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"How Changes in the Indian Market Price for Crops Affect Terms of Trade and Farmer Welfare"

1: Abstract:

This paper determines if Indian farming households rose or fell in welfare after an increase in the Indian (domestic) crop price. I examine India Human Development Survey (IHDS) data from two different "waves," 2004-5 (wave one) and 2011-12 (wave two), which surveyed more than 40,000 households across India. To determine welfare change, I calculate a metric named here "net share" that, when negative means the farmer decreased in economic welfare and when positive correlates to an increase in welfare. Finally, I examine characteristics of the farming households that had negative net shares and compare them to those with positive net shares. This research is both novel and highly useful for a country's trade policy. So far, no publications have used this in-depth IHDS questionnaire to examine the impact of price changes on farmer welfare. Furthermore, due to the impact an open market has on price fluctuations, the results of this paper have important economic and policy implications on whether or not a country should open up its borders to trade liberalization.

The paper is structured as follows: Section 2 presents background information on India and its trade policy, Section 3 details the IHDS data, Section 4 expounds on previous literature surrounding the topic, Section 5 explains the methodology, Section 6 presents the results, and Section 7 concludes.

2: Background on Farmers and Trade Policy in India:

Indian farmers are in a crisis. According to Aggarwal (2019), "in the past ten years, more than 300,000 farmers have committed suicide." Annual income data compiled by Narayanamoorthy (2006) helps us visualize their living conditions. Results from the "Income, Expenditure, and Productive Assets of Farmer Households" survey carried out by the Indian National Sample Survey Organization in 2003 showed that, on average across Indian states, the farmer household receives Rs 25,380 per year. However, only 45% of that income comes from cultivation; 39% alone is accounted for by wage income outside of the farm. Thus, cultivation income amounts to only about Rs 11,628 per year, on average, or a meager 167.45 USD (Narayanamoorthy 471). Even worse, many farmers face cultivation expenditures that exceed their cultivation incomes. This translates to indebtedness on a state-level. As shown in Table 1, Indian states with lower net incomes (column 7) correlate with states facing higher rates of indebtedness (columns 8 and 9).

States (1)	Annual Cultivation Income (2)	Annual Total Income (3)	Annual Cultivation Expen-diture (4)	Annual Consump-tion Expen-diture (5)	(2) – (4) (6)	(3) – (5) (7)	Incidence of Indebted-ness (Per Cent) (8)	Extent of Indebted-ness (9)
AP	8916	19608	12085	28632	-3169	-9024	82.0	23965
Assam	21504	37932	3370	32568	18134	5364	18.1	813
Bihar	10152	21720	6809	29508	3343	-7788	33.0	4476
Gujarat	13968	32208	11456	37524	2512	-5316	51.9	15526
Haryana	17928	34584	18270	52968	-342	-18384	53.1	26007
J&K	29112	65856	6342	49308	22770	16548	31.8	1903
Karnataka	15192	31392	10344	31296	4848	96	61.6	18135
Kerala	13440	48048	7793	51000	5647	-2952	64.4	33907
MP	11952	17160	8886	28068	3066	-10908	50.8	14218
Maharashtra	15156	29556	10793	32268	4363	-2712	54.8	16973
Orissa	4032	12744	3143	20364	889	-7620	47.8	5871
Punjab	33864	59520	25945	58080	7919	1440	65.4	41576
Rajasthan	4308	17976	7668	39456	-3360	-21480	52.4	18372
Tamil Nadu	7908	24864	8597	30072	-689	-5208	74.5	23963
Uttar Pradesh	10032	19596	9151	34788	881	-15192	40.3	7425
West Bengal	8844	24948	8429	32016	415	-7068	50.1	5237
All-India	11628	25380	8791	33240	2837	-7860	48.60	12585

Sources: NSSO (2005 and 2005b).

Table 1: Income, Expenditure and Indebtedness of Farmer Households, July 2002-June 2003 (Rs). From Narayanamoorthy (2006). Note especially negative net income (col 7).

Thus, it is not difficult to see why 40% of farmers would quit agriculture for another job (NSSO 2005:11). Narayanamoorthy lists several hypotheses as to why Indian farmers face such low (and often negative) net incomes. Among them are "spurious" seed, fertilizer, and pesticide consumption leading to crop failure, middlemen who take over 60% of the final selling price of an agricultural commodity, borrowing from non-institutional sources with high interest rates, and "decelerating prices" (472). Whatever the cause, the impoverished state of Indian farmers demands reform in agrarian practice and policy.

In this paper, I will examine one piece of this puzzle. Namely, does the crop price increase that occurred between 2004-5 and 2011-12 (here, named wave one and wave two) help or hurt farmers? Since price changes such as these are exacerbated by an open trading policy, we must briefly analyze the history of Indian trade policy.

Before examining Indian trade policy, it is helpful to be familiar with the overall economic landscape of India to understand the economic role farmers play. India is one of the largest countries by population, as well as GDP, in the world. Table 2 summarizes key economic facts about India, for reference.

GDP (2017 EST.)	9.459 trillion USD
GDP REAL GROWTH RATE (2017)	6.7%
GDP PER CAPITA (2017 EST.)	7,200 USD
GDP COMPOSITION (2016 EST.)	Agriculture: 15.4% Industry: 23% Services: 61.5%
LABOR FORCE BY OCCUPATION (2014 EST.)	Agriculture: 47% Industry: 22% Services: 31%
KEY AGRICULTURAL PRODUCTS	Rice, Wheat, Oilseed, Cotton, Jute, Tea, Sugarcane, Lentils, Onions, Potatoes, Dairy Products, Sheep, Goats, Poultry, Fish
EXCHANGE RATES (2013 & 2017, RESPECTIVELY)	61.03 Rs/USD, 65.17 Rs/USD

EXPORTS (2017)	299.3 billion USD
EXPORTS: COMMODITIES	petroleum products, precious stones, vehicles, machinery, iron and steel, chemicals, pharmaceutical products, cereals, apparel
EXPORT PARTNERS (2017)	US 15.6% UAE 10.2% Hong Kong 4.9% China 4.3%
IMPORTS (2017)	426.8 billion USD
IMPORTS: COMMODITIES	crude oil, precious stones, machinery, chemicals, fertilizer, plastics, iron and steel
IMPORT PARTNERS (2017)	China 16.3% US 5.5% UAE 5.2% Saudi Arabia 4.8% Switzerland 4.7%

Table 2: Key economic facts about India. Note the moderately high fraction of the labor force involved in agriculture (47%). (South Asia:: India, 2019)

Still, there a few important demographics that this summary excludes. While agriculture employs roughly 47% of the entire population as shown in Table 2, it employs 70% of India's rural workforce (Himanshu et al, 2011). Thus, we can see that there is a division of labor between rural and urban areas, with urban areas accounting for a smaller portion of farmers than rural areas. Additionally, the overall rural population is quite large-75% of India's population. Concerningly, however, the rural population is home to many (approximately 75%) of the poor in India (Himanshu et al, 2011). This adds gravity to the question posed in this paper: how do crop price increases affect farmers? If they increase their welfare, then one would expect poverty in India to decrease after a price increase since such a large percentage of the poor are employed in rural agriculture. Yet, if this price increase decreases their welfare, the rural poor could suffer devastation.

Now we will investigate the history of India's trade policy to better understand the government's position on a liberal versus closed trade policy. Before 1991, India's global trade was limited and protectionist. Using world prices from the UNCTAD Monthly Commodity Price Bulletin as well as annual averages of wholesale crop prices, Nayyar and Sen (1994) graph 15 different crop prices over the period of 1980 to 1990. They found that rice, cotton, coffee, tobacco, pepper, and bananas had a consistently lower price in India compared to the world price, while sugar, rubber, and oilseeds were more expensive in

India than the global market. India controlled domestic prices of these goods above or below the world price by regulating the volume or value of imports and exports. The reasoning behind this policy was to have a large domestic supply of agricultural commodities, which would reduce the price to Indian consumers (Nayyar & Sen, 1994). Thus, the Indian government was effectively repressing price fluctuations inherent in an open world market.

In 1991, at about the time when other developing countries, such as those in Latin America, began to pursue a market-based, liberalized economy, the Indian government also implemented a program to open their economy. They hoped to match their domestic import and export prices to the world prices. The only exports the public sector did not allow the private sector to produce were onions, while the only imports were cereals, oilseeds, and edible oils (Nayyar & Sen, 1994). While Nayyar and Sen do not provide a reason that these specific goods were not decanalized, it can be hypothesized that it was the same reason that India controlled prices before 1991: price stability.

Since the government's shift towards a more liberal trade policy, trade as a percentage of GDP has increased from 15% in 1990 to 35% in 2005. With non-agricultural tariffs reduced to less than 15% (down from an average tariff rate of 200% pre-1990s), quotas eliminated, and foreign investment more relaxed, the Indian economy "is now among the fastest growing in the world" (India: Foreign Trade, 2013).

Furthermore, India formed bilateral and regional trade agreements to facilitate their open policy, including 1) the India-Sri Lanka Free Trade Agreement, 2) the Trade Agreements with Bangladesh, Bhutan, Sri Lanka, Maldives, China, and South Korea, 3) the India-Nepal Trade Treaty, 4) the Comprehensive Economic Cooperation Agreement (CECA) with Singapore, and 5) Framework Agreements with the Association of Southeast Asian Nations (ASEAN), Thailand and Chile. However, there is still room for India to liberalize, since agricultural tariffs still amount to 30-40%, anti-dumping measures are in place, and a ban still exists on foreign investment in retail trade (India: Foreign Trade, 2013).

Why is India's trade policy important for this paper? Because trade policy affects prices. Fluctuating prices are inherent in open world trade, while price stability is an effect of a closed trade policy. Since I examine the effect of a price increase on farmer welfare, it is extremely relevant for politicians to know whether the open trade policy causing this price increase helps or hurts their farmer population.

This topic is especially relevant to politicians now. The Indian parliamentary elections begin soon (April 11 through May 19, 2019), and farmers' unions are demanding action from their government. According to Aggarwal (2019), among the 18 items in their agenda include: a special parliamentary session focused on this crisis, improved crop insurance, annual income support of Rs 10,000/acre per farmer, and better social security. Although the Indian government has responded quickly, saying they have made their budget more advantageous for farmers and will provide Rs 6,000/year to farmers with less than two hectares of land, farmers still say it is not enough (Aggarwal, 2019). In order to build stability in India, farmers must be supported by their own government. This paper will elucidate the effect of price increases on farmer welfare, which could be extremely beneficial to Indian policymakers.

Before moving on to the Data section of the paper, I will briefly introduce a counterargument to the agriculture-focused solution (i.e. improving farmer practice and policy) for Indian farmers. Some argue that improving farmer practice and policy is not the only way to approach poverty reduction. Scholars such as Himanshu et al. (2011) argue for a shift in labor composition from agriculture to the non-farm sector, which includes Manufacturing, Construction, Social services, Trade, Transport, and Communication jobs. This sector has grown since the 1980s, especially in the late 1990s through mid-2000s, while the agricultural employment has decreased since the 1970s. Himanshu et al. claim that the rural non-farm sector is a "key source of jobs," as displayed in Figure 1.

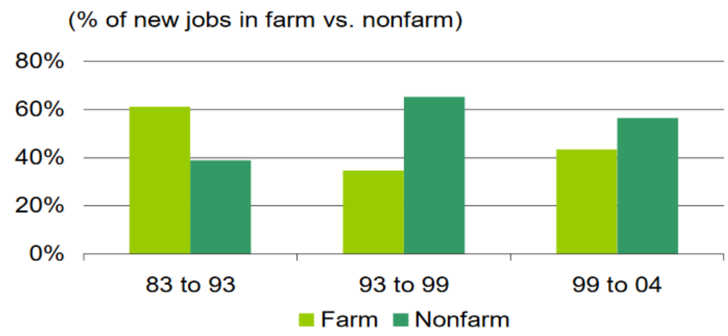


Figure 1: Percent of New Jobs in the Farm versus Nonfarm sector, from 1983-2004. One can see how, over time, the percent of new jobs in the Nonfarm sector has outweighed those in the Farm sector. From Himanshu et al, 2011.

Additionally, Himanshu et al. (2011) showed econometrically that the expansion of the non-farm sector decreases poverty both directly and indirectly by increasing the agricultural wage (since the supply of farm laborers decreases as more of the rural population seeks non-farm employment). While the goal of this paper is not to focus on the non-farm sector, it is worthwhile to keep in mind that improving farming conditions is not the only way to fight poverty.

3: Data:

In order to determine the effect of crop price changes to Indian farmer welfare, microdata is best since it has detailed data on a vast quantity of farmers. I used the India Human Development Survey (IHDS), which is a:

> Nationally representative, multi-topic survey of 41,554 households in 1503 villages and 971 urban neighborhoods across India ... [in which the] first round of interviews were completed in 2004-5... [and a] second round of IHDS reinterviewed most of these households in 2011-12 (N=42,152). (Desai & Vanneman, 2015)

This survey is divided into several different questionnaires, including: Household, Individual, Medical facility, primary school, village data, crop production[1], and others.

[1] Only available in wave 1 (2004-5)

Table 3 reviews key statistics regarding the samples in waves one and two, which give us a picture of the sample households.

CATEGORY	SPECIFICS	2004-5 (WAVE 1)	2011-12 (WAVE 2)
RELIGION	Hindu	80.7%	81.6%
	Muslim	11.5%	11.7%
	Christian	3.3%	2.9%
	Sikh	2.4%	2.3%
	Buddhist, Jain, Tribal, Others	2.1%	1.5%
CASTE	Brahmin	5.8%	5.2%
	Forward caste	17.2%	16.7%
	Other Backward Caste	33.9%	33.9%
	Dalit	20.1%	21.2%
	Adivasi	8.3%	8.6%
	Muslim, Christian, Sikh, or Jain	13.7%	14.9%
MAIN INCOME SOURCE	Cultivation	23.6%	24.4%
	Non-Ag Wage Labor	17.6%	22.5%
	Salaried	20.4%	19.3%
	“Petty shop”	4.5%	11.1%
	Ag Wage Labor	13.6%	10.1%
	Artisans, Organized businesses, Professions, or Other	20.3%	12.6%

OWN OR CULTIVATE LAND	Yes	41.9%	44.6%
	No	58.1%	55.4%
RURAL OR URBAN?	Rural	65%	65.4%
	Urban	33%	34.6%
	Slums	2%	NA
ABOVE POVERTY LINE?	Yes	80.3%	83.5%
	No (poor)	19.6%	16.4%

Table 3: Key Demographics regarding the IHDS Sample in 2004-5 and 2011-12.

The IHDS is unique in that it contains microdata that can be linked between the two waves (2004-5 and 2011-12), providing quasi- panel data. While the National Sample Survey Organization[2] (NSS) has extensive data on household consumption per year since the 1970s, it was not used here since it aggregates data on a state level, losing detailed information on household changes across time. Although the IHDS data is smaller in household quantity and years observed (only two waves) than the sample surveyed by the NSS, its questions are more detailed than any survey before it. For example, it is the first in India to record income, caste, and religious affiliation since 1931 (Khamis et al, 2012).

4: Previous Literature

I divide this section into three parts for greater clarity. The first briefly discusses publications that have used the IHDS data, the second relates literature citing various reasons behind agricultural production inefficiencies and the third explores literature on crop price changes. The first part of this section determines what has already been done before with the IHDS data and what areas could be further explored, while the second and third help construct a theoretical framework and hypothesis for the tests I will conduct using the IHDS data.

[2] part of the Indian Government's Ministry of Statistics & Programme Implementation

4.1: Publications that have used this data

Many publications have used this data. However, most of them deal with health aspects or gender inequality issues in India. Surprisingly, a very small amount deal with crop price changes. Three of these publications are summarized below.

In 2012, Oldiges used the IHDS data from wave one (2004-5) to conclude that per capita cereal consumption does not vary significantly among different income levels, but does increase as monthly per capita expenditures increase. The IHDS data was crucial in determining the regional, as well as occupational (i.e. the labor activity of an individual was correlated with his or her consumption), differences in per capita cereal consumption. For the purpose of this paper, it is important that Oldiges (2012) compared the IHDS data with the NSS, 2001 Census, and National Family Health Survey data since Oldiges thought the IHDS "require[d] some scrutiny." This comparison of different variables, such as "scheduled tribe population," knowledge of AIDS, and households with electricity, yielded similar statistics between the four different surveys, increasing the IHDS's credibility. Thus, this gives us more confidence that the 40,000-household sample in the IHDS data is a good representation of the entire Indian population.

In 2012, Khamis, Prakash, and Siddique published another paper using IHDS data that researched patterns of consumption among different religious groups and castes. They found that "Other Backward Castes (OBCs) spend more on visible consumption [such as bicycles and scooters, footwear, household repairs, and vacations] than Brahmin and High Caste groups," and spend less on education (364). This publication emphasizes the richness of the IHDS data regarding the sample's religious affiliation and caste.

Finally, another paper used IHDS data to find caste differences in net farmer income per acre (Singh 2011). This publication and its relevance to this paper will be explored in the next section.

While these three publications use the IHDS data to research crop or commodity consumption, no publications have used this rich dataset to determine the effect of domestic crop price changes on farmer welfare. Thus, my project is indeed novel.

4.2: Literature on causes of agricultural production inefficiencies

As I will explain later in my paper, I will focus on several dependent variables to measure the characteristics of farmers after the price increase. Some of these variables are: age, level of education, and caste. Part of the reason why I chose these variables was that previous publications have stated their influence on farmer output.

In the first of these publications, Coelli and Battese (1996) built a production frontier function with the natural log of the value of output on the left with hectares of land, human labor, the year of observation, and costs of other inputs on the right. They included two important error terms: one for unobserved measurement error and another for the "technical inefficiency of production." Using data from three villages in Andhra Pradesh, they found that the farmer's age and level of education, as well as farm size, have significant effects on production efficiency. Specifically, all three of these factors were inversely correlated to technical inefficiency. Building off of this publication, I will test the variables age, education, and farm size to determine if these variables differ in farmers who did better after the price change versus those who did not fare as well.

Another study (mentioned above in Section 4.1) measured the role of caste in cultivation income. Using the IHDS 2004-5 data, Singh (2011) determined that the profit per acre was higher for higher castes (termed "Other Castes"). This finding is surprising. Indeed, castes were known to differ in terms of unequal land holdings,[3] but once amount of land and years of education were accounted for, Singh *still* found differences in net income between different castes. Singh argues that this can best be explained by *social* exclusion practices between castes, as well as exclusion from *public resources* such as water wells and public grounds. Lower castes also have worse plots of land, with lower soil fertility than

[3] Singh (2011) cites Deshpande 2001; Thorat 2002; Gaiha et al., 2007; and Bakshi 2008

those of higher castes. In addition, Singh cites a study by Action Aid (2000) that found other reasons why lower caste farmers had lower net incomes. Firstly, they face discrimination through higher input prices, yielding lower profits. Secondly, they have restrictions on selling food in the market place, therefore lowering their selling price and overall revenues. In this paper, in addition to the variables of age, education, and farm size, I would like to explore if the caste of farmers who did better after the price increase differed significantly from those who did not do so well. Building off of Singh's paper, I would hypothesize that farmers who did well after a price increase were of higher castes than those who did not do as well.

4.3: Literature on Crop Price Changes

According to De Janvry and Sadoulet's theory (2016), the farmer household is both a "firm" that sells all they produce *as well as* a consumer who buys everything they consume.[4] Thus, since this paper focuses on farmers, we must also briefly discuss consumer buying patterns. Specifically, we will discuss elasticity of demand and income elasticity for crops.

Literature on crop price changes suggests two "frames" that determine crop elasticity of demand and income elasticity of demand: one's income bracket (e.g. poor, middle, or upper socioeconomic class), and the crop itself. According to Seale et al.'s empirical work in 2003, the elasticity of demand for a broad range of consumption categories such as clothing, house operations, education, recreation, and food for low income countries was greater in magnitude than that of high-income countries. For example, on average, low income countries had price elasticities of -0.426, middle-income had -0.302, and high-income countries had -0.138 in 1996 for cereals. India was not included in this publication, however, as a developing country, one can estimate that its elasticity of demand is also very

[4] For example, let's look at the example of a rice-farming household. They may produce five hectares of rice but consume one hectare and sell the other four. Therefore, under de Janvry and Sadoulet's theory, we would say that this household first behaved as a firm and sold all five hectares of rice, then bought one hectare at the "market."

high in magnitude. Furthermore, Seale et al. determined empirically that lower-income countries have higher income elasticities than higher-income countries, and that these lower-income countries spend a larger percentage of their income on staples and lower-value foods.

The crop itself also affects elasticity of demand and income elasticity. Both Seale et al., as well as Kumar et al. (2011), confirm that high-value food has a larger absolute elasticity of demand. In other words, quantity demanded for cereals, a low-value, staple crop, is more resistant to price changes than, for example, dairy, or meat. In terms of income elasticity, both publications show that the income elasticity increases as the value of the commodity increases. These results are summarized below:

$$|low\ income\ \varepsilon| > |high\ income\ \varepsilon|$$

$$|low\ income\ \mu| > |high\ income\ \mu|$$

$$|low\ value\ good\ \varepsilon| < |high\ value\ good\ \varepsilon|$$

$$|low\ value\ good\ \mu| > |high\ value\ good\ \mu|$$

where ε is elasticity of demand and μ is income elasticity.

5: Method

I will be using the framework of terms of trade to determine whether farmer welfare increased or decreased after the price increase. This framework is adapted from Berka and Crucini (2009), which uses the production and consumption terms of trade to ascertain the sources of variability in different countries' terms of trade. In this paper, the metric with which I will test farmer welfare most resembles Berka and Crucini's "production terms of trade," which, put simply, is the aggregate value of exports for all exported goods out of a country minus the aggregate value of imports for all imported goods into a country. However, in my test, the difference is that the country is replaced with a farmer household whose exports are her farm's produced goods and imports are her consumed goods.

To understand the effect terms of trade has on farmer welfare, we will first analyze a simple graph, adapted from Professor Mario J. Crucini (2019):

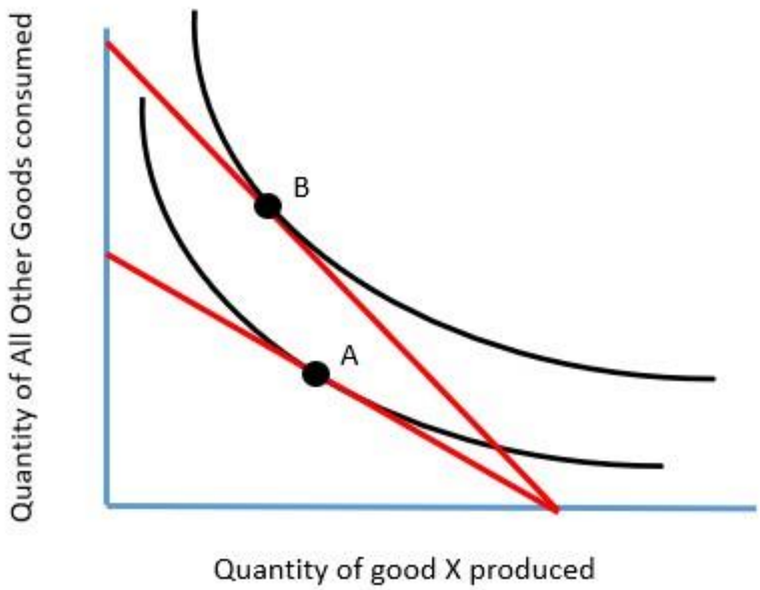


Figure 2: An improvement of terms of trade in the short run. Note how the total quantity of X produced remains fixed and the indifference curve is higher.

This graph represents an improvement in terms of trade in the short run. With international trade terminology, the X-axis to the left of point "A" can be translated as consumption of the export X, and the right of "A" as exports of X produced by the country. Meanwhile, the Y-axis is imports of All Other Goods (AOG) into a country. Again, in this paper, the farmer household replaces the country, and exports/imports are sales/purchases, respectively, in an Indian market. Therefore, the farmer's budget constraint generally has the following equation:

$$expenditure = \sum_{j=1}^{n} P_{jt} C_{jt}^{i} \quad \leq income = \sum_{j=1}^{n} P_{jt} Y_{jt}^{i} \quad ,$$

which calculates the summation of the products of price P for a given good j and a given year t, with the quantity consumed C or produced Y for each individual farmer i. In the graph, this budget constraint be summarized as:

$$AOG \times P_{AOG} \leq X \times P_X.$$

Because the relative price of good X has increased (i.e. price of AOG has decreased relative to good X), the farmer household can purchase more AOG. Furthermore, as shown in the graph by the higher indifference curve, the farmer attains a higher level of satisfaction after the improvement of terms of trade. Thus, the farmer's welfare increased.

In the long run, however, the graph is slightly different. The farmer realizes that they can produce more of good X since its value has increased, thereby raising their budget constraint.

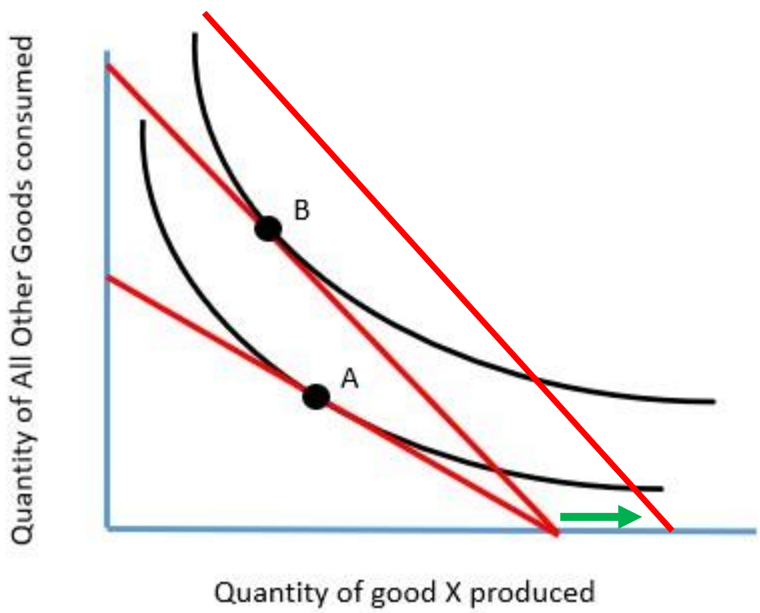


Figure 3: An improvement of terms of trade in the long run. Now, the total quantity of X produced increases and the farmer can reach an even higher indifference curve than in the short run.

While it would be interesting to note how farmer welfare in India is affected in the long term after a price change, the IHDS data unfortunately does not make this possible. The authors have not yet compiled the quantities of crops produced in wave two, so in this paper we will assume that the time spanning 2004-5 and 2011-12 is the short run.

Now that we better understand the theory of how terms of trade impact farmer welfare, we will explore the final piece of the methodology: how to determine if farmer welfare increased or decreased by calculating our "net share" dependent variable.

Briefly, this dependent variable is the metric below:

$$net\ share = (\theta_2^y - \theta_2^c) - (\theta_1^y - \theta_1^c)$$

which calculates the difference between aggregate production share of all goods *j* minus the aggregate consumption share of all goods *j* in wave one versus wave two. The rationale for calculating this "net share" will be explained shortly after presenting the calculation of this metric.

First, to calculate θ_{jt}^y, which is the production share of a good *j* in wave one (t=1) or two (t=2), we simply use the following equation:

$$t = 1\frac{P_{j1} \times Y_{j1}}{P_1 \times Y_1}$$

$$t = 2\frac{P_{j2} \times Y_{j1}}{P_1 \times Y_1},$$

in which *Y* represents the quantity produced in production share. We can use the same calculation for θ_{jt}^c, except with *C* substituting *Y* for the quantity consumed of a particular good. Simply put, θ_{jt} is the revenue (or expenditure) from one good divided by the total household income (or total household expenditure). As explained previously, the data only allows us to use wave one quantities produced. Thus, both production and consumption θ_{jt} values in wave two differ from wave one in that the price is adjusted for each good.

Once we calculate θ_{jt} for many goods *j*, for example, goods 1, 2, 3, 4, and 5, we can build consumption and production share vectors for each household in each time period (wave one or wave two).

$$\begin{bmatrix} \theta_{1t}^{c} \\ \theta_{2t}^{c} \\ \theta_{3t}^{c} \\ \theta_{4t}^{c} \\ \theta_{5t}^{c} \end{bmatrix} consumption\ share\ vector$$

$$\begin{bmatrix} \theta_{1t}^{p} \\ \theta_{2t}^{p} \\ \theta_{3t}^{p} \\ \theta_{4t}^{p} \\ \theta_{5t}^{p} \end{bmatrix} production\ share\ vector$$

Next, we add up all of the values in each vector to generate the aggregate share, θ_t^y for production and θ_t^c for consumption. In wave one, this should equal one in both vectors. For the final step, we calculate $\theta_t^y - \theta_t^c$ for each household. Once we have this value for wave one and wave two, we can subtract wave one from wave two, generating our "net share" dependent variable of interest:

$$net\ share = (\theta_2^y - \theta_2^c) - (\theta_1^y - \theta_1^c).$$

How will this help us determine the impact of a price increase on farmer welfare? This is best illustrated by the following example. Suppose a rice farmer in India produces only rice and no other product. Furthermore, she and her household consume two goods only: beef and rice. In wave one, she budgets her yearly disposable income and uses 3/5 of her disposable income to "purchase" rice[5] and 2/5 of it for meat consumption. Thus, her wave one production and consumption share vectors (with rice on the top and meat on the bottom) are as follows:

$$\begin{bmatrix} 1 \\ 0 \end{bmatrix} = production\ share$$

[5] as explained before, her household may simply consume from their own rice field

$$\begin{bmatrix} 0.6 \\ 0.4 \end{bmatrix} = consumption\ share.$$

Calculating $\theta_t^y - \theta_t^c$ for wave one, we have $1 - 1 = 0$. Now let's say there is a shock to the quantity of rice supplied in the world, or an increased demand for rice because consumers note a health benefit in rice. Thus, there will be a relative price change in India, in which the price of rice increases by 20%. This is synonymous with a terms of trade increase as shown in Figure 2. Therefore, holding total quantities produced constant (quantity consumed can change), her household's new production and consumption share vectors are:

$$\begin{bmatrix} 1.2 \\ 0 \end{bmatrix} = production\ share$$

$$\begin{bmatrix} 0.72 \\ 0.4 \end{bmatrix} = consumption\ share.$$

Now, $\theta_t^y - \theta_t^c$ for wave two is $1.2 - 1.12 = 0.08$. Since $0.08 > 0.00$, the farmer's welfare in this example increased because she and her household now have more disposable income to spend on all other goods (AOG).

When I calculated the "net share" metric, I adjusted the sample due to a couple of obstacles in the data set. First, I only used five goods *j* since the data set did not include the prices for other goods in wave two. The only goods the survey collected per-kilogram prices on were: rice, wheat or flour, sugar, pulse products (legumes), and other cereals. While this slightly limits the scope of my test, it also leads to a more focused analysis of five important goods. Furthermore, households that split up in the time between wave one and wave two were taken out of the data set since they led to merging errors. This resulted in a sample size of 5,666 farmers who produced one or more of the crops (rice, wheat or flour, sugar, pulse products (legumes), or other cereals) and consumed one or more of these goods.

6: Results

After aggregating the production shares of rice, wheat (or flour), sugar, other cereals, and pulse products for each farmer (as shown in the Production Share Vector in "Methods," I plotted a histogram (Figure 4) of the frequencies of this aggregate production share, θ_2^y, among all farmers. Next, I did the same (Figure 5) for the consumption shares of rice, wheat (or flour), sugar, other cereals, and pulse products for those same farmers. This aggregate consumption share is θ_2^c.

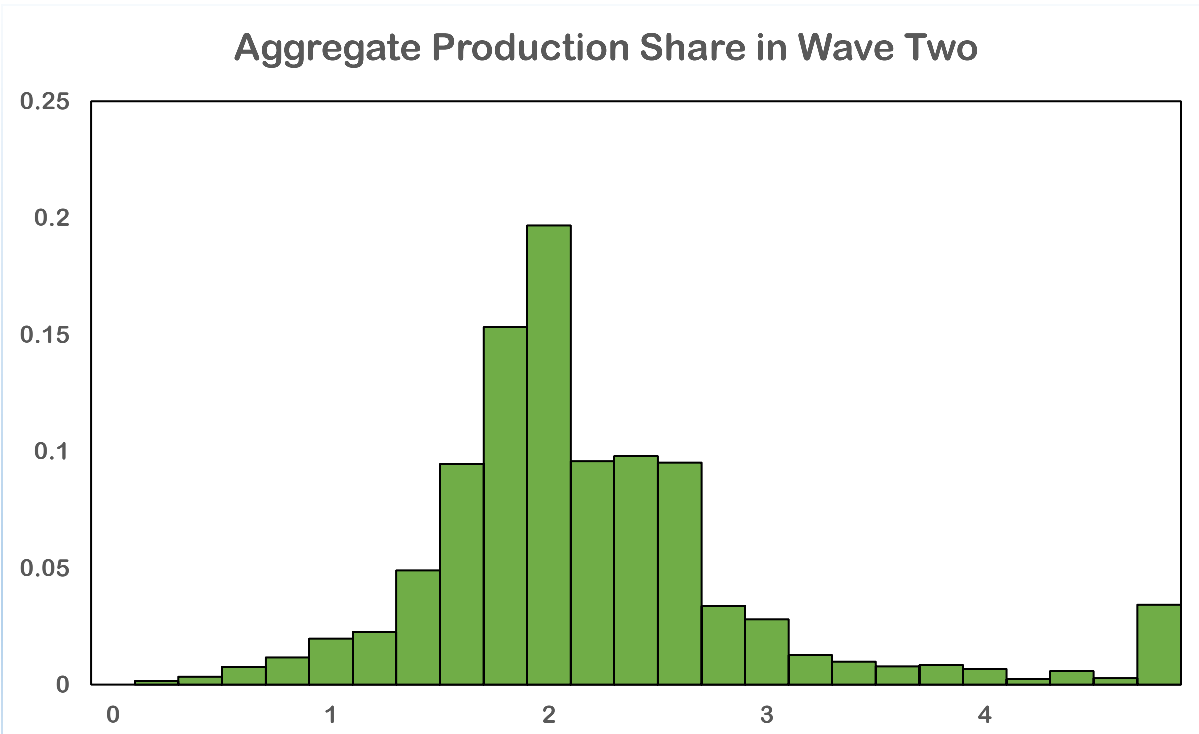


Figure 4: Histogram of θ_2^y for farmer households in wave two. The mean value is 2.194

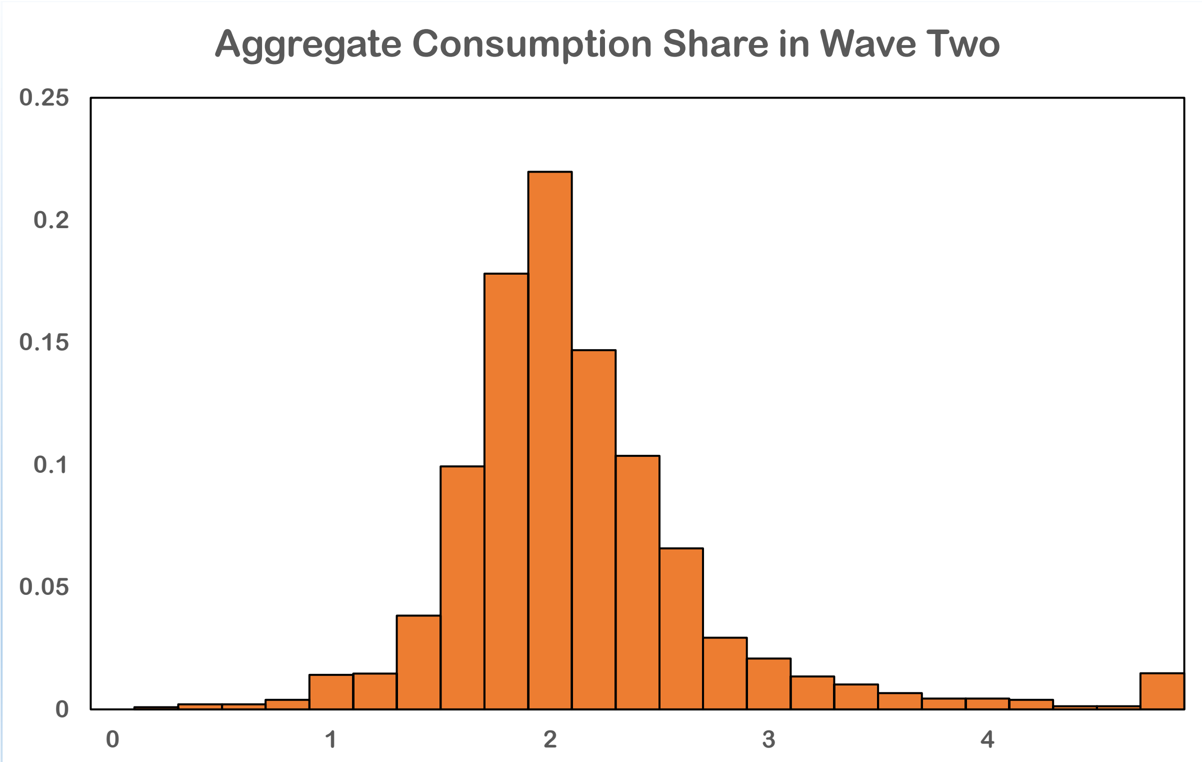


Figure 5: Histogram of θ_2^c for farmer households in wave two. The mean value is 2.063

Both histograms have extreme values over five, as seen by the bar on the far right in both figures. For Aggregate Production Share, this value was as high as 24.306. For Aggregate Consumption Share, it was as high as 19.667, and was principally caused by a high pulse product price, meaning its price must have increased significantly between waves one and two.

Next, I calculated $\theta_2^y - \theta_2^c$, or the aggregate production share minus aggregate consumption share in wave two for each farmer, shown in Figure 6.

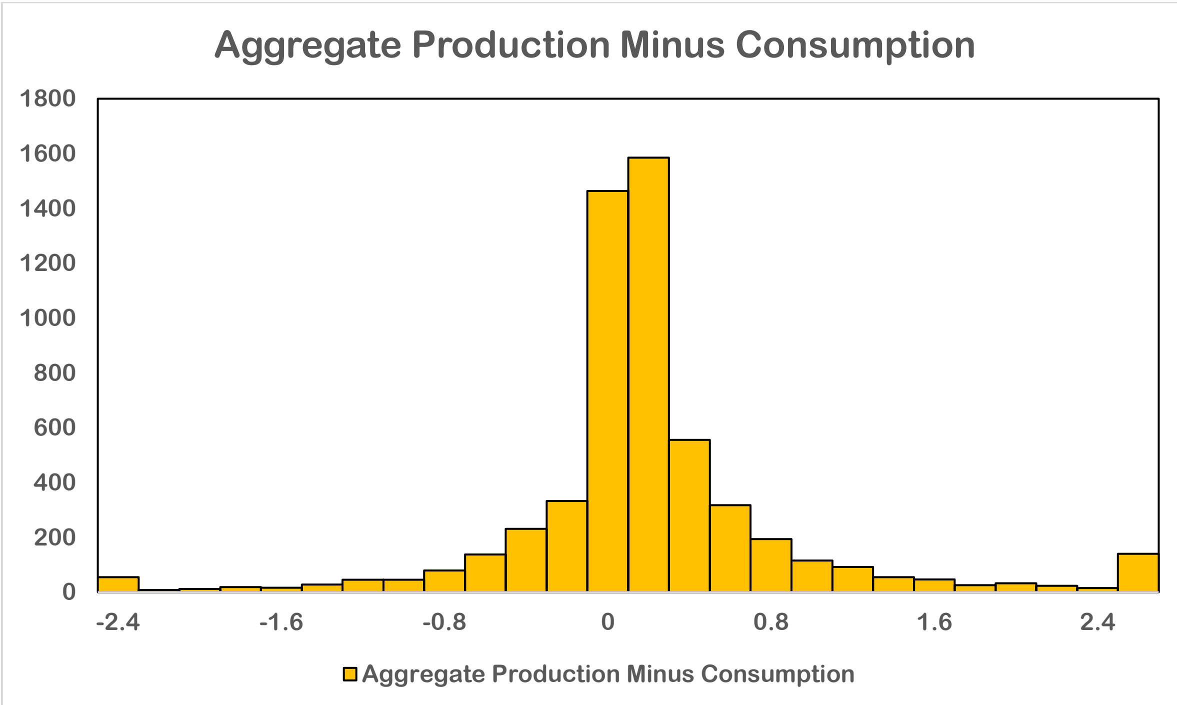
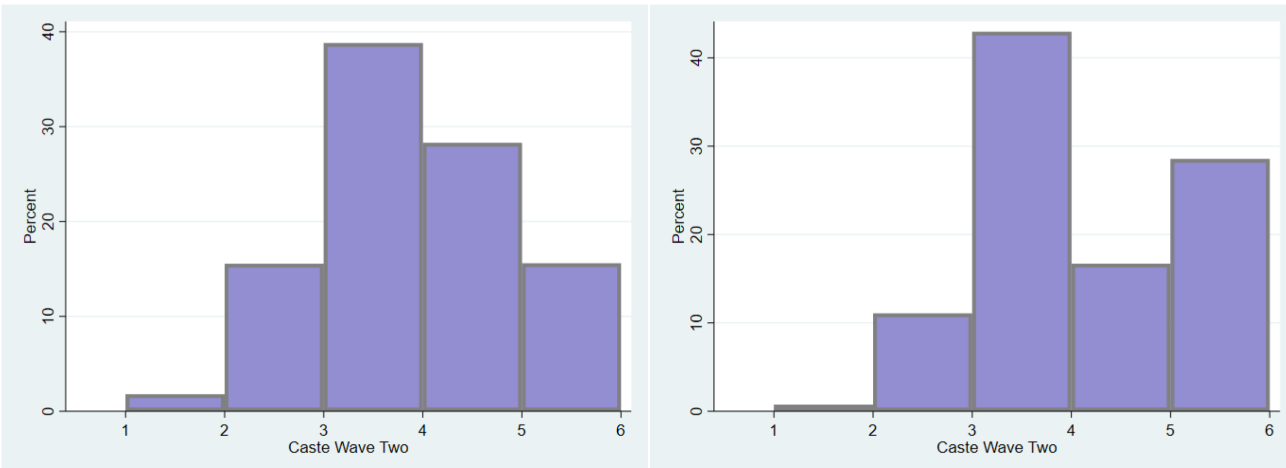


Figure 6: $\theta_2^y - \theta_2^c$, or Aggregate Production Share Minus Aggregate Consumption Share of each farmer in wave two. The average is 0.131.

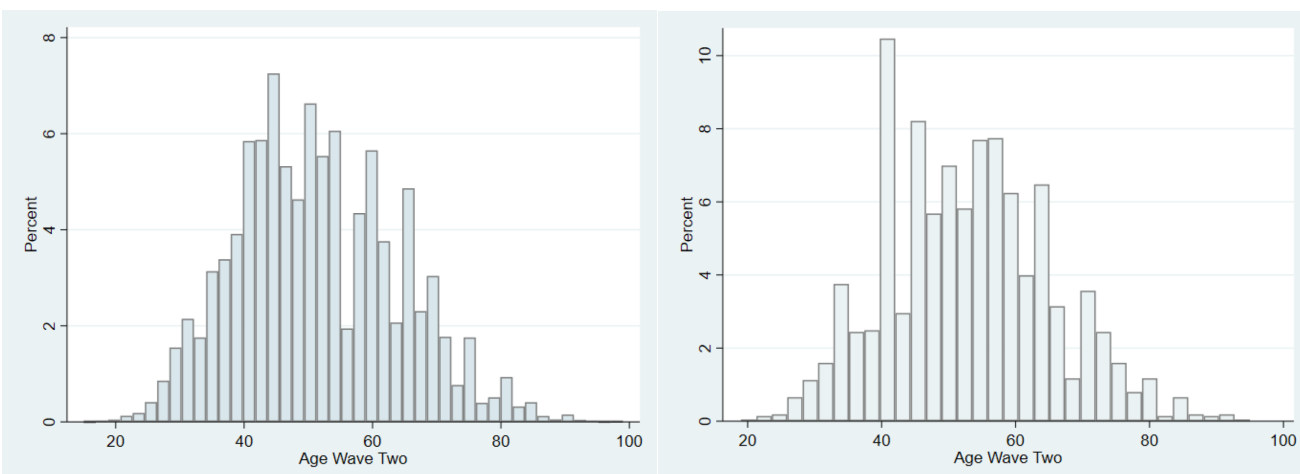
As one can note from Figure 6, the average of this histogram is not zero. Rather, it is slightly over zero, 0.131, to be exact. Why is this important? As described in the example in the "Methods" section, a positive "net share" means the farmer has more disposable income and increases in economic welfare. If the net share were zero, i.e., $\theta_2^y - \theta_2^c = 0 = \theta_1^y - \theta_1^c$, then a price increase would not make the farmer better-off. He would gain more income from an increase in the price of what he is selling, but would have to spend more for the same good. Thus, for the farmer household to have a welfare increase after the price change, he would have to have a positive $\theta_2^y - \theta_2^c$.

To make sure that $\theta_2^y - \theta_2^c$ significantly increased compared to wave one, I conducted a paired t-test comparing $\theta_2^y - \theta_2^c$ to $\theta_1^y - \theta_1^c$. Through this test, I rejected the null hypothesis ($\theta_2^y - \theta_2^c = \theta_1^y - \theta_1^c$) since the 95% confidence interval of $\theta_1^y - \theta_1^c$ was $5.59\text{x}10^{-9}$ - $8.07\text{x}10^{-9}$ and 0.1018 to 0.1601 for $\theta_2^y - \theta_2^c$ (t = -8.81).

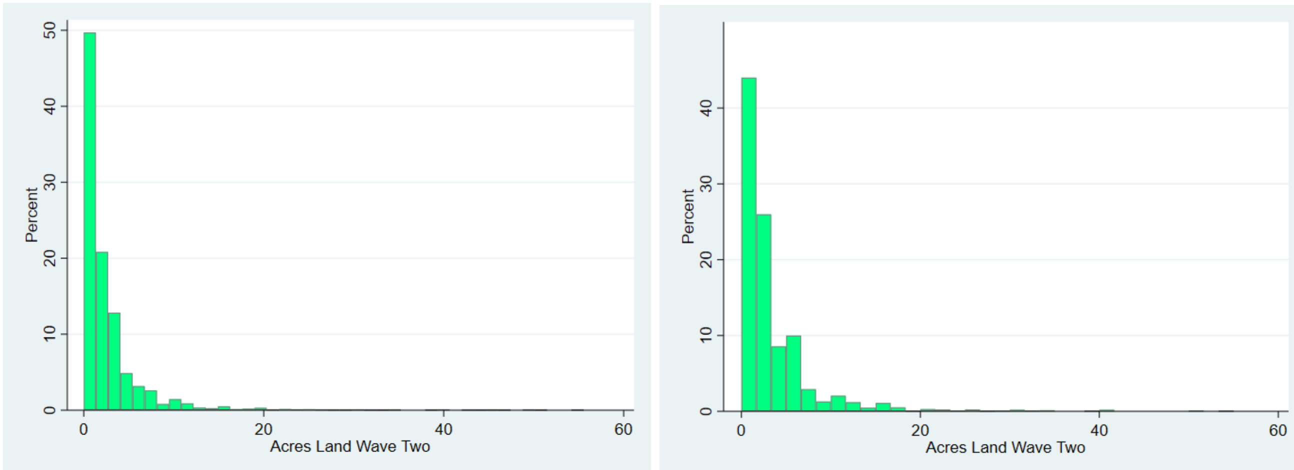
The second part of my analysis compares farmers whose welfare increased after the price change and those whose welfare decreased after the price change. In other words, I am determining characteristics of farmers to the left ("losers") of zero in Figure 6 compared to those to the right ("winners") of zero. Below are a series of histograms that compare education levels, caste, age, and land size of the "winners" and "losers" of a price increase.



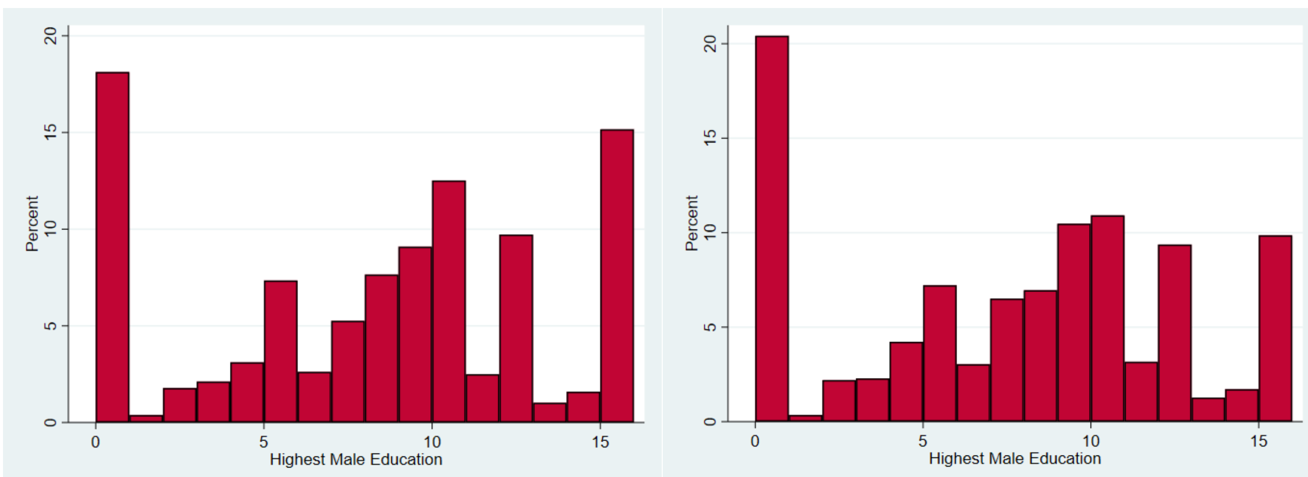
Figures 7 (left) and 8 (right) represent the distribution of castes for those whose welfare increased (left) and decreased (right) after a price increase. 1: Brahmin, 2: Other Backward Caste, 3: Scheduled Caste, 4: Scheduled Tribe, 5: Other



Figures 9 (left) and 10 (right) represent the age distribution of the male head of household for those whose welfare increased (left) and decreased (right) after a price increase.



Figures 11 (left) and 12 (right) represent the household total land owned for those whose welfare increased (left) and decreased (right) after a price increase. Several outliers whose land acreage totaled over 60 acres were removed from these histograms.



Figures 13 (left) and 14 (right) represent the highest male adult education for those farmer households whose welfare increased (left) and decreased (right) after a price increase. Legend: 0: no education; 1: 1st class; 2: 2nd class; 3: etc... 10: Secondary; 11: 11th class; 12: High Secondary; 13: 1 year post-secondary; 14: 2 years post-secondary 15: Bachelors; 16: Above Bachelors.

<u>7: Conclusion:</u>

Overall, this paper determined that, on average, an Indian farmer's welfare increases after an increase in the price of a crop. Additionally, it analyzed the distribution of age, education levels, farm size, and caste of farmers who "won" and "lost" after a price increase. Most of these distributions were similar for farmers on both sides, but caste was more skewed towards higher castes for those whose welfare increased. Regarding applications of this research, policymakers could enable Indian crop prices to increase if they want to support their farmers. However, this does not come without its costs. As shown in Figure 6, many farmers were not aided by the price increase because the amount they spent in wave two was greater than the farm revenue they generated. Therefore, Indian policymakers will have to decide whom they would rather support: their net consumers or their net producers.

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