviously not a formal test of that hypothesis, which is well beyond the scope of this paper. Numerous factors could influence the relationship between international prices and local producer or consumer prices including exchange rates, transportation costs, and variation in the quality of exportable or non-traded quinoa. That said the relationship appear relatively constant as the exchange rate-adjusted international price has a year-to-year correlation coefficient of over 0.95 with both local producer and consumer prices.

Lastly, the revenue of quinoa sellers grew almost sevenfold over the period 2004–2014 (seventh column of Table 3), although that increase has not been steady. There are also three jumps in revenue: the first occurring between 2008 and 2009, when revenue almost doubled; the second one occurring between 2011 and 2012, when revenue increased by over 80%; and the third occurring between 2013 and 2014, when revenue almost doubled. This rise in revenue was even more pronounced when looking at all quinoa farmers (eighth column of Table 3), and not just quinoa sellers.

Taken together, Tables 2 and 3 suggest that the percentage of households that consume or produce quinoa is unrelated to the price. To demonstrate this more directly, in Fig. 2 we graph the percentage of households in each category (producer, consumers, or neither) along with the international price of quinoa. No clear relationship seems to exist between the two figures as the percentage of each group appears stable as the price of quinoa rises. Second, Fig. 3a and b maps the percentage of quinoa consumers and producers in each Peruvian department. These maps suggest that regions with a higher proportion of producers typically also have a higher proportion of consumers. Moreover, there is little change in the map between 2004 (well before the price spike) and 2014 (at peak quinoa prices) in terms of which regions consume and produce quinoa, suggesting that not only is the average number of quinoa consumers and producers relatively constant nationally, but also within departments.

Beginning in 2007 a subsample of the full cross section was selected to be re-interviewed in the following year, thereby creating a rotating household panel for a sub-sample of ENAHO households. The average household in the panel was resurveyed 2.7 times. As expected, there is a high correlation between the subsample and full sample. All main variable of interest show over a 0.9 year-to-year correlation between the panel and full data sets, which can be seen in Appendix Tables A1, A2, A3, where we recreate Tables 1–3 from the full data set. We elected to use the pseudo-panel as the main results as it shows what happens to the average member of the locality based on the concentration of quinoa consumers and farmers, while the household panel is a comparison between consumers, producers and those who are neither. As we

[13] Quinoa production in Peru is seasonal. The sowing season usually starts in September, peaking in October-November. The harvest season usually takes place in April to June.

[14] Producers reported their annual sales in an agricultural production module in the ENAHO. Consumer prices were taken from the two-week recall consumption model which included purchase prices.

Table 3
Descriptive statistics for quinoa producers, 2004–2014.

Year	Sample proportion of quinoa producers (%)	Proportion of quinoa producers that sold quinoa (%)	Quinoa production, past 12 months (kg), quinoa producers only	Quinoa production for own consumption (%), quinoa producers only	Average sales price (per kg, 2004 PEN)	Quinoa revenue (quinoa sellers only, 2004 PEN)	Quinoa revenue (all quinoa farmers, 2004 PEN)
2004	3.69%	8.13%	69.02	85.10%	1.34	173.38	14.07
2005	3.92%	10.71%	63.15	81.96%	1.57	206.41	22.28
2006	3.90%	9.49%	70.49	81.75%	1.62	202.40	19.17
2007	3.69%	8.40%	56.44	68.34%	1.42	101.37	8.38
2008	3.06%	6.54%	39.60	74.76%	1.91	191.71	12.59
2009	3.38%	8.88%	49.15	68.84%	3.35	419.34	37.40
2010	3.56%	8.15%	51.80	68.54%	2.98	299.60	24.45
2011	3.38%	14.79%	70.58	63.19%	2.99	449.60	66.53
2012	2.81%	16.37%	86.53	62.53%	3.33	787.66	128.73
2013	2.63%	17.49%	75.85	67.04%	4.44	855.47	149.02
2014	3.34%	19.76%	158.64	64.58%	6.18	2045.47	403.49

Note: All descriptive statistics are weighted using the sampling weights provided in the ENAHO. In addition to being expressed in constant (i.e., 2004) terms, all prices are deflated using departmental-level deflators.

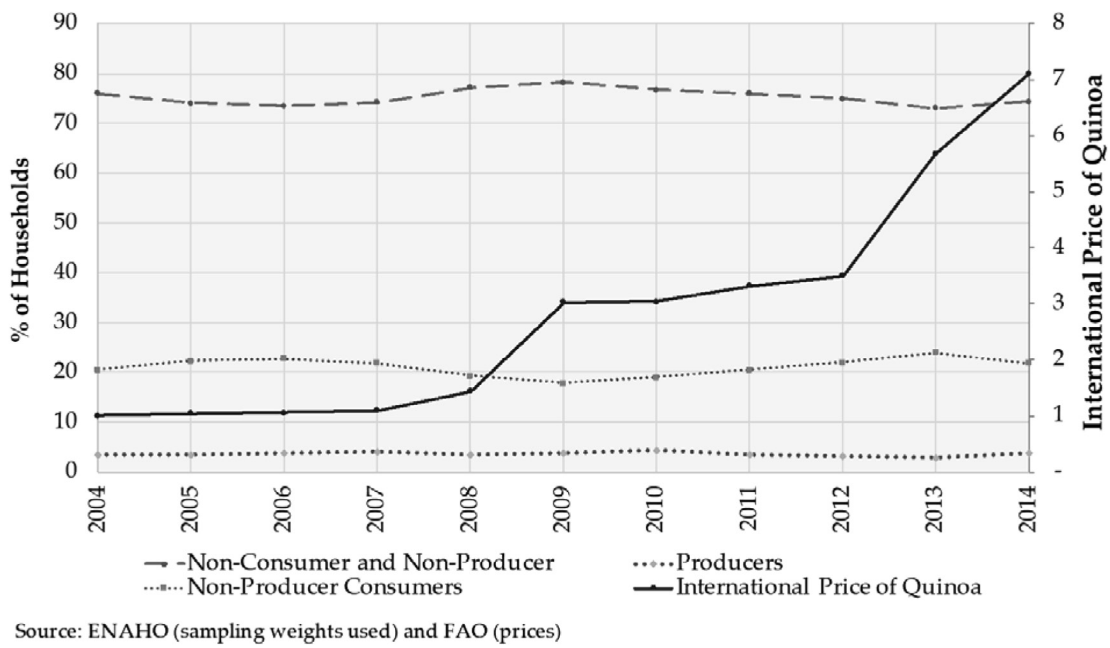

Fig. 2. Evolution of the Proportion of Quinoa Consumer and Producer as well as Autarkic Households (Left) as well as the International Price of Quinoa (Right).

explain below, the panel data yield results similar to our pseudo-panel. Furthermore, the panel data set is too small for regional analyses as the average sample size would be 5, 49 and 374 households respectively at the district, province, and departmental levels.

The household of interest in this study is a quinoa consumer, producer, or both. The core analysis uses all non-producing and non-consuming households in Peru as the comparison group. That said, an argument could be made for instead limiting the comparison group to areas where quinoa is traditionally consumed if, for instance, economic shocks were an omitted variable that was unrelated to quinoa, but positively influence quinoa growing and consuming areas. To address this issue we also perform all of the analyses on two subgroups of the dataset where we limit to geographic units that either consume or produce quinoa. The results do not substantially change by limiting to the geographic regions that either consumer or produce quinoa, which supports our core analysis.

3. Empirical framework

The ENAHO is a repeated cross-sectional household survey, so household fixed effects are not feasible in this context. A standard strategy proposed by Deaton (1985) to overcome the type of data limitations one faces with repeated cross-sections, is to rely on pseudo-panel methods.

Intuitively, pseudo-panel methods treat groups of observations (e.g., cohorts of observations rather than the observations themselves) as units of analysis by averaging the variables retained for analysis within each group. In our application, instead of treating the household as our unit of analysis, we treat geographical units (1838 district, 195 provinces, and 25 departments) as our units of analysis, and we use geographical unit-level averages as our primary data to use panel data methods. As a first check on the robustness of our results, we estimate each set of results three times, respectively treating districts, provinces, and departments as our units of observation. The ENAHO has data on all 25 departments, on all but one of the 195 provinces, and on 1401 of 1838 districts. Given the random selection of communities and the nationally representative nature of the ENAHO, those missing districts should not compromise the external validity of our results. It is worth noting, however, that the survey is designed to be representative at the departmental level, and not at the province or district level. Therefore, the results at the province and district levels are more suggestive than definitive.

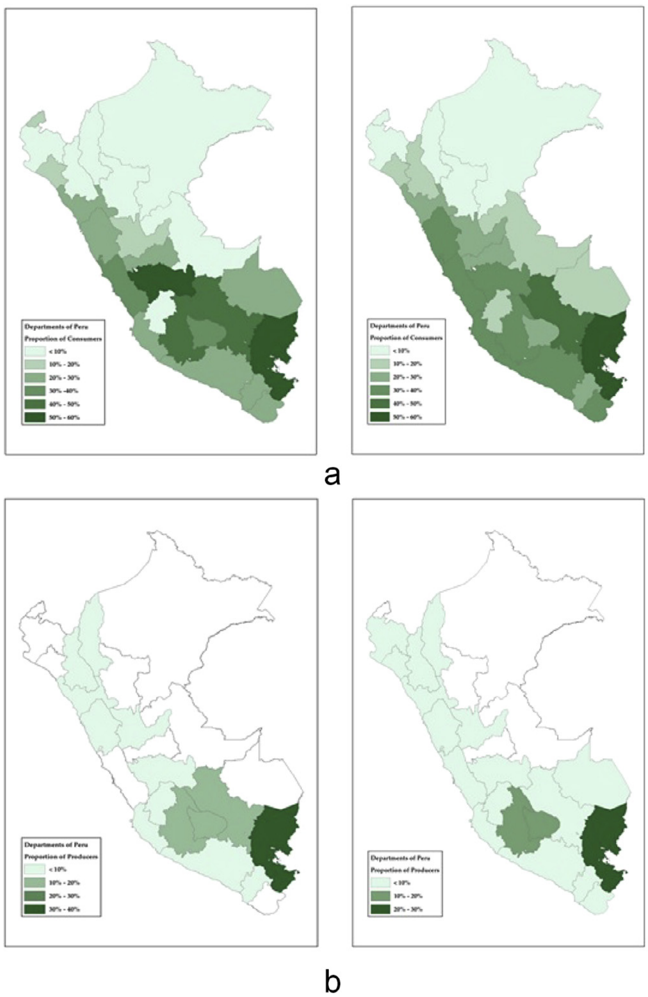

Fig. 3. (a) Consumers by Department, 2004 and 2014. (b) Producers by Department, 2004 (left) and 2014 (right).

Pseudo-panel methods like the ones we use in this article have been used to estimate economic mobility (Cuesta et al., 2011; McKenzie, 2004) and to study poverty in developing countries (Antman & McKenzie, 2007a, 2007b; Christiaensen & Subbarao, 2005; Angrist & Pischke, 2008). Again, recall that in a pseudo-panel, the outcome variable (here, household welfare) and the treatment variable (here, the interaction of international price of quinoa interacted with the proportion of quinoa consumers when studying the welfare of consumers, and the interaction of international price of quinoa interacted with the proportion of quinoa producers when studying the welfare of producers) as well as the control variables are averaged across geographical unit. Because households are chosen at random within each geographic region, the average among sampled households should track the average among population households.

Our variable of interest is the total real value of household consumption (deflated using departmental deflators provided by INEI), which we use here as a proxy for household welfare. For each geographical unit g, we compute the regional sample mean of the total value of household consumption $\bar{c}_{gt}$ as the average of the total value of household consumption c_{hgt} over all observed households h in the set H_{gt} of all households h sampled in geographical unit g in year t, such that

$$\bar{c}_{gt} = \frac{1}{H_{gt}} \sum_{h=1}^{H_{gt}} c_{hgt}$$

Here, pseudo-panel methods have two clear benefits. First, because the ENAHO covers over 20,000 households annually, the data is rich at both the national and sub-national levels, and statistical power is not a concern. Second, as the number of households the average is calculated over increases when computing the geographical unit-level mean, the effect of potential error in the measurement of a given 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 error would still be present, and fixed effects are thought to compound measurement error problems (Wooldridge, 2002).[15] This would be an issue especially regarding food consumption, where annual data are extrapolated from two weeks' worth of food consumption. Our use of pseudo-panel methods reduces this problem.

As a robustness check to ensure that the type of measurement error just described does not bias our results, because the median of a distribution is less sensitive to outliers than the mean of the same distribution, we replace mean regional consumption with median regional consumption for our estimations. This should eliminate the influence of outliers in the measurement of consumption, which are likely the result of measurement error. We are not aware of other empirical research using pseudo-panels where the median has been used instead of the mean to account for such measurement error issues, and to our knowledge this is an additional, if modest contribution of this study.

As with many of the decisions one has to make in applied work, moving from the largest (i.e., department) to the smallest (i.e., district) geographical unit involves a tradeoff. As the geographical unit gets smaller, fewer observations go into making the geographical level-unit average, which maximizes measurement error but also presents the most amount of statistical power in this context. Conversely, as the geographical unit gets larger, there are fewer units of observations available for analysis, which decreases statistical power, but which also minimizes measurement error problems. To examine this tradeoff we estimate all of our specifications for each of the three levels of geographic analysis.

We use two variables as our treatment variable, depending on whether we want to study the welfare effects of rising quinoa prices on consumers or on producers of quinoa. For consumers, the treatment variable is the proportion of quinoa consumers within a geographical unit interacted with the annual international price of quinoa reported by the FAO.[16] For producers, the treatment variable is the proportion of quinoa producers within a geographical unit interacted with the annual international price of quinoa reported. Both treatment variables vary over time and across space, and it is this spatiotemporal variation which we exploit here to identify the effect of rising quinoa prices on welfare. Though in theory, the treatment variable could be endogenous to household welfare, as rising prices may encourage (or discourage) production (or consumption), empirically there appears to be no such relationship between either treatment measure and prices, as shown in Fig. 2 above. Though it is common in studies of this kind to interact prices with the value of the treatment variable in the first period (here, this would be the proportion of quinoa producers or consumers 2004) only to avoid reverse causality, note that this is not feasible in this context. Indeed, because we only have 11 observations for the price

[15] More specifically, Wooldridge (2002, p. 311) writes: "It is widely believed in econometrics that ... FE transformations exacerbate measurement error bias (even though they eliminate heterogeneity bias). However, it is important to know that this conclusion rests on the classical errors-in-variables model under strict exogeneity, as well as on other assumptions."

[16] These are nominal prices received by farmers for quinoa sales as collected at the point of initial sale (prices paid at the farm-gate). They are expressed in PEN per metric ton.

variable (i.e., the international price of quinoa does not vary over space within each year), interacting the international price of quinoa with baseline proportions of producers or consumers of quinoa in each district would merely take the variation in price over time and rescale it by a constant equal to that baseline proportion, which would mean that the welfare effects we are interested in would only be identified off of temporal variation. The method we use exploits spatiotemporal variation. Again, though reverse causality would normally be a source of bias, it appears that it is not in this context given Fig. 2. We use the international price of quinoa in place of local prices as regional variation in prices may reflect omitted variables such as other local economic conditions that could influence both quinoa prices and total household consumption.

To recapitulate, for our analysis of quinoa consumers, we regress the logarithm of the total value of household consumption on the proportion of quinoa consumers within a geographical unit interacted with the annual international price of quinoa. The proportion of quinoa consumers within a geographical unit allows the extent of quinoa consumption to vary over time as households choose which products to consume each year (recall that this measure comes from an annual extrapolation of a variable reported in a two-week recall period.) Similarly, for our analysis of quinoa producers, we regress the logarithm of the total value of household consumption on the proportion of quinoa producers within a geographical unit interacted with the logarithm of the annual international price of quinoa. The proportion of quinoa producers within a geographical unit allows the extent of quinoa production to vary over time as households choose which crops to grow each year.

We considered running regressions with both the consumer and producer treatment terms on the RHS to estimate the effects for the concentration of consumers controlling for production. Upon closer inspection, and consistent with the maps in Fig. 3, we found a high correlation between the two measures. The correlation for each geographic observation year ranges from 0.62 at the district level to 0.70 at the province level. Thus, to avoid multicollinearity issues, we do not estimate regressions wherein both the proportion of producers and consumers are included on the RHS.

3.1. Estimation strategy

3.1.1. Consumers

In the case of quinoa consumers, our equation of interest is

$$\ln c_{gt} = \alpha_0 + \alpha_1 \ln p_t \times S_{gt} + \delta_g + \tau_t + \epsilon_{gt}$$

where $\ln c_{gt}$ is the mean of $\ln c_{hgt}$ in geographical unit g in year t, p_t is the international price of quinoa in year t, S_{gt} is the proportion of quinoa consumers in geographical unit g in year t, δ_g is a vector of geographical-unit fixed effects, and ϵ_{gt} is an error term with mean zero. The term τ_t denotes either (i) year fixed effects, (ii) linear time trends, or (iii) higher-order geographical unit-specific linear time trends, whenever feasible. We cluster the standard errors at the level of the geographical unit (i.e., district, province, or department) we use as our unit of analysis.

3.1.2. Producers

In the case of quinoa producers, our equation of interest is

$$\ln c_{gt} = \beta_0 + \beta_1 \ln p_t \times D_{gt} + \gamma_g + \theta_t + \upsilon_{gt}$$

where $\ln c_{gt}$ and p_t are defined as in Eq. (2), but where D_{gt} is the proportion of households that produce quinoa in geographical unit g in time t, γ_g is a vector of geographical unit fixed effects, and υ_{gt} is an error term with mean zero. As τ_t in Eq. (2), the term θ_t denotes either (i) year fixed effects, (ii) time trends, or (iii) higher-order geographical unit-time trends, whenever feasible. We again cluster the standard errors at the level of the geographical unit we use as our unit of analysis.

3.1.3. Panel analysis of producers and consumers

As mentioned above, we conduct a robustness check using the panel sub-set of the ENAHO data. This allows treating the households within the rotating panel as the unit of observation and to incorporate household fixed effects. In the analysis we include the product of the log of the international price of quinoa $\ln p_t$ and the producer, consumer, and interaction terms of the two as our variables of interest. We also estimate additional specifications where we drop the interaction term and either of the consumer or producer dummies to mirror the pseudo-panel. We also estimate these specifications with and without consumer or producer households in the sample. Finally, we vary the trend and geographic interactions and reduce the sample to only quinoa consuming districts. As we explain below, our results are robust to estimating these additional specifications.

3.2. Identification strategy

3.2.1. Consumers

The error term in Eq. (2) contains everything that is unobserved in that equation. Because the households surveyed in the ENAHO are randomly selected, when controlling for the passage of time, the households in a given geographical unit in a given year are similar to the households in the same geographical unit the following year, and this holds both in terms of their observable and unobservable characteristics. Thus, provided we account for the passage of time in our estimations, our use of geographical unit-level fixed effects should take care of the time-invariant heterogeneity between households.

To account for time-variant unobserved heterogeneity, we estimate several different specifications, the idea being that if we find similar effects throughout, our results are less likely to be biased. First, for our district-level analysis, on top of including district fixed effects, we estimate specifications with: (i) year fixed effects; (ii) time trends; (iii) province-time trends; and (iii) department-time trends. Second, for our provincial-level analysis, on top of including province fixed effects, we estimate specifications with: (i) year fixed effects; (ii) time trends; and (iii) department-time trends. Finally, for our departmental-level analysis, on top of including departmental fixed effects, we estimate specifications with year fixed effects.

How do those specifications help identify the welfare effects of rising quinoa prices for consumers? To help think through this, it helps to consider the three sources of statistical endogeneity, viz. (i) reverse causality or simultaneity; (ii) unobserved heterogeneity; and (iii) measurement error. As regards reverse causality or simultaneity, quinoa appears to be a normal or a luxury good, and as consumers get better off, they are likely to start consuming more quinoa, which might cause local quinoa prices to increase. Over the period 2004–2014, however, quinoa price increases were largely due to an increased international demand for quinoa rather than to an increased domestic demand for it. Moreover, even if an increased domestic demand for quinoa had driven prices up, our use of geographical unit fixed effects would control for the average demand for quinoa in a given geographical unit, and the various means of controlling for the effect of time enumerated above would absorb the evolution of that demand.

As regards unobserved heterogeneity, as we discussed above, our use of pseudo-panel methods allows for matching the households in a given geographical unit from year to year along both their observable and their unobservable characteristics. Our use of fixed effects at the geographical unit level, along with the various methods we deploy to control for the effect of time, purge the error term of most of its prospective endogeneity due to unobserved heterogeneity.

One potential source of unobserved heterogeneity comes from an increase in total consumption from income effects. For example, if there is unobserved variation in income that differs between geographic regions and is not consistent with geographic time-trends this may bias the estimate through rising prices of all goods. To control for this issue we use an annual departmental level deflator for the welfare measure. Unfortunately, deflators at smaller geographic regions are not available. Our results, however, are mostly consistent across the two lower geographical levels we study.

As regards measurement error, we noted earlier that this is a concern, especially at the district level, where few observations go into making geographical unit-level averages. For this reason alone, we estimate everything at higher administrative levels (i.e., province and department). But our various layers of fixed effects and time controls control for the measurement error that is systematic at those levels. Moreover, note that we conduct robustness checks wherein, instead of using the within-geographical unit mean of household welfare as our dependent variable, we use the within-geographical unit median household welfare as our dependent variable, given that the latter is less sensitive to outliers likely to stem from measurement error. What remains is likely to be classical measurement error, which causes attenuation bias, in which case α_1 is an estimate of the lower bound on the true effect of quinoa price changes on household welfare.

3.2.2. Producers

The error term in Eq. (3) contains everything that is unobserved in the same equation. If those unobservable factors are correlated with the variables on the RHS of Eq. (3), our estimate of the impact of quinoa production on household welfare is biased.

Again, 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 if the prospect of a higher welfare (as proxied by household consumption) works through a price effect to induce 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, through a price effect. Our use of geographical unit fixed effects, however, would control for the average production for quinoa in each geographical unit, and the various means of controlling for the effect of time enumerated above would absorb the evolution of quinoa supply. As mentioned above we do not observe a relationship between price and the percentage of producers in the sample.

Unobserved heterogeneity issues might arise in this context if some unobservable factor is correlated with the variables on the RHS of equation (3). 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 studies such as this one, unobserved heterogeneity is generally the most important problem plaguing the identification of causal relationships. This problem is considerably lessened here 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 geographical unit in each year are representative of that geographical unit, our use of geographical unit fixed effects should control for all things time-invariant within a geographical-unit, both observable and unobservable.[17] Of course, this does not control for those factors that are time-variant within a geographical unit, which are unobserved and correlated with the variables on the right-hand side of Eq. (3). Our use of year dummies should partly obviate that issue.

Finally, measurement error issues can bias our estimate of the impact of quinoa production on household welfare in two ways. With classical measurement error, 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 the geographical unit level would be controlled for by the geographical unit fixed effects. Here, the measurement error we should be most preoccupied with are: (i) classical measurement error; and (ii) time-variant systematic measurement error in our variable of interest, i.e., the proportion of households that produce quinoa in a geographical unit. On the former, we have discussed above how the extent of measurement error is dependent upon the geographical unit we use as an observation. On the latter, 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 produce quinoa or not.

The change in welfare over time before the rapid increase in the price of quinoa is likely similar for quinoa producers and non-producers. Fig. 1, which plots the evolution of household welfare for quinoa producers, consumers, and non-consumers show that average household welfare followed a similar course from 2004 to 2010, after which the welfare of net sellers of quinoa has clearly evolved faster than the welfare of the other groups.

Another threat to identification when using pseudo-panel methods is the possibility that the composition of the relevant groups—here, households that produce (consume) quinoa versus households that do not produce (consume) quinoa—changes over time. In our application, it is possible that some households that did not grow (consume) quinoa decide to grow (consume) quinoa in response to higher expected levels of welfare. That said, for producers, Fig. 2 and Table 3 shows that the proportion of quinoa producers is relatively stable over the sample period. If anything, that proportion declines slightly toward the end of the sample period. Similarly, given that the dramatic increase in the price of quinoa in 2012–2014 was largely unpredictable and driven by an increased international demand for quinoa, we are not worried about a potential Ashenfelter dip (see Heckman & Smith, 1999).[18] Looking at Fig. 1, it does not look as though the welfare of quinoa-producing households was significantly lower than that of other households before the quinoa price increase of 2012–2014.

4. Estimation results and discussion

4.1. The welfare effects of rising quinoa prices on consumers

Tables 4a to 4c, present estimation results for the welfare effects of rising quinoa prices on consumers. The tables differ by the size of geographical unit of observation 4a (district), 4b (province) and 4c (department), which are ordered from smallest to largest. In each table, the coefficient on the logarithm of the international price of quinoa interacted with the proportion of quinoa consumers is an estimate of the quinoa price elasticity of household welfare, on average, for those households in geographical units where quinoa was consumed for the period 2004–2014. In other words, this coefficient tells us how, for a 1% increase in the price of quinoa in those districts, provinces, and departments

[17] The ENAHO includes a subsample that is resurveyed as part of a panel. These households are randomly chosen and the combination of the panel and non-panel households is nationally representative.

[18] In this context, an Ashenfelter dip would involve households self-selecting into quinoa cultivation ex ante of the quinoa price spike, based on their expectation that the price of quinoa would increase significantly.

Table 4a
Pseudo-panel regression of total household consumption on the proportion of households who consume quinoa treating districts as units of observation, 2004–2014.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable: mean log of total household consumption (in 2004 PEN)							
% of Quinoa consumers × Log of international price of quinoa	0.059***	0.041***	0.037***	0.040***	0.040***	0.033***	0.036***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)
Constant	8.842***	8.652***	8.654***	−62.951***	−60.810***	8.731***	8.255***
	(0.006)	(0.009)	(0.004)	(2.138)	(2.292)	(0.011)	(0.021)
Observations	10,774	10,774	10,774	10,774	10,774	7,814	2,678
R-squared	0.050	0.196	0.426	0.266	0.231	0.186	0.203
District fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Linear trend	No	Yes	No	No	Yes	Yes	Yes
Year fixed effects	No	No	No	No	No	No	No
District-specific linear trends	No	No	Yes	No	No	No	No
Province-specific linear trends	No	No	No	Yes	No	No	No
Province-year fixed effects	No	No	No	No	No	No	No
Department-specific linear trends	No	No	No	No	Yes	No	No
Quinoa consuming only	No	No	Yes	No	No	Yes	No
Quinoa producing only	No	No	No	No	No	No	Yes

Note: *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.
Standard errors clustered at the district level are shown in parentheses. Each household is weighted according to the sampling weight it was given in the ENAHO. In addition to being expressed in constant (i.e., 2004) terms, all prices are deflated using departmental-level deflators.

Table 4b
Pseudo-panel regression of total household consumption on the proportion of households who consume quinoa treating provinces as the units of observation, 2004–2014.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: mean log of total household consumption (in 2004 PEN)						
% Quinoa consumers × Log of international price of quinoa	0.101***	0.046***	0.041***	0.045***	0.042***	0.029***
	(0.010)	(0.009)	(0.009)	(0.010)	(0.008)	(0.010)
Constant	8.792***	8.674***	8.680***	8.683***	8.689***	8.446***
	(0.019)	(0.019)	(0.013)	(0.018)	(0.017)	(0.025)
Observations	2113	2113	2113	2113	1939	956
R-squared	0.099	0.364	0.554	0.412	0.380	0.404
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Linear trend	No	Yes	No	No	Yes	Yes
Year fixed effects	No	No	No	No	No	No
Province-specific linear trends	No	No	Yes	No	No	No
Department-specific linear trends	No	No	No	Yes	No	No
Quinoa consuming only	No	No	Yes	No	Yes	No
Quinoa producing only	No	No	No	No	No	Yes

Note: *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.
Standard errors clustered at the province level are shown in parentheses. Each household is weighted according to the sampling weight it was given in the ENAHO. In addition to being expressed in constant (i.e., 2004) terms, all prices are deflated using departmental-level deflators.

Table 4c
Pseudo-panel regression of total household consumption on the proportion of households who consume quinoa treating departments as the units of observation, 2004–2014.

	(1)	(2)	(3)	(4)
Dependent variable: mean log of total household consumption (in 2004 PEN)				
% Quinoa consumers × Log of international price of quinoa	−0.029	−0.045**	−0.029	−0.035**
	(0.019)	(0.019)	(0.019)	(0.016)
Constant	−67.504***	9.121***	9.088***	8.930***
	(7.930)	(0.028)	(0.037)	(0.045)
Observations	275	275	275	164
R-squared	0.665	0.814	0.665	0.668
Department fixed effects	Yes	Yes	Yes	Yes
Linear trend	No	No	Yes	Yes
Year fixed effects	No	No	No	No
Department-specific linear trends	No	Yes	No	No
Quinoa consuming only	No	Yes	Yes	No
Quinoa producing only	No	No	No	Yes

Note: *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.
Standard errors clustered at the department level are shown in parentheses. Each household is weighted according to the sampling weight it was given in the ENAHO. In addition to being expressed in constant (i.e., 2004) terms, all prices are deflated using departmental-level deflators.

where quinoa was consumed for the study period, household welfare changed.

The relationship between the interaction of prices and the percentage of consumers is positive and statistically significant in Tables 4a and 4b, which are the smaller geographic units (i.e., districts and provinces). In terms of economic significance, for those specifications where it is statistically significant, the quinoa price elasticity of household welfare ranges from 0.03 to 0.1, which

Table 5a
Pseudo-panel regression of total household consumption on the proportion of households who produce quinoa treating districts as units of observation, 2004–2014.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable: mean log of total household consumption (in 2004 PEN)							
% of Quinoa producers × Log of international price of quinoa	0.021***	0.013**	0.015***	0.014***	0.013**	0.007	0.006
	(0.006)	(0.005)	(0.006)	(0.005)	(0.005)	(0.006)	(0.007)
Constant	8.938***	8.703***	8.695***	−67.769***	−65.428***	8.794***	8.343***
	(0.003)	(0.008)	(0.003)	(2.151)	(2.310)	(0.010)	(0.020)
Observations	10,774	10,774	10,774	10,774	10,774	7,814	2,678
R-squared	0.003	0.174	0.412	0.246	0.210	0.169	0.180
District fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Linear trend	No	Yes	No	No	Yes	Yes	Yes
Year fixed effects	No	No	No	No	No	No	No
District-specific linear trends	No	No	Yes	No	No	No	No
Province-specific linear trends	No	No	No	Yes	No	No	No
Province-year fixed effects	No	No	No	No	No	No	No
Department-specific linear trends	No	No	No	No	Yes	No	No
Quinoa producing only	No	No	No	No	No	No	Yes
Quinoa consuming only	No	No	No	No	No	Yes	No

Note: *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.
Standard errors clustered at the district level are shown in parentheses. Each household is weighted according to the sampling weight it was given in the ENAHO. In addition to being expressed in constant (i.e., 2004) terms, all prices are deflated using departmental-level deflators.

Table 5b
Pseudo-panel regression of total household consumption on the proportion of households who produce quinoa treating provinces as units of observation, 2004–2014.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: mean log of total household consumption (in 2004 PEN)						
% of Quinoa producers × Log of international price of quinoa	0.010	−0.017	−0.005	−0.013	−0.017	−0.032**
	(0.014)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Constant	8.972***	8.748***	8.740***	8.754***	8.765***	8.545***
	(0.008)	(0.014)	(0.006)	(0.012)	(0.014)	(0.022)
Observations	2113	2113	2113	2113	1939	956
R-squared	0.000	0.347	0.542	0.396	0.364	0.401
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Linear trend	No	Yes	No	No	Yes	Yes
Year fixed effects	No	No	No	No	No	No
Province-specific linear trends	No	No	Yes	No	No	No
Department-specific linear trends	No	No	No	Yes	No	No
Quinoa producing only	No	No	No	No	No	Yes
Quinoa consuming only	No	No	No	No	Yes	No

Note: *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.
Standard errors clustered at the province level are shown in parentheses. Each household is weighted according to the sampling weight it was given in the ENAHO. In addition to being expressed in constant (i.e., 2004) terms, all prices are deflated using departmental-level deflators.

means that a 10% increase in the price of quinoa is associated with a 0.3% to 1% increase in household welfare on average in those geographical units where quinoa is consumed by everyone for the period 2004–2014. In effect, the result is moderated by the fact that it is never the case that everyone consumes quinoa in a district or in a province. On average, one quarter of households in each district consume quinoa and roughly one-third consume in districts where there is at least one consumer. So, for the typical quinoa consuming district, a 10% increase in price is associated with a 0.1 to 0.33% increase in average welfare for the district. From a macroeconomic perspective, this suggests that the increase in the price of quinoa over the period 2004–2014 has had positive general equilibrium effects extending to consumers of quinoa in addition to producers of quinoa. More specifically, between 2013 and 2014, the international price of quinoa rose by 25%, which would be associated with a 0.42% increase in household welfare given our estimates. Though it is impossible to determine the precise mechanism through which this might have happened, this likely took place via a multiplier effect.

Results at the departmental level paint a different story. Here, the coefficients are negative and statistically significant in two out of the four specifications. The statistically significant results are found only when linear trends are interacted with the departmental fixed effects and when the sample is limited to quinoa growing areas. For the first, these departmental trends would potentially include rising welfare related to the trend of rising quinoa prices. Similarly, limiting the sample to quinoa growing areas, which also have a higher concentration of consumers shows negative effects. Either way these coefficients are slightly smaller in terms of absolute value than the positive ones found at the district and province level. For instance, the coefficient from column 3 of Table 4c (−0.045) would indicate that for the average department with 24% of households consuming quinoa, a 100% increase in quinoa prices would result in a decline in welfare of roughly 1%. This result is consistent in magnitude with the descriptive statistics shown in Table 2, which showed that the average household would need to pay an additional 200 PEN to purchase the baseline consumption of quinoa per year, which is roughly 0.8% of baseline consumption.

At worst (i.e., at the departmental level), welfare decreased in an imperceptible way for those households that are consumers of quinoa in response to rising quinoa prices; at best (i.e., at the district and provincial levels), it increased very slightly for those same households. Either way, our results suggest that the quinoa price spike did not have the dramatic negative consequences that the "hot takes" of some media commentators have assumed.

4.2. The welfare effects of rising quinoa prices on producers

The results for consumers are similar to producers. Tables 5a to 5c, present estimation results for our analysis the welfare impacts of rising quinoa prices on quinoa producers at the district, province and departmental level respectively. In each table, the coefficient on the logarithm of the international price of quinoa interacted with the proportion of quinoa producers is an estimate of the quinoa price elasticity of household welfare, on average, for those households in geographical units where quinoa was produced for the period 2004–2014.

The results from our core specification at the district level, shown in Table 5a, suggest that the quinoa price elasticity of household welfare ranges from 0.01 to 0.02. Between 2013 and 2014, the price of quinoa rose by 25%, which means that the welfare of quinoa producers has increased by 2.5 to 5%. This number is in line with the increase in quinoa revenues from 1.5% to 4% of total household consumption shown in Table 3.

With that said, as the size of the geographical unit of observation increases, from district to province (Tables 5a to 5b), and then from province to department (Tables 5b to 5c), we find that the size of the point estimate decreases and even turns negative (at the provincial level controlling for year fixed effects in column 1 of Table 5b, and at the departmental level controlling for year fixed effects in column 1 of Table 5c.) This is similar to our results for quinoa consumers. A comparison of the average number of quinoa producers (conditional on the region producing any quinoa) may help explain some of these differences in the point estimates. For departments (i.e., the largest geographical unit) that produce quinoa, the average percentage of households that were producers was 6%, while it is 16% and 29% for province and districts that have any quinoa production. This increase in the point estimate as the geographical units get smaller is not surprising, as quinoa producing departments contain provinces or districts that do not produce quinoa.

Again, at worst (i.e., at the departmental level), welfare decreased in an imperceptible way for those households that are producers of quinoa in response to rising quinoa prices; at best (i.e., at the district and provincial levels), it increased very slightly for those same households. Either way, here too our results suggest that the quinoa price spike did not have negative consequences for Peruvian households.

4.3. Robustness checks

The point estimates for the robustness checks using the panel subset of the data are slightly smaller but of similar magnitudes to those using the district level pseudo-panel for both consumers and producers. As can be seen in Appendix B, Table B1, the estimate coefficients on both the consumer and producer dummies are approximately equal to .01 and are statistically significant. In other words, the 25% increase in prices between 2013 and 2014 should have been associated with a 0.25% increase in total consumption. This positive increase, despite being small, supports our assertion that quinoa consumers were not substantially harmed by rising prices. The coefficient is slightly smaller than the range of .03 to.06 for consumers and .01 to.02 for producers for the pseudo-panel from Tables 4a and 4b. The interaction term is of similar size to the coefficient on consumers. This suggest that households the report consuming and producing do not see different effects from those who only produce or only consuming. Finally, it is worth noting that the results do not substantially change to a number of adjustments to trends or limiting the sample to quinoa only growing districts.

Measurement error which creates outliers for total household consumption could potentially bias the results. In an attempt to correct for the potential caused by those outliers, we estimated both Eqs. (2) and (3) by replacing the dependent variable with the median of household consumption in the geographic unit of interest in each year.

Results using the median measurement are qualitatively similar to the results using the mean measurement, and they can be found in Appendix Tables C1a to C1c, for consumers and Appendix Tables C2a to C2c, for producers. Even though these median-measurement regressions do not differ sensibly from our core mean-measurement regressions, the two sets of results could likely differ in response to measurement error in other applications, and we encourage researchers using pseudo-panel techniques to conduct robustness checks using median measurement.

5. Summary and concluding remarks

We have looked at how the sharp rise in the international price of quinoa over the period 2004–2014 has affected the welfare of quinoa consumers and producers in Peru. On both the consumer and producer sides of the quinoa market, we find that at the district and province levels, rising quinoa prices appear to have had a small, positive effect on the welfare of quinoa-consuming and quinoa-producing households. At the departmental level, rising quinoa prices appear to have had an almost imperceptible, negative effect on the welfare of the same households. Finally, analyzing the household panel subset of the data for robustness, we obtain results similar to the district-level analysis.

Table 5c
Pseudo-panel regression of total household consumption on the proportion of households who produce quinoa treating departments as units of observation, 2004–2014.

	(1)	(2)	(3)	(4)	(5)
Dependent variable: mean log of total household consumption (in 2004 PEN)					
% of Quinoa producers × Log of international price of quinoa	−0.061	−0.061	−0.070	−0.061	−0.066
	(0.093)	(0.093)	(0.070)	(0.093)	(0.089)
Constant	−64.450***	9.062***	9.072***	9.062***	8.896***
	(7.510)	(0.038)	(0.019)	(0.038)	(0.060)
Observations	275	275	275	275	164
R-squared	0.664	0.664	0.810	0.664	0.667
Department fixed effects	Yes	Yes	Yes	Yes	Yes
Linear trend	No	Yes	No	Yes	Yes
Year fixed effects	No	No	No	No	No
Department-specific linear trends	No	No	Yes	No	No
Quinoa producing only	No	No	No	No	Yes
Quinoa consuming only	No	No	No	Yes	No

Note: *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.
Standard errors clustered at the department level are shown in parentheses. Each household is weighted according to the sampling weight it was given in the ENAHO. In addition to being expressed in constant (i.e., 2004) terms, all prices are deflated using departmental-level deflators.

Either way, our results in no way suggest that the recent spike in the international price of quinoa, which was due to a rapidly rising international demand for quinoa, threatened the livelihoods of Peruvian households. Recall that in 2013, some people advocated that consumers in rich countries feel guilty about and reduce their consumption of quinoa because the rising international demand for quinoa was hurting those who had traditionally produced and consumed it. It is useful to know that the claim that rising quinoa prices were substantially hurting those who had traditionally consumed it was likely overblown, as most of our estimates show positive impacts. Even the worst negative estimates show that a 100% increase in price would decrease total consumption in a community where everyone consumed quinoa by only 5%.

Moreover, the positive general equilibrium effects of rising quinoa prices we identify at the district and provincial levels for those households that consume quinoa are interesting in and of themselves. Indeed, though Deaton (1989a) short-term, partial-equilibrium measure of the welfare impacts of an increase in the price of a commodity would suggest that quinoa consumers would be hurt by rising quinoa prices, our longer-term (i.e., annual) estimates show that for a 1% increase in the price of quinoa, household welfare increases by a modest 0.05%. These findings should assuage rich-country consumers' concerns about whether their growing demand for quinoa is having a negative influence on Andean households.

With that said, our analysis raises important questions for future research that are well beyond the scope of this article. For example, what about the indirect effects of rising quinoa prices? These could include nutritional and health outcomes,[19] agricultural wages, technology adoption, or educational outcomes. Second, though quinoa producers tend to be poorer, our analysis does not get into the distributional effects of rising quinoa prices, nor does it look at changes in poverty rates. For now, we leave these questions to future research.

Conflict of interest statement

Both Marc F. Bellemare and Seth R. Gitter have served as paid consultants for the International Trade Center (a United Nations agency in Geneva) on a project looking at the welfare impacts of rising quinoa prices in Peru in 2014–2015. The work done as part of this article was not vetted in any way, shape, or form by the International Trade Center, though some of the preliminary findings for this paper were used in a report by the International Trade Center.

Johanna Fajardo-Gonzalez has no conflict of interest to report.

Appendix A

Table A1
Household welfare trends in constant terms, 2007–2014.

Year	Non-consumers and non-producers of quinoa		Producers of quinoa		Non-producer consumers of quinoa	
	% Households	Value	% Households	Value	% Households	Value
Household consumption in 2004 PEN (excluding quinoa purchases)						
2007	72.88%	15373.10	4.56%	6782.67	22.56%	20942.94
2008	77.54%	15297.66	3.80%	6938.88	18.66%	21078.68
2009	79.31%	16502.18	4.53%	6813.98	16.16%	22627.44
2010	77.07%	16628.82	4.39%	7495.57	18.55%	22684.25
2011	76.05%	17122.51	3.80%	8754.11	20.15%	22800.02
2012	75.56%	17162.89	2.85%	9241.43	21.60%	23426.45
2013	70.81%	16693.44	3.15%	9562.72	26.04%	23571.74
2014	75.06%	16408.46	3.98%	10045.75	20.95%	24283.00
Correlation to means from full data	0.96	0.93	0.91	0.96	0.97	0.97

Note: Figures measured in 2004 PEN and exclude consumption of cultivated and purchased quinoa. All descriptive statistics are weighted using the sampling weights provided in the ENAHO. In addition to being expressed in constant (i.e., 2004) terms, all prices are deflated using departmental-level deflators.

Table A2
Descriptive statistics for quinoa consumers, 2007–2014.

Year	Proportion of quinoa-consuming households (%)	kg of whole quinoa purchased, past two weeks	Purchase price of whole quinoa per kg, 2004 PEN	Budget share of annual total consumption of quinoa, all households (%)	Budget share of annual total consumption of quinoa conditional on consumption (%)
2007	30.89%	0.81	3.18	0.12%	0.39%
2008	25.41%	0.75	4.19	0.62%	0.62%
2009	22.53%	0.71	6.37	0.71%	0.71%
2010	25.42%	0.73	6.28	0.68%	0.68%
2011	27.30%	0.75	6.14	0.70%	0.70%
2012	28.63%	0.72	6.07	0.73%	0.73%
2013	33.45%	0.66	7.37	0.80%	0.80%
2014	29.62%	0.61	10.93	0.96%	0.96%
Correlation to means from full data	0.96	0.94	1.00	0.99	

Note: Average purchase amount for households who purchased quinoa. In addition to being expressed in constant (i.e., 2004) terms, all prices are deflated using annual departmental-level deflators. Budget shares are imputed by multiplying the value of purchases in the previous two weeks by 26 and dividing by total household consumption.

[19] Stevens (2017) looks at whether the quinoa price boom has affected nutritional outcomes in the Peruvian regions where quinoa has traditionally been consumed and finds no negative effects of rising quinoa prices on nutrition.

Table A3
Descriptive statistics for quinoa producers, 2007–2014.

Year	Sample proportion of quinoa producers (%)	Sample proportion of quinoa sellers (%)	Quinoa production, past 12 months (kg), quinoa producers only	Quinoa production for own consumption (%), quinoa producers only	Average sales price (per kg, 2004 PEN)	Quinoa revenue (quinoa sellers only, 2004 PEN)	Quinoa revenue (all quinoa farmers, 2004 PEN)
2007	4.20%	0.39%	53.17	68.63%	1.40	115.39	10.76
2008	3.31%	0.22%	41.59	73.32%	1.94	148.69	9.80
2009	3.77%	0.22%	34.15	72.68%	3.07	170.20	9.87
2010	3.74%	0.28%	52.98	68.42%	2.80	298.13	22.49
2011	3.51%	0.52%	78.58	63.28%	2.94	631.26	93.47
2012	2.61%	0.44%	89.82	63.25%	3.52	899.95	150.11
2013	2.75%	0.46%	72.88	67.88%	4.23	1085.81	182.00
2014	3.37%	0.73%	310.02	63.54%	6.05	3448.68	746.99
Correlation to means from full data	0.95	0.96	0.97	0.92	1.00	0.99	0.99

Note: All descriptive statistics are weighted using the sampling weights provided in the ENAHO. In addition to being expressed in constant (i.e., 2004) terms, all prices are deflated using departmental-level deflators.

Appendix B

Table B1
Robustness checks with the panel sub-sample of the ENAHO.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Proportion of quinoa consumers × Log of international price of quinoa	0.009***	0.008***	0.009***	0.009***	0.008***	0.009***	0.009***	0.007***	0.008***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Proportion of quinoa producers × Log of international price of quinoa	0.010***	0.010***	0.010***	0.011***	0.010***	0.011***	0.010***	0.007**	0.010***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Quinoa producers × Quinoa consumers × Log of international price of quinoa	−0.007**	−0.006**	−0.007**	−0.007***	−0.007**	−0.007**	−0.006**	−0.002	−0.007**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Constant	−27.537***	9.231***	9.171***	−26.500***	9.244***	−25.909***	9.235***	8.675***	9.323***
	(7.907)	(0.020)	(0.001)	(0.066)	(0.001)	(0.064)	(0.001)	(0.003)	(0.002)
Observations	74,729	74,729	74,729	74,729	74,729	74,729	74,729	11,773	62,097
R-squared	0.010	0.011	0.063	0.024	0.074	0.014	0.030	0.056	0.029
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Linear trend	Yes	No	No	No	No	Yes	Yes	Yes	Yes
Year fixed effects	No	Yes	No	No	No	No	No	No	No
District-specific linear trends	No	No	Yes	No	No	No	No	No	No
Province-specific linear trends	No	No	No	Yes	No	No	No	No	No
Province-year fixed effects	No	No	No	No	Yes	No	No	No	No
Department-specific linear trends	No	No	No	No	No	Yes	No	No	No
Department-year fixed effects	No	No	No	No	No	No	Yes	Yes	Yes
Quinoa producing districts only	No	No	No	No	No	No	No	Yes	No
Quinoa consuming districts only	No	No	No	No	No	No	No	No	Yes

Appendix C

Table C1a

Pseudo-panel regression of total household consumption on the proportion of households who consume quinoa treating districts as units of observation, 2004–2014.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable: median log of total household consumption (in 2004 PEN)							
% of Quinoa consumers × Log of international price of quinoa	0.057***	0.038***	0.035***	0.038***	0.038***	0.030***	0.034***
	(0.004)	(0.003)	(0.004)	(0.003)	(0.003)	(0.004)	(0.006)
Constant	8.895***	8.702***	8.699***	−63.936***	−61.788***	8.785***	8.332***
	(0.006)	(0.010)	(0.005)	(2.340)	(2.421)	(0.012)	(0.023)
Observations	10,774	10,774	10,774	10,774	10,774	7,814	2,678
R-squared	0.040	0.169	0.401	0.234	0.201	0.156	0.163
District fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Linear trend	No	Yes	No	No	Yes	Yes	Yes
Year fixed effects	No	No	No	No	No	No	No
District-specific linear trends	No	No	Yes	No	No	No	No
Province-specific linear trends	No	No	No	Yes	No	No	No
Province-year fixed effects	No	No	No	No	No	No	No
Department-specific linear trends	No	No	No	No	Yes	No	No
Quinoa producing only	No	No	No	No	No	No	Yes
Quinoa consuming only	No	No	No	No	No	Yes	No

Note: *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.
Standard errors clustered at the district level are shown in parentheses. Each household is weighted according to the sampling weight it was given in the ENAHO. In addition to being expressed in constant (i.e., 2004) terms, all prices are deflated using departmental-level deflators.

Table C1b

Pseudo-panel regression of total household consumption on the proportion of households who consume quinoa treating provinces as the units of observation, 2004–2014.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: median log of total household consumption (in 2004 PEN)						
% Quinoa consumers × Log of international price of quinoa	0.103***	0.045***	0.039***	0.045***	0.041***	0.022*
	(0.012)	(0.010)	(0.010)	(0.011)	(0.010)	(0.012)
Constant	8.838***	8.714***	8.722***	8.723***	8.733***	8.518***
	(0.022)	(0.021)	(0.015)	(0.020)	(0.020)	(0.030)
Observations	2,113	2,113	2,113	2,113	1,939	956
R-squared	0.088	0.338	0.505	0.372	0.344	0.361
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Linear trend	No	Yes	No	No	Yes	Yes
Year fixed effects	No	No	No	No	No	No
Province-specific linear trends	No	No	Yes	No	No	No
Department-specific linear trends	No	No	No	Yes	No	No
Quinoa producing only	No	No	No	No	No	Yes
Quinoa consuming only	No	No	No	No	Yes	No

Note: *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.
Standard errors clustered at the province level are shown in parentheses. Each household is weighted according to the sampling weight it was given in the ENAHO. In addition to being expressed in constant (i.e., 2004) terms, all prices are deflated using departmental-level deflators.

Table C1c

Pseudo-panel regression of total household consumption on the proportion of households who consume quinoa treating departments as the units of observation, 2004–2014.

	(1)	(2)	(3)	(4)
Dependent variable: median log of total household consumption (in 2004 PEN)				
% Quinoa consumers × Log of international price of quinoa	−0.031	−0.046*	−0.031	−0.040**
	(0.022)	(0.023)	(0.022)	(0.018)
Constant	−71.256***	9.155***	9.122***	8.982***
	(8.229)	(0.034)	(0.043)	(0.054)
Observations	275	275	275	164
R-squared	0.655	0.801	0.655	0.654
Department fixed effects	Yes	Yes	Yes	Yes
Linear trend	No	No	Yes	Yes
Year fixed effects	No	No	No	No
Department-specific linear trends	No	Yes	No	No
Date of survey	No	No	No	No
Quinoa producing only	No	No	No	Yes
Quinoa consuming only	No	No	Yes	No

Note: *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.
Standard errors clustered at the department level are shown in parentheses. Each household is weighted according to the sampling weight it was given in the ENAHO. In addition to being expressed in constant (i.e., 2004) terms, all prices are deflated using departmental-level deflators.

Table C2a
Pseudo-panel regression of total household consumption on the proportion of households who produce quinoa treating districts as units of observation, 2004–2014.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable: median log of total household consumption (in 2004 PEN)							
% of Quinoa producers × Log of international price of quinoa	0.020***	0.012**	0.015**	0.013**	0.013**	0.007	0.005
	(0.007)	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)	(0.008)
Constant	8.987***	8.750***	8.738***	−68.467***	−66.126***	8.844***	8.418***
	(0.004)	(0.009)	(0.003)	(2.343)	(2.432)	(0.010)	(0.023)
Observations	10,774	10,774	10,774	10,774	10,774	7814	2678
R-squared	0.002	0.152	0.391	0.218	0.186	0.144	0.145
District fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Linear trend	No	Yes	No	No	Yes	Yes	Yes
Year fixed effects	No	No	No	No	No	No	No
District-specific linear trends	No	No	Yes	No	No	No	No
Province-specific linear trends	No	No	No	Yes	No	No	No
Province-year fixed effects	No	No	No	No	No	No	No
Department-specific linear trends	No	No	No	No	Yes	No	No
Quinoa producing only	No	No	No	No	No	No	Yes
Quinoa consuming only	No	No	No	No	No	Yes	No

Note: *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.
Standard errors clustered at the district level are shown in parentheses. Each household is weighted according to the sampling weight it was given in the ENAHO. In addition to being expressed in constant (i.e., 2004) terms, all prices are deflated using departmental-level deflators.

Table C2b
Pseudo-panel regression of total household consumption on the proportion of households who produce quinoa treating provinces as units of observation, 2004–2014.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: median log of total household consumption (in 2004 PEN)						
% of Quinoa producers × Log of international price of quinoa	0.014	−0.014	−0.002	−0.010	−0.014	−0.031*
	(0.017)	(0.016)	(0.017)	(0.016)	(0.016)	(0.016)
Constant	9.019***	8.785***	8.778***	8.793***	8.805***	8.600***
	(0.009)	(0.016)	(0.008)	(0.014)	(0.016)	(0.026)
Observations	2113	2113	2113	2113	1939	956
R-squared	0.001	0.324	0.496	0.358	0.331	0.363
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Linear trend	No	Yes	No	No	Yes	Yes
Year fixed effects	No	No	No	No	No	No
Province-specific linear trends	No	No	Yes	No	No	No
Department-specific linear trends	No	No	No	Yes	No	No
Quinoa producing only	No	No	No	No	No	Yes
Quinoa consuming only	No	No	No	No	Yes	No

Note: *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.
Standard errors clustered at the province level are shown in parentheses. Each household is weighted according to the sampling weight it was given in the ENAHO. In addition to being expressed in constant (i.e., 2004) terms, all prices are deflated using departmental-level deflators.

Table C2c
Pseudo-panel regression of total household consumption on the proportion of households who produce quinoa treating departments as units of observation, 2004–2014.

	(1)	(2)	(3)	(4)	(5)
Dependent variable: median log of total household consumption (in 2004 PEN)					
% of Quinoa producers × Log of international price of quinoa	−0.075	−0.075	−0.078	−0.075	−0.080
	(0.095)	(0.095)	(0.073)	(0.095)	(0.092)
Constant	−68.109***	9.097***	9.108***	9.097***	8.946***
	(7.950)	(0.039)	(0.020)	(0.039)	(0.062)
Observations	275	275	275	275	164
R-squared	0.655	0.655	0.797	0.655	0.653
Department fixed effects	Yes	Yes	Yes	Yes	Yes
Linear trend	No	Yes	No	Yes	Yes
Year fixed effects	No	No	No	No	No
Department-specific linear trends	No	No	Yes	No	No
Quinoa producing only	No	No	No	No	Yes
Quinoa consuming only	No	No	No	Yes	No

Note: *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.
Standard errors clustered at the department level are shown in parentheses. Each household is weighted according to the sampling weight it was given in the ENAHO. In addition to being expressed in constant (i.e., 2004) terms, all prices are deflated using departmental-level deflators.

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