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Research article

DRY BEANS PRICES AND INCOME DISTRIBUTION IN RWANDA: A NON-PARAMETRIC ANALYSIS

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Abstract

In the post-genocide period, the government of Rwanda has exercised a range of policy instruments that have influenced the prices of agricultural goods. Using household survey of 2010-2011, higher dry beans prices can be expected to provide direct benefits to households at all levels of living. The objective of this paper is to study the effect of a price change on household welfare. Household survey data is used to carry out a comprehensive analysis of the impact of price changes on household welfare using the first-order approximation. The impacts are estimated across the income distribution for the total population and subsets of the population: rural versus urban households, and female- versus male-headed households. Variables of interest are the log per capita expenditure (as a measure of household well-being), the share of dry beans in total expenditure, the share of income generated by dry beans sales, and the net income generated by dry beans (sales minus consumption of dry beans). Using non-parametric regressions, the relative vulnerability of various household groups are mapped across per capita expenditure according to the gender of the household heads and whether the household is urban or rural. The analysis shows that, with a general rise in the price of dry beans, household-groups that will be severely affected are those that are poor, rural and male headed. The findings are useful in helping the government identify vulnerable households in the wake of price increases of staple food crops such as dry beans.

Key Words: Trade, Agriculture, Poverty, Gender, Non-parametric Regression, Rwanda

1- Introduction

Beans being a key staple food of the Rwandan diet are the largest crop of all the agricultural commodities produced in the county. Beans have traditionally been grown as a staple crop to ensure household food security

(Loveridge et al, 2007, McKay, 2007, NISR, 2011, EDPRS2 and Rwanda Vision 2020). According to the Rwanda Cross-Border Agricultural Trade Analysis (2013), exports to cross border markets (particularly those in Uganda) can substantially be increased resulting in higher prices and enhanced incomes.

Beans are grown throughout the country with the highest concentration being in the Western Province (41% of production). The crop is grown in two seasons i.e. Season A (September to February) where 57% of production is derived and Season B (March to July). Although the production acreage has remained almost the same over the last decade, average yields have increased by 40 per cent. Over the last few years production has averaged around 350,000 metric tonnes per annum.

Enquête Intégrale sur les Conditions de Vie des Ménages,EICV3 (Third Integrated Household Living Conditions Survey, 2011) data shows that domestic utilization of beans in 2010/2011 was as follows: total annual consumption about 332, 280 metric tonnes, almost 20,000 used as seeds and an estimated 30,000 incurred as post-harvest losses (estimated at 10% of production). During this period, urban dry bean consumption was about 31,330 metric tonnes equivalent to per capita consumption of 14.7 kg (urban population estimated at 2.13 million people). Rural consumption was 244,700 metric tonnes of dry beans and 56,250 metric tonnes of fresh beans equivalent to annual per capita consumption of 27 kg and 6.2 kg respectively. Assuming an average price of RWF 450/kg, expenditure on dry beans can be estimated at RWF 14.1 billion in 2011. Generally, there was 40% increase in the consumption of beans between 2005 and 2010/2011. EICV3 data further shows that only 38% of the beans consumed were sourced from the market indicating that the crop is largely subsistence.

2- Regional Trade in Dry Beans

According to the Rwanda Cross-Border Agricultural Trade Analysis (2013), Rwanda has been a net exporter of beans over the last few years. Exports were about 5.9% of annual production while imports were less than 1.6% in 2011. Imports are mainly from Tanzania (36%) and exports largely to Uganda (54%).

3- Research Objectives

Increases in prices of dry beans have different welfare effects on households depending on whether the increases affect net producers or net consumers of the crop. The net-benefit ratio introduced by Deaton (1989a) is used to analyse the relative vulnerability of different households to increases in the price of dry beans. The household's model specification includes gender and whether the household is located in the rural or urban areas.

4- Theoretical Underpinnings

Under the standard framework, consider a farm or non-farm household that consumes dry beans but may produce or not produce the dry beans. Trade affects prices faced by producers and consumers of a given agricultural produce and in turn prices affect poverty through its distributional impacts resulting from price changes. Therefore, poverty and individual household welfare depend on prices (Mellor, 1989, Minot et al, 2000, Deaton, 1989b, CFSVA, 2009).

In this section, we establish the impact of price changes on household's welfare by quantifying the impact on the consumption and production surplus of a household *h* when the price of good *i* changes. Assuming that the household consumes the good, the impact on consumption surplus can be estimated by multiplying the amount of the price change by the quantity consumed before (or after) the price shock. In the case of a price increase, this would be an approximation of the loss in consumption surplus. The impact of a price increase on the production surplus would be positive if the household produces the good. This may also be estimated by the price differential multiplied by the production level before (or after) the shock.

The sum of the impacts on consumption and production surpluses yields an estimate of the total impact of a price change on household welfare. If the consumption surplus loss is lower than the production surplus gain,

household welfare would increase. A household whose production of the good is higher than its consumption will gain from a price increase of the good. Conversely, if consumption exceeds production the household will lose.

If the household is a net consumer of the good, the loss of welfare after the price increase can be estimated as:

$$\Delta W = -\Delta p\ (c_0 - q_0) \text{ or } \Delta W = -\Delta p\ (c_1 - q_1)$$

where Δp is the amount of the price change, c_0 and q_0 are the quantities consumed and produced before the price shock respectively and c_1 and q_1 are the quantities consumed and produced after the price shock.

In the case of a net producer household, the impact of price change on welfare will be positive and can be estimated as:

$$\Delta W = \Delta p\ (q_0 - c_0) \text{ or } \Delta W = \Delta p\ (q_1 - c_1)$$

The principle is to minimize expenditure incurred by households in order to attain a given level of utility. If the fixed utility level used in expenditure minimization is the same as the one obtained through utility maximization, the minimum expenditure level obtained through expenditure minimization is equal to the budget constrain used in utility maximization.

The expenditure incurred by the household $e\ (p, u)$, dependent upon a vector of prices p and utility level u, which equals the income of the household (consisting of exogenous source of income x^h_0 and all incomes generated by selling goods $\sum_i \pi_i(p_i)$

$$e\ (p, u) = x^h_0 + \sum_i \pi_i(p_i)$$

Differentiating the expenditure function with respect to a price change for good i, we obtain

$$\frac{\partial e}{\partial \pi_i} dp_i = dx^h_0 + \frac{\partial \pi_i}{\partial \pi_i} dp_i$$

(Re-arrange using household production function $\frac{\partial \pi_i^h}{\partial p_i} = q_i^h$ and note that consumption of a good equals the derivative of the expenditure function with respect to the price of the good $\frac{\partial e}{\partial \pi_i} = ci$)

$$dx_0^h = (c_i^h - q_i^h) dp_i$$

Now, multiply the expression by the price of the good p_i and divide by total expenditure e^h to obtain the impact of a price change as a share of the total expenditure of the household.

This result can be used to evaluate the impact of a price change on households using the survey data

$$\frac{dx_0^h}{e^h} = \frac{c_i^h dx_i - q_i^h dx_i}{e^h}$$

$$\frac{dx_0^h}{e^h} = (s^h_i - \emptyset_i^h)\, d\ln p_i$$

The compensating variation (revenue required to compensate a household for the effects of the price change) is given as: $CV^h = - -\frac{dx_0^h}{e^h}$

The compensating variation ensures that the utility of the household remains unchanged after the price change. Assuming a price increase, net producer household gains and hence $\left[\emptyset_i^h > s_i^h \rightarrow \frac{dx_0^h}{e^h} < 0\right]$ the negative transfer is a surplus for the planner. With the same price increase, net consumer household losses $\left[\emptyset_i^h < s_i^h \rightarrow \frac{dx_0^h}{e^h} > 0\right]$ and the positive transfer is a deficit for the planner.

5- Methodology

(a) Data Collection

The Rwanda 2010/11 Integrated Household Living Conditions Survey or EICV3 (Enquête Intégrale sur les Conditions de Vie des Ménages) is the third in the series of surveys which started in 2000/01 and was designed to monitor poverty and living conditions. The sample size of 14,308 households in the EICV3 was sufficient to provide estimates which are reliable at the district level.

The survey fieldwork commenced in November 2010 and continued for one full year, ensuring that seasonal variations in consumption and income were accounted for in the survey. The sample of households was divided into 10 equally sized cycles and distributed across the country to minimise climatic and regional variation over the period of fieldwork. Interviewers visited households on several occasions over each cycle in order to aid households in recalling all their consumption items.

(b) Descriptive Statistics

A descriptive analysis of household characteristics through expenditure distributions of households across different groups is presented in order to assess the well-being of various households i.e. total sample, female and male headed households, and urban and rural households.

These statistics describe levels of living standards in Rwanda for the total, rural and urban populations. Histograms and kernel density plots are used to represent the statistics. We estimate the density plots of log per capita consumption for all households, and then for male and female headed households. For each of these categories, we first estimate the density at the national level, then for only urban households, and finally for only rural households. We produce three density plots (national, urban, rural) for each of the three graphs (all households, male-headed, female headed).

Table I shows the number of survey households and their distribution over the urban (15%) and rural areas (85%). Over 26.8% of households in the sample are in the nothern province while Kigali City has the least number (9.42%).

Table I: Structure of the Sample (Distribution of Households). Source: Household survey

		Urban	**Rural**	**Total**	**Percentage**
Provinces					
Kigali City		1,177	171	1,348	9.42
Northern		492	3,348	3,840	26.84
Western		204	3,156	3,360	23.48
Eastern		132	2,268	2,400	16.77
Southern		144	3,216	3,360	23.48
Total		**2,149**	**12,216**	**14,308**	

Table II presents the distribution of households by the gender of the head. Female-headed households are 27.8% of all households in the sample.

Table II: Structure of the Sample (Distribution of Households by Gender of the Head). Source: Household survey

		Female Head	**Male Head**	**Total**	**Percentage**
Provinces					
Kigali City		313	1,035	1,348	9.42
Northern		1,173	2,667	3,840	26.84

Western		966	2,394	3,360	23.48
Eastern		602	1,798	2,400	16.77
Southern		924	2,436	3,360	23.48
Total		**3,978**	**10,330**	**14,308**	

6- Empirical Results

(a) Kernel Density Estimation of Expenditure

This section presents kernel density estimation of the log of per capita expenditure in order to assess the living standards of households in terms of expenditure. The log of per capita expenditure is used as an estimation of household welfare.

Kernel densities of expenditure show the distribution of living standards across households. The graphs show the estimated density functions of the logarithm of household per capita expenditure for the national, rural and urban areas. The logarithmic transformation is chosen because the distribution of per capita expenditure is significantly positively skewed. Taking logs induces symmetry. The density functions are estimated by kernel smoothing.

(i) Kernel Density of Expenditure for all Households (Figure 1A)

The kernel density shows the distribution of well-being (log per capita household expenditure) for the entire population, for rural households, and for urban households. Each distribution is similar to a normal distribution. The density of urban households is shifted to the right relative to the density of rural households implying that urban households are on average richer than rural households.

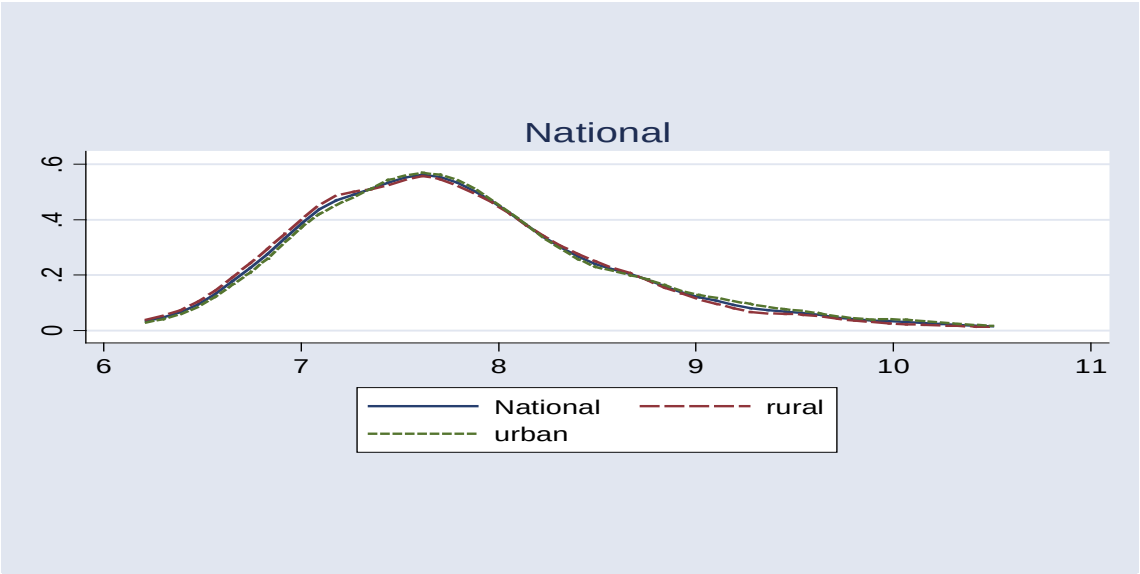

Figure 1A: Kernel Density of Expenditure for all households. Source: Data from ECIV3 Household Survey

(ii) Kernel Density of Expenditure for Male-headed Households (Figure 1B)

The kernel density shows the distribution of well-being among male-headed households (log per capita household expenditure) for the entire population, for rural households, and for urban households. The density of urban male-headed households is shifted to the right relative to the density of rural male-headed households implying that urban male-headed households are on average richer than those of rural households.

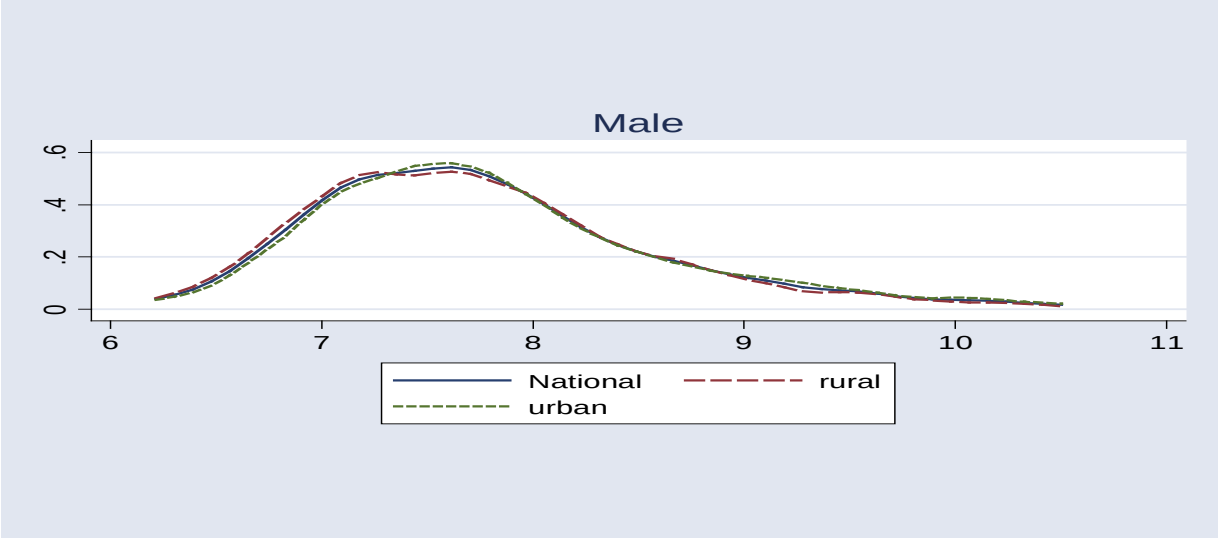

Figure 1B: Kernel Density of Expenditure for Male-headed Households. Source: Data from ECIV3 Household Survey

(iii) Kernel Density of Expenditure for Female-headed Households (Figure 1C)

The kernel density shows the distribution of well-being among female-headed households (log per capita household expenditure) for the entire population, for rural households, and for urban households. The density of urban female-headed households is shifted to the right relative to the density of rural female-headed households implying that urban female-headed households are on average richer than those of rural households.

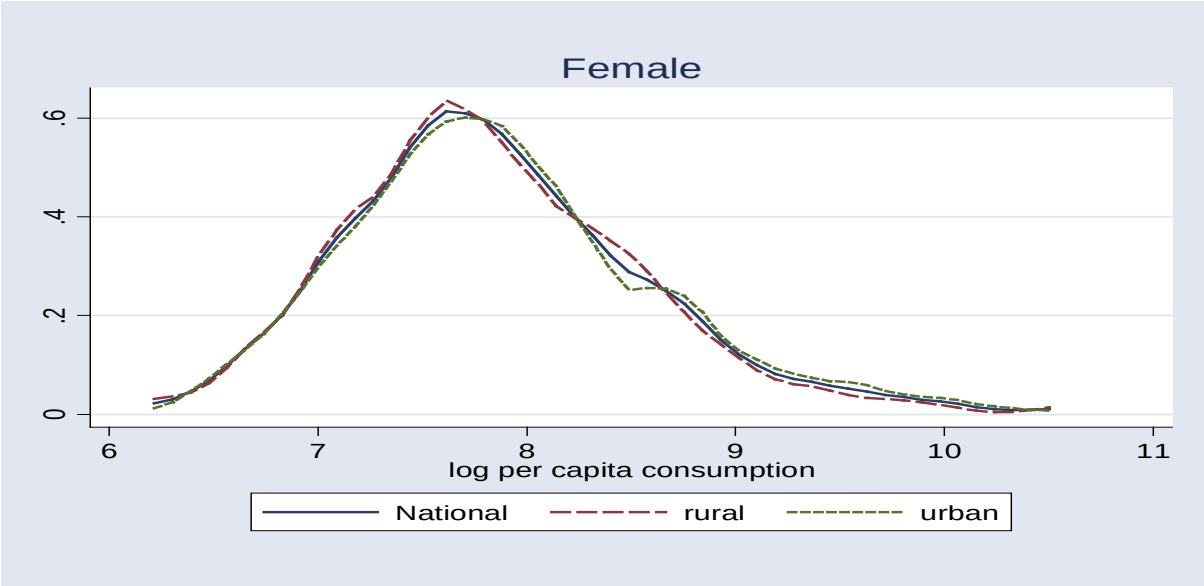

Figure 1C: Kernel Density of Expenditure for Female-headed Households. Source: Data from ECIV3 Household Survey

(b) Non-parametric Regression

This section presents graphs of non-parametric regressions showing relationship between two variables, in this case, level of livelihood and the level of consumption and production of dry beans. This shows how changes in the price of dry beans affect different 'types' of households. Non-parametric regressions of consumption/expenditure, production/income and net income (income less expenditure) on log per capita expenditure are then given. In other words, non-parametric regressions of dry beans expenditure share, income share and net income share on log per capita expenditure are presented. The aim is to evaluate how a change in price of dry beans affects households depending on whether the households are net producers or net consumers of dry beans.

The regressions help in explaining the distributional effects of shocks in the price of dry beans while taking into account the disparities in living standards based on the gender of the household head and whether the households are residing in the rural or urban areas.

(i) Dry Beans Expenditure (Figure 2A and 2B)

Figure 2A and 2B show dry beans estimated expenditure share at each point of the distribution. These are non-parametric regressions of the dry beans share on the logarithm of household per capita expenditure estimated by kernel smoothing. Figure 2A and 2B curves slope downwards indicating that the share of the budget spent on dry beans declines as leaving standards rise (i.e. Engel's Law).

From Figure 2A, at the bottom of the expenditure distribution (among the poor rural households), more than 15% of the budget goes to dry beans. This share is about 0.4% among the richest rural households. Although regressions for male and female headed rural households are close to one another, female-headed households spend more on dry beans even after controlling for the size of the budget.

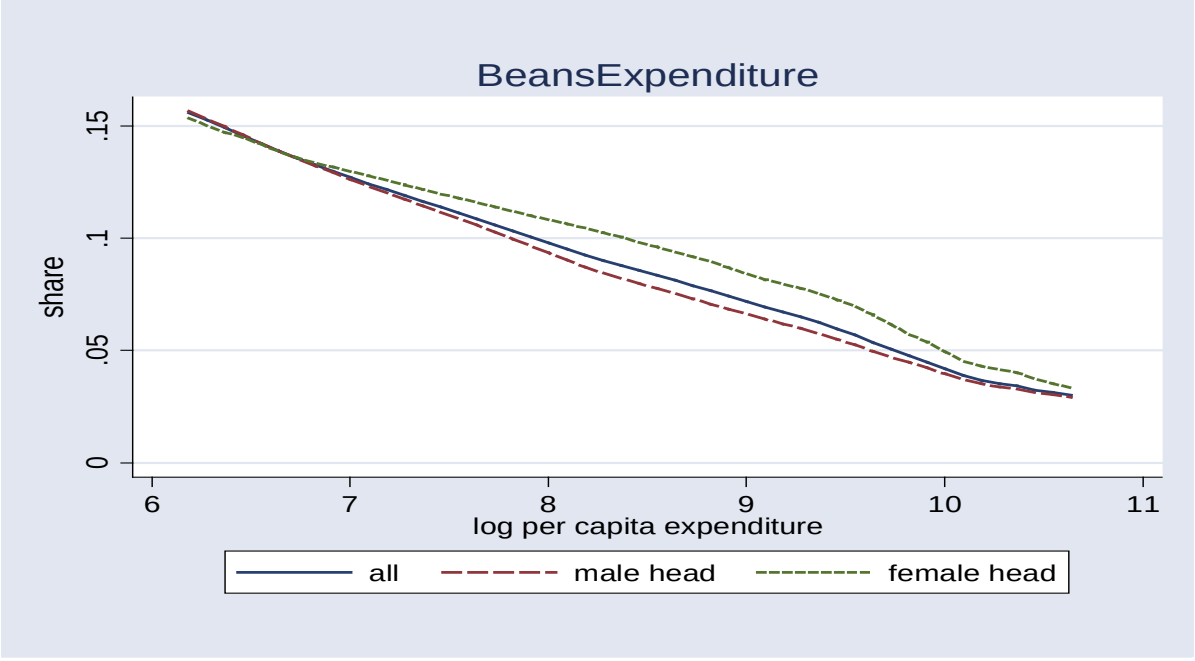

Figure 2A. Dry beans expenditure for rural households. Source: Data from ECIV3 Household Survey

From Figure 2B, at the bottom of the expenditure distribution (among the poor urban households), more than 16% of the budget goes to dry beans. This share is about 0.3% among the richest urban households. Although regressions for male and female headed rural households are close to one another, female-headed households spend more on dry beans especially among the richer households. At the same level of living, urban households generally spend proportionately less on dry beans than the rural households. This may be due to the fact that urban environment provides more substitutes for dry beans than the rural one.

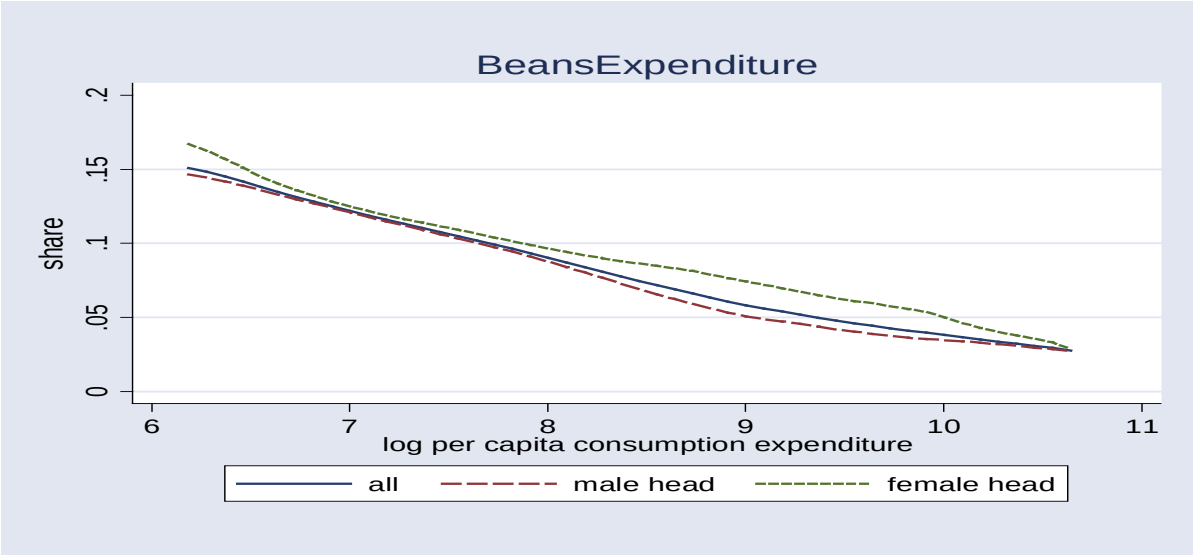

Figure 2B: Dry beans expenditure for urban households. Source: Data from ECIV3 Household Survey

For both rural and urban households, the association between the dry beans share and the log per capita expenditure is almost linear over the entire range of levels of living standards.The curve is steeper at low levels of living and flattens out among the rich.

(ii) Dry Beans Income

From Figure 3A, dry beans income as a proportion of total income in the rural areas increases with the level of livelihood for both male and female headed households. Once livelihood reaches a certain point, the two trends diverge, and shares decrease for male-headed households while they increase for female-headed ones. At low levels of livelihood, the share of income coming from dry beans in male-headed households is much lower than that of female-headed households. This gap increases as the level of livelihood increases.

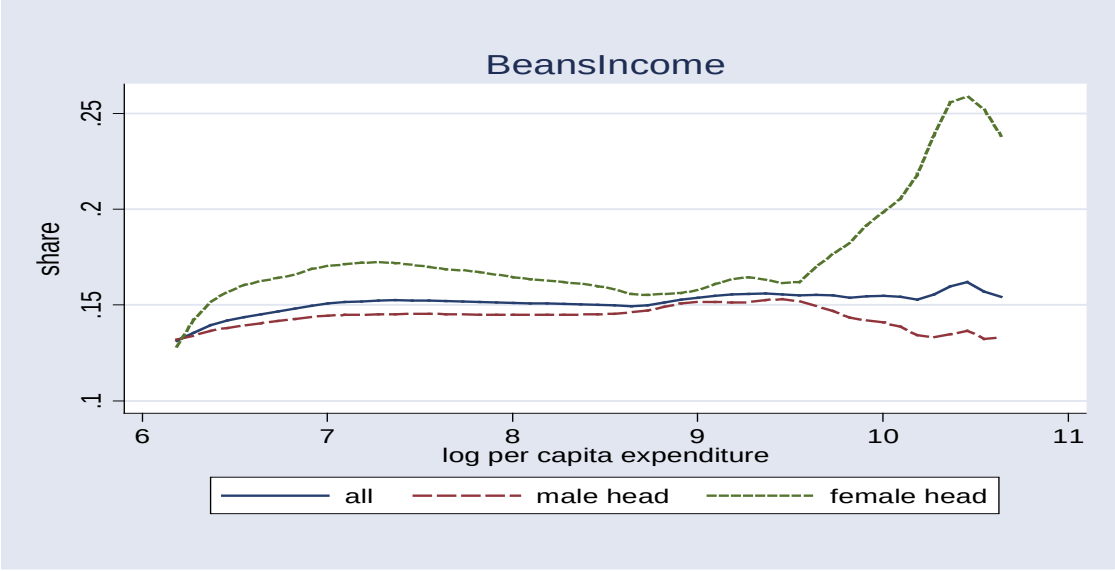

Figure 3A: Dry beans income as a proportion of the total income in rural areas. Source: Data from ECIV3 Household Survey

From Figure 3B, dry beans income as a proportion of total income in the urban areas increases with the level of livelihood for both male and female headed households. However, female-headed households derive higher proportion of their income from dry beans over most of the livelihood range. Once livelihood reaches a certain point, the two trends diverge. At low levels of livelihood, the share of income coming from dry beans for male-headed households is much lower than that of female-headed households. This gap increases as the level of livelihood increases.

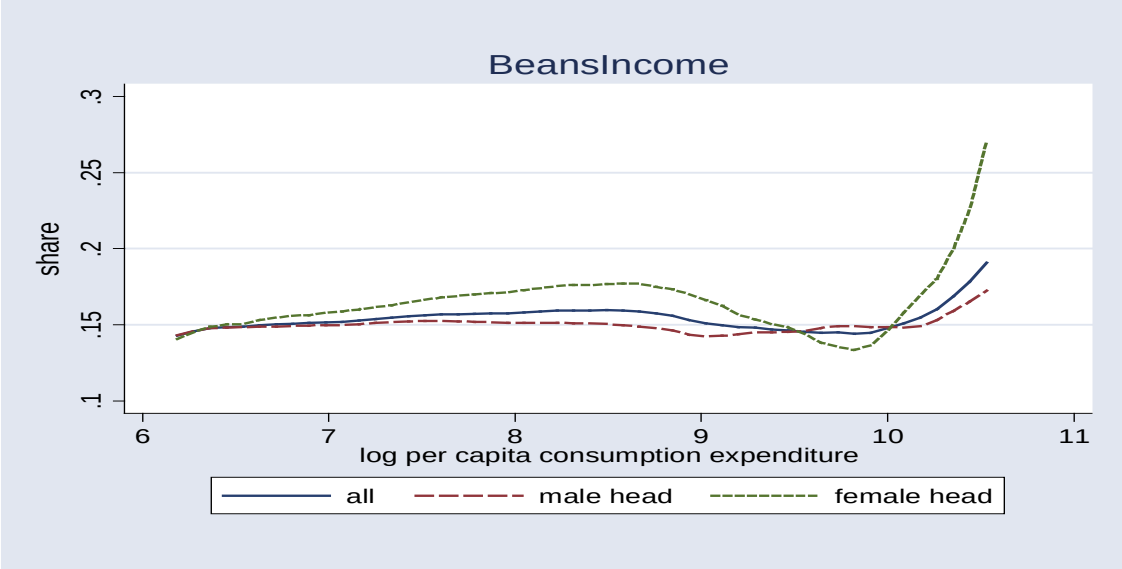

Figure 3B. Dry beans income as a proportion of total income in the urban areas Source: Data from ECIV3 Household Survey

(iii) Net Dry Beans Income

In order to establish the short-term impact of beans price changes on households with different consumption expenditure levels, a non-parametric regression of the net income share of dry beans is undertaken. This is equivalent to the net benefit ratio (*NBR*) of Deaton (1989b). *NBR* is a short term measure that assumes no response from households as producers or consumers. In addition it assumes no changes in the labour market or non-farm income resulting from the price change.

The *NBR* can be defined as:

NBR=PR-CR

Where *PR* is the value of dry beans production as percentage of income or expenditure and *CR* is the value of dry beans consumption as percentage of income or expenditure. If *NBR* is positive the household is a net seller and if negative, it is a net buyer of the commodity.

The regressions are presented separately by gender of the household head and whether the household resides in rural or urban areas. This helps in establishing the difference in consumption and production patterns across household types.

From Figure 4A, the net share of dry beans in total income in rural areas is on average positive across all levels of livelihood except for poorer households. Net dry beans income for female-headed households is equal or higher than that of male-headed households for the entire range of livelihood except for the very poor households.

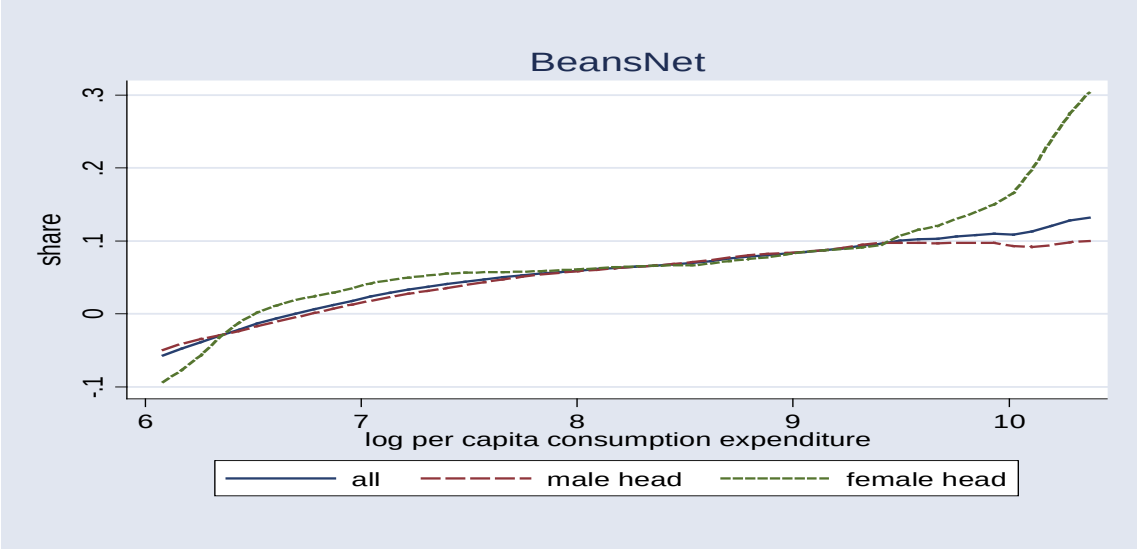

Figure 4A: Net share of dry beans in total income in rural areas. Source: Data from ECIV3 Household Survey

From Figure 4B, the net share of dry beans in total income in the urban areas is on average positive across all levels of livelihood except for poorer households. The net share of dry beans in total income for female-headed households is higher than that of male-headed households for almost the entire range of livelihood except for the very poor households and a limited range of rich households.

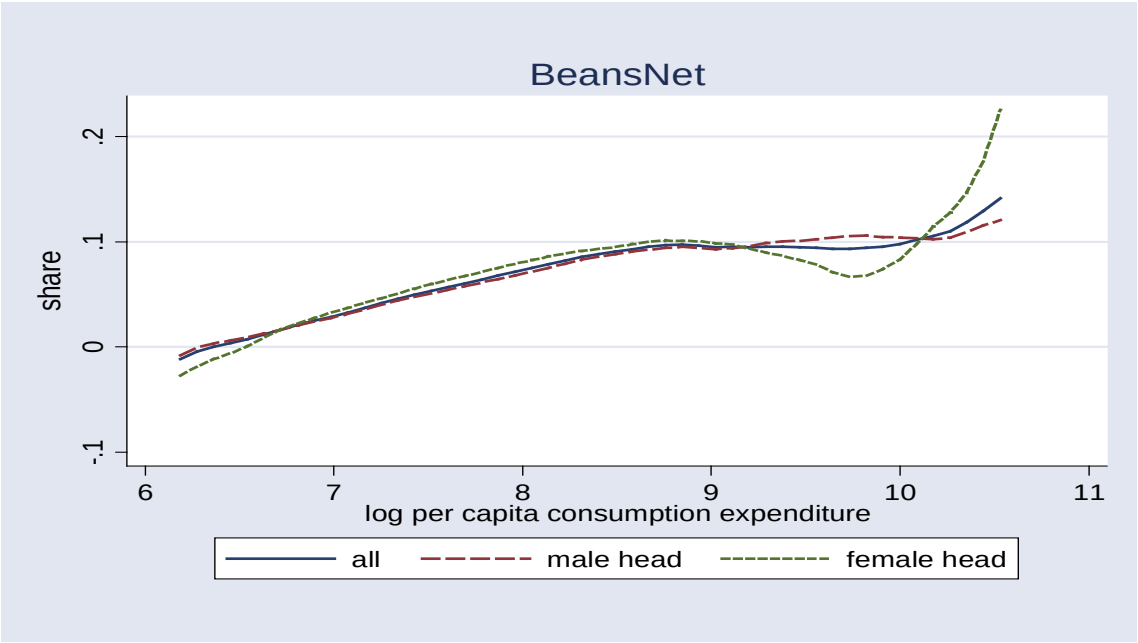

Figure 4B: Net share of dry beans in total income in the urban areas. Source: Data from ECIV3 Household Survey

An increase in the price of dry beans would have a negative effect on the poor households (especially among female-headed households) assuming no behavioural responses take place (i.e. second order effects). Income

share of dry beans tends to be higher than the expenditure share implying that households are mainly net producers of dry beans.

7- Conclusions and Policy Implications

Based on the methodology of Deaton, this study identified the vulnerability of various household groups to increase in the price of dry beans using non-parametric regressions of the net beans share on per capita expenditure for different groups.
Therefore, net producers become better off and net consumers worse off as a result of price increase in a food commodity. Conversely, net consumers are better off and net producers worse off following a fall in the price of the commodity.
This paper has derived the first-order effects of price changes on household welfare. The effects were estimated by income and budget shares for given price changes. The welfare implications with respect to net consumers and net producers of dry beans were discussed.
With respect to policy, net consumers of a food commodity need to be cushioned against price increases. Further research can consider second order effects of a price change by taking into account the effect of this price change on other related goods consumed and produced by the household and on wages and other income of household members.

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