Food Security Dynamics in the United States: An Asset Based Approach

Siwen Zhou
Department of Agricultural and Resource Economics, Colorado State University
Email: siwen.zhou@colostate.edu
Joshua P. Berning
Department of Agricultural and Resource Economics, Colorado State University
Email: joshua.berning@colostate.edu

Selected Paper prepared for presentation at the 2023 Agricultural & Applied Economics Association Annual Meeting, Washington DC; July 23-25, 2023

Food Security Dynamics in the United States: An Asset Based Approach

Abstract

Given the importance of food insecurity for a population to remain healthy and well-nourished, understanding the dynamics of food insecurity matters fundamentally for developing effective policy. An important question that remains unanswered in dynamic analysis: who will remain in food insecurity (or caught in a food insecurity trap) in the long run. Using a long household-level panel dataset from Panel Study of Income Dynamics (PSID) over 19 years from 2001 to 2019, the goal of this study is to explore the nature of food insecurity dynamics by examining persistent long-run food insecurity in the United States. To do so, we develop a new asset-based food insecurity measure and attempt to identify the dynamic asset threshold in the form of multiple asset dynamic equilibria, which will ultimately help measure the persistence of food insecurity in United States.

Key words: Food Insecurity, Food Security Dynamics, Asset

1. Introduction

Food insecurity (FI) is one of the biggest threats to public health in the United States (Gundersen et al., 2011). Most empirical studies on FI conduct cross-sectional estimates of a household's food security status at a specific point in time, often using the official Household Food Security Measure (HFSM)[1] (Alaimo, 2005; Coleman-Jensen et al., 2022). However, household food insecurity is likely dynamic with most households moving in and out of food security over time as their household circumstances change (Grineski et al., 2018). Evaluating dynamic household food insecurity is more informative as it can provide more information on how, why, and when households become food insecure and helps explain whether households are likely to remain in need and how long households remain food insecure, (Wilde et al., 2010; Kennedy, et al., 2020; Lee et al., 2021). Some household may remain food insecure for a short spell only. Meanwhile, households with extreme economic hardship may be persistently food insecurity in the long run. The distinctions among the food insecure households matters fundamentally for developing effective policy.

While a few studies that have examined the intertemporal dynamics of household food insecurity in the US over years, an important question that remains unanswered in dynamic analysis: who will remain in food insecure (or be caught in a food insecurity trap) in the long run. Most of the existing literature tracks intertemporal food insecurity mobility and transitions using categorical food secure status based on longitudinal surveys that have fielded the official HFSM among the same households (Kennedy et al., 2013, Ryu and Bartfeld 2012, Wilde, Nord, and Zager

[1] This official HFSM is mainly and officially estimated from the affirmed number of self-reported 18 questions per household (10 questions for household without children) in the Household Food Security Survey Module (HFSSM) developed by USDA. Then this measure categorizes the households into food secure, low food insecure, and very low food insecure status.

2010). Consistently, these studies indicate that food insecurity is generally a transient rather than a persistent status but the households who are food insecure in one period are at high risk of staying in food insecurity in the following multiple observed years. None of the existing work using the HFSM measure has a longer survey span than five observations per household, making their dynamic analysis somewhat vulnerable to measurement errors and real but transient shocks to the food security situation (Dercon and Shapiro, 2007; Naschold and Barrett 2011; Duffy and Zizza 2016; Maitra and Rao 2018). Additionally, the food insecurity estimates from these broad official categories limit our knowledge of prospective changes in the severity of the food insecurity households experience over time which could be achieved by continuous measurement of food insecurity. (Bickel et al., 2000; Lee et al., 2021).

A notable exception is a recent study by Lee et al. (2021), who introduced a new continuous measurement of household food security based on food expenditures, examining the severity of dynamics of food security at the household level in the US from 2001 to 2017 by distinguishing between chronic food insecurity and transient food insecurity. Using 17 years of Panel Study of Income Dynamics (PSID) data, they found that while roughly 70% of households never experience food insecurity, while more than half of food insecure households face chronic food insecurity based on food expenditure, meaning they're expected to be food insecure at every survey period. Since the observed food expenditure used to estimate food insecurity does not consider welfare dynamics but is stochastic due to the short-term shocks and measure error, their study of food security mobility still cannot answer whether households will be persistently food insecure long-term.

As suggested by the poverty literature, to identify a household that is persistently food insecure in the long run (or facing a food insecurity trap), we should consider the structural (or asset) mechanism which makes it difficult for households to escape food insecurity (Barrett & carter, 2013; Carter & Barrett, 2006; Carter & May, 2001; Naschold & Barrett, 2011). Household assets, a key mechanism for maintaining the current socioeconomic structure and inequality in the poverty literature, are suggested to be a better indicator of long-term welfare than income and expenditure. (Oliver and Shapiro, 1990; Carter and Barrett, 2006; Nam et al., 2008). Relevant food security literature also echoes that households with sufficient assets, especially financial assets, are more likely to be sheltered from the risk of food insecurity (Chang et al., 2014; Guo, 2011). Based on the idea of poverty traps, a food insecurity trap stresses how people save and accumulate asset stocks (and the consequent returns) to climb out of food insecurity - or fail to climb out- over time (Barrett & Carter, 2013). Recognizing the households most at risk of long-term persistent food insecurity might help target more effective public policies.

The goal of this study is to explore the nature of household food insecurity dynamics by examining persistent long-run food insecurity in the United States. To do so, we employ the Panel Study of Income Dynamics (PSID) from 2001 to 2019 which is a nationally representative sample of approximately 23,000 survey responses from 2,700 households surveyed every two years over a 19-year period. The PSID collects detailed household wealth data consisting of reported or imputed values of specific components of household assets and the USDA's core food security module, enabling long-term dynamics to be studied in a way that other datasets cannot. With this leading nationally representative panel dataset, our study makes the following three contributes to the food insecurity literature.

First, this paper offers a novel attempt at establishing empirically whether there might exist food insecurity traps by identifying the dynamic asset threshold in the form of multiple asset dynamic equilibria. According to the work on poverty traps by Barrett and Carter (2013), we estimate the dynamic path of assets by regressing the household asset on higher order polynomials of its lagged value which allows for nonlinear dynamics. It is expected that there exist multiple dynamic equilibria. And the dynamic asset threshold will be the unstable point between the multiple stable equilibria in the dynamic path of assets, with at least one equilibrium associated with being food insecure (Barrett & Carter, 2013). If the dynamic asset threshold exists， households whose assets place them below the threshold are attracted to low levels of equilibrium when they are initially asset-poor with limited initial assets or when they suffer severe shocks to permanent asset stock or productivity loss. These households would remain food insecurity for a long time and are expected to be trapped in a food insecurity trap. By contrast, households whose assets place them above the threshold would naturally accumulate their assets and would be expected to escape food insecurity by themselves over time.

Second, we use the PSID data to develop a new asset-based food security continuous measurement, the estimated probability of food security (PFS), which is the likelihood that a household's observed assets will equal or exceed the minimal adequate asset holdings that provide an additional “cushion” to help avoid food insecurity trap. We adapt the development resilience method [2] from Cissé and Barrett (2018) for our asset-based food security measurement. Specifically, the asset based PFS is estimated by computing the conditional density of household assets for each household and survey period, the inverse cumulative density beyond the minimal adequate asset holdings specific to that household composition and survey date from a system of conditional moment functions of household assets. With the dynamic asset threshold as minimal adequate asset holdings, we get the estimated household-year-specific PFS. Then we use a logit

[2] Barrett and Constas (2014, p.14626, hereafter BC) conceptualize the development resilience as “the capacity over time of a person, household, or other aggregate unit to avoid poverty in the face of various stressors and in the wake of myriad shocks. This development resilience method is a forward-looking, probabilistic measure of well-being that can be used for targeting and program evaluation.

model to examine the relationship between official discrete HFSM and our PFS to relate the household-year-specific PFS to the official USDA Household Food Security Measure (HFSM). In addition, we attempt to obtain a minimal food insecure probability threshold for PFS, above which a household is deemed food secure and below which it is considered food insecure. The minimal probability threshold for PFS will be the average value of PFS which corresponds to a predicted food insecure probability of less than 0.5.

Third, we examine the long-run persistent food insecurity in the US with FGT-style measure. Because our asset based PFS is a continuous measure, we could use a Foster, Greer, Thorbecke (FGT) style food insecurity measure around the dynamic asset threshold to aggregate the estimated households' PFS for the entire sample in each year or pooled across periods (Foster et al.,1984). With this FGT style measure, we can construct various persistently food insecurity measures (e.g., headcount, gap and the squared gap) depending on the distribution-sensitivity parameter, which helps examine the severity of persistent food insecurity. Meanwhile, we decompose the aggregate measure into various subgroups by targetable attributes like gender, race, education level, whether there are children and even forecast the probability of food security for each household and even subgroups in future periods under different scenarios (e.g., higher unemployment rate). This aggregate measure of persistent food insecurity can help policymakers to target food insecurity reduction interventions appropriately for the key populations in need of assistance.

In the remainder of this proposal, we first describe the theoretical conceptual framework of dynamic assets and food insecurity trap from the poverty literature in Section 2. In Section 3, we introduce the PSID data used to estimate US food insecurity dynamics. Building on recent empirical work in development resilience (Cissè and Barrett, 2018), we further implement this new approach to estimate asset-based food security measure in household panel survey data in Section 4. Afterwards, we propose how to conduct the severity of persistent food insecurity of persistent food insecurity using FGT style poverty measure. In section 5 and 6, we provide the expected results and make the conclusion for our study.

2. Economic Theoretical framework for food security trap

We adapt the theoretical model about the dynamic determinants of food insufficiency from Gundersen and Gruber (2001) for our basic dynamic food insecurity theoretical framework. Our theoretical model assumes a household maximize its utility derived from the consumption of food and other good subject to a budget constraint over multiple periods. To be simplify, this budget constraint equals current income to total expenditures of food and other good consumptions. Since there is larger measurement error in (expenditure) data due to the short-term period, the household-period-specific observed income is stochastic. Therefore, following the suggestion from poverty literature (Barrett et al., 2006), we include the structural pattern by incorporating the asset returns in the household income to consider the transitory variation in the income equation. Finally, at time *t*=0, a household solves the following problems:

$$max\ E_0(\sum_{t=0}^{T} U(F_t\,, OG_t\,)),$$

Subject to：

$$Y_t = \ p_F\, F_t + p_{OG}\, OG_t \ \ (1),$$

$$Y_t = \ A_t * [r_t(A_t) + \varepsilon_t^R] + y + \varepsilon_t^T + \varepsilon_t^M \quad (2).$$

Where E is the household's expectations operator, T is the end of the planning horizon, U is the utility function, F and OG are food and other goods (non-food) consumption. In the constraint equation (1), Y_t is the household income in year t, p_F and p_{OG} are prices for food and other goods respectively. The constraint given in equation (2) is a decomposition of household income at time t. The income includes A which is a vector of assets, r that is the corresponding vector of expected returns per unit asset held, ε_t^R represents shocks to period and household specific returns of assets. Additionally, y is the household-specific but time invariant income flows (for example, fixed salary, pensions, or transfers); ε_t^T is transitory income (for example, period-specific deviations from the mean value) and ε_t^M is measurement error. We assume each of the stochastic components, ε_t^R, ε_t^T and ε_t^M is zero mean and independently and identically distributed over time.

Assuming there is a quadratic utility function which implies the constant levels of consumption of food and other goods, we can solve the maximization problem by using the first-order condition and the constraints to get the total consumption C including both food and non-food items in period t:

$$C_t = Y_t = A_t * [r_t(A_t) + \varepsilon_t^R] + y + \varepsilon_t^T + \varepsilon_t^M \quad (3)$$

Then the expected value of total consumption for this household (is also equal to term 'structural income' in Carter and May (2001)) at any t:

$$E(C_t) = E(Y_t) = E\,(A_t * r_t(A_t)) + y \quad (4)$$

The equation expressed in terms of food and other good is:

$$E(p_F\, F_t + p_{OG}\, OG_t\,) = E(Y_t) = E\,(A_t * r_t(A_t)) + y \quad (5)$$

Let $\underline{F}$ be the minimum amount of food needed to be food secure for this household, and let $\underline{OG}$ be the minimum amount of other goods needed to be secure in other goods. Therefore, $\underline{Z} = p_F\,\underline{F} + p_{OG}\,\underline{OG}$ is the minimum expenditure needed to maintain both food security and other goods security ($E(\underline{Z}) = \underline{Z}$). Then the possibility of being both food insecure and other good insecure for a household exists if :

$$E\,(A_t * r_t(A_t)) + y \leq \underline{Z} \quad (6)$$

For this household, the choice set between food insecurity and deprivation over other goods are based on the current household-specific but time invariant income flows and their assets holdings. But it does not include the food security and non-deprivation over other goods. In the following, we only consider the food insecurity outcomes——it is presumed that a household can always avoid food insecurity when asset returns (structural part) plus time-invariant income are less than Z, but only if it accepts deprivation over other goods. It also indicates that the existing literatures (e.g., Lee et al. 2021) that only consider income or expenditures but not assets ignore the additional "cushion" that helps households avoid food insecurity.

Now we turn to consider all households within the economy. Since the importance of assets varies from household to household, it is relevant to define asset A in equation (3) and (4) as a vector of assets in welfare dynamics. Growth in observed income and consumption is calculated by totally differentiating equation (3):

$$dC_{it} = dY_{it} = dA_{it} * [r_{it}(A_t) + \varepsilon_{it}^{R}] + A_{it} * [dr_{it}/dA_{it} + d\varepsilon_{it}^{R}] + d\varepsilon_{it}^{T} + d\varepsilon_{it}^{M} \quad (7)$$

Taking the expectations of equation (7) will lead to the expected change in consumption or the structural dynamics of the household：

$$\mathrm{E}\{dC_{it}\} = E\{dY_{it}\} = E\{dA_{it}\} * r_{it}(A_{it}) + A_{it} * E\{dr_{it}/dA_{it}\} \quad (8)$$

Now this equation (8) emphasizes the components of structural consumption (or income) growth including changes in asset holdings and the changes in rates of return on assets. This derived equation reflects the central idea of poverty traps theory based on household asset evolution which we use to explain our food insecurity trap. Households who are on their way out of food insecurity will accumulate assets or enjoy shifts or changes in the returns of their assets. However, the exogenous changes in price and productivity (e.g., technical changes) and even changes in asset holdings (e.g., permanent loss) will affect their expected returns of assets, which ultimately affect the evolution of their assets and climb out of the food insecurity trap.

According to Barrett et al., (2006) and Carter & Barrett (2006), the existence of multiple dynamic equilibria representing the nonlinear returns on assets implies the existence of food insecurity traps. Specifically, it needs not be monotonically negatively sloped (dr_{it}/dA_{it} <0) but multiple dynamic equilibria exist only if there are locally increasing returns to assets (dr_{it}/dA_{it} >0) at some points (or some asset levels). This poverty trap hypothesis provides us the guidance to empirically test for a food insecurity trap. There are two approaches to our study long-term dynamics of food insecurity. One is to evaluate structural income (Y_{it}) or consumption (C_{it}) dynamics by regressing the changes in income (actually the assets) on the structure income in equation (4). The other is to explore the dynamics of household assets by regressing future assets on current assets. Since assets generate changes in income, the income dynamics stem from the asset dynamics. Therefore, our empirical approach uses the second approach on asset dynamics to understand the dynamics of food insecurity better.

Figure 1 depicts both the theoretical process of asset dynamics and the corresponding food insecurity trap. The bottom panel first shows the asset dynamics with multiple equilibria that ultimately drive the whole system. Around each dynamic equilibrium point there are non-linear dynamic paths of assets across the zero-asset change line (45-degree line) towards which households will converge. The stable equilibria (A_1^* & A_2^*) and unstable equilibria (A^*) occurs where the dynamic path crosses the point of zero expected change with a negative (or positive) slope (or return). Similar to the Micawber threshold (Zimmerman and Carter 2003) in poverty traps, we denote the unstable dynamic equilibrium point A^* as the critical dynamic asset FI threshold. The dynamic asset line A^* considers any predictable future changes in the assets of the food insecure households or predictable changes in the future returns of these assets. Households with initial assets above this point will naturally save and accumulate assets to arrive at high-level equilibrium point $A^*{}_2$ in the long-term (Barrett et al., 2006). Inversely, households with assets far from this critical threshold (for example their asset holdings are lower, or they experience permanent loss from trade) will naturally shed their assets down to $A^*{}_1$, the low-level equilibrium.

The top panel in Figure 1 depicts how a household allocate its assets to two distinct food secure livelihood strategies with different returns (or called productive activities/technologies), L_1 and L_2. There are diminishing returns to assets for both strategies[3]. But in contrast to L_1, L_2 strategy exhibiting higher marginal returns at the same asset level has a minimal asset value of operation or switching from L_1 to L_2.

If we don't consider the dynamic asset threshold A^*, it looks like households with asset stocks up to A_s will optimally switch from L_1 to L_2 since there are locally increasing returns in the neighborhood of A_s, a classic assumption of the poverty literature (Carter and Barrett, 2006). But this locally increasing returns around A_s fail to impede the ability of this household to accumulate, and cross over asset level A_s, which is a key dynamic question for food insecurity trap we discussed before. Meanwhile, even the $\underline{A}$, the static asset poverty line in a single period, has low marginal returns, households with assets below or above this threshold will always choose to increase their accumulation of assets to leap to and settle at a long-term equilibrium asset stock $A^*{}_2$. So $\underline{A}$ is also not the key dynamic asset threshold.

Rather, the unstable dynamic asset equilibrium A^* we discussed in the bottom panel is the critical dynamic threshold. Even when there is low marginal returns to assets, household with assets in excess of A^* will choose to accumulate assets until they research point A_s at which point it will be optimal to switch to food secure livelihood strategy L_2 and maintain a steady state level (or long-term high-level equilibrium) of asset $A^*{}_2$ resulting in a high level of food security. By

[3] Diminishing marginal returns to assets in production is under the canonical neoclassical growth model.

contrast, a household below the critical threshold A^* will not find it optimal to make sacrifice by accumulating assets to pass A^*. Without the assistance of intermediate capital, such households will naturally return to a lower steady state level of assets, ${A^*}_1$ and face long term food insecurity. In this particular case illustrated in Figure 1 (${A^*}_1 < A^* < \underline{A}$), we can distinguish households who will be long-term persistently food insecure (A $< A^*$) and those who will ultimately pass by $\underline{A}$ and escape from food insecurity on their way to the high-level equilibrium, ${A^*}_2$.

Finally, as suggested by the poverty trap literature, multiple equilibrium food insecurity traps, as shown in figure 1, may not empirically exists. A single equilibrium food insecurity trap may exist with a single stable state (or dynamic equilibrium) at a low level of well-being toward which everyone converges[4]. This also can be empirically tested by exploring the asset dynamic path.

3. Data

To develop our asset-based measure of food insecurity dynamics in the US, we use the Panel Study of Income Dynamics (PSID) from 2001 to 2019. Beginning in 1968 with the release of wave 41, the PSID has collected data on the same families over more than five decades, annually from 1968-1997 and biennially from 1997 until 2019. Moreover, since 1984, the PSID has collected detailed household wealth data consisting of reported or imputed values of specific components of household assets over past 35 years, and biennially for the last 20 years. Finally, the PSID is one of a few national surveys that includes the USDA's core food security module biennially in the 1999-2003 and 2015-2017 waves. This enables us to validate our new asset based PFS measure against the USDA's official food security measure from CPS data.

---

[4] This kind of poverty trap usually has been found in poverty countries and been the result of a technology (understood broadly to include institutional arrangements of production and exchange) that is insufficiently productive to generate non-poor standards of living (Acemoglu, Johnson, & Robinson, 2001; Jalan & Ravallion, 2000).

Importantly, we need to define the specific components of assets that are expected to explain food insecurity. Chang et al. (2014) provides evidence that non-pension financial assets represent a household's readily available financial resource to maintain current consumption levels and keep food secure over longer periods when income flow is interrupted by negative shocks. With the PSID wealth module in the 2001-2019 waves, we construct our asset-measure by summing up all the non-pension financial assets including the liquid assets[5], equity in stock, mutual funds, investment trusts, other liquid assets such as bond funds, cash value in life insurance, valuable collections for investment purposes, and rights in a trust or estate.

4. Empirical Strategy

4. 1. Estimate household asset dynamics

As illustrated in the theoretical section, we study long-term dynamics of household assets by regressing the household non-pension financial asset in period t ($\boldsymbol{A_{ijt}}$) on a polynomial function of lagged values in prior period ($\boldsymbol{A_{ijt-1}}$) and a vector of household-level covariates ($\boldsymbol{X_{ijt}}$), including shocks directly experienced by household i or risks to which household i is exposed:

$$A_{ijt} = \sum_{\gamma=1}^{n} \beta_{M_\gamma} A_{ijt-1}^{\gamma} + \delta_M X_{ijt} + \theta_{Mj} + \eta_{Mt} + \mu_{Mijt} \quad (9).$$

In equation (9), A_{ijt} is the aggregated household non-pension financial asset for household i, in state j and year t. X_{ijt} includes household demographics (age and squared age to account for life cycle effects, gender, race, and educational attainment of the household head), income (which does not include the value of government transfers, such as SNAP), changes since the prior survey round in employment status, household composition (marriage, number of children, number of household member), housing, and disability status. We further control for environmental or

[5] Liquid assets included funds in checking and saving accounts, money market funds, certificates of deposit, government bonds, and treasury bills.

geographic effects like urban or rural residence, the unemployment rate in each state (also represents economic fluctuations). θ_j and η_t are year and state fixed effect to absorb time and spatially invariant unobservable variables. The M subscript distinguishes the parameters from the conditional mean. We estimate equation (9) using a generalized linear model (GLM) logit link regression.

This asset dynamic model assumes a first-order Markov process which only uses a lag at the preceding position since the use of a single lag is economical while also helping to address possible autocorrelation in the errors of the panel data. For the polynomial function, Barrett et al. (2006) suggests a cubic specification of the polynomial function of lagged household assets (A_{ijt-1}) would be the most parsimonious parametric specification as it allows for the S-shaped dynamics characterized by multiple equilibria asset-poverty traps, even though higher order polynomials may be used. We further test various polynomial specifications to determine the preferred order using the Akaike information criterion (AIC) and t-tests on the equality of means between the predicted values of the higher-order specifications.

Based on the estimation of equation (9), we plot the path of household asset dynamics with future assets against the current assets. As shown in Section 2, a food insecurity trap exists when asset dynamics indicate multiple stable dynamic equilibrium resulting in an S-shape, as shown in the lower panel figure (1). The unstable equilibria among the stable dynamic equilibria represents the dynamic assets threshold.

4. 2. Construct the asset-based probability of food insecurity (PFS)

To construct our new asset-based food security measure, the PFS, we adapt an econometric strategy for estimating individual or household-level development resilience from panel data, which is introduced by Cissè and Barrett (2018, CB hereafter). As we illustrated in the theoretical conceptual framework in Section II, we need to construct the association between household assets and household food insecurity probability. However, due to the sample limitations of the official Household Food Security Measure (HFSM) in PSID data, we cannot directly get the association by regressing household food security status on possessed assets. Nevertheless, we are able to develop a new asset-based continuous measure of food security that estimates the probability of food security as the likelihood that a household's observed assets equal or exceed the minimal adequate asset holdings. This estimation follows the conditional moments-based approach recommended by CB. The approach allows the new asset-based measurement of probability of household food security to behave as a random variable with its own distribution in each period. This is essential for identifying potentially heterogeneous, wealth-dependent responses caused by nonlinear persistence of shocks and considering heteroscedasticity and other non-constant higher-order central moments in estimated path dynamics. The steps to construct asset based PFS using a system of conditional moment functions are as follows:

First, for household i, in state j and year t, we parametrically estimate the conditional mean of the food security indicator, household non-pension financial asset in period t, using the model of asset dynamics in equation 9.Second, we estimate the conditional variance (${\hat{\sigma}_{ijt}}^2$) of household financial assets using the residuals from the conditional mean equation (9). Assuming that the random error term μ_{Mjit} from equation (1) is mean zero ($\mathrm{E}[\mu_{Mit}] = 0$), the expected value of squared residuals, $\mathrm{E}[\mu_{Mit}^2]$, equals the conditional variance. Therefore, regressing the squared residuals of the conditional mean equation on covariates gives the regression equation for the conditional variance of household financial assets, using the same basic specification as in equation (9):

$$ {\hat{\sigma}_{ijt}}^2 = (\hat{\mu}_{Mit} - E[\hat{\mu}_{Mit}])^2 = {\hat{\mu}_{Mit}}^2 = \sum_{\gamma=1}^{n} \beta_{V_\gamma} A_{ijt-1}^{\gamma} + \delta_V X_{ijt} + \theta_{Vj} + \eta_{Vt} + \mu_{Vjit} \quad (10) $$

where V denotes conditional variance. As suggested by Lee et al. (2021), the conditional variance equation is estimated by ordinary least squares (OLS) as GLM may not reliably converge.

Assuming household financial assets $A_{ijt} \sim Gamma\ (\alpha, \beta)$[6], we calibrate the parameters of the household-and-period-specific cumulative density function F(·) using the predicted conditional moments such that ($\alpha = \frac{\hat{A}_{ijt}^{2}}{\hat{\sigma}_{ijt}^{2}}$; $\beta = \frac{\hat{\sigma}_{ijt}^{2}}{A^{*}}$), where is $\underline{A}$ the critical dynamic asset threshold we estimate from asset dynamics in equation (9).

Finally, we estimate the household-specific probability of food security (PFS) using the complementary cumulative density function (CCDF) of household assets holding. For the survey time series defined by t ≥ 0, we can define a household's food security resilience as the estimated complementary cumulative probability based on the sequence of estimated probabilities $(\hat{\rho}_{ijt})_{t=1}^{T}$:

$$\hat{\rho}_{ijt} = P(A_{ijt} \geq \underline{A}\ |A_{ijt-1}, X_{ijt}) = \bar{F}(X_{ijt}, A_{ijt-1}|\underline{A}) = 1 - F(X_{ijt}, A_{ijt-1}|\underline{A}) \in [0,1] \qquad (11)$$

Where F(·) is the assumed CDF and $\overline{\text{F}}$(·) is the corresponding CCDF. The PFS as defined by ρ is our asset-based household food security measure representing the probability that household i's non-pension financial assets in period (t) is equal or above the dynamic asset threshold.

We then relate the household-year-specific PFS to the official USDA Household Food Security Measure (HFSM) and attempt to obtain a minimal probability threshold ($\underline{P}$) for PFS, above which a household is deemed food secure and below which it is considered food insecure. Specifically, using the PSID data in 2001-2003 and 2015-2017 which collects the official HFSM, we first employ the logit model to examine the relationship between official discrete HFSM and

[6] Because A_{ijt} is continuous and non-negative. We also need to compare whether the mean and variance in our sample is significantly the same. If not, we may consider a Poisson distribution.

our PFS. We then estimate the probability of a household i with PFS_i to be food insecure. The minimal probability threshold ($\underline{P}$) will be the average value of PFS_i which corresponds to a predicted food insecure probability of less than 0.5.

Now we could sort households into period-specific three categories of dynamic food security over the long term. The first category is the persistent FI households who indeed fall into the food insecurity trap if $A_{ijt} < A^*$ (we assume the corresponding PFS (denoted by P^*) of the households with assets holding A^*, is less than $\underline{P}$). In this case, these households will be persistently food insecure in the long term since any unfavorable conditions (like shocks, vulnerability, and imperfect financial markets) prevent the initially less resilience households from using time as a way to save and accumulate assets and achieve a higher level of well-being (Dasgupta, 1997; Carter and Zimmerman, 2000). The second category is the dynamic mobile households in the long term if $A_{ijt} > A^*$ & $\exists t$ such that $PFS_{it} < \underline{P}$. These households who have certain assets greater than the dynamic asset threshold might be food insecure in some points. Nevertheless, they can steadily build up their asset stock over time and will eventually on their way to be food secure with a high-level living standard. The last category is the never food insecure households, i.e., $A_{ijt} > A^*$ & $PFS_{it} \geq \underline{P}\ \forall t$.

4.3 Measure long-run persistence of food insecurity based on dynamic asset threshold

Because PFS is a continuous measure, we use a Foster, Greer, Thorbecke (FGT) style (Foster et al.,1984) food insecurity measure around the dynamic asset threshold to aggregate the estimated household specific PFS for the entire sample, pooled in each year or across periods:

$$R_\alpha(PFS_{it};\ A^*, P^*) = \frac{1}{N}\sum_{n=1}^{N}\left(1 - \frac{min(PFS_{it}, P^*)}{P^*}\right)^\alpha \quad (12)$$

Where N is the total observed households or subgroups in period t, A^* is the dynamic asset threshold to measure PFS, PFS_{it} is the estimated food security probability of household i and

P^* is the estimated persistently food insecurity probability threshold using households with assets holding A^*. With the change of distribution sensitive parameter α, we construct three different FGT-style national indices in reporting on severity of food insecurity. $\alpha = 0$ yields the headcount ratio R_0 representing the proportion of persistently food insecure households; Setting $\alpha = 1$, R_1 describes the depth or gap of persistent food insecurity. The squared food insecurity gap ($\alpha = 2$) is typically the preferred measure as it reports the severity of persistent food insecurity and is sensitive to the distribution of well-being amongst the persistent food insecure population, as suggested in the poverty literature (Purwono et al., 2021).

One of the appealing features of FGT-style measure is that the sample observations can be broken down into various subgroups by policy target attributes, like race, gender, age, education of a household head, geographic area, number of children etc. Therefore, we further decompose the above three aggregated persistent food insecurity measures with different α values into groups and unpack the different food insecurity prevalence and severity across the different groups. This suggests the targetable characteristics for policy interventions that aim at helping these vulnerable populations escape from food insecurity trap.

Another advantage is that given current and previous observed assets, we are able to forecast the probability of food security for each household and even subgroups in future periods. This is based on benefit of the development resilience estimation whose built-in path dynamics contribute to the develop resilience predictions. For example, we can simulate how the prevalence of food insecurity among immigrant households headed by women with a high school education will evolve over two years following the 2019 survey if the households were subjected to an economic shock with higher unemployment rates by adjusting the unemployment rate in the model.

5. Expected results

5.1. The asset based PFS measure and dynamic asset threshold

With the PSID household panel survey data from 2001-2019, we first plot the asset dynamics from the conditional mean estimates of assets from equation (9). We expect there exists an unstable point between the two stable equilibria in the dynamic path of assets from the estimation of Equation (9), which will be the critical dynamic asset food insecurity line A^*. As we illustrate in part 2, such multiple equilibria imply there might really exist food insecurity traps in the US.

Additionally, with the estimates of both conditional mean and variance from equation (9) and (10), we parameterize the resilience measurement of household-year-specific food insecurity probability(PFS) which is the likelihood that a household possesses the normative minimum threshold of dynamic assets in each period, which is illustrated in Equation (11). Each household-period-specific PFS lies in the interval [0,1]. Furthermore, we could regress the estimated household-period-specific PFS on the same set of covariates used in the conditional mean and variance functions. Then we could report and compare the marginal effects of same household characteristic on conditional mean, variance and household food insecurity probability.

Finally, once we get the key dynamic asset threshold A^* and each household's PFS, we could estimate the corresponding persistently food insecurity probability P^* and the food insecurity probability threshold ($\underline{P}$) by linking the household-year-specific PFS to the discrete official USDA Household Food Security Measure. As we assume a household with A^* or less than A^* asset holding (the very low asset representing food insecurity trap) is always under food insecurity condition, we expected the P^* is less than $\underline{P}$ like shown in figure 1. Now the period-specific households could be divided into persistently food insecure households ($A_{ijt} < A^*$), dynamic mobile households ($A_{ijt} > A^*$ & $\exists t$ such that $PFS_{it} < \underline{P}$) and never food insecure households ($A_{ijt} > A^*$ & $PFS_{it} \geq \underline{P}$ $\forall t$).

5.3 Measure long-run persistence of food insecurity based on dynamic asset threshold

With the dynamic asset threshold and persistently food insecurity probability, we conduct the FGT style measure of the persistent food insecurity headcount ratio, persistent food insecurity gap and the squared persistent food insecurity gap (or called the severity of persistent food insecurity) (DSFIG) in US in each survey year or over the survey periods. With the benefit of development resilience approach, we could further decompose the aggregated persistent food insecurity measure into specific household characteristics, such as sex, education level, race, marital status, number of children and regions, and project these aggregated measures out two years into the future based on some reasonable assumptions about the evolution of covariates, such as an increase of the unemployment rate or change of unemployment status during the pandemic.

6. Conclusion

As the first application of asset-based approach to measure food insecurity in US, we expect to explore the household food insecurity dynamics by examining persistent long-run food insecurity in US in 2001-19 PSID data. Undoubtedly, our asset-based food insecurity measures will offer important policy insights and implications (Carter and Barrett, 2006). On one hand, the minimum dynamic asset threshold provides a very strong indicator and standards for food security trap. This threshold requires the households have the minimal financial assets to ultimately engineer their own escape from food insecurity. On the other hand, our asset-based approach to measuring food insecurity provides an analytical tool which can be used to explore the nature and extent of persistent food insecurity. The distinguished vulnerable groups that may be caught in the food insecurity trap in the future are the key population in need of assistance to buffer their resilience of food insecurity, which has implications for the design and eligibility of safety net programs.

References

Acemoglu D, Johnson S, Robinson J A. The colonial origins of comparative development: An empirical investigation[J]. American economic review, 2001, 91(5): 1369-1401.

Alaimo K. Food insecurity in the United States: An overview[J]. Topics in Clinical Nutrition, 2005, 20(4): 281-298.

Barrett C B, Carter M R. The economics of poverty traps and persistent poverty: empirical and policy implications[J]. The Journal of Development Studies, 2013, 49(7): 976-990.

Barrett C B, Constas M A. Toward a theory of resilience for international development applications[J]. Proceedings of the National Academy of Sciences, 2014, 111(40): 14625-14630.

Barrett C B, Marenya P P, McPeak J, et al. Welfare dynamics in rural Kenya and Madagascar[J]. The Journal of Development Studies, 2006, 42(2): 248-277.

Bickel G, Nord M, Price C, et al. Guide to measuring household food security, revised 2000[J]. US Department of Agriculture, Food and Nutrition Service, 2000: 52.

Carter M R, Barrett C B. The economics of poverty traps and persistent poverty: An asset-based approach[J]. The Journal of Development Studies, 2006, 42(2): 178-199.

Carter M R, May J. One kind of freedom: Poverty dynamics in post-apartheid South Africa[J]. World development, 2001, 29(12): 1987-2006.

Carter M R, Zimmerman F J. The dynamic cost and persistence of asset inequality in an agrarian economy[J]. Journal of Development Economics, 2000, 63(2): 265-302.

Chang Y, Chatterjee S, Kim J. Household finance and food insecurity[J]. Journal of Family and Economic Issues, 2014, 35(4): 499-515.

Cissé J D, Barrett C B. Estimating development resilience: A conditional moments-based approach[J]. Journal of Development Economics, 2018, 135: 272-284.

Coleman-Jensen, Alisha, Matthew P. Rabbitt, Christian A. Gregory, Anita Singh, September 2022. Household Food Security in the United States in 2021, ERR-309, U.S. Department of Agriculture, Economic Research Service.

Dasgupta P. Nutritional status, the capacity for work, and poverty traps[J]. Journal of Econometrics, 1997, 77(1): 5-37.

Dercon S, Shapiro J S. Moving on, staying behind, getting lost: Lessons on poverty mobility from longitudinal data[J]. Moving out of Poverty, 2007, 1: 77-126.

Duffy P A, Zizza C A. Food insecurity and programs to alleviate it: what we know and what we have yet to learn[J]. Journal of Agricultural and Applied Economics, 2016, 48(1): 1-28.

Foster J, Greer J, Thorbecke E. A class of decomposable poverty measures[J]. Econometrica: journal of the econometric society, 1984: 761-766.

Grineski S E, Morales D X, Collins T W, et al. Transitional dynamics of household food insecurity impact children's developmental outcomes[J]. Journal of developmental and behavioral pediatrics: JDBP, 2018, 39(9): 715.

Gundersen C, Gruber J. The dynamic determinants of food insufficiency[C]//Second food security measurement and research conference. Food Assistance and Nutrition Research Report, 2001, 2: 11-2.

Guo B. Household assets and food security: Evidence from the survey of program dynamics[J]. Journal of family and economic issues, 2011, 32(1): 98-110.

Jalan J, Ravallion M. Is transient poverty different? Evidence for rural China[J]. The Journal of Development Studies, 2000, 36(6): 82-99.

Kennedy E, Jafari A, Stamoulis K G, et al. The first Programmefood and nutrition security, impact, resilience, sustainability and transformation: Review and future directions[J]. Global food security, 2020, 26: 100422.

Kennedy S, Fitch C A, Warren J R, et al. Food Insecurity during Childhood: Understanding Persistence and Change Using Linked Current Population Survey Data. University of Kentucky Center for Poverty Research Discussion Paper Series, DP2013-03[J]. University of Kentucky Center for Poverty Research, 2013.

Lee S, Barrett C B, Hoddinott J F. Food Security Dynamics in the United States, 2001-2017[J]. 2021.

Maitra C, Prasada Rao D S. An empirical investigation into measurement and determinants of food security[J]. The Journal of Development Studies, 2018, 54(6): 1060-1081.

Nam Y, Huang J, Sherraden M. Assets, poverty, and public policy: Challenges in definition and measurement[J]. 2008

Naschold F, Barrett C B. Do short-term observed income changes overstate structural economic mobility?[J]. Oxford Bulletin of Economics and Statistics, 2011, 73(5): 705-717.

Oliver M L, Shapiro T M. Wealth of a nation: A reassessment of asset inequality in America shows at least one third of households are asset-poor[J]. American Journal of Economics and Sociology, 1990, 49(2): 129-151.

Purwono R, Wardana W W, Haryanto T, et al. Poverty dynamics in Indonesia: Empirical evidence from three main approaches[J]. World Development Perspectives, 2021, 23: 100346.

Ryu J H, Bartfeld J S. Household food insecurity during childhood and subsequent health status: the early childhood longitudinal study—kindergarten cohort[J]. American Journal of Public Health, 2012, 102(11): e50-e55.

Wilde P E, Nord M, Zager R E. In longitudinal data from the survey of program dynamics, 16.9% of the US population was exposed to household food insecurity in a 5-year period[J]. Journal of hunger & environmental nutrition, 2010, 5(3): 380-398.

Zimmerman F J, Carter M R. Asset smoothing, consumption smoothing and the reproduction of inequality under risk and subsistence constraints[J]. Journal of Development Economics, 2003, 71(2): 233-260.

Figures

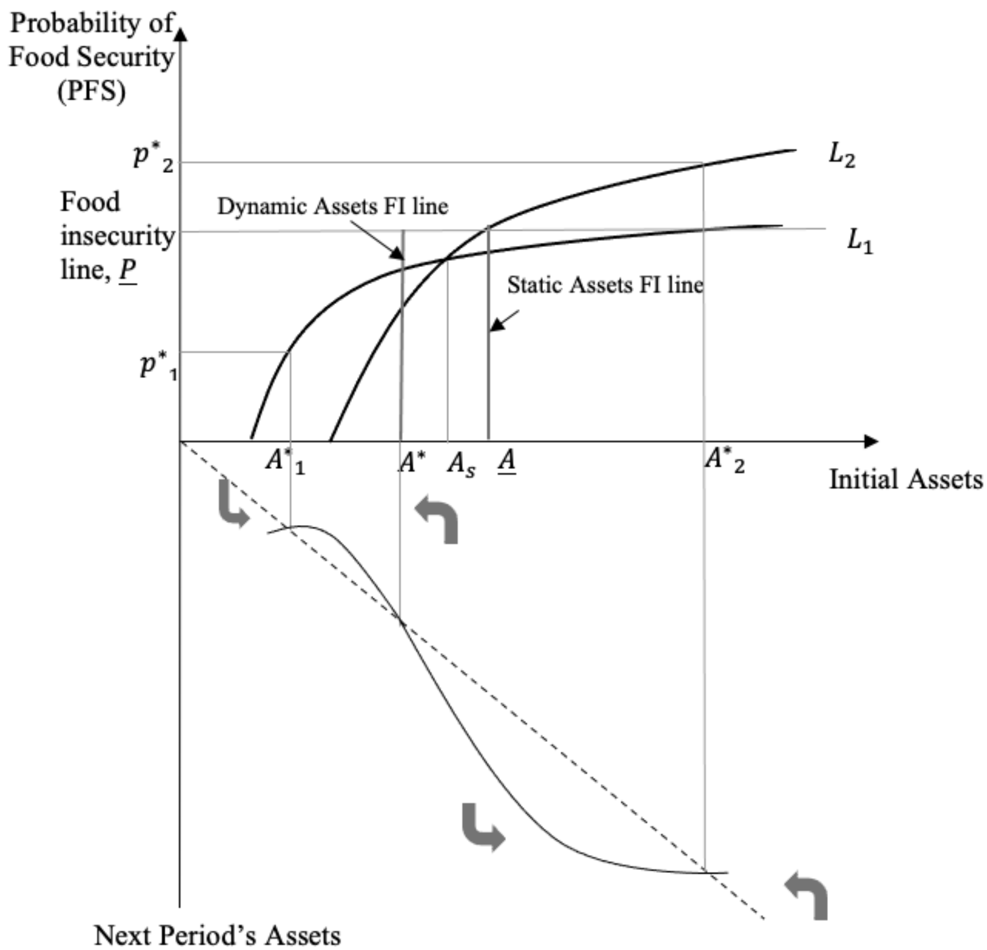

Figure 1. The Dynamic Assets and food insecurity trap (adapted from Carter & Barrett, 2006)