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Submitted Article

Measuring Food Expenditure Poverty in SNAP Populations: Some Extensions with an Application to the American Recovery and Reinvestment Act

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Abstract *The adequacy of the Supplemental Nutrition Assistance Program (SNAP) benefits is always an important concern. This article extends the most common measure for evaluating the adequacy of SNAP, food expenditures, and uses more comprehensive metrics to evaluate the impact of the American Recovery and Reinvestment Act (ARRA). These more comprehensive metrics are easy to implement with existing data, more closely tied to the purpose of the SNAP, and indicate a slightly larger impact of the ARRA.*

Key words: Supplemental Nutrition Assistance Program, Food Expenditure Poverty, Thrifty Food Plan.

JEL codes: D13, H53, I32.

The Supplemental Nutrition Assistance Program (SNAP) is the largest U.S. nutrition program, accounting for 80% of the USDA budget (Monke 2013). Recently, questions have arisen about the adequacy of SNAP benefits (Caswell and Yatkine 2013). However, adequacy, by definition, implies some goal or target. The U.S. Code 2011 states the purpose of SNAP is to "permit low-income households to obtain a more nutritious diet through normal channels of trade by increasing food purchasing power for all eligible households who apply for participation," (SNAP 7 USC 2011).

Though general welfare may be the final goal, in the language of economic policy theory (e.g., Acocella, Di Bartolomeo, and Hughes-Hallett 2012),

"increasing food purchasing power" is an intermediate goal or target. An intermediate target is often favored over a final target for multiple reasons, such as easier observability, measurement, and monitoring, and greater uncertainties associated with the structure and number of determinants of a final outcome (e.g., Holbrook and Shapiro 1970 in a macro context).

The purpose of this article is to extend the most common measure of this explicitly stated intermediate goal in order to provide a more comprehensive picture of the adequacy of SNAP benefits. This purpose is accomplished by using the well-known Foster, Greer, and Thorbecke (1984) poverty index to tie together and also extend two connected but limited strands of the literature measuring SNAP benefit adequacy.

This extension is important because the effectiveness of any anti-poverty program depends on the stated goal and how accurately the chosen metrics reflect that goal. The advantages of the extended metrics are demonstrated by answering the following question: Did the SNAP component of the American Recovery and Reinvestment Act (ARRA) improve the food expenditure poverty situation for SNAP participants as was intended? We find that the current less comprehensive measures are not closely tied to the purpose of the SNAP and tend to underestimate the effectiveness of the ARRA, whereas the more comprehensive metrics presented here are more closely tied to the purpose of the SNAP and indicate a slightly larger impact.

The next section first presents the most common measure of purchasing power required for a nutritious diet, which we call the normalized food expenditure, and discusses some of its limitations as a measure of food expenditure poverty. The following section then demonstrates how the Foster, Greer, and Thorbecke index embeds and extends the normalized food expenditure. However, the normalized food expenditure is a partial expenditure measure that does not include the labor cost of home food production. Based on Becker's (1965) seminal household production theory and recent literature, the next section shows how the "full cost" of food production approach including labor has stronger theoretical foundations and can also be incorporated into the normalized food expenditure formula to yield what we call the normalized money-time expenditure. While being an improvement over the partial normalized food expenditure, this full-cost normalized money-time expenditure still suffers similar limitations as a measure of food expenditure poverty. We then show how the full cost normalized money-time expenditure can also be embedded in and extended by the Foster, Greer, and Thorbecke index. All the metrics are then applied to evaluating the impact of the ARRA. We close the paper by presenting conclusions and limitations.

Normalized Food Expenditures

SNAP benefits are derived from the USDA Thrifty Food Plan (TFP), which is considered the minimum monetary cost required to meet the U.S. dietary guidelines (see Wilde and Llobrera 2009 for an overview). As quoted, the U.S. Code 2011 goal is about "purchasing power" relative to a "nutritious diet" so the ratio of actual food expenditures to the TFP is a simple, intuitive, and ubiquitous evaluation metric.[1]

[1]*This ratio goes by various names (e.g., Needs Standard, Hoynes, McGranaham, and Schanzenbach 2016; TFP Adjusted Food Expenditures, Nord and Prell 2011; Money Expenditure Ratio, Davis and You 2011; Ratio of Actual Expenditures to TFP, Stewart and Blisard 2006; Standardized Cost, Horning*

Let M_i^a denote actual food expenditures and M_i^{TFP} the recommended TFP food expenditure amount for household i. The TFP normalized money expenditures are then

$$NME_i = M_i^a \div M_i^{TFP} \; : \; Normalized\,Money\,Expenditures. \tag{1}$$

SNAP benefits are not intended to cover all food expenditures. Participants are assumed to spend 30% of their own net income, which depends on several allowable deductions from their gross income (see Caswell and Yatkine 2013 for more details). Consequently, the appropriate numerator is food expenditures from all sources, SNAP and personal. If $NME_i > 1$, the household is spending more than enough to reach the nutrition target. Otherwise, it is not. Of course, the *NME* does not tell us anything about household diet quality or more distant outcomes such as food security or childhood obesity, but these are not the focus of the U.S. Code 2011.

Some central tendency measure of the normalized food expenditure is the most common measure of resource adequacy found in the literature. The Annual Food Security Report of the USDA (e.g., Coleman-Jensen et al. 2017) reports the normalized food expenditure every year and it can be found in numerous reports and journal articles (e.g., Stewart and Blisard 2006; Rose 2007; Davis and You 2011; Nord and Prell 2011; Nord 2013; Horning and Fulkerson 2014; Hoynes, McGranaham, and Schanzenbach 2016; Katare and Kim 2017; Tiehen, Newman, and Kirlin 2017). For SNAP eligible or participating households, the mode across studies is usually a little less than 1.0, implying SNAP households are not spending enough to reach the TFP target, but that interpretation is misleading.

While the *NME* does provide useful information about expenditures, it suffers three limitations. First, it only provides information on expenditures, not households. The ultimate subject of interest in U.S. Code 2011 is "low-income households", not money. Even for a sample restricted to SNAP participants, the mean or median *NME* tells us nothing about how many low-income households are above or below the TFP threshold. Second, the *NME* does not give a clear indication of how far low-income households may be below the TFP threshold. Finally, the *NME* does not give any indication of the concentration of households below the TFP threshold. Fortunately, these limitations are easily addressed by connecting the *NME* to a well-known poverty metric.

A Poverty Index Extension of the Normalized Money Expenditure

The fundamental question implied by the U.S. Code 2011 is, how are individual households doing relative to some minimum standard or target? This is a poverty question (See Ziliak 2006 for a good overview of poverty). As normally defined, poverty is to be below some minimum income level. The implicit assumption is that if income, which is an intermediate target and an input in an indirect utility function, is above some threshold, so too will be the final output or target (utility). Of course, this poverty concept can be applied more generally to any case where a household is below some minimum resource (input) threshold (Citro and Michael 1995). Thus, the

and Fulkerson 2014; Food Spending Relative to the TFP, Coleman-Jensen et al. 2017, Tiehen, Newman, and Kirlin 2017).

TFP defines a minimum food expenditure threshold and standard poverty metrics can be used to define what we will call *food expenditure poverty*: food expenditures below the TFP threshold.

The poverty index developed by Foster, Greer, and Thorbecke (Foster, Greer, and Thorbecke index; 1984) has very appealing theoretical properties, is very easy to implement, and is a staple in the poverty literature. With the notable exception of Jolliffe et al. (2005), and similar studies by Tiehen, Jolliffe, and Gundersen (2012) and Tiehen, Jolliffe, and Smeeding (2016), the SNAP has not been viewed through the lens of the Foster, Greer, and Thorbecke index. These authors considered how SNAP benefits affected income poverty, so their relevant threshold was the income poverty level. In line with U.S. Code 2011, our interest is in food expenditure poverty, so our relevant threshold is the TFP food expenditures.

The Foster, Greer, and Thorbecke poverty index is

$$P_\alpha = N^{-1}\sum_{i=1}^{N} I(z_i > y_i)\left(\frac{z_i - y_i}{z_i}\right)^\alpha \tag{2}$$

where y_i denotes the value of the variable of interest and z_i the threshold value defining "poverty" for the ith household. The i subscript on z indicates the threshold may vary by household. The indicator function $I(z_i > y_i) = 1$ if the household is below the poverty threshold, and zero otherwise. The term $(z_i - y_i) \div z_i = 1 - (y_i \div z_i) = g_i$ is the normalized poverty gap g_i. In the present application, $y_i = M_i^a$ and $z_i = M_i^{TFP}$, so the indicator function only counts those households below the TFP. The normalized poverty gap is $g_i = 1 - (M_i^a \div M_i^{TFP}) = 1 - NME_i$, which shows how the normalized gap is related to the NME_i. The normalized gap is expressed in percentage terms below the threshold, so if $g_i = 0.25$, the household is 25% *below* the threshold. The "poverty aversion" parameter α defines the poverty measure of interest: $P_{\alpha=0}$ gives the percentage of households below the poverty threshold—the poverty rate or *prevalence*, $P_{\alpha=1}$ gives the per capita household distance from the poverty threshold in percentage terms or *depth*, and $P_{\alpha=2}$ gives degree of skewness in depth or *severity* and in the present context would be considered a measure of food expenditure poverty and inequality. Which measure is the focus of analysis will have different policy implications in terms of the efficient allocation of funds to reduce food expenditure poverty. For example, in the depth formula ($P_{\alpha=1}$), all individual normalized poverty gaps receive the same weight, so a one-unit change in a poverty gap will have the same effect on depth regardless of which household changed. Alternatively, in the severity formula ($P_{\alpha=2}$), the gap is weighted by the gap and so a one unit change in the gap will have a larger impact on severity the larger is the initial gap.

The Foster, Greer, and Thorbecke index addresses all three of the *NME* limitations mentioned above. The mean *NME*, that is usually reported, is related to the poverty index as

$$\overline{NME} = (P_0 - P_1) + N^{-1}\sum_{i \in N_A} NME_i \tag{3}$$

where N_A is the sample above the threshold. The mean *NME* conflates information on prevalence and depth (the first term) and also includes

information for those above the threshold (the last term), so it could increase even as the prevalence and depth of poverty did not change or actually increased. Alternatively, the Foster, Greer, and Thorbecke poverty index, via the indicator function, limits the sample to those individuals who are of most concern, those below the threshold, or who are in poverty. Furthermore, by setting $\alpha = 0$, 1, and 2, the focus is on the number of households in poverty (prevalence) and how far the households in poverty are from reaching the threshold (depth) and to what degree they are in poverty (severity) (e.g., Ravallion 1994).

Is the Denominator Wrong? The "Full Cost" of the TFP

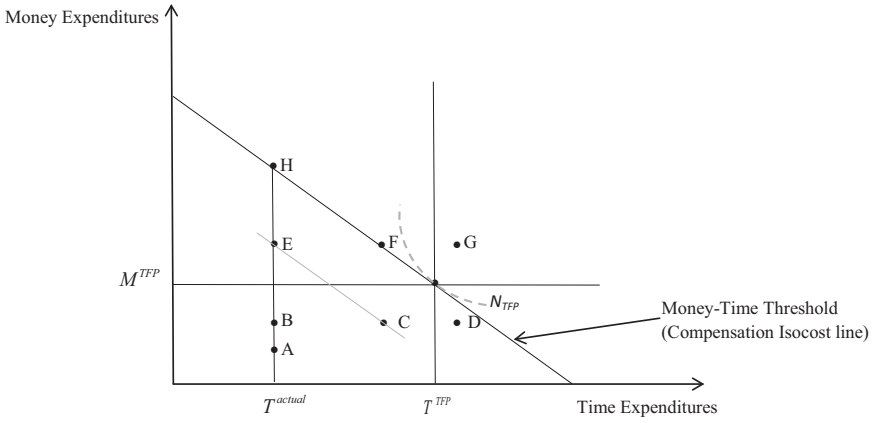
The normalized money expenditure also suffers from another limitation; it underestimates the cost of a nutritious diet because the TFP only estimates the cost of *one* input (groceries). But a nutritious diet also requires labor: labor in meal planning, travel to the store, shopping, preparing the food for assembly, and cooking. Ignoring the labor cost in food production leads to an underestimation of the full cost of a diet, which in turn leads to an overestimation of the effectiveness of SNAP and an underestimation of food expenditure poverty. This is a direct application of household production economics and the "full cost" of production (Becker 1965).

There is now a rather substantial body of literature on the role that time plays in nutrition-related outcomes, ranging from lower diet quality being associated with lower time in food preparation (e.g., Jabs and Devine 2006; Monsiavais, Aggarwal, and Drewnowski 2014), to mealtime planning and food insecurity (Fiese et al. 2016) and healthy child weight (Fiese, Hammons, and Grigsby-Toussaint 2012). Marshall and Pires (2017) and Hilbert et al. (2016) find that travel costs, which are directly proportional to time, are more important in determining grocery choices and diet quality than food prices. Landfield, Fraumeni, and Vojtech (2009) argue that a time-adjusted food price index helps better explain the increase in convenience food consumption than just the unadjusted price index. In a comprehensive review of the literature of numerous nutrition and health outcomes related to home cooking, Mills et al. (2017) find that one of the main factors affecting food preparation is time availability and employment.

In the present context, recent research finds that labor (time) in food production is more important than money in reaching the TFP nutrition target (e.g., Rose 2007; Davis and You 2011; Rashcke 2012). The underlying logic is straightforward and can be illustrated with a standard two-input isocost isoquant (household) production diagram (figure 1). The vertical axis represents household (food) money expenditures or materials M. The horizontal axis represents household (food) labor expenditures or time T. There is an implicit target nutrition isoquant that is consistent with the TFP (dashed N_{TFP}), and (M^{TFP}, T^{TFP}) denotes a money−time input combination that lies on this isoquant.

Given there are two required inputs for reaching a nutrition target, a household could be "time poor and money rich", or vice versa (Davis and Serrano 2016). Any of the households E, F, H are "time poor but money rich", but household D is "money poor and time rich". So the reason for not reaching the nutrition target could be different for different households. In this context, as Atkinson (2003) states, "There is widespread agreement that deprivation is multidimensional. It is not enough to look only at income

Figure 1 Alternative thresholds and measurement differences



poverty; we have to also look at other attributes." One of the *atheoretical* multidimensional poverty measures could be implemented, such as the intersection method, union method, or counting method (see Alkire et al. 2015 for an overview) but in the present context, there are two fundamental questions: (*a*) how much is the "full" cost of the TFP? and (*b*) how far is the household from this full cost TFP target? These are standard compensation questions, so a well-established theoretical measure can be utilized.

Davis and You (2011) demonstrate that the cost difference approach (Machlup 1957), in conjunction with the market substitute approach to valuing time in food production (Gronau 1986), will give an isocost line consistent with the TFP nutrition level. The cost difference approach answers the question: what is the appropriate compensation isocost line showing different input combinations that lead to the same "full" cost that includes all inputs?[2] Regarding valuing of time, there are generally two approaches: the opportunity cost approach and the market substitute approach. The opportunity cost approach values the input at how the individual values the input (i.e., a point on their demand curve or willingness to pay) whereas the market substitute approach values the input similar to how the market values the input. As with any good, there is a difference between an individual's willingness to pay and how the market values the good, but similar to all income product accounting, the TFP is based on market value prices of groceries, not the individual's willingness to pay for groceries. As Schreyer and Diewert (2014) have recently shown theoretically, when the purpose is to determine the full cost of production, the market substitute approach for valuing time is appropriate and will be internally consistent with how the TFP is valued (see Hawrylyshyn 1976; Chiswick 1982; Hill 2009; Bridgman 2016 for more discussion on valuing time in production).

The cost difference isocost line (money-time threshold) is given by the equation

[2]*Similar to compensating variation or equivalent variation, the cost difference compensation is about the amount of resources needed to* possibly *reach the targeted isoquant. There is no guarantee that households will allocate these resources in the optimal way to reach the targeted level. That is a different question.*

$$MT_i^{TFP} = M_i^{TFP} - p(T_i^a - T_i^{TFP}) \; : \; Money\text{-}Time \;\; Threshold \tag{4}$$

where p is the market value of time in food production and T_i^a is actual food production time. Equation (4) gives the amount of money the household needs to reach the "full" cost of the TFP (groceries + labor) once their labor in food production is taken into account.[3] So given a household's time allocation to food production, the money-time threshold becomes the relevant "full cost" nutritional expenditure for normalizing food expenditures.

$$NMTE_i = M_i^a \div MT_i^{TFP} \; : \; Normalized \, Money \, Time \, Expenditures \tag{5}$$

The normalized money-time expenditures (*NMTE*) in equation (5) will nest the normalized money expenditures (*NME*) from equation (1) as follows:

$$NMTE_i = \frac{1}{[1 + p(T_i^{TFP} - T_i^a)/M_i^{TFP}]} \times NME_i. \tag{6}$$

With a positive price of the labor input ($p > 0$) and a time requirement to reach the TFP greater than actual time $(T_i^{TFP} - T_i^a) > 0$, the partial normalized money expenditures (*NME*) will always overestimate the full cost normalized money-time expenditures (*NMTE*), implying the *NME* will always overestimate SNAP benefit adequacy (Davis and You 2011). Davis and You (2011) are the only ones to have calculated the *NME* and *NMTE*, and estimate these to be about 1.35 and 0.60, respectively, for single-headed households, demonstrating the importance of taking into account labor costs. Equation (6) further implies, in the context of the Foster, Greer, and Thorbecke index measures, using the money-only *NME* will give a lower bound to the full cost prevalence, depth, and severity measures obtained from using *NMTE*. Simply stated, the *NME* will underestimate the degree of food expenditure poverty.

Pulling all this together, by defining y_i and z_i appropriately in the Foster, Greer, and Thorbecke index equation (2), the prevalence, depth, and severity can be generated in three dimensions: (*a*) money expenditure only, (*b*) time expenditure only, and (*c*) "full" expenditure. None of the mentioned literature has used the Foster, Greer, and Thorbecke index, or used them in these three dimensions.

Importantly, the conclusion about poverty (prevalence, depth, and severity) will differ depending on the dimension. For example in figure 1, the prevalence rate for money only is 50%, for time only 75%, and for money-time (full cost) 63% (i.e., 4/8: households A, B, C, D; 6/8: households A, B, C, E, F, H, and 5/8: households A, B, C, D, E). Depth and severity increase as the normalized gaps increase—the distance below the relevant threshold increases—so will also differ depending on the threshold. To demonstrate, consider households B, C, and D in figure 1, which are all equal distances below the money only threshold (i.e., their $NME < 1$), so all have the same

[3] *The intuition of the cost difference approach is easily seen by rewriting equation (4) as* $\mathrm{MT} + \mathrm{pT}^{\mathrm{a}} = \mathrm{M}^{\mathrm{TFP}} + \mathrm{pT}^{\mathrm{TFP}}$. *The right side gives the "full cost" to reach the TFP nutrition target, including labor. With a given time allocation valued at the market substitute rate* pT^{a}, *solving for* MT *gives the amount required to have the equivalent expenditures to the full cost TFP consistent expenditures.*

money only "poverty level". Now suppose, perhaps due to an increase in SNAP benefits, household B increases its food expenditures, but not their time expenditures, to point E (i.e., now $NME > 1$). How would this household compare to households C and D? In the money-only dimension, household E would be better off than households C and D. However, in the full-cost context, household E is no better off than household C. In fact, household D is closer to the full-cost threshold than C or E, even though E has more spending and C has the identical spending level as D.

Households C and E lie on a line parallel to the full cost money-time threshold, so consequently, these households are the same distance from the full-cost money-time threshold (same gap value). However, the gap value is the same for different reasons. For household E, the distance H – E is achieved by spending more money but less time in home food production, whereas the equal distance F – C is achieved by spending less money but more time, but their actual full cost is the same. Thus, we would expect to observe, *ceteris paribus*, that households with more income spend more money and less time to reach the full-cost threshold, but those with less income (e.g., SNAP households) to spend more time and less money to reach the full-cost threshold. But as C and E demonstrate, observing different money and time allocations does *not* mean the households have different gaps; indeed, the gaps may be identical. So, just focusing on a money-only metric may lead to the conclusion that households spending less money on food are worse off (e.g., SNAP households) than those spending more on food (e.g., Non-SNAP households) when in fact, once the adjustment for time is made they are more similar because the full costs are similar. This is the importance of recognizing that it takes two inputs to reach the full-cost target. As basic economics indicates, when there are two inputs, multiple input combinations can be on the same isocost line. Spending more money or time, in isolation, is neither necessary nor sufficient to reach or exceed the full-cost TFP food expenditure level, and this has important implications for policy evaluation and targeting.

An Application to the Effect of the ARRA on Food Expenditure Poverty

The idea behind an increase in SNAP benefits, which occurred with the American Recovery and Reinvestment Act (ARRA), is that actual money (food) expenditures will increase—and also possibly time in food production—thereby decreasing all of the three poverty measures in money/time or both dimensions. The ARRA provides a good case for highlighting the strengths of the more comprehensive measures because the ARRA did not increase SNAP benefits by a large amount. Thus, we would expect that the current measures that are not very sensitive to distance will likely show little impact, whereas the metrics proposed here would provide a more complete picture and show a larger impact.

Data and the ARRA Premium

Equation (2) is used to measure of prevalence (P_0), depth (P_1), and severity (P_2) for (*a*) only a money threshold, (*b*) only a time threshold, and (*c*) the theoretically-based cost−difference money-time threshold. Each measure is

evaluated with and without the ARRA premium amount to determine (*a*) how much the ARRA affected all three measures and (*b*) if it affected some measures more than others.

The ARRA was signed into law in February of 2009. Effective on April 1, 2009, the ARRA raised the maximum SNAP allotment by an average of 13.6%, which ended on October 31, 2013 (USDA/ERS 2015). However, because the maximum allotments varied by household composition and the level of benefits received vary by household-specific deductions, all households did not receive the same dollar increase in benefits.

For this analysis, the data requirements are household food money *and* time expenditure data, household composition, and SNAP benefit data. These requirements limit dataset options. We follow Davis and You (2011) and use the Food Security Supplement (FSS; USDA/ERS/CPS-FSS 2009–2011) and the American Time Use Survey (ATUS; USDL/BLS 2009–2012), which can be matched because they are both supplements and subsamples of the Current Population Survey (CPS) and contain household compositional information. We focus on single-headed households who are most susceptible to resource constraints (e.g., Casey and Maldonado 2012; Meyer and Abdul-Malak 2015), and because the ATUS collects time diary information from a single individual in the household. Given the focus of the study, we also limit the analysis to SNAP-participating households. Finally, the ARRA increment varies over Alaska, Hawaii, Guam, and the Virgin Islands, but is the same across the 48 contiguous states and Washington, DC, so we focus only on the 48 contiguous states and Washington, DC. The time period is 2009 to 2011.

Money and Time Thresholds

The weekly money expenditure threshold M_i^{TFP} comes from the June Thrifty Food Plan (TFP) Official USDA Food Plans table (USDA Food Plans: Cost of Food 2009–2011) with household composition adjustments made according to the table footnotes. For the weekly time expenditure threshold T_i^{TFP}, we use the median 13.13 hours per week estimate from Davis and You (2011), which is based on 1,000 USDA weekly meal plans satisfying the TFP. As in Davis and You (2011), we use the annual median hourly wage of Cooks, Private Household (code: 35-2013) from the Bureau of Labor Statistics, Occupational Employment Statistics, and Occupational Employment Wages from 2009 to 2011(BLS 2009–2011) for the market substitute price, p.

Money and Time Expenditures with ARRA Premium

For actual money expenditures M_i^a, we use the "usual" weekly food expenditures reported in the FSS. During the time period under consideration, actual food money expenditures M_i^a would *include* the effect of the ARRA on food expenditures. The actual weekly time expenditures come from the American Time Use Survey (BLS/ATUS 2009-2012) and are for Food and Drink Preparation (ATUS code 020101), Food Presentation (ATUS Code 020202), Kitchen and Food Clean-up (ATUS Code 020203), Grocery Shopping (ATUS Code 070101), and Travel Related to Food and Drink Preparation, Clean-up, and Presentation (ATUS Code 180202). From each ATUS household, one individual age 15 or older is randomly chosen to be interviewed by telephone about his/her activities from the

previous day. The ATUS households are stratified by race, ethnicity, and the presence of children and randomized by weekday (50%) and weekend (50%) to ensure that estimates will be temporally and nationally representative. Because the highest frequency of M_i^{TFP} and M_i^a is weekly, a weekly household time estimate, that includes all days of the week and holidays, is obtained using a nonparametric Horovitz and Thompson (1952) estimator as described in Davis and You (2011). Similar to the actual money expenditures, we use the superscript a to indicate actual time expenditures, T_i^a.[4]

Money Expenditure and Time Expenditure without ARRA

We need estimates of M_i^a *without* the ARRA. The actual money expenditure M_i^a will depend on the amount of SNAP benefit received and the marginal propensity to spend on food out of the received SNAP benefit (*MPS*). The general benefits formula *without* the ARRA premium (see Caswell and Yatkine 2013) is

$$SNAP_i^o = M_i^{TFP} - Deductions_i. \tag{7}$$

After April 2009, the SNAP benefits were increased by a fixed $ARRA_i$ amount, depending on the household composition, but the deduction formulas were not affected. So the SNAP benefit *with* the ARRA premium is

$$SNAP_i^w = (M_i^{TFP} + ARRA_i) - Deductions_i. \tag{8}$$

The difference in SNAP benefits ($\Delta SNAP_i$) is then

$$\Delta SNAP = SNAP_i^w - SNAP_i^o = ARRA_i. \tag{9}$$

The Food Nutrition Service of USDA reports the maximum benefit *with the* ARRA or $(M_i^{TFP} + ARRA_i)$ (USDA/FNS 2009–2011). The Center for Nutrition Policy and Promotion at USDA reports the value of M_i^{TFP} (USDA Food Plans: Cost of Food 2009–2011). Taking the difference between the two reported figures yields the value of $ARRA_i$ per household. The per capita amount is about $5.00 per week.

As is well documented, the marginal propensity to spend out of SNAP benefits (*MPS*) is normally less than one (Fraker 1990; Fox, Hamilton, and Lin 2004; Breunig and Dasgupta 2005; Hoynes and Schazenbach 2009; Beatty and Tuttle 2014; Tuttle 2016). Thus, the reduction in food expenditures associated with removing the *ARRA* would be

[4]*The FSS has two types of food expenditure questions: "last week" and a generic "usual". We use the usual weekly household food expenditures because the ATUS is conducted 2–5 months after the household has completed the final CPS interview. Implicitly, the usual weekly household food expenditures are considered representative of any week and so would apply to the ATUS week for the time data. As with any variable that varies by day, such as money and time expenditures, there will be temporal variations making any specific week chosen perhaps unique. Though the ATUS is a great improvement in measuring time use and is designed to be temporally and nationally representative, it still has limitations, which we discuss in the conclusions.*

$$\Delta M_i = -MPS \times ARRA_i.$$

The *MPS* falls in the interval of [0.17, 0.47] for most studies, though Fox, Hamilton, and Lin (2004) have a high estimate of 0.86, and Tuttle (2016) reports estimates in the 0.39 to 0.62 range. Given this uncertainty, we consider three cases: $MPS_1 = 0.17$, 0.47, and 1.00.

With respect to changes in time expenditures, only Beatty, Nanney, and Tuttle (2014) have looked at the relationship between SNAP benefit levels and food production time. For single-headed households, which we are considering here, SNAP benefits had no statistically significant effect on any meal preparation or grocery shopping time. Consequently, in this main text we focus on the case where the time allotted to food production does not change as a result of the ARRA. In the online supplementary appendix, results are provided where the time allocated to food production could change by −5% and +5%. We will briefly allude to these findings in the discussion as well.

In summary, the poverty index formulas *with* and *without* the ARRA premium are

$$P_\alpha^j = N^{-1}\sum_{i=1}^{N} I\left[M_i^{TFP} > (M_i^a + \Delta M_i)\right]\left(\frac{M_i^{TFP} - (M_i^a + \Delta M_i)}{M_i^{TFP}}\right)^\alpha \tag{11}$$

$$P_\alpha^j = N^{-1}\sum_{i=1}^{N} I\left[T_i^{TFP} > T_i^a\right]\left(\frac{T_i^{TFP} - T_i^a}{T_i^{TFP}}\right)^\alpha \tag{12}$$

$$P_\alpha^j = N^{-1}\sum_{i=1}^{N} I\left[MT_i^{TFP} > (M_i^a + \Delta M_i)\right]\left(\frac{MT_i^{TFP} - (M_i^a + \Delta M_i)}{MT_i^{TFP}}\right)^\alpha. \tag{13}$$

The *with* ARRA premium formula occurs when $\Delta M_i = 0$ and the j superscript is w (i.e., P_α^w). The *without* ARRA premium formula occurs when $\Delta M_i \neq 0$ for the values discussed and the j superscript is o (i.e., P_α^o). Prevalence, depth, and severity are associated with $\alpha = 0$, 1, and 2, respectively.

Results

We present the components of the normalized poverty gap from equation (2) (table 1) and the poverty metrics with and without the ARRA (table 2). As in Jolliffe et al. (2005), table 2 contains the percentage change in each poverty metric associated with the ARRA premium, which is calculated as $(P_\alpha^w - P_\alpha^o) \div P_\alpha^w$. Their general variance calculation approach is followed for each metric and the percentage change. However, in contrast to Jolliffe et al. (2005), whose focus was overall income, given our focus is food expenditures, we use per capita food expenditures in the sorting step. We use the four regions (Northeast, Midwest, South and West) as the synthetic strata.[5]

[5]*We considered another, more complicated sorting approach using household size and money expenditures and the variances estimates are virtually identical to what we report here.*

Table 1 Summary Statistics for Metric Components

Variables	Units	Mean	Median	S.D	95% Percentile	
Actual money expenditure (M^a)	$/week	109.15	91.00	80.36	9.33	319.58
Money expenditure threshold (M^{TFP})	$/week	114.64	109.10	59.79	40.44	229.49
Money expenditure gap ($M^{TFP} - M^a$)	$/week	5.49	9.10	72.33	–184.71	116.98
Normalized money gap ($1 - M^a / M^{TFP}$)		–0.03	0.08	0.71	–2.35	0.89
Actual time expenditure (T^a)	h/week	4.64	4.37	0.84	3.86	7.23
Time expenditure threshold (T^{TFP})	h/week	13.13	13.13	0.00	13.13	13.13
Time expenditure gap ($T^{TFP} - T^a$)	h/week	8.49	8.76	0.84	5.90	9.27
Normalized time gap ($1 - T^a / T^{TFP}$)		0.65	0.67	0.06	0.45	0.71
Actual money expenditure (M^a)	$/week	109.15	91.00	80.36	9.33	319.58
Money-Time expenditure threshold (MT^{TFP})	$/week	213.74	206.93	61.63	122.39	329.48
Money-Time expenditure gap ($MT^{TFP} - M^a$)	$/week	104.59	107.90	73.95	–87.79	219.83
Normalized money-time gap ($1 - M^a / MT^{TFP}$)		0.50	0.55	0.33	0.39	0.95

Note: $N = 692$.

Components

The money expenditure gap ($M_i^{TFP} - M_i^a$) in table 1 shows that on average, the TFP target expenditures are $5.49 above what households are actually spending, ignoring the value of labor. The average normalized money expenditure gap is −0.03, so on average, households are spending 3% *more than enough* to reach the TFP target. The higher median of 0.08 indicates the distribution is skewed left, so the average may be a little misleading. Half of the households are spending *at least* 8% *less than* the TFP target. The 95th percentile intervals indicate households above and below the target.[6]

The time components paint a more severe picture. On average, the TFP time threshold is about 8.50 hours per week higher than actual time expenditures (i.e., time expenditure gap $T_i^{TFP} - T_i^a$). The median is similar. The 95th percentile (5.90 to 9.27) indicates virtually all households fall short of the required TFP time. The average normalized time expenditure gap indicates that households are 65% below the TFP time threshold.

As shown earlier, the required money-time threshold will be greater than when labor is ignored and this is confirmed. The required money-time expenditure threshold averages about $105 higher than the actual money

[6]*The summary statistics for some of the gaps and normalized gaps may seem at odds (e.g., money or money-time). This puzzle is easily reconciled by recalling that the normalized gap is a ratio and the distribution of a ratio does not equal the distribution of the difference in its elements (i.e., Jensen's inequality).*

Table 2 Foster, Greer, and Thorbecke Indices with ARRA and without ARRA Assuming No Household Time Allocation Change Associated with ARRA[a]

			Without ARRA			Percent Poverty Increase Without ARRA		
Indices	**Expenditure Type**	**With ARRA**	**MPS=0.17**	**MPS=0.47**	**MPS=1**	**MPS=0.17**	**MPS=0.47**	**MPS=1**
Prevalence(P_0)	Money	59.3	60.1	62.4	67.1	1.36%	5.22%	13.19%*
		(0.03)	(0.03)	(0.03)	(0.03)	(0.07)	(0.07)	(0.08)
	Time	100.0	100.0	100.0	100.0	0.00%	0.00%	0.00%
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Money–Time	92.8	93.4	93.8	94.4	0.61%	1.07%	1.74%
		(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
Depth(P_1)	Money	21.8	23.0	25.3	29.5	5.64%	15.89%	35.12%**
		(0.02)	(0.02)	(0.02)	(0.02)	(0.11)	(0.12)	(0.13)
	Time	64.7	64.7	64.7	64.7	0.00%	0.00%	0.00%
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Money–Time	52.7	53.6	55.3	58.4	1.82%	5.05%	10.81%**
		(0.01)	(0.01)	(0.01)	(0.01)	(0.04)	(0.04)	(0.05)
Severity(P_2)	Money	11.7	12.7	14.4	18.0	7.88%	22.90%	53.13%**
		(0.01)	(0.01)	(0.01)	(0.02)	(0.16)	(0.17)	(0.21)
	Time	42.2	42.2	42.2	42.2	0.00%	0.00%	0.00%
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Money–Time	34.0	35.1	37.0	40.6	3.15%	8.87%	19.47%***
		(0.01)	(0.01)	(0.01)	(0.02)	(0.06)	(0.06)	(0.07)

Note: *Superscript [a] Indicates that each index is multiplied by 100. For each index P_i , i=0,1,2, a percent decrease is calculated as $(P_{i,\ w} - P_{i,\ w/o})/P_{i,w}$ but given this number is negative it is therefore the percent increase, hence the heading title and the negative sign is dropped. Standard errors are in parentheses. The estimated change is superscripted with asterisks *, **, or *** if the p-value is less than 0.1, 0.05, or 0.001, respectively. An online supplementary appendix has results assuming time allocation change associated with ARRA.*

expenditures (i.e., the money-time expenditure gap $MT_i^{TFP} - M_i^a$). Given the 95th percentile overlaps zero (−87.79 to 219.83), some households are spending more than required to meet the TFP threshold. However, the normalized money-time expenditure gap indicates households are only spending, on average, about 50% of the amount required to meet the TFP target that takes into account labor cost. All households within the 95th percentile interval are below the labor-inclusive threshold.

Poverty Metrics with and without the ARRA. Did the ARRA premium improve the poverty metrics? Column three in table 2 gives the prevalence, depth, and severity measures *with* the ARRA premium and demonstrates that focusing solely on prevalence and monetary resources gives a distorted picture of the degree of poverty.

In terms of *prevalence*, about 60% of the sample is below the money expenditure threshold, but 100% are below the time expenditure and about 93% are below the money-time expenditure thresholds. So ignoring labor cost, 40% of the sample is above the money expenditure threshold. With labor cost included, only 7% are above the money-time threshold. Regarding *depth*, the money expenditure depth of 21.8 indicates that the average "poor" household (i.e., those below the threshold) falls about 22% below the threshold. For time expenditure, the average "poor" household falls about 65% short of the time threshold and for the money-time threshold the average household falls about 53% short of the money-time threshold. *Severity* places a greater weight on a larger normalized poverty gap and, like prevalence and depth, a smaller severity number is preferred. Severity appears smallest in the money-only dimension (11.7) and is the worst in the time only dimension (42.2), but as expected falls between these extremes in the money-time dimension (34.0). This result just reflects the order of the normalized gap sizes across these dimensions. Regardless of the poverty measure used, ignoring labor cost underestimates food expenditure poverty.

As indicated, the effect of the change in SNAP benefits on total food expenditures depends on the *MPS*. Columns four through six in table 2 give the poverty measures *without* the ARRA premium for values of the *MPS* of 0.17, 0.47, and 1.00, assuming there is no change in the time allocation. As the *MPS* increases, the *removal* of the ARRA premium will lead to a *greater* decrease in food expenditures and *greater* poverty measures. The absolute changes in the poverty measures (not shown) are quite small, however, and this is because the average ARRA premium is about $12 per week, or about $5.00 per capita for our sample. Thus, the issue is *not* that the ARRA did not have the desired effect, but rather that the "dose" was perhaps too small to make much of a difference in absolute terms. However, columns seven through nine reveal the ARRA premium was more impactful in percentage terms than in absolute terms.

The last three columns in table 2 demonstrate the importance of going beyond just the prevalence rate and monetary resources. Regardless of the *MPS* value, removing the ARRA leads to a larger increase in the severity measure, followed by a larger increase in the depth measure, and finally an increase in the prevalence measure for the money-only expenditure threshold. A similar pattern emerges for the money-time poverty metrics. As shown in the online supplementary appendix, these general ordinal patterns remain when we allow time to change by −5% and +5%. Based on figure 1,

it should not be surprising that the time-only and money-time poverty measured worsen when time in food production decreases, but improve when time in food production increases, but depth and severity are impacted more than prevalence. Furthermore, the fact that there is only statistical significance when the $MPS = 1$ in table 2 provides further evidence that dose is the issue, in that a larger *MPS* is effectively equivalent to a larger dose of SNAP benefits being used on food expenditures. The practical translation is the ARRA did more for improving depth and severity than it did prevalence. Just focusing on prevalence underestimates the positive impact of the ARRA.

Importantly, the ordinal finding that across all measures the percentage change in severity is greater than the percentage change in depth, which is greater than the percentage change in prevalence warrants closer consideration. As demonstrated in the online supplementary appendix, under some rather mild conditions, this ordinal ranking is actually an analytical relationship. This indicates the effectiveness of a policy will be understated if only the prevalence rate is considered, regardless of what threshold is considered. Furthermore, this implies the choice of the measurement matters. Again, as stated in the U.S. Code 2011, the purpose of SNAP is "to permit low-income households to obtain a more nutritious diet through normal channels of trade by increasing food purchasing power for all eligible households who apply for participation." This directive is better measured by depth or even severity than a normalized food expenditure or prevalence.

The importance of taking into account time is further documented by comparing the poverty measures from SNAP households (shown) with Non-SNAP households (not shown). Given the above discussion, we just report here the differences in depth and severity in the text. In the money-only dimension, SNAP depth was *greater* than Non-SNAP depth by 6.3 and severity by 3.7. But in the time-only dimension, SNAP depth was *less* than Non-SNAP depth by 11.9, and severity by 16.8. However, in the full-cost money-time dimension, SNAP depth was only *greater* than Non-SNAP depth by 2.5 and severity by 2.1. Simply stated, once the full cost of the TFP is taken into account, SNAP and Non-SNAP households are much more similar, but for different reasons, as explained earlier via figure 1. Non-SNAP households spend more money and less time in food production than SNAP households (at the mean, $8.60 more and 1.6 hours less per week), but because the food production requires both inputs, the full costs are comparable. This attenuation of inequality differences, once labor is taken into account, is a common finding in the product accounting literature (e.g., Frazis and Stewart 2006; Bridgman et al. 2012). Furthermore, similarities between Non-SNAP and SNAP households is common across many nutrition dimensions—not all—as well (e.g., Mabli et al. 2010; Gregory et al. 2013; Andreyeva, Tripp, and Schwartz 2015), suggesting SNAP does help make households more similar to Non-SNAP households in many dimensions, but perhaps through a different allocation of all resources.

Conclusions and Limitations

In evaluating the effectiveness of a poverty policy, measurement matters. The chosen metric(s) should capture the intent of the policy and include the most important resources for reaching the policy target. This paper extends the literature on measuring SNAP benefit adequacy as called for in the IOM

report (Caswell and Yaktine 2013) by using the Foster, Greer, and Thorbecke poverty index to capture the prevalence, depth, and severity, and by incorporating labor (time) cost into the analysis. Previous analyses, even those including time cost, have only considered the prevalence rate. Consistent with this previous research, if time cost is ignored there is an overly optimistic evaluation of the effectiveness of SNAP benefits that extends to depth and severity. In terms of the impact of the ARRA, it had a much larger positive impact on the percentage change in depth and severity than prevalence. One could argue the issue was dose level, not systematic ineffectiveness. We believe that depth and severity are more appropriate for measuring SNAP benefit adequacy because they are more in line with the language of the policy intent than the commonly encountered normalized money expenditure or prevalence rate.

By measuring food expenditure deprivation using the Foster, Greer, and Thorbecke index, this article opens up the policy-targeting literature as a source of ideas and guidelines for more effective policies to reduce food expenditure poverty (e.g., Kanbur 1987; Besley and Kanbur 1988; Dasgupta and Kanbur 2005). For example, assume there is a fixed amount of money that can be allocated and, for simplicity, assume that a dollar increase in SNAP benefits increases food expenditures the same amount for every household. If prevalence reduction is the goal, then funds should be allocated in the order of smallest to largest gap size from the threshold (i.e., those closest first, next closest second, etc.). Alternatively, if the goal is reducing depth, because the weight on each household depth is the same, then it does not matter how the marginal transfer is allocated (i.e., each household gets the same amount). However, if the goal is severity reduction, because those with greater gaps contribute more to the severity index, the money should be allocated in the order of largest to smallest gap size from the threshold (i.e., those furthest first, next to furthest second, etc.). More generally, optimal targeting depends on the stated goal and the appropriate corresponding metric. By embedding the existing metrics within the Foster, Greer, and Thorbecke index, future research can now utilize insights from the poverty-targeting literature to address important policy questions.

As with all analyses, there are limitations and future research needs. Though the ATUS is a drastic improvement in time use data, there are still some outstanding measurement issues. For example, while the ATUS and FSS can be matched by household, the food and time expenditures are not synchronized so there is certainly some possible measurement error, and more empirical work is needed on the relationship between money, time, nutrition, and health, not only in general but also in specific populations, locations, and contexts. In addition, the ATUS only collects information on a single individual in the household, so there is no accounting for intra-household time substitution, which is known to be important. This is the main reason we limited our analysis to single-headed households. The "time deficit" between actual and TFP-consistent time expenditures is likely to be smaller in dual-headed households. Furthermore, as Davis and You (2011) have discussed, much more work is needed on the amount of time required to meet the TFP target.

Also, much of the SNAP literature focuses on estimating the effects of SNAP participation (or benefit levels) on some more distant nutrition-related outcomes such as diet quality, food security, and child health outcomes, along with moderators or mediators (e.g., education level,

employment) via statistical modeling (see Bartfield et al. 2016 for a good overview). The research reported here focuses on the directly-stated intermediate target of the U.S. Code 2011 and should be viewed as complementary, not competitive with these endeavors. Some rather straightforward mathematics such as those found in the structural equation modeling literature can demonstrate that (in)significance in an intermediate target implies nothing about (in)significance in a more distant target, and vice-versa. This is an area in need of a lot more research to determine the causal pathway relationships between intermediate and final targets.

Though important, none of these remaining limitations or future directions change the main conclusion: measurement matters in evaluating the SNAP benefit adequacy, and the extensions presented here are very easy to implement with existing data, overcome several existing limitations, and provide opportunities for gaining greater insights and designing better policies.

Supplementary Material

Supplementary material is available at *Applied Economic Perspectives and Policy* online.

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