A Comment on "The Welfare Impacts of Commodity Price Volatility: Evidence from Rural Ethiopia"

Linden McBride

This comment discusses the robustness of the policy implications of Bellemare, Barrett, and Just's paper, "The Welfare Impacts of Commodity Price Volatility: Evidence from Rural Ethiopia" (2013). Bellemare, Barrett, and Just present a theoretical and empirical approach to the estimation of willingness to pay for food price stabilization that accounts for the covolatility of prices, making a significant contribution to the literature. However, in the course of applying their model to data from rural Ethiopia, the authors make an empirical assumption in the treatment of zero-valued income households that produces a distortion in the distribution of household budget shares. This comment identifies the consequences of this assumption for the estimated relationship of poor and wealthy households' willingness to pay for food commodity price stabilization, and shows the results one would obtain under a different, distribution-preserving treatment of zero-valued income. The key finding is that the distributional benefit incidence of food price stabilization found in Bellemare, Barrett, and Just (2013) is reversed when the budget share of marketable surplus is calculated over observed, as opposed to mean, household income where available.

Key words: Benefit incident of policy, price risk, willingness to pay, zero-valued income data.

JEL codes: C13, D30, O12.

An extensive body of literature suggests that teasing out the effects of commodity price stabilization policies on agricultural households is a challenging task (Sandmo 1971; Turnovsky, Shalit, and Schmitz 1980; Newbery and Stiglitz 1981; Finkelshtain and Chalfant 1991; Barrett 1996; Barrett and Dorosh 1996; Barrett 1999; Dawe and Timmer 2012; Bellemare, Barrett, and Just 2013; Lee, Bellemare, and Just 2015). Indeed, in agricultural households both income and consumption are affected by price volatility; therefore preferences under price risk are reflective not only of income risk preferences and budget shares, but also of households' net relationship with the market—whether net buyer, net seller, or autarkic. Given the policy interest in mitigating the effects of food price volatility (FAO 2012), and given the mixed messages regarding the effects of price stabilization on the poor emerging from theoretical and empirical analyses, it is important that the likely welfare impacts of price stabilization policies be thoroughly investigated.

Drawing on the theoretical framework of the agricultural household model and extending Sandmo (1971), Turnovsky, Shalit, and Schmitz (1980), Finkelshtain and Chalfant (1991, 1997), and Barrett (1996), a recent paper by Bellemare, Barrett, and Just (2013) presents a model that accommodates the multivariate and multiple-commodity price risk faced by agricultural households in the estimation of household willingness to pay (WTP) for price stabilization. Applying this approach to Ethiopian Rural Household Survey (ERHS) data from the 1990s, Bellemare, Barrett, and Just find that wealthier households have a greater WTP for food commodity price stability than do poorer households. This finding suggests a regressive benefit incidence of price stabilization in Ethiopia.

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In the course of applying their model to the estimation of WTP for food price stabilization in rural Ethiopia, Bellemare, Barrett, and Just make an empirical assumption in the treatment of zero-valued income households that distorts the distribution of the household budget share and therefore distorts the policy implications of their findings. This comment identifies the consequences of this assumption for the estimation of WTP and shows the empirical results one would obtain under a different, distribution-preserving treatment of the zero-valued income households. The key finding is that the distributional benefit incidence of food price stabilization found in Bellemare, Barrett, and Just is reversed when the budget share of marketable surplus is calculated over observed, as opposed to mean, household income where available.

Bellemare, Barrett, and Just's Methods and Findings

Bellemare, Barrett, and Just (2013) develop a model for estimating household WTP for price stabilization over commodities as

$$(1) \qquad WTP = \frac{1}{2}\left[\sum_{j=1}^{m}\sum_{i=1}^{m}\sigma_{ij}\, A_{ij}\right]$$

where σ_{ij} is the covariance between the price of commodity i and the price of commodity j, and A_{ij} is the matrix of price risk aversion coefficients, calculated as

$$(2) \qquad A_{ij} = -\frac{M_i}{P_j}\left[B_j\left(\eta_j - R\right) + \epsilon_{ij}\right].$$

With the exception of R, the Arrow-Pratt coefficient of relative income risk aversion, each of the parameters of equation (2) can be observed in, calculated with, or estimated from the data. Variable M_i is the marketable surplus of commodity i; P_j is the price of commodity j; η_j and ε_{ij} are the income and price elasticity of marketable surplus, respectively; and B_j is the budget share of marketable surplus for commodity j. In Bellemare, Barrett, and Just's paper, R=1 is initially assumed for all households. Details on the mathematical derivation and estimation of this model are available in Bellemare, Barrett, and Just (2013) and its online supplement.

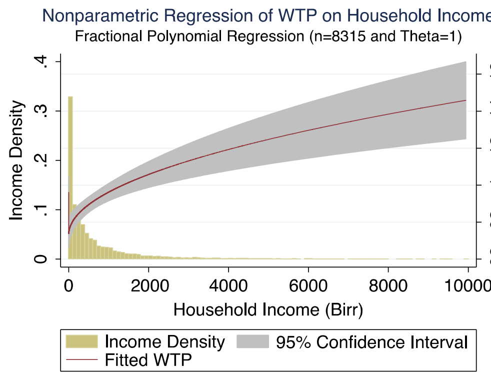

Figure 1. Reproduction of fractional polynomial regression of household WTP to stabilize commodity prices at their means (Bellemare, Barrett, and Just 2013)

As estimated, negative WTP values represent the amount by which a household would need to be compensated to accept price stabilization, while positive WTP values represent the amount a household would be willing to pay for price stabilization. Bellemare, Barrett, and Just estimate this model using four rounds of the ERHS data over a set of commodities including coffee, maize, barley, beans, wheat, teff, and sorghum. The authors find that wealthier households have a greater positive WTP than do poorer households. This finding is illustrated in the fractional polynomial regression of income on WTP overlaying a histogram of household income in figure 1, reproduced from the Bellemare, Barrett, and Just replication materials, which shows that WTP for stabilization rises with income. As the authors note, this result "goes against the conventional wisdom that holds that the poor in developing countries are the ones who are most hurt by price volatility," (Bellemare, Barrett, and Just 2013).

Treatment of Zero-valued Income

Bellemare, Barrett, and Just have made their data and Stata-executable data analysis code available for replication.[1] As noted in their paper (see footnote 19 in Bellemare, Barrett, and Just 2013) and as shown in their Stata code, the authors estimate the budget share

[1] Replication materials are available at http://marcfbellemare.com/wordpress/research.

Table 1. Comparison of the Moments of the Budget Share Distribution for a Single Commodity Using Actual and Mean income

Sample moments	Using actual income	Using mean income
Mean	$\frac{1}{n}\Sigma\left(\frac{M_kP}{y_k}\right)$	$\frac{\Sigma M_kP}{\Sigma y_k}$
Variance	$\frac{1}{n}\Sigma\left(\frac{M_kP}{y_k}-\frac{1}{n}\Sigma\frac{M_kP}{y_k}\right)^2$	$\frac{1}{n}\Sigma\,(nM_k-\Sigma M_k)^2\left(\frac{P}{\Sigma y_k}\right)^2$
Skewness	$\frac{\frac{1}{n}\sum\left(\frac{M_kP}{y_k}-\left(\frac{1}{n}\right)\sum\left(\frac{M_kP}{y_k}\right)\right)^3}{\left[\frac{1}{n-1}\sum\left(\frac{M_iP}{y_k}-\left(\frac{1}{n}\right)\sum\left(\frac{M_kP}{y_k}\right)\right)^2\right]^{\frac{3}{2}}}$	$\frac{\frac{1}{n}\sum(nM_k-\Sigma M_k)^3}{\left[\frac{1}{n-1}\sum(nM_k-\Sigma M_k)^2\right]^{\frac{3}{2}}}$
Kurtosis	$\frac{\frac{1}{n}\sum\left(\frac{M_kP}{y_k}-\left(\frac{1}{n}\right)\sum\left(\frac{M_kP}{y_k}\right)\right)^4}{\left[\frac{1}{n}\sum\left(\frac{M_kP}{y_k}-\left(\frac{1}{n}\right)\sum\left(\frac{M_kP}{y_k}\right)\right)^2\right]^2}-3$	$\frac{\frac{1}{n}\sum(nM_k-\Sigma M_k)^4}{\left[\frac{1}{n}\sum(nM_k-\Sigma M_k)^2\right]^2}-3$

Note: The variable k indexes household; other indexes have been suppressed.

of marketable surplus for each commodity, i, in each household, k, as

$$\text{(3)}\qquad \hat{B}_{ik}=\frac{M_{ik}P_i}{\bar{y}}$$

where $\bar{y}$ is the mean income across all households and all time periods in the ERHS data used in the analysis.

The authors explain that this measure was taken due to the large number of zero-valued income households in the ERHS. For the 1,583 households (19% of the total observations) reporting zero-valued income, the budget shares would be undefined in the case that the budget share was calculated over actual household income, as laid out in the theoretical model,

$$\text{(4)}\qquad B_{ik}=\frac{M_{ik}P_i}{y_k}.$$

However, calculating the budget share with sample mean income in place of household income produces a serious distortion in the budget share. The consequences of this distortion are demonstrated below by proof (proposition 1), by derivation of the moments of the budget share distribution using mean income (table 1), and by simulation (figure 2).

Proposition 1. *Calculating the budget share by fixing the denominator of the budget expression at $\bar{y}$ produces B_{ik} values that are 1) underestimated if y_k lies below $\bar{y}$ and overestimated if y_k lies above $\bar{y}$ in the case that marketable surplus is positive, and 2) overestimated if y_k lies below $\bar{y}$ and underestimated if y_k lies above $\bar{y}$ in the case that marketable surplus is negative.*

Proof. Suppose two households have marketable surplus, M_i, at price P_i for commodity i. Let household h have greater income than household k such that $y_k < y_h$. The true budget share of the commodity for household k is $B_{ik}=\frac{M_{ik}P_i}{y_k}$. Substituting the average of the incomes, $\bar{y}$, where $\bar{y}=(y_k+y_h)/2$, in the denominator in the place of y_k produces an estimated budget share of $\hat{B}_{ik}=\frac{M_{ik}P_i}{\bar{y}}$.

Case 1) Let both households have positive marketable surplus, M_i. Because $y_k<(y_k+y_h)/2$, it is the case that $\hat{B}_{ik}<B_{ik}$. By the same logic, $B_{ih}<\hat{B}_{ih}$. Therefore, the substitution of $\bar{y}$ for y_k and y_h in the calculation of household budget shares generates an underestimate of B_{ik} and an overestimate of B_{ih}.

Case 2) Let both households have negative marketable surplus, M_i. Because $y_k<(y_k+y_h)/2$, it is the case that $\hat{B}_{ik}>B_{ik}$. By the same logic, $B_{ih}>\hat{B}_{ih}$. Therefore, the substitution of $\bar{y}$ for y_k and y_h in the calculation of household budget shares generates an overestimate of B_{ik} and an underestimate of B_{ih}. ■

This proof demonstrates a deflation (inflation) of the budget shares for net seller (net buyer) households below the sample mean

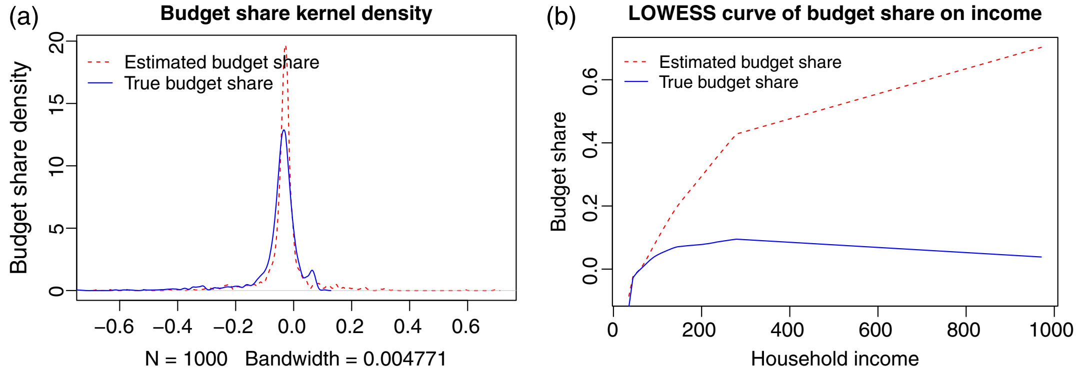

Figure 2. a) True and estimated budget share kernel density; b) LOWESS curve of true and estimated budget share on household income

income (i.e., relatively poor households) and inflation (deflation) of budget shares for net seller (net buyer) households above the sample mean income (i.e., relatively wealthy households). The extent and shape of the distortion relative to the true budget share distribution is suggested by comparing the sample moments of the budget share distribution for a single commodity using actual and mean income (table 1).

While the mean and variance of the budget distribution are not dramatically affected by the exchange of mean for actual income in the budget calculation, higher moments such as skewness and kurtosis are significantly affected. Including mean income in the calculation of the budget share causes income to drop out of these moment equations altogether; that is, when mean income is used in place of actual, the skewness and kurtosis of the budget share distribution become the skewness and kurtosis of the marketable surplus distribution only. Further, because they are not scaled by household income, the skewness and kurtosis of the budget share distribution under mean income are exaggerations of the true sample moments, producing an estimated budget share that is skewed and peaked relative to the true sample budget share distribution. These distorted budget shares feed into the calculation of the matrix of price risk aversion coefficients in equation (2), causing the reversal in the distributional WTP preferences seen in Bellemare, Barrett, and Just (2013).

A Monte Carlo simulation, presented graphically in figure 2, illustrates the distributional consequences of these moment distortions, taking the commodity maize as an example. The income, price, and marketable surplus distributions generated for this simulation approximate those seen in the ERHS data, as made available for replication by Bellemare, Barrett, and Just. In particular, 1,000 observations of price, P, are drawn from the normal distribution with a mean of 1.3 and a standard deviation of 0.4, approximating the price distribution of the commodity maize in the ERHS data. Likewise, 500 observations of marketable surplus, M, are drawn from the Weibull distribution, with scale and shape parameters of 0.5 and 1. To produce a symmetric distribution with 1,000 data points, the 500 draws are reflected across the y-axis. The data are then centered around -1.2 to produce a highly peaked and symmetric distribution with a mean of -1.2 and a standard deviation of 3.5, closely approximating the (scaled by 100) distribution of the marketable surplus of maize in the ERHS data. Finally, to approximate the (scaled by 100) log-normally distributed income observed in the ERHS, 1,000 observations of income, y, were drawn from the normal distribution with mean 1.8 and standard deviation 1.4; these data were then exponentiated and shifted to the right sufficiently for income to exceed the product of marketable surplus and price. The simulation dataset was completed by sorting income, y, and the product of marketable surplus and price, $M \times P$ (i.e., income for net sellers of maize, expenditures for net buyers of maize) from smallest to largest, and then pairing these sorted vectors to produce an $M \times P$ that rises with income, following the general trend of the ERHS data.

By design, the simulation data abstract from the ERHS in two significant ways: 1) in the simulation data, income exceeds $M \times P$ in each household, whereas in the ERHS this is not always the case. Consequently, in the simulation data the correlation between income and $M \times P$ is much higher (correlation coefficient of 0.66) than that of the ERHS data (0.0295). 2) There are no zero-valued income households in the simulation data.

To demonstrate the distortions to the relationship between income and budget share that emerge when mean income (equation 3) is used in place of household income (equation 4) in the calculation of the household budget share, household budget shares are calculated in both manners using the simulation data; the results are displayed in figure 2. Figure 2a presents the kernel densities of estimated (using $\bar{y}$) and true (using y_k) budget shares. As suggested by the moment equations in table 1, the substitution of $\bar{y}$ for y_k produces a budget share distribution that is dramatically peaked relative to the true budget share distribution. Further, locally weighted scatterplot smoothing plots of the true and estimated budget shares on income are shown in figure 2b. The estimated budget share rises monotonically in income, whereas the true budget share rises among low-income households but falls as household income grows large.

For the reasons detailed in the proof and in table 1, and illustrated via the simulation reported in figure 2, mean income is not a distribution-preserving substitution for household income in the calculation of the budget share. So how can one estimate WTP for price stabilization in the ERHS data, where 19% of the observations have zero-valued income? Unfortunately, there is no assumption-free approach to this problem. Dropping zero-valued income households from the estimation would introduce selection bias in the estimation of WTP, so this is not a compelling option. However, noting that those with zero valued income are indeed low-income earners, several distribution-preserving alternatives for treating the zero-valued income households are available.

One approach, used to produce figure 3 below, involves assigning zero-valued income households the minimum non-zero income observed in the data. Such a substitution serves to place a lower bound on the budget share estimation for these households. One might instead/also assign all zero-income earning households an annual income of one Birr, or one-tenth of a Birr, to obtain an upper bound estimate, and perform sensitivity analysis between the lower and upper bound estimates. One could also use regression analysis to assign income estimates to households based on observable household characteristics. Like the approach taken in Bellemare, Barrett, and Just (2013), each of these alternative approaches requires marking untestable assumptions about the zero-valued income households; however, the advantage of these approaches is that they do not affect the distribution of the budget share with respect to income where non-zero valued income is observed.

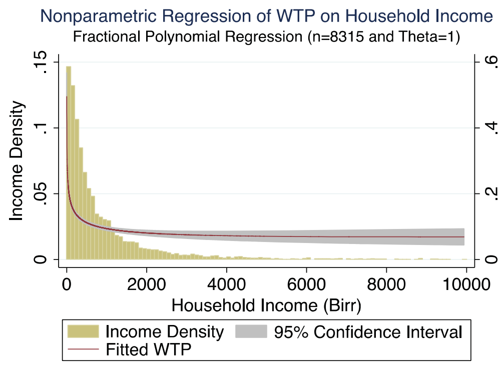

Figure 3. Reproduction of fractional polynomial regression of household WTP to stabilize commodity prices at their means using $B_{ik} = \frac{M_{ik}P_{itl}}{y_k}$ where y_k is observed, and using $\min(y)$ where $y_k = 0$

Replacing the zero-valued incomes with the minimum observed income in the ERHS data and using observed household income to estimate the budget shares for all other households produces the relationship between WTP and income displayed in figure 3. This figure shows that WTP for stabilization falls with income, suggesting a distributionally progressive benefit incidence of food price stabilization. Note that this approach is not offered as a solution to the zero-valued income problem in the ERHS; rather, it is shown to further demonstrate the distributional consequences of the approach taken in Bellemare, Barrett, and Just (2013).

Conclusion

Estimating the budget share over mean income deflates (inflates) the budget shares of relatively poor net seller (net buyer) households and inflates (deflates) the budget shares of relatively wealthy net seller (net buyer) households, thus causing a serious distortion in the distribution of budget shares relative to income. These findings suggest that the budget share calculations in Bellemare, Barrett, and Just (2013) reverse the relationship of poor and wealthy households to WTP in the ERHS data. Under another treatment of the zero-valued income households in these data, the policy implications are reversed. When observed, as opposed to mean, income is used in the budget share calculations where available, the relationship between WTP for price stabilization and income suggests a distributionally progressive benefit incidence of food price stabilization.

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