FOOD INSECURITY IN THE U.S.: MEASUREMENT AND EVALUATION

BY

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THESIS

Submitted in partial fulfillment of the requirements
for the degree of Master of Science in Agricultural and Applied Economics
in the Graduate College of the
University of Illinois at Urbana-Champaign, 2016

Urbana, Illinois

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Abstract

Most food insecurity research within the United States has focused on the headcount ratio of food insecurity, whic is, the percentage of households that are considered food insecure. Although this measure is important, using this measure alone, ignores the variation within the food hardship being experienced by U.S. households. In 2008, Dr. Craig Gundersen translated the Foster-Greer-Thorbecke income poverty index to measure the extent, depth, and severity of food insecurity. Within chapter 1 of this paper, I use the income poverty index literature to define axioms that an appropriate food insecurity index would need to satisfy in order to accurately measure the depth of food insecurity. I translate income poverty indices from Kakwani, Chakravarty, and Watts and then evaluate how these indices as well as the one proposed by Dr. Gundersen measure food insecurity within the U.S.. Within chapter 2, I use the food insecurity index proposed by Dr. Gundersen to evaluate how Broad Based Categorical Eligibility, a change in SNAP eligibility policy affected U.S. food insecurity between 2001 and 2013.

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Chapter 1

Moving past the headcount ratio: how to better measure food insecurity

1.1 Introduction

In the United States, food security measures are predominately based on the responses to the Core Food Security Module (CFSM) which is included in the Current Population Survey every December. The CFSM consists of 18 questions, with 10 questions for all households and an additional 8 for households with children. These questions range in severity. The least severe being: how often the following statement is true for a household in the prior 12 months "We worried whether our food would run out before we got more money to buy more" to the most serve for households without children being "In the last 12 months, did you or other adults in your household ever not eat for a whole day because there was not enough money for food?" and "In the last 12 months, did a child ever not eat for a whole day because there wasn't enough money for food?" for households with children.[1] Each question is asked in a way such that affirmative responses can be attributed to budgetary constraints. Meaning a person who is not eating for other reasons such as religious or fasting purposes would not be counted as food insecure.

Most research on food insecurity in the United States, uses data from the CFSM to calculate the headcount ratio: the percentage of households considered food insecure out of the total number of households in the population. However, with this measure alone, we lose a significant amount of the variation in responses. A household is considered food insecure if they respond to 3 or more questions affirmatively (this is true for both households with and without children). However, the number of affirmative responses can vary from 0 to 18 for households with children (and 0 - 10 for households without children). Meaning, even though the hardship experienced by households that respond affirmatively to 18 questions is likely greater than that of the households that respond affirmatively to 3 they will both simply be categorized as food insecure. This does not tell us anything about the depth or severity of the food insecurity being experienced.

Researchers will sometimes add to these measures slightly by separating food security into (at most) 4 categories: high, marginal, low, and very low food security. However, when aggregated these categories are still presented as headcount ratios or the percentage of households experiencing that level of food security. Since a household is reg-

[1] The full list of the Core Food Security Module Questions can be found at http://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/survey-tools.aspx

ularly considered to have very low food security by answering 8 or more questions affirmatively (6 for households without children), there is still likely a significant amount of variation of the hardships experienced by the population of households considered food insecure.

Insofar as more affirmative responses means a worse food hardship being experienced by the household, it is worthwhile to capture these variations of depth within food insecurity measurement. The goal of this paper is to design such an index that recognizes more affirmative responses to indicate a worse food hardship, to best capture all of the information available in the responses to the CFSM.

To accomplish this goal, I draw on the literature of another type of negative welfare index. Like food insecurity, income poverty is also an undesirable condition that negatively affects household welfare. Since there is already a body of literature on income poverty indices, I used this literature to derive potential food insecurity indices. Within this paper, I will first review axioms from the income poverty literature that are attractive for food insecurity research and then translate them. I then translate three well-known indices from the income poverty literature into food insecurity indices: Kakwani (1980), Chakravarty (1983), and Watts (1968). To the best of my knowledge Gundersen (2008) is the only paper to previously create a food insecurity index based on one of the income poverty indices of the 1970s-1990s. Gundersen's index was based off of the Foster-Greer-Thorbecke (1984) index. Finally, I evaluate how the indices I propose, as well as, the one proposed in (2008) measure food insecurity using data from the 2001 to 2013 CFSM.

1.2 Income Poverty Literature

1.2.1 Sen's Original Axioms

Amartya Sen's (1976) "Poverty: an ordinal approach to measurement" was the first paper to propose an income poverty index using an axiomatic approach. Sen saw that the most common ways to measure poverty at the time were less than ideal. The headcount ratio, the percentage of people in poverty, tells the researcher nothing of the depth of the poverty being experienced. Every poor individual could have an income of $1 less than the poverty line, or they could each have an income of $0 and the headcount ratio would be the same in both cases. The poverty gap, the aggregate income shortfall of each person in poverty from the poverty line, tells researchers how much money it would take to eliminate poverty if that money was distributed to the poor individuals in the society. However, from the poverty gap alone the researcher would not know how much of the society was experiencing poverty.

Sen (1976) sought to remedy this issue in the measurement of poverty by creating an index that would take into account not only the percentage of people within the society in poverty and the severity of the poverty being experienced but also the inequality of incomes among the poor. Although the particular index Sen proposed has not often been used, the sentiment of the paper sparked a body of literature on income poverty indices derived from an axiomatic approach. Many of the papers use, at least in part, the original or similar axioms to the ones Sen proposed, making it desirable to detail them within this paper and to discuss whether similar axioms are appropriate for food insecurity measurement. I then formally define axioms desirable for a food insecurity index to meet.

The first axiom Sen proposed was the Monotonicity Axiom, which requires "given other things, a reduction in income of a person below the poverty line must increase the poverty measure." A similar axiom is desirable and can be easily directly translated for a food insecurity index. Sen also proposed the Monotonic Welfare Axiom which clarifies how to satisfy the Monotonicity Axiom within an index format. This axiom requires that the variable reflecting the welfare for any individuals should reflect their incomes; that is if the income of one individual is greater than the income of another individual, the welfare of the individual with more income should be greater than the welfare of individual with less income. One axiom can easily be derived from the other. So much so, that in the majority of the later literature only one of the two is a formally defined axiom within any given paper. For this reason, I will only include one version of the Monotonicity Axiom formally within my paper.

The Impartiality Axiom defined with later literature can also easily be derived from Sen's monotonicity axioms. It requires that if the incomes of the population were to be switched between the households but the overall distribution remain the same, the measure would remain equal. That is, one household must not be given a weight to the measure based on something other than their income. For the Monotonic Welfare axiom to be satisfied, the welfare condition being studied must be the only condition affecting their individual welfare, which ensures the impartiality axiom is satisfied. Within Sen's paper he explains this as a necessity due to the limited information researchers have access to. This necessity applies to the study of food insecurity as well. Household A may have the ability to ask a family member outside of the household for help buying groceries when in need when household B may not have access to similar help. However, without very detailed information it would be difficult to add differences such as the previous example to any given food insecurity axiom. Additionally, there would need to be agreement on which differing household attributes were important and how much weight they should be given. Requiring this axiom ensures some simplicity in the indices proposed. Moreover, since the indices are a way to aggregate food insecurity measures rather than compare food insecurity between two individual households, as long as it is believed on average that more affirmative responses mean a worse food hardship being experienced by the household, impartiality is an attractive axiom.

The next axiom Sen proposed was the Transfer Axiom, which requires "Given other things, a pure transfer of income from a person below the poverty line to anyone who is richer must increase the poverty measure." At first glance, this may seem to be an unnecessary axiom for food insecurity index because an affirmative response to the

CFSM cannot be transferred to another household in the way that income can be. However, I argue the math behind this axiom is still desirable. The rationale for why a society would care if income is transferred from a poor individual to a richer but still poor individual is the belief not just that the condition of poverty is an undesirable condition but that the depth of poverty matters; the less income a person in poverty has, the less well-off they are. That is, I believe the welfare of the poorer individual is affected more by the decrease in income than the welfare of the comparatively richer individual by the decrease in income even though the magnitude change of income is equal. This sentiment would be the same even if the changes in income did not happen from a direct transfer but rather from other means. One can argue this sentiment is true for food insecurity as well. On average, the more affirmative responses to the CFSM the worse the hardship faced for a food insecure household. Meaning, an increase in affirmative responses for a food insecure household from 9 to 10 would indicate a larger increase in hardship faced by the household than an increase in affirmative responses from 3 to 4. This property will be met by any index that satisfies the transfer axiom. For this reason, I will change the language of the axiom somewhat to meet the needs of a food insecurity index but the sentiment will be the same.

The monotonicity axiom and the transfer axiom are important for the income poverty literature and included in most papers proposing an income poverty index. However, there is not a consensus on the desirability of the next two axioms; they have been incorporated in some of the later income poverty indices but omitted from others.

The relative equity axiom requires weights to be added to the individual welfare measure so that the index is measuring relative deprivation, similar to the monotonic welfare axiom, the magnitude of the weights indirectly reflect the welfare of the individual. That is, if one individual's welfare is smaller than another's welfare, then the weight for the individual with the lower welfare should be greater than that of the individual with more welfare. In the ordinal rank weights axiom, Sen proposed meeting the relative equity axiom by setting the weight equal to the "interpersonal welfare ordering" of the individual's income gap. That is, (q+1-i), where q stands for the total number of people in poverty and i is the number of the order individual i's income appears in a distribution of incomes for the society such that $y_1 \leq y_2 \leq ... \leq y_q \leq y_n$. Sen proposes these axioms due to the relative nature of poverty. Sen includes these axioms due to his assertion of the relative nature of deprivation from poverty. In his paper, he argues that an individual's "sense of poverty" is heightened by their knowledge that their income is relatively lower than the income of others within the income distribution. This necessitates a weight being put on the income gap measure to reflect this.

Within my paper, the index translated from Kakwani (1980) will be the only one to include a measure of relative deprivation. This index uses the type of ordinal rank weight that Sen proposed but there have been indices that include other ranks measuring relative deprivation. For example, Takayama (1979) uses the rank (n+1-i), where n stands for the total number of people in the society, making (n+1-i) the interpersonal welfare ordering of the society rather than just the poor, arguing that the perceived deprivation would be from one's position in society as a whole rather than just the rank among the poor individuals of the society.

I assert that although relative deprivation may affect a household's sense of food insecurity, it may instead be the case that conditions such as hunger, which may be experienced within households with very low food security, have a much more direct effect on well-being. Meaning that, the physical pain of hunger may affect the households sense of food insecurity much more than any sense of how their food insecurity ranks within the society. On the other hand, it could be argued that adults within the household feel shame for not being able to be able to provide enough or consistent food for their household in a way that others can. I will include one index that includes the rank order and three that do not and ultimately leave the judgment of which is the most compelling argument to the reader.

The final axiom proposed in Sen's paper was his normalization axiom. It required that when all poor individuals have equal income that the poverty index is equal to the headcount ratio multiplied by the aggregate income gap, since if all poor individuals have the same income relative equity would not be an important component. Although one index that will be analyzed in this paper will adhere to this axiom it should be noted that much of the literature determined this particular variation of normalization to be arbitrary and many papers proposed other variations of this axiom. For my food insecurity indices, I propose a simpler normalization axiom meant to provide a more intuitive understanding of the axioms.

One additional axiom often attributed to Sen, although not formally defined within his paper, is the focus axiom. It requires that the incomes of the rich do not affect an income poverty index. This axiom will be important for food insecurity indices as well. A household can answer 1 or 2 questions on the CFSM affirmatively and still be considered food secure. Since the indices proposed in this paper are meant to study food insecurity it would then be inappropriate for these affirmative responses from food secure households to affect the measures.

The axioms from Sen's original paper set a foundation for the literature on income poverty indices, but as the literature grew, alternate variation of these axioms as well as new axioms were proposed. The following subsection describes the additional axioms I argue are most important for a food insecurity index to meet.

1.2.2 Additional Axioms Important for Food Insecurity Measurement

Kakwani (1980) proposed transfer sensitivity axioms to compliment Sen's original axioms and proposed a generalized version of Sen's index that could potentially satisfy these axioms. This is the first paper from which I translate a food insecurity index and my transfer sensitivity axioms will be modeled after the transfer sensitivity II axiom with Kakwani's paper. That axiom required that for transfers occurring between individuals with different incomes, the measure would convey a larger weight to transfers between individuals who had larger income differences than an equal transfer between two individuals with a comparatively smaller income difference.

The transfer axiom requires that when two households experience an “equal” reduction in food security the household with the larger original food insecurity score will have a greater effect on the overall measure than the household with a comparatively smaller food insecurity score. The transfer sensitivity axiom requires not only the greater effect described in the first axiom but that the difference in the effect on the overall measure would increase as the difference between the individual food insecurity scores for the two households increased. I chose not to include a translation of Kakwani’s transfer sensitivity I axiom within this paper because it is ultimately a weaker axiom than the second and any index satisfying the second transfer sensitivity axiom would meet it.

There are two final axioms I assert are important within the study of food insecurity. Decomposibility requires the welfare measure be equal to the weighted welfare measure of any combination of subgroups of the population such that each individual in the population is within exactly one subgroup and the weights are equal to the percentage of the population each subgroup represents. This is an important axiom for relating the food insecurity of a subgroup to the food security of the overall population. However, both decomposable and non-decomposable indices can be used to compare the negative welfare between sub-group populations (Foster, 1984). Subgroup Monotonicity is a related axiom that requires, all else equal, when a subgroup of the population experiences a change in welfare, the overall welfare measure should change in the same direction. This is a desirable axiom when researchers are concerned about the food insecurity of sub-groups of society rather than just the total population. If an index does not satisfy the subgroup monotonicity axiom, it is possible for one or several subgroup(s) could experience a decrease in food insecurity while food insecurity stays the same for all other sub-groups but the measure for the total population could actually increase (Foster and Shorrocks, 1991).

Neither the decomposibility axiom or the subgroup monotonicity axiom can be satisfied by a welfare index that directly includes a relative deprivation variable. Meaning neither Sen’s or Kakwani’s indices will satisfy these axioms. Thus, researchers must choose which axiom(s) are more important for adequately answering their research question before choosing an index to use.

Axioms for Food Insecurity Indices:

Monotonicity: *Ceteris Paribus, a increase in food insecurity of an insecure household must increase the food insecurity index.*

That is, if all else remains equal, if the number of affirmative responses given for a food insecure household increases, the food insecurity should also increase.

Impartiality: *If the individual food insecurity scores were permuted, the overall food insecurity measure would remain unchanged.*

Transfer: *Ceteris Paribus, a reduction in food security for a food insecure household should have a greater affect on the food insecurity measure than an "equal" reduction for a more food secure household.*

That is if household i is more food insecure than household j (measured by responding affirmatively to more questions on the CFSM), if an increase in affirmative responses were to occur. The increase in food insecurity of household i would have a greater effect on the overall food insecurity measure than the increase in food insecurity for household j.

Transfer Sensitivity: *The difference in effect on the overall food insecurity measure for an "equal" decrease in food security for households i and j will increase as the difference in individual food security measures increases.*

Ordinal Rank Weights: *The weight on the food security measure of person i in the interpersonal welfare ordering of the food insecure.*

Normalization: *The food security measure will be on the interval [0,1]. The measure will equal 0 if no households is food insecure. The measure will equal 1 if every household is experiencing the worst possible food insecurity outcome.*

In this measure, the worst possible food insecurity outcome for a household with children is responding affirmatively to all 18 questions in the CFSM and a household without children responding affirmatively to all 10 questions in the CFSM.

Focus: *The food insecurity measure will be independent from the food security of the food secure.*

Decomposability: *The overall food insecurity measure will be equal to the weighted food insecurity measures of any mutually exclusive groups within the population where the weights are according to population size.*

Subgroup Monotonicity: *The overall food insecurity measure is directly related to the food security measure of any subgroup within the population.*

That is, all other things being equal, if food insecurity increases for a subgroup of the population, the overall food insecurity measure should increase as well.

1.3 Methods

I was able to translate income poverty indices to food insecurity indices because both income poverty and food insecurity are undesirable conditions that negatively affect a household's welfare. Additionally, the way data on household food insecurity is collected in the U.S. allows variables to be created that are mathematically comparable to the variables used within the income poverty literature. I chose to translate the indices from Kakwani (1980), Chakravarty (1983), Foster et al. (1984), and Watts (1968) because of their popularity within the literature, as well as, the ability to meet many axioms I argue are important for food insecurity measurement. Each translated variable and index will be explained within the model estimation section of this paper. These indices are meant to give researchers the ability to capture more of the differences within household responses to the CFSM than the headcount ratio alone allows.

1.4 Model Estimation

1.4.1 Index FGT-FI: From Gundersen (2008) translated from Foster, Greer, and Thorebecke (1984)

$$FI_{\alpha}(f;z) = \frac{1}{n}\sum_{i=1}^{q}[(\frac{s_i - 2}{z_i - 2})^{\alpha}] \quad where \quad \alpha \geq 0 \tag{1.1}$$

This index proposed in Gundersen (2008) was translated from Foster et al. (1984). To the best of my knowledge, this is the only other paper to use an income poverty index to create a food insecurity index. Throughout this paper, I will refer to this index as FGT-FI, FGT for the initials original authors of the income poverty index Foster, Greer, and Thorebecke and FI for food insecurity.

For Index FGT-FI and throughout this paper, s_i will denote the food hardship indicator, specifically, the number of affirmative responses to the CFSM for an individual household. Then $s_i - 2$ measures the food insecurity gap or the "distance" a food insecure household is from being food secure The gap for a food secure households is equal to 0 since there is no "distance" from food security these households.

The food insecurity gap is then divided by $z_i - 2$ to calculate the household's food insecurity ratio. That is the individual household's food insecurity as a proportion of the worst case scenario for that household. The ratio is then taken to the power α, the aversion parameter for this index. The aggregated measure is divided by the total number of households within the population so that it reflects food insecurity of the population being studied.

In general, an aversion parameter for a food insecurity index has a range of acceptable choices. Changing the aversion parameter allows the researcher to change how sensitive the food insecurity index is to changes in food insecurity for the most food insecure households as compared to households that are more food secure. Although the aversion parameter can be set to varying levels, the overall food insecurity measure is only comparable when the aversion parameters are equal. That is, a researcher could not set the aversion parameter to 1 in one year, 2 in another and compare the outputs. For this index, the greater α is the more sensitive the measure is to changes in food insecurity of the most food insecure households.

It is important to note that when $\alpha = 0$, $(\frac{s_i-2}{z-2})^0 = 1$ for all households $1-q$. Therefore, this index is equivalent to the headcount ratio $(\frac{q}{n})$ and measures the percentage of the population that is food insecure when $\alpha = 0$. In the literature on income poverty, the measures from this index are often referred to as extent, depth and severity for $\alpha = 0$, $\alpha = 1$, and $\alpha = 2$ respectively. These are also the values of α I will use when evaluating this index.

Index FGT-FI always satisfies the Independence, Normalization, Impartiality, Decomposibility and Subgroup Monotonicity axioms. The index will satisfy additional axioms depending on the value of α. If $\alpha > 0$, it satisfies the Monotonicity axiom. If $\alpha > 1$, it satisfies the Transfer axiom. Finally, if $\alpha > 2$, it satisfies the Transfer Sensitivity axiom. The index does not satisfy the Ordinal Rank Weights axiom, but again if an index meets this axiom it cannot meet the Decomposibility or Subgroup-Monotonicity axioms.

Figure 1.1 depicts individual food insecurity measures (the measures from this index before aggregation) for households with and without children based on the number of affirmative responses to the CFSM when α equals 0,1, and 2. From this figure, it is easily seen how the index becomes more sensitive to the food insecurity of the most food insecure as α increases. This figure makes it apparent, when the number of affirmative responses is between 3 and 17 the individual food insecurity measured decreases when α increases. Consequently, the difference between the food insecurity measured for any two different s_i's of food insecure households will increase as α increases. This means the individual measures of those will high food insecurity will have a greater impact on the overall measure.

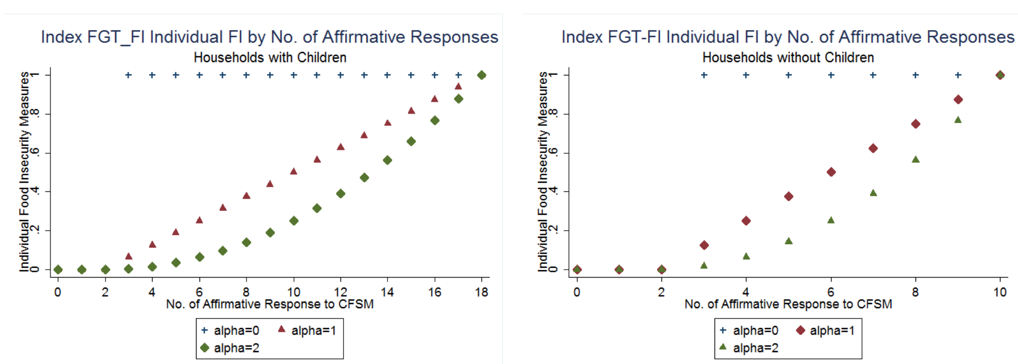

Figure 1.1: The individual food insecurity measured is $(\frac{s_i-2}{z_i-2})^\alpha$ where α equals 0, 1, and 2.

1.4.2 Index K-FI: Translated from Kakwani (1980)

$$FI(k) = \frac{q}{n\phi_q(k)} \sum_{i=1}^{q} (q+1-i)^k \frac{(s_i - 2)}{z_i - 2} \quad where \quad \phi_q(k) = \sum_{i=1}^{q} i^k \tag{1.2}$$

This index is the summation of the individual welfare gap ratios ($\frac{s_i-2}{z_i-2}$) of the food insecure weighted by the interpersonal welfare ordering ranks $(q+1-i)$ of each food insecure household taken to the power of k. Throughout this paper, I will refer to this index as Index K-FI.

The welfare gap ratio alone will not satisfy the transfer sensitivity axiom. Index FGT-FI is able to satisfy the axiom only when $\alpha > 2$. This index satisfies the axiom by weighting the welfare gap ratio by the interpersonal welfare ordering ranks $(q+1-i)$ to satisfy the transfer axiom. This was also a part of Sen's original index as described in the income poverty literature section.

Since many households will have the same food hardship indicator (s_i), I choose to assign households with the same s_i to have equal interpersonal welfare ordering ranks. For example, if a population of households without children responded to 3, 5, 5, 5, 8, 8,and 10 affirmatively, the household with 10 affirmative responses would have the worst outcome and therefore the interpersonal rank (i) of 1. Both of the households responding affirmatively to 8 would have interpersonal ranks of 2. Then the households responding affirmatively to 5 would have interpersonal ranks of 4 since 3 households have worse welfare outcomes. This system would make the interpersonal welfare ordering ranks $(q+1-i)$ equal to 1, 4, 4, 4, 6, 6, and 7 respectively.

However, the welfare gap ratio weighted by the interpersonal welfare ordering ranks alone will still not satisfy the transfer sensitivity axioms. For this reason, Kakwani (1980) proposed the rank order measure by taken to the power k, the aversion parameter for this index. The greater the value of k, the greater weight given to changes of welfare of those lowest in the welfare distribution.

To meet the sensitivity axioms, k will at least need to be greater than 1, however, this number may be bigger depending on the distribution of incomes. Satisfying these axioms is a desirable trait when looking for an index that puts more weight on the households experiencing greater negative welfare conditions such as poverty and food insecurity. Despite this benefit it may cause confusion and/or research difficulties. The poverty measures output from this index are only comparable if the k used for the measures is equal. Further, since the minimum k needed to meet the sensitivity axioms will vary depending on the income distribution, a standard k cannot be chosen to remedy this issue. If these barriers are known and understood at the beginning of the research process it should be relatively easy to overcome them as a researcher can just calculate the minimum k needed for each distribution being researched and set the overall k used to at least the largest of the minimum k's.

Index K-FI satisfies the Monotonicity, Impartiality, Transfer, Ordinal Rank Weights, Normalization and Independence axioms when $k \geq 1$. The index can satisfy the Transfer Sensitivity axiom if k is large enough but the minimum

k required for this will vary depending on the distribution of food insecurity outcomes of the population being studied. Index K-FI will not satisfy the Decomposibilty axiom or the Subgroup Monotonicity axiom no matter what value is chosen for k. For simplicity, within this paper, I will evaluate this index with k being set to 1 and 2.

Figure 1.2 shows a potential distribution of food insecurity measures based on Index K-FI when $k = 1$. For this figure, I assumed there was only one household with each potential number of affirmative responses to the CFSM since this would affect the interpersonal welfare rank. If there was more than one household responding to a specific potential number of affirmative responses, it would cause the individual food insecurity measured for all the households with s_i greater than or equal to the specific potential number to increase. The most important aspect of this figure is the concavity of the curve of individual food insecurity measured by potential affirmative responses. If the food insecurity curve of potential responses to an index is concave, the index satisfies the transfer axiom. This is because for the curve to be concave the increase in individual food insecurity from any increase in the number of affirmative responses must be increasing as s_i increases. For any $k > 1$ this increase would be happening at a faster rate, thus more sensitive to changes in food insecurity from households with higher interpersonal welfare ranks than "equal" changes for households with lower ranks. It should be noted that the values of the interpersonal welfare rank $(q+1-i)$ are dependent on the distribution of household food insecurity indicators (s_i). However, for any given distribution an individual household's $q+1-i$ will always increase as s_i increases.

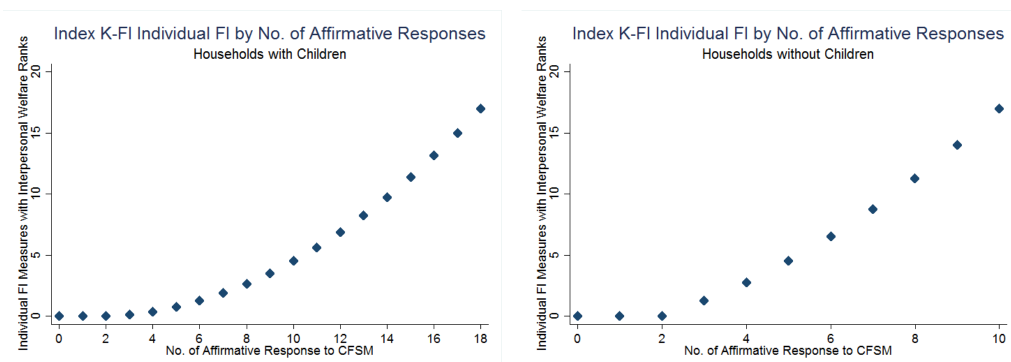

Figure 1.2: The individual food insecurity measured is $(q+1-i)^k(\frac{s_i-2}{z_i-2})$ where $k = 1$ and it is assumed there is 1 household s_i for each potential number of affirmative responses.

1.4.3 Index C-FI: Translated from Chakravarty(1983)

$$FI(v,z) = \frac{1}{n}\sum_{i=1}^{q}[1-(\frac{v_i}{z_i-2})^e] \quad where \quad 0 < e < 1 \tag{1.3}$$

Chakravarty's index used an income variable rather than an income gap variable. In my translation of the index, v_i will denote a food security indicator, which will represent the number of negative responses to the CFSM for household i. Then since the fraction $(\frac{v_i}{z-2})^e$ is subtracted from 1, the overall individual measure indicates the negative welfare.

As v_i increases the negative welfare decreases, that is the household is better off as they respond to more questions negatively. Since $v_i = z_i - s_i$, this is equivalent to saying as a household's food hardship decreases, the household is better off. The fraction $(\frac{v_i}{z_i-2})^e$ is then subtracted from 1 so that it reflects the household's food insecurity before being aggregated. The aggregated measure is divided by the total number of households within the population so that it reflects food insecurity of the population being studied. For this index, the variable e is the aversion parameter. In order to satisfy the majority of the axioms, e needs to be between 0 and 1. The closer e is to 0 the more sensitive the measure will be to changes in food insecurity for the most food insecure households.

It should be noted, when the welfare indicator for an index is v_i, the z variable should be thought of somewhat differently than when the welfare indicator is s_i. This is because the purpose of the z_i variable is to put the individual welfare indicator into context. When v_i is used, $z_i - 2$ should be thought of as the number of negative responses to the CFSM for the household to be considered food secure. This will be $18-2$ for households with children and $10-2$ for households without children.

Index C-FI satisfies the Monotonicity, Impartiality, Transfer, Transfer-Sensitivity, Normalization, Independence, Decomposibility and Subgroup Monotonicity when $0 < e < 1$. The only axiom proposed within this paper that this index does not satisfy is the ordinal rank weights axiom. For this paper, I will evaluate this index with $e = \frac{1}{2}$ and $e = \frac{1}{3}$

Figure 1.3 shows the individual food insecurity measures for households with children based on the number of affirmative responses to the CFSM. I used the number of affirmative responses rather than negative responses so that the figures are easily comparable across indices. If the number of negative responses was used, the curves will be inverted. The figure depicts the curves of individual food insecurity measures when the aversion parameter is equal to $\frac{1}{2}$ and $\frac{1}{3}$. These are the aversion parameters that I will use in the empirical results section of this paper. As with the previous indices, the most important aspect of figure is the concavity of the potential response curves. As stated previously the closer e gets to 0 the more sensitive the index will be to changes in food insecurity for the most food insecure.

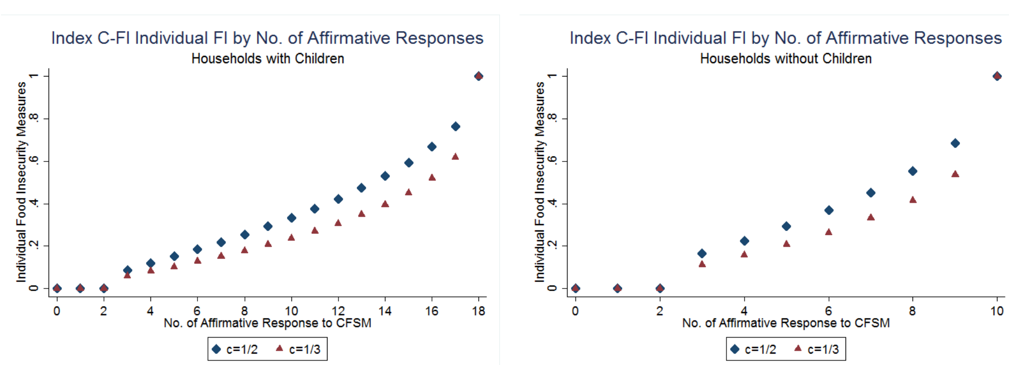

Figure 1.3: The individual food insecurity measured is $[1-(\frac{v_i}{z_i-2})^e]$ where e equals $\frac{1}{2}$ and $\frac{1}{3}$.

1.4.4 Index W-FI: Translated from Watts (1968)

$$FI(v;z) = \frac{1}{n}\sum_{i=1}^{q}[log(z_i - 1) - log(v_i + 1)] \tag{1.4}$$

The Watts index was actually the earliest income poverty index to be purposed however it did not have the axiomatic characterization that made Sen's index so popular. Zheng (1993) revisited the Watt's index and analyzed which axioms from the income poverty index literature the Watts Index satisfied.

Index W-FI is the log $z_i - 1$ minus the log of the household's number of negative responses to the CFSM + 1. This difference will show the household's food insecurity. This individual food insecurity measure ($\log(z_i - 1) - log(v_i + 1)$) is then aggregated and divided by the number of people within the population being studied.

Since this index uses logarithms, I cannot just use v_i and $z_i - 2$ as I do in Index C-FI. This is because logarithmic functions are undefined at zero and it is possible for a household to have a $v_i = 0$, that is respond negatively to zero questions. Since these households represent the most food insecure, I want them to be reflected in the food insecurity measures from this index. Since the number of negative responses reflects one household's food security compared to another rather than an absolute measure, I can add 1 to v_i and it will have the same comparative relationship. Since I add 1 to v_i I also need to add 1 to $z - 2$.

The logarithms in this index allow the individual food insecurity measures to naturally to meet the transfer and transfer sensitivity axioms. Whereas, the other indices meet concavity requirement through the requirements for the aversion parameter variables.

Index W-FI meets the Monotonicity, Impartiality, Depth-Sensitivity I, Depth-Sensitivity II, Independence, Decomposibility, and Subgroup Monotonicity. This Index does not satisfy the Ordinal Rank Weights axiom or Normalization axiom as defined by this paper. If no household in the population is food insecure Index W-FI will equal 0 as the first half of the axiom requires, but if every household is experiencing the worst possible food insecurity outcome, Index W-FI would be greater than 1. This will somewhat decrease the intuitive understanding of the index however the index can still be useful in understanding comparative questions.

Figure 1.4 depicts the individual food insecurity measures for households with children based on the number of affirmative responses to the CFSM. Again, if it was based on the number of negative responses the graphs would just be inverted since $v_i = z_i - s_i$.

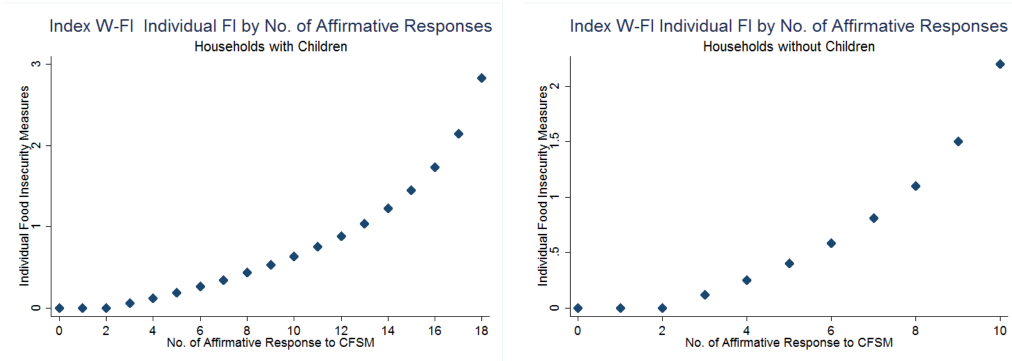

Figure 1.4: The individual food insecurity measured is $log(z_i - 1) - log(v_i + 1)$.

1.5 Results

Within this section, I compare how each the indices presented in this paper measure food insecurity. Of the indices that had aversion parameters, I choose at least two aversion parameters for analysis. However, there are several limitations in doing this. First, each of the indices aggregate the individual food insecurity measures differently, the measures output cannot just be directly be compared to each other and give us any discernible information. Second, for any index that measures depth, the measures for households with and without children should be separated. This is because households with and without children are asked a different amount of questions in the CFSM. That is, it cannot be assumed that a household with children responding to 9 out of 18 questions has equal food insecurity to a household without children answering 5 out of 10 affirmatively. Comparing the food insecurity (using an index that measures depth) of households with children and children assumes this type of relationship. Lastly, any index that does not satisfy the decomposability and subgroup monotonic axioms (within this paper, this is Index K-FI) can only be used to compare food insecurity of mutually exclusive subgroups.

To bypass these limitations, I focus on two ways to compare the indices presented within this paper. First, I compare how the indices measure food insecurity for mutually exclusive subgroups that are often considered important for food insecurity. Second, I compare the trends of food insecurity measured by the indices during the time period of 2001 to 2013.

Tables 1.1 and 1.2 depict the average values for each index and their specified aversion parameters for households with children and without children respectively. Whereas tables 1.3 and 1.4 depict the percent change in food insecurity between 2001 and 2013 for households with children and without children respectively. Again, the measure outputs cannot be directly compared when the indices or aversion parameters differ. Therefore, to compare the average values from 2001 to 2013 presented in tables 1.1 and 1.2, I focus on the ratio of food insecurity measures between mutually exclusive subpopulations.

First, within both tables 1.1 and 1.2, indices FGT-FI, C-FI, and W-FI show the average food insecurity from 2001 to 2013 is substantially higher for households where the household head is black or Hispanic, where their home is rented, and where household income is below either the poverty line or even 200% of the poverty line compared to all households. The measures from Index K-FI cannot be compared in this way, but each of these measures show higher food insecurity for these subgroups when compared to the mutually exclusive subgroup listed directly below. That is, households where the household head is white or non-Hispanic, where their home is owned, and where household income is above the poverty line and income above 200% of the poverty line, respectively. This is also true of measures from indices FGT-FI, C-FI, and W-FI.

The ratios comparing mutually exclusive subgroups by race, ethnicity, homeownership, and income actually remain relatively constant across the indices and aversion parameters. For households with children, households where the race of the household head is black have about 2 times as much food insecurity as households with children where the household the race of the household head is white. The lowest ratio was from Index FGT-FI when $\alpha = 0$ at 1.82 and the highest ratio was also from Index FGT-FI when $\alpha = 2$ at 2.04. For households without children, most ratios were slightly higher at around 2.3 or 2.4. This time with the measure from Index FGT-FI when $\alpha = 1$ was the lowest ratio at 2.33 and the measure from Index K-FI when $k = 2$ was the highest ratio at 2.43. The greatest ratios comparing the mutually exclusive subpopulations within these tables were comparing households with income below and above 200% of the poverty line for both households with and without children. These were also the ratios that varied the most over indices and aversion parameters for any of the subpopulations compared. For households with children, the ratio comparing households with income below 200% of the poverty line to households with income above 200% of the poverty line ranged from 4.7 to 6.22. The lowest ratio was from Index FGT-FI when $\alpha = 0$ and the highest ratio was also from Index FGT-FI when $\alpha = 2$.

Tables 1.3 and 1.4 then depict the percent change in food insecurity between 2001 and 2013 for households with children and without children respectively. A positive number implies that food insecurity increased over this time period. Only one subpopulation was measured as having a decrease in food insecurity during this time, that is households with income below the poverty line. Even this is only measured as a decrease for two indices Index FGT-FI when $\alpha = 0$ and Index K-FI when $k = 2$.

In general, the difference in the percent changes for food insecurity measures from 2001 to 2013 varies more when comparing indices and aversion parameters for specific mutually exclusive subpopulations than they did for the ratios discussed above. For example, for households with children, when comparing the measures for households based on the ethnicity of the household head. There is over a 40 percentage point difference for the percent change for Index FGT-FI when $\alpha = 2$, whereas there is only about a 10 percentage point difference for Index FGT-FI when $\alpha = 0$. Interestingly, when comparing the percent changes between the mutually exclusive subpopulations for households with children for the Index FGT-FI. As the index becomes more sensitive to the most food insecure households (that is, α increases) the difference percent change from 2001-2013 increases. However, for households without children, this does not always hold. When comparing the percent changes by the race of the household head, the difference between percent changes decreases as α increases. As for Index K-FI, for households with children when the index was comparatively more sensitive to the most food insecure households (here when k=2) the difference between the percent changes for the mutually exclusive subpopulations tended to decrease as compared to when $k = 1$. Even more interestingly, this relationship flips for households without children. For Index K-FI when $k = 2$ the difference between the percent changes for specific mutually exclusive subgroups is larger than when $k = 1$. There is no consistent trend in this regard for Index C-FI and since Index W does not have aversion parameters the percent change measures cannot be compared this way for this index.

The results from tables 1.1 to 1.4 are somewhat conflicting. Since the ratios comparing the food insecurity of mutually exclusive subgroups remain relatively constant over the indices and aversion parameters presented, it may seem using an index capable of measuring depth is unnecessary. However, when comparing the differences in percent change in food insecurity from 2001 to 2013, there are large differences between indices and aversion parameters. Next, I use figures 1.5 to 1.12 to analyze the trends in the food insecurity measured from 2001 to 2013 for each of the indices proposed using the same aversion parameters as tables 1.1 to 1.4.

Figure 1.5 depicts the food insecurity measured by Index FGT-FI when $\alpha = 0$ (the headcount ratio), the way food insecurity is most commonly measured within food insecurity research. This figure shows the story that is typically told about the time period from 2001 to 2013. The food insecurity rate was relatively stable before 2008, in 2004 there was a small increase but in 2005 the rate fell back to about where it was before. Then in 2008, there was a significant increase in the food insecurity measured and the food insecurity rate had not returned to the typical pre-2008 levels by the year 2013. Although the food insecurity rate was lower for households without children, the same trend was true for both households with and without children.

Mostly, the trends described above hold true when α is increased to 1 or 2 (depicted in figures 1.6 and 1.7 respectively). The one distinct difference being that for both $\alpha = 1$ and $\alpha = 2$ the food insecurity for households with children increased from 2006 to 2007. This is a year earlier than the increase seen for food insecurity when $\alpha = 0$. This indicates that although the food insecurity rate was relatively constant between 2006 and 2007, the food hardship being faced by households with children that were food insecure was increasing. Another difference is that when $\alpha = 2$ the food insecurity for households without children increased in 2004 (as it did when α was equal to 0) it did not decrease the in the next year but instead steadily increased until 2006. Then after 2008, the food insecurity did not decrease as it did when α equaled 0 or 1. Indicating again, the food hardship being faced by households was increasing even when the food insecurity rate was relatively constant.

Figures 1.8 and 1.9 show food insecurity as measured by Index K-FI when $k = 1$ and $k = 2$ respectively. It should be noted that the main difference between Index K-FI measures and Index FGT-FI when $\alpha = 1$ is the interpersonal welfare ranking and subsequent normalization factor. As such, the shapes of the food insecurity graphs for Index K-FI when $k = 1$ and $k = 2$ are very similar to that of the shape of the food insecurity graph for Index FGT-FI when $a = 0$. One notable difference is from 2011 to 2013 food insecurity as measured by Index FGT-FI was trending downwards, whereas the food insecurity as measured by Index K-FI when "$k = 2$ increased from 2012 to 2013 for households without children. This indicates that although the overall depth of food insecurity was decreasing the number of households within comparatively high food insecurity indicators was increasing.

Figures 1.10 and 1.11 show food insecurity as measured by Index C-FI when $e = \frac{1}{2}$ and $e = \frac{1}{3}$ respectively. The shapes of these graphs are very similar to one another. As the aversion parameter, e gets closer to 0 the food insecurity measure becomes more sensitive to changes in food hardship for the most food insecure households. The fact these graphs look almost identical in shape may indicate that $e = \frac{1}{2}$ and $e = \frac{1}{3}$ is not a large difference in the aversion parameter to actually change the sensitivity of the index. This is further confirmed by comparing the results in tables 1.3 and 1.4. These tables show the percent changes in food insecurity from 2001 to 2013 for several sub-populations considered important with food insecurity research. The percent changes for Index C-FI when $e = \frac{1}{2}$ compared to when $e = \frac{1}{3}$ from 2001 to 2013 are similar, for almost every sub-population there is less than a 2 percentage points difference between the two measures. The graphs for Index C-FI follow a similar pattern to the graph for Index FGT-FI when $\alpha = 2$. For households with children, food insecurity was relatively constant between 2001 and 2006. There was a small increase in 2004 but it returned to near the previous level by the next year. Then food insecurity began to increase between 2006 and 2007 before a dramatic increase in 2008. Finally, food insecurity began to decrease in 2009 but still had not returned to pre-2008 levels by 2013. For households without children food insecurity steadily increased from 2001 to 2007. Then drastically increased in 2008 and continued to slightly increase after.

Figure 1.12 depicts food insecurity as measured by Index W. The shape of this graph also closely follows that of the graph for Index FGT- FI when $\alpha = 2$. The fact that theses graphs for Index W-FI, Index C-FI, and Index K-FI all follow a similar pattern to the graphs for Index FGT-FI when $\alpha = 1$ or $\alpha = 2$ but differ from when $\alpha = 0$ indicate that food insecurity adding the depth dimension of food insecurity measurement could lead to different results within food insecurity research.

Figures 1.6 to 1.12 show clear differences in how food insecurity changed over the time period of 2001 to 2013 as compared to figure 1.5. This means there are differences within the trends of food insecurity during this time period when using an index capable of capturing depth rather than the headcount ratio. This indicates if researchers use an index capable of capturing depth they may have different findings than if they only use to the headcount ratio to measure food insecurity. If we believe the depth of food insecurity matters this is a loss to food insecurity research.

1.6 Conclusion

Within this chapter, I propose axioms needed for a potential index to accurately and appropriately measure food insecurity. I then propose indices translated from income poverty as a way to use data currently collected to measure the depth of food insecurity being experienced in the United States. I analyze how using these different indices with varying aversion parameters change the food insecurity for select subpopulations and over time. This is a meaningful addition to the literature because it gives researchers the ability to move past only using the headcount ratio to study food insecurity. This is an important pursuit if we believe the food hardship being experienced by households is greater for households responding to more questions affirmatively. This is especially important if using an index that can measure depth would lead to different research findings. The results section of this paper indicates at least in some circumstances this is likely to happen. When analyzing tables 1.3 to 1.4, the differences in the percent change in food insecurity between 2001 and 2013 for mutually exclusive subgroups varied greatly depending on index and aversion parameter. Similarly, examining figures 1.5 - 1.12, using an index that measures some depth of food insecurity (figures 1.6 - 1.12) tells a much different story about the food hardship being experienced then using the headcount ratio (figure 1.5). These findings indicate research using an index capable of capturing the depth of food insecurity could lead to richer findings and improved, more nuanced research.

1.7 Tables and Figures

Table 1.1: Average FI Measures for Households with Children by sub-population

	Index FGT - FI			Index K - FI		Index C - FI		Index W - FI
	$\alpha=0$	$\alpha=1$	$\alpha=2$	$k=2$	$k=1$	$e=\frac{1}{2}$	$e=\frac{1}{3}$	
All	0.186	0.048	0.019	0.111	0.081	0.028	0.019	0.059
Race								
Black	0.305	0.082	0.034	0.184	0.136	0.047	0.033	0.102
White	0.167	0.043	0.016	0.098	0.071	0.024	0.017	0.052
Ethnicity								
Hispanic	0.283	0.07	0.027	0.164	0.119	0.04	0.028	0.086
Non-Hispanic	0.165	0.043	0.017	0.099	0.073	0.025	0.018	0.053
Homeownersip Status								
Rent	0.337	0.091	0.037	0.202	0.151	0.053	0.037	0.113
Own	0.112	0.027	0.01	0.065	0.046	0.015	0.011	0.032
Income								
Below Poverty Line	0.445	0.125	0.052	0.27	0.203	0.072	0.051	0.157
Above PL	0.132	0.032	0.012	0.077	0.055	0.018	0.013	0.039
Below 200% of the PL	0.361	0.097	0.039	0.216	0.16	0.056	0.039	0.12
Above 200% of the PL	0.077	0.018	0.006	0.044	0.031	0.01	0.007	0.021

Table 1.2: Average FI Measures for Households without Children by sub-population

	Index FGT - FI			Index K - FI		Index C - FI		Index W - FI
	$\alpha=0$	$\alpha=1$	$\alpha=2$	$k=2$	$k=1$	$e=\frac{1}{2}$	$e=\frac{1}{3}$	
All	0.103	0.043	0.025	0.109	0.077	0.029	0.022	0.06
Race								
Black	0.208	0.087	0.051	0.228	0.156	0.058	0.045	0.121
White	0.089	0.037	0.022	0.094	0.066	0.024	0.019	0.051
Ethnicity								
Hispanic	0.283	0.07	0.027	0.191	0.127	0.045	0.035	0.094
Non-Hispanic	0.098	0.041	0.024	0.104	0.073	0.027	0.021	0.057
Homeownership Status								
Rent	0.194	0.085	0.052	0.205	0.148	0.057	0.045	0.12
Own	0.061	0.024	0.013	0.064	0.043	0.015	0.012	0.031
Income								
Below Poverty Line	0.305	0.138	0.086	0.329	0.238	0.094	0.074	0.198
Above PL	0.076	0.03	0.017	0.079	0.055	0.02	0.015	0.041
Below 200% of the PL	0.229	0.1	0.061	0.247	0.175	0.067	0.053	0.141
Above 200% of the PL	0.051	0.019	0.011	0.052	0.035	0.012	0.009	0.026

Table 1.3: Percent Increase in FI Measures from 2001 - 2013 for Households with Children by sub-population

	Index FGT - FI			Index K - FI		Index C - FI		Index W - FI
	$\alpha = 0$	$\alpha = 1$	$\alpha = 2$	$k = 2$	$k = 1$	$e = \frac{1}{2}$	$e = \frac{1}{3}$	
All	15.66	28.68	40	23.63	26.11	30.74	31.48	32.45
Race								
Black	4.98	14.88	18.77	10.36	12.71	14.15	12.75	13.89
White	22.39	37.43	55.37	32.75	35.16	41.15	43.61	44.78
Ethnicity								
Hispanic	4.28	2.76	5.08	4.35	3.13	3.26	3.5	3.86
Non-Hispanic	14.52	33.33	48.89	26.3	29.87	35.58	37.93	38.41
Homeownersip Status								
Rent	.48	10.1	19.37	8.04	9.09	12.08	13.39	13.69
Own	19.92	35.02	46.05	26.79	30.63	36.07	36.47	37.89
Income								
Below Poverty Line	-4.85	1.18	6.72	-.46	.36	2.34	2.9	3.13
Above PL	17.52	35.6	53.57	27.59	31.59	37.86	40.21	41.1
Below 200% of the PL	2.47	13.91	24.39	10.73	12.33	16.19	17.34	17.87
Above 200% of the PL	22.94	36.43	47.62	23.93	30.08	37.5	36	38

Table 1.4: Percent Increase in FI Measures from 2001 - 2013 for Households without Children by sub-population

	Index FGT - FI			Index K - FI		Index C - FI		Index W - FI
	$\alpha = 0$	$\alpha = 1$	$\alpha = 2$	$k = 2$	$k = 1$	$e = \frac{1}{2}$	$e = \frac{1}{3}$	
All	45.35	61.22	71.84	47.69	55.3	64.85	68.18	66.75
Race								
Black	31.96	49.39	65.29	37.05	43.66	57.82	64.09	59.95
White	45.33	58.46	65.36	44.86	52.6	60.23	60.74	61.37
Ethnicity								
Hispanic	4.28	2.76	5.08	16.05	25.95	33.53	33.85	33.24
Non-Hispanic	35.7	53.85	66.09	39.58	47.65	58.42	62.34	60.29
Homeownership Status								
Rent	40.32	57.07	69.48	48.92	54.08	63.17	67.67	64.42
Own	51.97	68.82	80.9	50.19	60.49	71.3	72.84	73.3
Income								
Below Poverty Line	19.07	35.37	44.95	20.2	28.77	38.85	40.52	40.25
Above PL	57.06	72	84.11	61.19	67.65	76.98	80	78.46
Below 200% of the PL	31.96	48.74	59.8	34.28	42.43	52.89	55.4	54.58
Above 200% of the PL	64.29	76.8	86.15	67.86	73.31	80.77	82.76	81.88

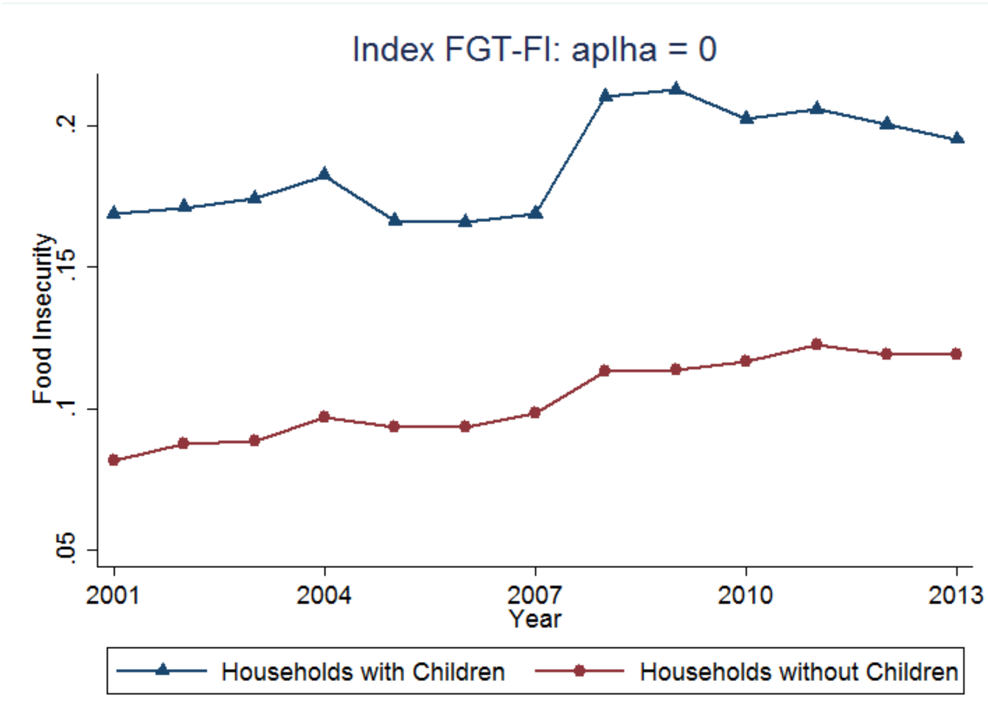

Figure 1.5: FGT Index $\alpha = 0$ Food Insecurity Measures for households with and without children by year

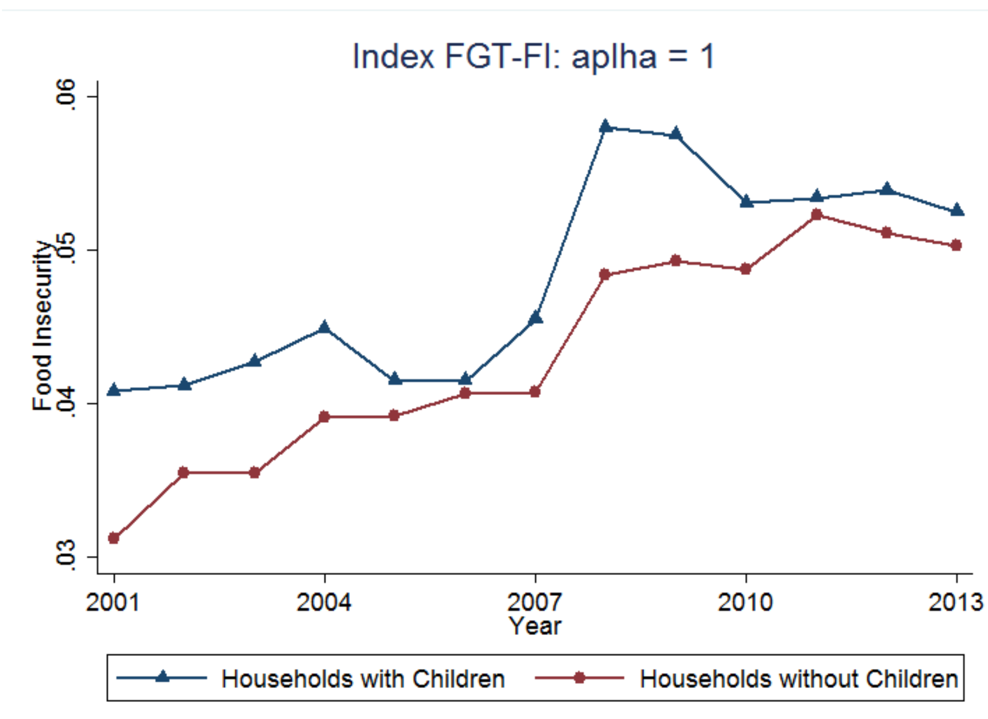

Figure 1.6: FGT Index $\alpha = 1$ Food Insecurity Measures for households with and without children by year

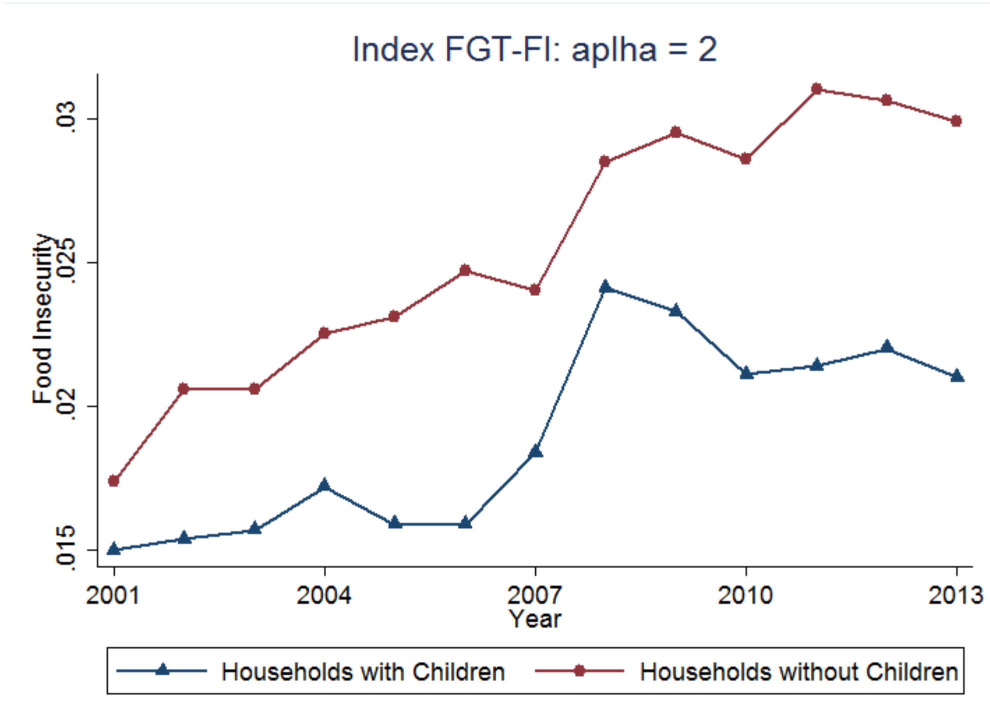

Figure 1.7: FGT Index $\alpha = 2$ Food Insecurity Measures for households with and without children by year

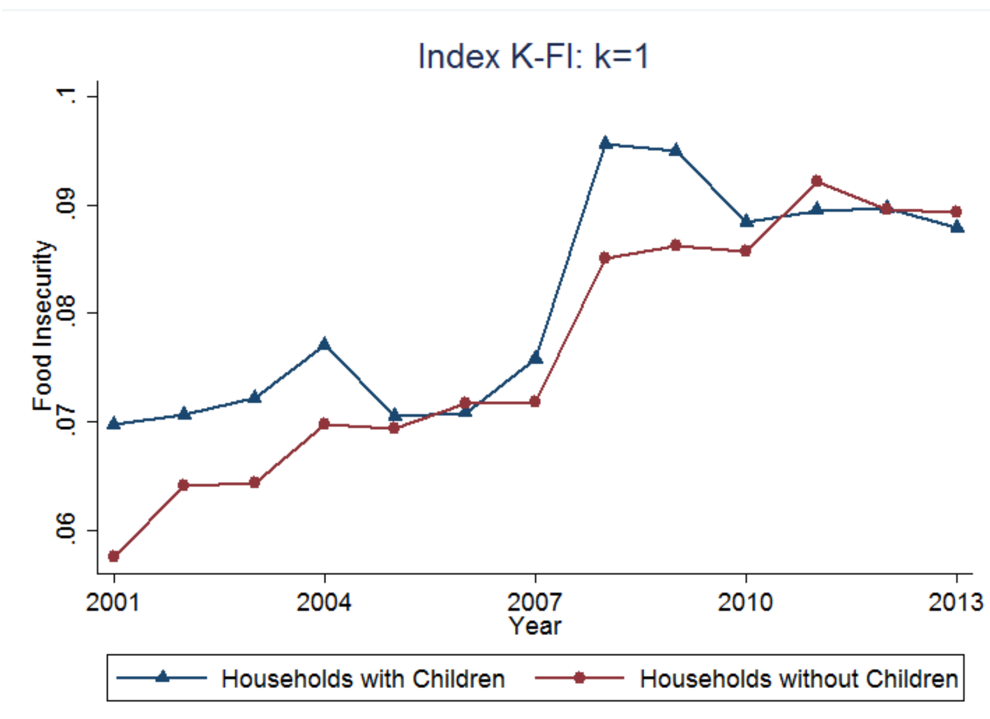

Figure 1.8: Index K-FI $k = 1$ Food Insecurity Measures for households with and without children by year

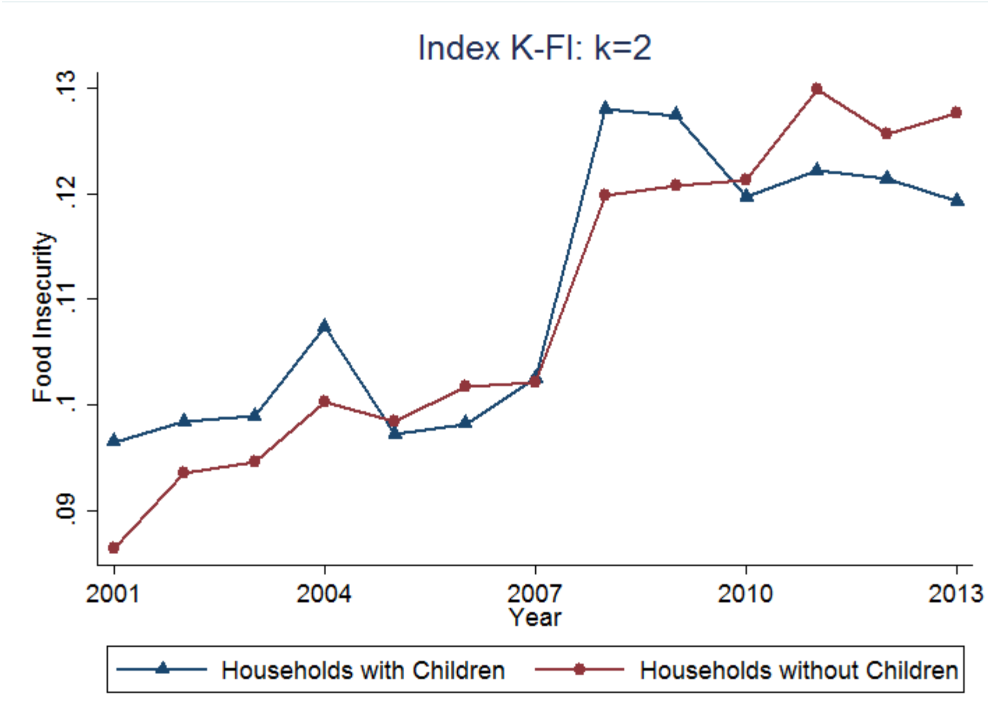

Figure 1.9: Index K-FI $k = 2$ Food Insecurity Measures for households with and without children by year

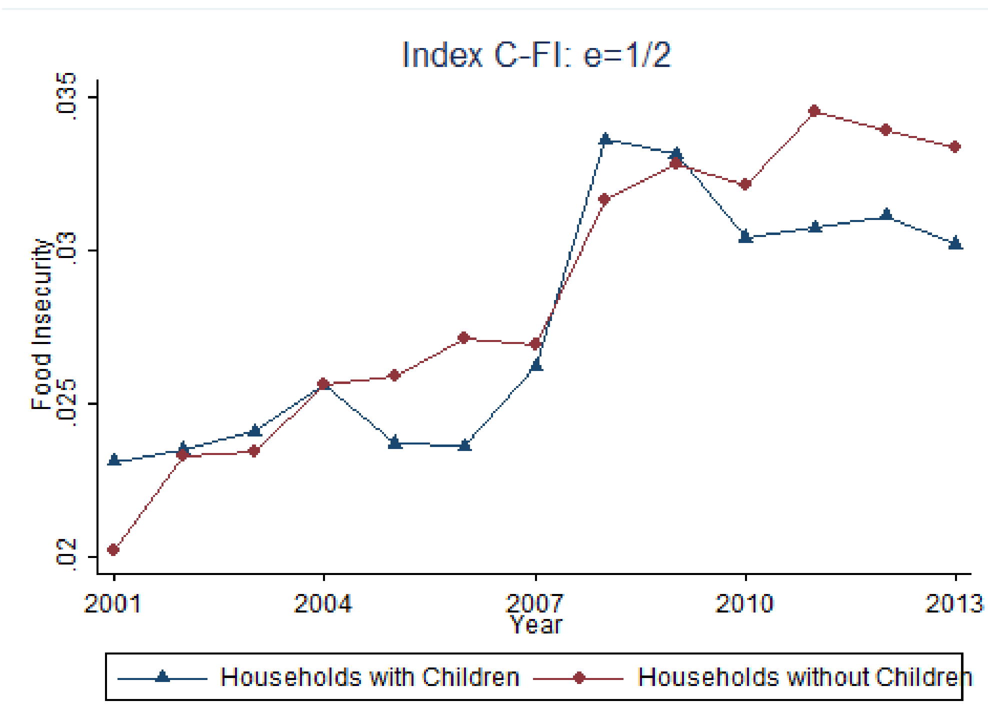

Figure 1.10: Index C-FI $e = \frac{1}{2}$ Food Insecurity Measures for households with and without children by year

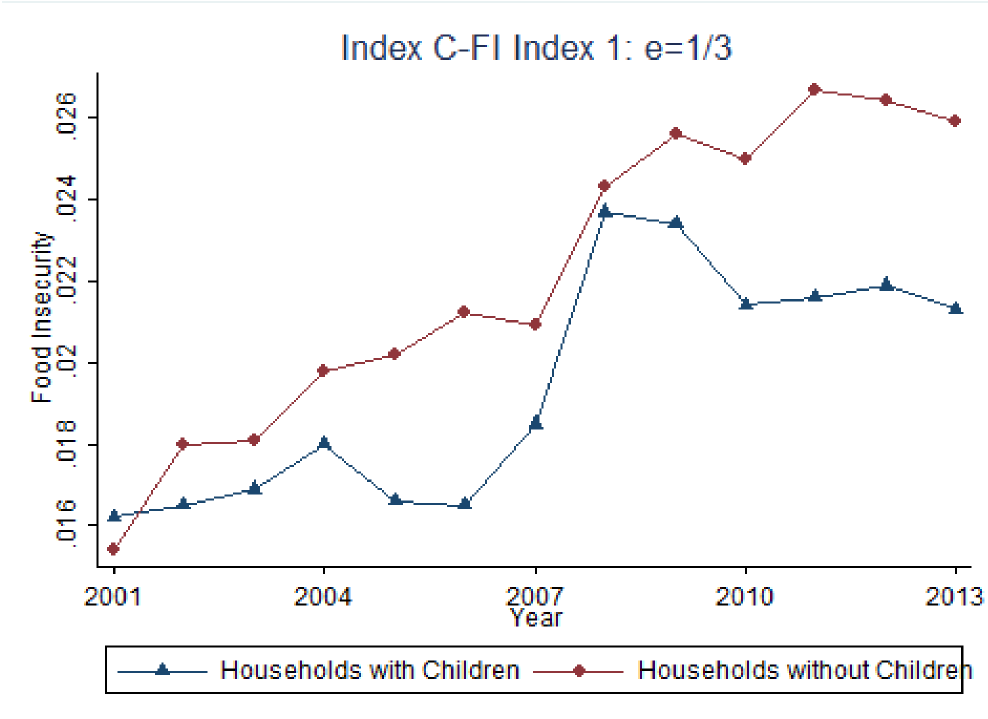

Figure 1.11: Index C-FI $e = \frac{1}{3}$ Food Insecurity Measures for households with and without children by year

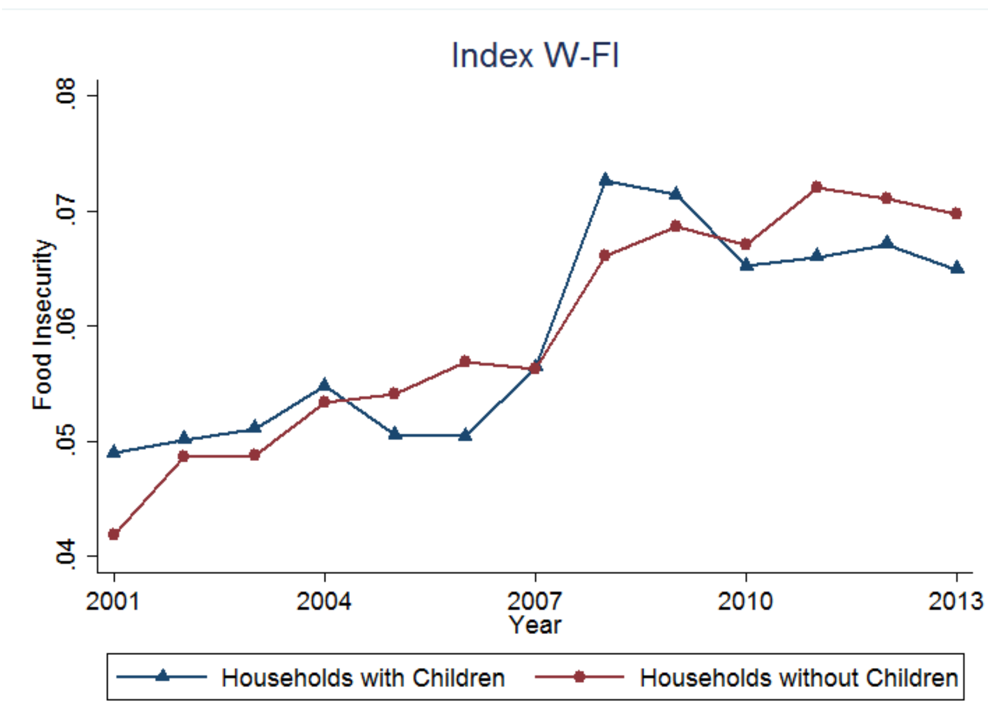

Figure 1.12: Index W Food Insecurity Measures for households with and without children by year

Chapter 2

The Effect of Increased Gross Income Thresholds for SNAP Eligibility on Food Insecurity

2.1 Introduction

The Supplemental Nutrition Assistance Program (SNAP), formerly known as the Food Stamp Program, is the United States' largest hunger safety net program. SNAP benefits are meant to alleviate household food insecurity, by giving households a near-monetary benefit on electronic benefit transfer (EBT) cards. EBT cards can be used at authorized retailers to buy food products, increasing a household's budgetary constraint. It allows them to spend more on food than they would have otherwise or frees up cash that would have been needed to be spent on food for other essential spending. This is a large program affecting many households within the United States. On average, in the fiscal year 2013, 23.1 million households were receiving SNAP benefits each month (Gray et al., 2014).

The benefits of SNAP are numerous. There is a growing body of literature finding that SNAP is successful in its intended purpose of reducing food insecurity (Kreider et al., 2012; Nord and Golla, 2009; Nord and Prell, 2011; Ratcliffe et al., 2011). The reduction in food insecurity is important in its own right but also because of the many negative health outcomes food insecurity is associated with (for a review see Gundersen and Ziliak 2015). States have a vested interest in having healthy and productive citizens, meaning they also have a direct interest reducing food insecurity within their State. This interaction makes understanding how state-level policies affect food security important.

Since SNAP is a federal program that is administered by the states, most program regulations are consistent throughout all 50 states. For example, the amount of benefits that a household is eligible to receive is determined in the same way in every state, through a function of the maximum benefit for the household size – 30% of the household's earned income. However, states do have some ability to govern how the program works within their state; such as implementing broad-based categorical eligibility (BBCE) and increasing gross income thresholds. States implementing BBCE policies, which will be explained in detail later in this paper, increases the number of households eligible for SNAP. This should in turn reduce state level food insecurity. Within this paper, I will use state and time level variation in the implementation of to study whether states increasing gross income thresholds does indeed decrease state level food insecurity. To the best of my knowledge, this is the first paper to examine how these eligibility policies affect food insecurity.

For this analysis, I will use Index FGT-FI from chapter 1 of this paper to measure food insecurity. This index was developed by Gundersen (2008) from the Foster-Greer-Throbecke poverty index measure and can be used to measure the extent, depth, and severity of food insecurity. By using depth and severity measures, I can capture more of the differences within aggregated state-level food insecurity than would be possible using only a measure of extent (the percentage of the population who is food insecure).

Traditionally, household eligibility for SNAP has been determined by three federal guidelines: 1) Household gross income must be less than 130% of the poverty line for that year; 2) Household net income (gross income minus allotted deductions[1]) must be less than 100% of the poverty line; 3) Household assets must be under a certain amount. In the fiscal year 2011 that limit was \$2,000 or \$3,250 if at least one household member was an elderly or disabled (**?**). Additionally, households could be categorically eligible for SNAP if they were eligible for other specific government programs. Before 1996, this was largely for administrative efficiency since the specific government programs, Supplemental Security Income (SSI), Aid to Families with Dependent Children (AFDC), or state-run General Assistance (GA) programs had stricter requirements than SNAP to receive assistance.

However, in the 1996 welfare reform the Temporary Assistance for Needy Families (TANF) program was created. TANF is a wide reaching program that sometimes provides non-cash assistance to reach program goals. Through TANF states could now provide non-cash assistance to households that would not be traditionally eligible for SNAP and make them categorically eligible. This type of categorical eligibility allows states to choose to have more lenient eligibility requirements for SNAP by adjusting the state requirements for TANF. For instance, states can choose to eliminate the asset limit altogether and/or increase the gross income threshold from 130% up to as much as 200% of the poverty line.

In 2009, the USDA began to officially use the term broad-based categorical eligibility (BBCE) to describe the state level policies that make all or most households under a certain gross income threshold eligible for SNAP. Before this several differing terms had been used including both hard categorical eligibility and soft categorical eligibility. The memo that designated the term broad-based categorical eligibility also defined traditional and narrow eligibility policies. Traditional categorical eligibility describes states where categorical eligibility is only extended to households receiving cash benefits from the federal assistance programs mentioned above. Narrow categorical eligibility includes policies that increase categorical eligibility but not as drastically as BBCE (Shahin, 2009).

Broad-based categorical eligibility has been a popular policy for states. By the time broad-based categorical eligibility was the official name for the policy, over half of the states had already implemented it in some form (Shahin,

[1]Possible deductions include: a standard deduction depending on household size (\$155 for households with 1-3 people), 20% deduction of earned income, cost of some dependent care, legally owed child support, some medical expenses for the elderly or disabled, excess shelter costs (housing costs that are above of household income after other deductions)

2009). Again, BBCE still varies state by state. When states implement BBCE, they have the option to increase the gross income threshold up to 200% of the poverty line. Some states have indeed done this, while other chose to keep the 130% threshold, while still, others have chosen a threshold in-between. I will explore this variation within my model to see if an increased gross income threshold affects state level food insecurity.

It is important to note, even within states that have eliminated BBCE policies, households still need to meet the net income test to be able to receive SNAP benefits (Falk and Aussenberg, 2012). Within every state, the amount of benefits a household is eligible for is the maximum benefit for the household size – 30% of the household's earned income. If a household has a net income above 100% of the poverty line, their income would be too high to actually receive any benefits (Falk and Aussenberg, 2012).

SNAP benefits are a near-monetary good, that can free up cash that would have otherwise been needed to be spent on food, making them a desirable good. This can be especially helpful for households that are near or under the poverty level who often have very constrained budgets. Since SNAP is expected to have a positive effect on food security, all else equal, you would expect households who would be eligible for SNAP in one state, but ineligible in another would be better off in the state where they would be eligible. For example, a household with a gross income at 150% of the poverty line living in Iowa, where the gross income threshold to receive SNAP is 160%, should be more likely to be food secure than a household with a gross income at 150% of the poverty line living in Illinois, where the gross income threshold is 130%. This would imply that policies increasing eligibility would have positive effects on food security extent, depth, and severity.

2.2 Data

The food insecurity data used in this research comes from the Current Population Survey Food Security Supplement (CPS-FSS) from 2001-2011 and includes the Core Food Security Module (CFSM). The CFSM consists of 18 questions, with 10 questions for all households and an additional 8 for households with children. These questions range in severity from asking how often the following statement is true for a household in the prior 12 months "We worried whether food would run out before we got more money to buy more" to the most severe for households without children being "In the last 12 months, did you or other adults in any household ever not eat for a whole day because there was not enough money for food?" and "In the last 12 months, did a child ever not eat for a whole day because there wasn't enough money for food?" for households with children.[2] Each question is asked in a way such that affirmative responses come from budgetary constraints; a person who is not eating for religious or fasting purposes would not be counted as food insecure. The responses from this data will be used to calculate a household-level food

[2] A full list of the Core Food Security Module Questions can be found at http://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/survey-tools.aspx

security measure that will then be aggregated up to the state level measure of extent, depth, and severity.

The policy data is complied from both Feeding America's Map the Meal Gap Technical Briefs and the USDA's SNAP policy database[3]. Since BBCE policies were not given an official name until 2009 finding when states increased their gross income thresholds to SNAP proved difficult. Feeding America's Map the Meal Gap is an annual report on county-level food insecurity; I used several of the technical briefs to find the gross income thresholds for state TANF/MOE funds from 2009-2013 (Gundersen et al., 2011). The USDA's SNAP policy database includes when states implemented BBCE policies between 2001-2011 but not if/to what level states had increased gross income thresholds. For this reason, I make an assumption on when and what level gross income thresholds states implemented. I believe that for the most part the states that increased the gross income threshold for TANF/MOE funds, did so at the time they implemented BBCE policies and did not change the threshold thereafter. Based on this assumption, I use the 2010 threshold level data from Feeding America's Map the Meal Gap Technical Brief and assume they were implemented at the same time BBCE policies were within the USDA's SNAP policy database.

2.3 Methodology

This paper will employ Index FGT-FI from chapter 1 of this paper to measure food insecurity. For a more in-depth explanation of this index refer to chapter 1. This index will allow me to aggregate individual food insecurity data into a measure of the extent, depth, and severity of state-level food insecurity. I will then use these measures to evaluate how BBCE policies affect state-level food security.

To do this will use varying levels of α from Index FGT-FI:

$$FI_{\alpha}(f;z) = \frac{1}{n}\sum_{i=1}^{q}[(\frac{s_i-2}{z_i-2})^{\alpha}] \quad where \quad \alpha \geq 0 \tag{2.1}$$

Within this analysis, I will refer to the measure to the right of the summation $(\frac{s_i-2}{z_i-2})^{\alpha}$ as individual food insecurity. In the extent measure of food insecurity $\alpha = 0$; this will measure the percentage of households that are food insecure in each state since when $\alpha = 0$, the individual food insecurity will be 1 for all food insecure households. The aggregated measure is the number of households that are food insecure divided by the total number of households n. The depth measure of food insecurity will be when $\alpha = 1$, this measures the aggregated food insecurity welfare gap ratios. The measure will be larger when the individual household food insecurity welfare gap ratios measured within the state are larger, meaning a larger depth food insecurity measure indicates more food security hardship within the state. Lastly, the severity measure will be when $\alpha = 2$, this is the squared food insecurity welfare gap ratios. It will also increase as the individual food insecurity measures within the state increase. However this last measure will put a larger weight

[3]This database can be found at:http://www.ers.usda.gov/data-products/snap-policy-database.aspx

on the larger $(\frac{s_i-2}{z_i-2})^{\alpha}$ measures, than the smaller but still positive $(\frac{s_i-2}{z_i-2})^{\alpha}$ measures, since larger $(\frac{s_i-2}{z_i-2})^{\alpha}$ measures indicate a more severe food insecurity.

The measures of state-level food security will then be used as the dependent variable for the analysis of how state-level policies regarding categorical eligibility affect food security with separate regressions for α equal to 0, 1, and 2. FI_{st} will indicate the food security measure being regressed in each analysis for each state s and time t. There are then several regressions I use to determine if increased gross income thresholds affect state-level food insecurity. Each regression will include both year and state fixed effects to control for unobserved differences in each specific state and each specific year. For example, the fixed effect for the year 2008 will likely be large since the recession increased food insecurity that year across states. Each regression will also include time varying state demographic (DEM) variables that have been shown to be determinants of state-level food security within previous research (Gundersen et al., 2014), including unemployment rates, poverty rates, median income, race demographic variables and the percentage of homeownership. The GI variables then indicate the variables of interest, if the gross income threshold for that state in that year is above the federal 130% gross income threshold; the number following (i.e. 160, 165, 185, 200) indicates the raised gross income threshold. The first regression I use to determine if increased gross income thresholds affect food insecurity is expressed in equation (2.2):

$$FI_{st} = \beta_0 + \beta_1 GI160_{st} + \beta_2 GI165_{st} + \beta_3 GI185_{st} + \beta_4 GI200_{st} + \mu_t + v_s + \beta_{5-10} DEM_{st} + \varepsilon_{st} \tag{2.2}$$

Since the CFSM is taken December each year the gross income dummy variables indicate whether the state had a gross income threshold of that specified level in the December of the year CFSM was taken. However it is plausible that a policy such as this would need to be in place for some time before households are significantly affected by it. For this reason, I include the regression expressed in equation (2.3) where the gross income threshold variables indicate the thresholds were in place the previous December. This way households could benefit from the increased gross income thresholds throughout the year for which the CFSM is measuring food insecurity.

$$FI_{st} = \beta_0 + \beta_1 GI160_{st-1} + \beta_2 GI165_{st-1} + \beta_3 GI185_{st-1} + \beta_4 GI200_{st-1} + \mu_t + v_s + \beta_{5-10} DEM_{st} + \varepsilon_{st} \tag{2.3}$$

Additionally, I believe there may be too few states implementing specific threshold levels for the regressions to capture the policy's true effect. For example only 2 states, Iowa and Pennsylvania, implemented a gross income threshold of 165%. The regression expressed in equation (2.4) addresses this concern. Then the regression expressed in equation (2.5) takes into account the previous temporal concern.

$$FI_{st} = \beta_0 + \beta_1 GI-Increased_{st} + \mu_t + v_s + \beta_{2-8} DEM_{st} + \varepsilon_{st} \tag{2.4}$$

$$FI_{st} = \beta_0 + \beta_1 GI - Increased_{st-1} + \mu_t + v_s + \beta_{2-8} DEM_{st} + \varepsilon_{st} \tag{2.5}$$

As in chapter 1, I argue that the depth and severity measures of food insecurity for households with and without children are incomparable. This is because a relationship cannot be assumed between the number of affirmative responses as a percentage of the total questions asked to be equal between households with and without children. For this reason, we will run each regression listed above for households with children and households without children separately.

2.4 Results

The results of the analysis are presented in tables 2.3 -2.10; Tables 2.3 - 2.6 are for households with children and tables 2.7 -2.10 are for households without children. The state unemployment rate has a large positive and statistically significant correlation with the extent of food insecurity ($\alpha = 0$) for households with children. This implies that as the state unemployment rate increases, the extent of food insecurity among households with children also increases. Whereas, the median income of a state was found to have a negative correlation the depth of food insecurity ($\alpha = 1$) for households with children. These results hold true for each of the four regressions on the food insecurity of households with children. For households without children, more of the state demographic variables were found significant. The state poverty rate was found to have a positive and statistically significant correlations with each of the food insecurity levels. The state unemployment rate was also found to have a positive correlation with an even larger magnitude but was only found significant when $\alpha = 0$ or $\alpha = 1$. Whereas, the state homeownership rate found to have statistical significance for each of food insecurity levels with a negative correlation. This implies that an increase in the state poverty and unemployment rates are associated with an increase in food insecurity, whereas an increase in the homeownership rate is associated with a decrease in food insecurity. Of the demographic variables, the last finding was the percentage of households with Hispanic Ethnicity was found to have a statically significant and negative correlation with the extent and depth of food insecurity for households without children. This is a surprising result because Hispanic households have been found to have considerably larger rates of food insecurity than the national average in previous research (Nord et al., 2010). It is important to note, magnitudes of effect of significant demographic variables on food insecurity may seem smaller as α increases, however, it is important to note by design of the index the measures of food insecurity decrease as α increases, so this is expected.

Of my variables of interest, only one was found significant for households with children. Having a gross income threshold of 200% in place by that December was found to a negative correlation with the state depth ($\alpha = 1$) and severity ($\alpha = 2$) of food insecurity. Meaning having a gross income threshold of 200% was associated with a lower depth and severity of food insecurity for households with children as compared to having a gross income threshold of

130%.

For households without children, again only one threshold level was found to be significant. However, for this population, it was having a gross income threshold of 165% that was associated with lower food insecurity and was statically significant on the extent ($\alpha = 0$) and depth of food insecurity ($\alpha = 1$).

Although these results are in line with my hypothesis, that having a gross income threshold above 130% would lead to lower food insecurity, these findings are not robust. Nothing about increasing the gross income thresholds for SNAP eligibility targets households with or without children. If my model was finding the actual impacts of the policy change on food insecurity, you would expect the policy to have a similar affect food insecurity for on the two groups of households. Additionally, the differences within the temporal aspect seem irregular. Having a gross income threshold of 200% and 165% in place by that December was associated with a decrease in food insecurity for households with children and households without children respectively; However, neither was significant for the regression using the policy variables from the year before. This is an unlikely result, since with my dataset states would implement an increased gross income threshold and then keep that same threshold for the rest of the time period. If a policy in place by that December effected food insecurity, you would expect the policy being in place the previous December and then for the full year after would also affect food insecurity. Lastly, if a threshold of 165% decreased food insecurity compared to a 130% threshold, you would expect having an increased threshold of 185% or 200% where more households are eligible for SNAP would have at least that same effect, if not more.

2.5 Conclusion

Since these results were not robust, this may lead to the conclusion that an increased gross income threshold does not affect food insecurity and therefore is unneeded. However, I argue there are four reasons why it is possible an increased gross income threshold could decrease food insecurity but my model was not able to capture it. First, I made an assumption that has potential errors. If there are errors this could easily effect the result, if the data is wrong the model cannot reflect what the correct data would have shown. Second, even without potential errors, there may just not been enough variation within the data, for the most part, states would increase the gross income and then keep that threshold until the end of the time period, meaning almost all individual states have at most change within each of the policy variables. Moreover, several of the threshold levels had very few states ever implement them. Specifically, only 2 states ever had a gross income threshold of 160% and only 4 had a gross income threshold of 165%. Third, although these policies would make more households eligible for SNAP, it is possible the policies did not affect enough households for the aggregated state food insecurity to actually be affected.

Finally, this food insecurity measure is still relatively new and there is much to learned. Although this study did not have significant findings, more research like it is needed to understand how policies that meant to help food insecure households affect not only extent of food insecurity but also the depth and severity of food hardship being experienced by households within the U.S.

2.6 Tables

Table 2.1: Year of BBCE Implementation by State

2000	DE	ME	MI	ND	OR							
2001	MA	MD	SC	TX								
2002												
2003												
2004	WA	WI										
2005												
2006	MN											
2007	AZ											
2008	GA	NY	OH	PA	WV							
2009	CA	CT	ID	MT	NH	NV	OK	RI	VT			
2010	AL	DC	FL	HI	IA	IL	KY	LA	MS	NC	NJ	NM
2011	CO	NE										

This data is from the USDA's SNAP policy database and can be found at:
http://www.ers.usda.gov/data-products/snap-policy-database.aspx.

Table 2.2: Gross Income Thresholds by State in December 2013

130%	AK	AL	AR	CA	CO	GA	ID	IN	KS	KY	LA	MO
	MS	NE	OH	OK	SC	SD	TN	UT	VA	WV	WY	
160%	IA	PA										
165%	IL	MN	NM	TX								
185%	AZ	CT	ME	NH	NJ	OR	RI	VT				
200%	DC	DE	FL	HI	MA	MD	MI	MT	NC	ND	NV	NY
	WA	WI										

This data is from the Map the Meal Gap 2014 Technical Brief.

Table 2.3: Estimates of the Impact of Gross Income Thresholds above 130% (in Place by December) and Various Other Factors on State Level Food Insecurity for Households with Children, Using CPS Data, 2001-2013

VARIABLES	(1) $\alpha = 0$	(2) $\alpha = 1$	(3) $\alpha = 2$
160% Gross Income Threshold that December	-0.008	-0.004	-0.002
	(0.007)	(0.002)	(0.001)
165% Gross Income Threshold that December	0.001	-0.002	-0.002
	(0.007)	(0.002)	(0.001)
185% Gross Income Threshold that December	0.002	0.001	0.001
	(0.008)	(0.002)	(0.001)
200% Gross Income Threshold that December	-0.008	-0.004*	-0.002*
	(0.007)	(0.002)	(0.001)
Poverty Rate	0.142	0.035	0.006
	(0.086)	(0.028)	(0.015)
Median Income	-0.006	-0.002*	-0.001
	(0.003)	(0.001)	(0.001)
Unemployment Rate	0.617**	0.101	0.020
	(0.181)	(0.057)	(0.029)
Percentage Hispanic	-0.017	-0.021	-0.013
	(0.112)	(0.034)	(0.018)
Percentage Black	0.198	0.059	0.026
	(0.104)	(0.033)	(0.018)
Percentage Homeownership	-0.055	-0.011	-0.009
	(0.065)	(0.020)	(0.011)
Constant	0.153**	0.043*	0.021*
	(0.051)	(0.017)	(0.009)
State FE	yes	yes	yes
Year FE	yes	yes	yes
Observations	663	663	663
R-squared	0.741	0.698	0.608

Robust standard errors in parentheses
** $p<0.01$, * $p<0.05$

Table 2.4: Estimates of the Impact of Increased Gross Income Thresholds above 130% (in Place by Previous December) and Various Other Factors on State Level Food Insecurity for Households with Children, Using CPS Data, 2001-2013

VARIABLES	(1) $\alpha = 0$	(2) $\alpha = 1$	(3) $\alpha = 2$
160% Gross Income Threshold previous December	-0.007	-0.002	-0.001
	(0.007)	(0.002)	(0.001)
165% Gross Income Threshold previous December	0.009	0.002	0.000
	(0.008)	(0.003)	(0.001)
185% Gross Income Threshold previous December	0.006	0.002	0.001
	(0.008)	(0.002)	(0.002)
200% Gross Income Threshold previous December	-0.008	-0.002	-0.001
	(0.006)	(0.002)	(0.001)
Poverty Rate	0.139	0.033	0.004
	(0.086)	(0.028)	(0.015)
Median Income	-0.006	-0.002*	-0.001
	(0.003)	(0.001)	(0.001)
Unemployment Rate	0.628**	0.103	0.017
	(0.185)	(0.058)	(0.029)
Percentage Hispanic	-0.034	-0.027	-0.014
	(0.112)	(0.034)	(0.018)
Percentage Black	0.185	0.052	0.023
	(0.104)	(0.034)	(0.019)
Percentage Homeownership	-0.060	-0.013	-0.010
	(0.065)	(0.020)	(0.011)
Constant	0.157**	0.045**	0.022*
	(0.051)	(0.017)	(0.009)
State FE	yes	yes	yes
Year FE	yes	yes	yes
Observations	663	663	663
R-squared	0.742	0.696	0.602

Robust standard errors in parentheses
** p<0.01, * p<0.05

Table 2.5: Estimates of the Impact of an Increased Gross Income Threshold (in Place by December) on State Level Food Insecurity for Households with Children, Using CPS Data, 2001-2013

VARIABLES	(1) $\alpha = 0$	(2) $\alpha = 1$	(3) $\alpha = 2$
Gross Income Threshold Above 130% that Decemeber	-0.005	-0.002	-0.001
	(0.004)	(0.001)	(0.001)
Poverty Rate	0.144	0.036	0.006
	(0.086)	(0.028)	(0.015)
Median Income	-0.005	-0.002*	-0.001
	(0.003)	(0.001)	(0.001)
Unemployment Rate	0.610**	0.101	0.020
	(0.177)	(0.056)	(0.027)
Percentage Hispanic	-0.012	-0.020	-0.012
	(0.113)	(0.034)	(0.018)
Percentage Black	0.197	0.061	0.028
	(0.103)	(0.033)	(0.018)
Percentage Homeownership	-0.057	-0.011	-0.009
	(0.064)	(0.020)	(0.011)
Constant	0.153**	0.042*	0.021*
	(0.051)	(0.017)	(0.009)
State FE	yes	yes	yes
Year FE	yes	yes	yes
Observations	663	663	663
R-squared	0.740	0.696	0.604

Robust standard errors in parentheses
** $p<0.01$, * $p<0.05$

Table 2.6: Estimates of the Impact of an Increased Gross Income Threshold (in Place Previous December) on State Level Food Insecurity for Households with Children, Using CPS Data, 2001-2013

VARIABLES	(1) $\alpha = 0$	(2) $\alpha = 1$	(3) $\alpha = 2$
Gross Income Threshold Above 130% previous Decemeber	-0.002	-0.001	-0.000
	(0.004)	(0.001)	(0.001)
Poverty Rate	0.138	0.032	0.004
	(0.086)	(0.028)	(0.015)
Median Income	-0.006	-0.002*	-0.001
	(0.003)	(0.001)	(0.001)
Unemployment Rate	0.605**	0.097	0.018
	(0.179)	(0.057)	(0.028)
Percentage Hispanic	-0.010	-0.020	-0.012
	(0.114)	(0.034)	(0.018)
Percentage Black	0.190	0.053	0.023
	(0.104)	(0.034)	(0.019)
Percentage Homeownership	-0.056	-0.012	-0.009
	(0.065)	(0.020)	(0.011)
Constant	0.154**	0.044**	0.022*
	(0.052)	(0.017)	(0.009)
State FE	yes	yes	yes
Year FE	yes	yes	yes
Observations	663	663	663
R-squared	0.740	0.694	0.601

Robust standard errors in parentheses
** $p<0.01$, * $p<0.05$

Table 2.7: Estimates of the Impact of Increased Gross Income Thresholds above 130% (in Place by December) and Various Other Factors on State Level Food Insecurity for Households without Children, Using CPS Data, 2001-2013

VARIABLES	(1) $\alpha = 0$	(2) $\alpha = 1$	(3) $\alpha = 2$
160% Gross Income Threshold that December	-0.005	0.000	0.001
	(0.004)	(0.003)	(0.002)
165% Gross Income Threshold that December	-0.018**	-0.006*	-0.003
	(0.006)	(0.003)	(0.002)
185% Gross Income Threshold that December	-0.007	-0.000	0.002
	(0.004)	(0.002)	(0.001)
200% Gross Income Threshold that December	-0.000	-0.000	-0.000
	(0.004)	(0.002)	(0.001)
Poverty Rate	0.133**	0.068**	0.048*
	(0.051)	(0.026)	(0.019)
Median Income	0.000	-0.001	-0.001
	(0.002)	(0.001)	(0.001)
Unemployment Rate	0.379**	0.120**	0.044
	(0.099)	(0.046)	(0.033)
Percentage Hispanic	-0.166*	-0.076*	-0.050
	(0.071)	(0.036)	(0.026)
Percentage Black	-0.057	-0.044	-0.037
	(0.066)	(0.032)	(0.023)
Percentage Homeownership	-0.111**	-0.055**	-0.040**
	(0.040)	(0.020)	(0.014)
Constant	0.121**	0.063**	0.046**
	(0.031)	(0.016)	(0.012)
State FE	yes	yes	yes
Year FE	yes	yes	yes
Observations	663	663	663
R-squared	0.768	0.716	0.638

Robust standard errors in parentheses
** p<0.01, * p<0.05

Table 2.8: Estimates of the Impact of Increased Gross Income Thresholds above 130% (in Place by Previous December) and Various Other Factors on State Level Food Insecurity for Households without Children, Using CPS Data, 2001-2013

VARIABLES	(1) $\alpha = 0$	(2) $\alpha = 1$	(3) $\alpha = 2$
160% Gross Income Threshold previous December	-0.006	-0.001	-0.000
	(0.005)	(0.003)	(0.002)
165% Gross Income Threshold previous December	0.005	0.003	0.003
	(0.009)	(0.004)	(0.003)
185% Gross Income Threshold previous December	-0.003	0.001	0.002
	(0.004)	(0.002)	(0.001)
200% Gross Income Threshold previous December	0.001	0.000	-0.000
	(0.004)	(0.002)	(0.001)
Poverty Rate	0.122*	0.065*	0.048*
	(0.052)	(0.026)	(0.019)
Median Income	-0.000	-0.001	-0.001
	(0.002)	(0.001)	(0.001)
Unemployment Rate	0.404**	0.128**	0.047
	(0.098)	(0.045)	(0.033)
Percentage Hispanic	-0.180**	-0.085*	-0.056*
	(0.068)	(0.034)	(0.024)
Percentage Black	-0.064	-0.047	-0.037
	(0.066)	(0.032)	(0.023)
Percentage Homeownership	-0.106**	-0.053**	-0.039**
	(0.040)	(0.020)	(0.015)
Constant	0.121**	0.063**	0.046**
	(0.032)	(0.016)	(0.012)
State FE	yes	yes	yes
Year FE	yes	yes	yes
Observations	663	663	663
R-squared	0.765	0.715	0.638

Robust standard errors in parentheses
** p<0.01, * p<0.05

Table 2.9: Estimates of the Impact of an Increased Gross Income Threshold (in Place by December) on State Level Food Insecurity for Households without Children, Using CPS Data, 2001-2013

VARIABLES	(1) $\alpha = 0$	(2) $\alpha = 1$	(3) $\alpha = 2$
Gross Income Threshold Above 130% that Decemeber	-0.005	-0.001	0.000
	(0.003)	(0.001)	(0.001)
Poverty Rate	0.126*	0.066*	0.047*
	(0.052)	(0.026)	(0.019)
Median Income	0.000	-0.001	-0.001
	(0.002)	(0.001)	(0.001)
Unemployment Rate	0.411**	0.128**	0.046
	(0.097)	(0.045)	(0.032)
Percentage Hispanic	-0.170*	-0.078*	-0.051*
	(0.071)	(0.036)	(0.025)
Percentage Black	-0.047	-0.040	-0.033
	(0.066)	(0.032)	(0.023)
Percentage Homeownership	-0.109**	-0.052**	-0.038**
	(0.039)	(0.020)	(0.014)
Constant	0.120**	0.061**	0.045**
	(0.031)	(0.016)	(0.011)
State FE	yes	yes	yes
Year FE	yes	yes	yes
Observations	663	663	663
R-squared	0.765	0.714	0.636

Robust standard errors in parentheses
** p<0.01, * p<0.05

Table 2.10: Estimates of the Impact of an Increased Gross Income Threshold (in Place by Previous December) on State Level Food Insecurity for Households without Children, Using CPS Data, 2001-2013

VARIABLES	(1) $\alpha = 0$	(2) $\alpha = 1$	(3) $\alpha = 2$
Gross Income Threshold Above 130% previous Decemeber	-0.000	0.001	0.001
	(0.003)	(0.001)	(0.001)
Poverty Rate	0.120*	0.064*	0.047*
	(0.052)	(0.026)	(0.019)
Median Income	-0.000	-0.001	-0.001
	(0.002)	(0.001)	(0.001)
Unemployment Rate	0.401**	0.124**	0.044
	(0.097)	(0.045)	(0.032)
Percentage Hispanic	-0.172*	-0.080*	-0.052*
	(0.071)	(0.035)	(0.025)
Percentage Black	-0.066	-0.047	-0.037
	(0.066)	(0.031)	(0.023)
Percentage Homeownership	-0.112**	-0.054**	-0.039**
	(0.040)	(0.020)	(0.014)
Constant	0.125**	0.063**	0.046**
	(0.032)	(0.016)	(0.011)
State FE	yes	yes	yes
Year FE	yes	yes	yes
Observations	663	663	663
R-squared	0.764	0.714	0.636

Robust standard errors in parentheses
** $p<0.01$, * $p<0.05$

Chapter 3

Bibliography

Chakravarty, S. R. (1983). A new index of poverty. *Mathematical Social Sciences 6*(3), 307–313.

Falk, G. and R. A. Aussenberg (2012). The supplemental nutrition assistance program (snap): Categorical eligibility. *Congressional Research Service, March*.

Foster, J., J. Greer, and E. Thorbecke (1984). A class of decomposable poverty measures. *Econometrica*, 761–766.

Foster, J. E. (1984). *On economic poverty: a survey of aggregate measures*. Institute for Research in the Behavioral, Economic, and Management Sciences.

Foster, J. E. and A. F. Shorrocks (1991). Subgroup consistent poverty indices. *Econometrica: Journal of the Econometric Society*, 687–709.

Gray, K. F. et al. (2014). Characteristics of supplemental nutrition assistance program households: Fiscal year 2013. Technical report, Mathematica Policy Research.

Gundersen, C. (2008). Measuring the extent, depth, and severity of food insecurity: an application to american indians in the usa. *Journal of Population Economics 21*(1), 191–215.

Gundersen, C., E. Engelhard, F. America, A. Satoh, and E. Waxman (2011). Map the meal gap 2014: Technical brief.

Gundersen, C., E. Engelhard, and E. Waxman (2014). Map the meal gap: Exploring food insecurity at the local level. *Applied Economic Perspectives and Policy*, ppu018.

Gundersen, C. and J. P. Ziliak (2015). Food insecurity and health outcomes. *Health Affairs 34*(11), 1830–1839.

Kakwani, N. (1980). On a class of poverty measures. *Econometrica*, 437–446.

Kreider, B., J. V. Pepper, C. Gundersen, and D. Jolliffe (2012). Identifying the effects of snap (food stamps) on child health outcomes when participation is endogenous and misreported. *Journal of the American Statistical Association 107*(499), 958–975.

Nord, M., M. Andrews, and S. Carlson (2010). Household food security in the united states, 2009. *USDA-ERS Economic Research Report* (108).

Nord, M. and A. M. Golla (2009). Does snap decrease food insecurity. *Untangling the self-selection effect*.

Nord, M. and M. A. Prell (2011). *Food security improved following the 2009 ARRA increase in SNAP benefits*. US Department of Agriculture, Economic Research Service Washington, DC.

Ratcliffe, C., S.-M. McKernan, and S. Zhang (2011). How much does the supplemental nutrition assistance program reduce food insecurity? *American Journal of Agricultural Economics*, aar026.

Sen, A. (1976). Poverty: an ordinal approach to measurement. *Econometrica*, 219–231.

Shahin, J. (2009). Improving access to snap through broad-based categorical eligibility. *Food and Nutrition Service Memorandum*.

Takayama, N. (1979). Poverty, income inequality, and their measures: Professor sen's axiomatic approach reconsidered. *Econometrica*, 747–759.

Watts, H. W. (1968). *An economic definition of poverty*. Institute for Research on Poverty.

Zheng, B. (1993). An axiomatic characterization of the watts poverty index. *Economics Letters 42*(1), 81–86.