How Immigrants Use Time and Money to Manage Household Food Security

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Abstract

Since both time and money are essential constraints in food production, immigrant households who face the challenge of insufficient time for food production may have a higher likelihood of experiencing food insecurity (FI), similar to those who are financially disadvantaged. This paper uses a merged dataset covering 16 years (2003-2018) of both food security (FS) and time-use survey to examine how immigrant households use time and money to manage their household FS relative to natives. To overcome the potential measurement errors and endogeneity of household level time-use and expenditures, aggregated cell-level means of food production time and expenditures are employed as instruments to identify the causal effects of time and money inputs on household FI. Our findings suggest that the marginal returns on time and money inputs vary across different types of households, indicating that household structure matters in managing FI. For single households, more food expenditure is important, while for married households, more time commitment is crucial. Interestingly, more time input significantly improves FS of natives but does not work for immigrants who already spend more time maintaining cultural food preferences and producing food in either single or married households. Meanwhile, more food expenditures help reduce the probability of FI for both natives and immigrants in single households but not in married households. Our findings show an overall message that less time input and more money is required for immigrants in household food production to remain food secure.

Key words: Immigrant, Food Insecurity, Money, Time

JEL codes: J6, Q18, D13

1. Introduction

In the United States, households with immigrants are at a greater risk of FI (Chilton et al., 2009; Potochnick & Arteaga, 2016; Walker et al., 2021). FI occurs when households lack consistent access to enough food for an active and healthy life. Household FI is associated with an increased risk for various adverse health outcomes and health disparities (Hromi-Fiedler et al., 2011 Seligman et al, 2010). Although immigrants play a significant role in the US economy, having higher employment rates than natives since 2001, they face more economic challenges, earn about 20 percent less than US-born workers, and experience much higher poverty rates (Orrenius & Zavodny 2009). Additionally, conditional on their immigration status, immigrants are often ineligible for public assistance programs, and those who are eligible use fewer benefits than natives (Nowrasteh & Orr 2018). Meanwhile, immigration policy combined with other aspects of identity and structural constraints create barriers for immigrant to have adequate access to culturally appropriate foods which contributes to FI (Alonso et al. 2018; Wright et al., 2021). Consequently, immigrant households may lack the resources necessary to maintain adequate FS. By identifying limitations of resources to immigrants maintaining adequate FS, effective policies and procedures can be explored to mitigate FI and support the long-term health of immigrant households. This paper aims to examine how immigrant households use time and expenditures to produce food and manage their household FS.

In household food production, both time and money are essential inputs for FS. Becker (1965) explains that household production is a function of both market inputs and time. Vickery (1977) further notes that any income-support that only accounts for money differences but not for time differences across households may be biased against time-poor households and discriminates against households with one adult. Davis & You (2011) apply similar logic to explain the

inadequacy of food-assistance programs for achieving minimum nutritional standards, specifically the Thrifty Food Plan. Accounting for time, they find the mean poverty rate estimate increases from 38% to 87%. Thus, failing to account for the time required to produce food can severely distort estimates of the actual need of households. Building on this concept, Davis & You (2013) develop a household food production framework where time and money are inputs. They indicate that time and money are poor substitutes in household food production suggesting that time may be an essential constraint for food production faced by low-income and immigrant households. To our knowledge, nobody has considered how inputs of time and money simultaneously affect household FS, an important output of food production.

Immigrant households that are time-poor may be at risk of experiencing FI just as if they were money poor, particularly if money and time do not act as quality substitutes for FI. Given that many immigrants do not have access to food assistance or are hesitant to acquire it, immigrants are expected to be more reliant on their own money and time. However, immigrants are often more money poor with higher poverty rates than US-born workers (Orrenius & Zavodny 2009; Vahabi & Damba, 2013). Immigrants may also be more time poor than US-born households. Dramski (2017) shows that immigrants are more likely to work unusual hours, such as nights and weekends, taking jobs natives do not want to do. Further, immigrants have jobs that are characterized as being more physically arduous than jobs held by natives (Zavodny 2015) and riskier (Orrenius & Zavodny 2009). More intense work activities could allow for less time/energy to manage food production activities or make such food production more difficult, ultimately leading to household FI. Given the differences between natives and immigrants, and the long-term negative health implications of FI, it is essential to better understand the household food production challenges faced by immigrants relative to natives.

In this study, we compare how immigrant households use time and expenditures to produce food and thus manage their household FS in comparison with natives. To do this, we examine households from 2003-2018 that completed both the Current Population Survey (CPS) Food Security Supplement (FSS) and the American Time Use Survey (ATUS). The CPS dataset provides food expenditure, household FS information from FSS and households' demographic characteristics. The ATUS provides measures of the amount of time people spend doing various activities over a 24-hour period, including food production related activities. To account for the effect of different household structures on food production, we analyze the FS status of single and married headed households separately as a function of time and expenditures for natives and immigrants. Overall, our study makes the following three contributions.

First, we advance the literature on the determinants of household FI by considering both time and money invested in food production, separately for single and married headed households. Numerous studies have examined factors that determine FI, such as job loss and low income (Loopstra & Tarasuk 2013); socio-demographics (Tarasuk et al., 2019); food assistance and other welfare program participation (Borjas 2004; Gundersen & Kreider, 2008; Mykerezi & Mills 2010). Meanwhile, a few studies have explored the association between FI and food expenditure, or time spent on food related activities separately (Gundersen & Ribar 2005; Beatty et al, 2014; Berning et al., 2023). Nevertheless, we are the first paper to including both time and money in our FS function and explore the effects of time and money on FI simultaneously for all households, and households with different structures. Consistent with the literature, we find that more time and expenditures inputs in food production are both associated with a decrease in the likelihoods of FI across all households, single and married headed households. Specifically, there is a 2% to 3.3% decrease in the probability of FI for every additional 10 hours spent on food production. Likewise,

we find a 2.5% to 4% decrease in the probability of FI for every additional $100 spent on food production.

However, one concern about the estimations is that variation in time use and weekly food expenditures suffer from measurement error, may be subject to reverse causality, or may be correlated to unobserved shocks on households with particular demographic profiles which would bias our estimates. Based on the suggestions of Hanushek et al. (1996) and Frazis & Stewart (2012), we aggregate our data into different cell levels based on particular household characteristics and then instrument for household-level time and expenditure inputs with cell-level mean values. Using the matched dataset and instrumental variable approach, we make the second contribution to solve the bias in OLS estimates and identify the causal effects of time and money inputs on household FI with two-stage least squares (2SLS) regression analysis.

With well performing instrumental variables, the different results from 2SLS relative to OLS estimations emphasize the importance of adjusting for endogeneity and measurement error. For all households, on average, we find that both time (in units of 10 hours) and expenditures (in units of 100 dollars) statistically decrease the probability of financial instability by 3.6% and 22.6%, respectively, after correcting for potential measurement error and endogeneity using IV. However, for single households, we find that each additional $100 spent on food decreases the probability of financial instability by 26.5%, while time spent on food production has no significant effect. For married households, every additional 10 hours spent on food production decreases the probability of financial instability by 10.5%, but food expenditures have no statistical effect. Our results highlight the varying effects across different household structures, which may suggest different strategies employed by these households to deal with financial instability.

The last and most important contribution is our exploration of how time and money inputs in food production help mitigate the disparity in the likelihoods of FI between immigrants and natives. We compare the effects of time spent on food production and financial investments on financial instability among immigrants relative to natives, separately by marital status. Since citizenship is a strong predictor of FI (Kalil & Chen, 2008), we identify immigrants as non-citizens and citizens. Our benchmark regression models suggest there is no statistical difference in the likelihood of FI between single immigrants, with or without citizenship, and single natives. With married households, both noncitizen and citizen immigrants are statistically more likely to be food insecure than natives.

When we consider the effects of time and expenditure, we find that time spent on food production significantly reduce the likelihood of FI for natives but does not improve the likelihood of FI for both immigrant non-citizens and citizens in either single households or married households. The differences in FI between immigrants and natives further confirms that spending more time on food production does not help immigrants, no matter with or without citizenship, narrow the FI gap with natives. These results are contrary to the immigrant time-poor hypothesis that suggests immigrants may not have enough time to maintain household FS. Our descriptive results show that immigrant citizens and noncitizens have already spend more time in food production than natives. Thus, the impact of time investment on reducing the likelihood of FI is not significant for non-citizen and citizen immigrants. This may be because immigrants face barriers to access to culture already and therefore spend a lot of time trying to achieve cultural FS (Vahabi & Damba, 2013).

In comparison, more food expenditures help decrease the probability of FI for both natives and immigrants in single households but not in married households. This may reveal that marriage

may provide other benefits like higher household level income and joint food consumption with lower food due to household scale or scope economics. Meanwhile, there is no different effects of food expenditure on FI between single natives and single immigrant. This may indicate that food expenditure plays the same important role in the FS of both natives and immigrants. Finally, more food expenditures significantly narrow the FI gap between married immigrant citizens and married natives (Pilossoph & Wee, 2021). This is consistent with the descriptive findings that married immigrants with citizenship who have higher education levels and spend more money on food tend to be more food secure.

The remainder of the chapter is structured as follows. Section 3.2 describes the matched data we use and summary statistics. Section 3.3 introduces the empirical approach and identification strategy with IV. Section 3.4 reports the empirical results for all households, single and married headed households. Section 3.5 and 3.6 discuss the results and make the conclusion.

2. Data and Summary Statistics

CPS-FSS Data and ATUS Data

We create an integrated dataset pairing households that completed the CPS FSS in 2003 to 2018 and the ATUS in 2004 to 2019 (Flood et al., 2023). The universe for FSS are households eligible for the basic CPS in December. Households that have completed their final month of the CPS are selected randomly to participate in the ATUS, with one individual over the age of 15 being selected from each household. As a result, we analyze CPS data from FS Supplement in year t in conjunction with ATUS data in year t+1 using IPUMS-created individual identifier.

As the largest monthly national household survey conducted by the U.S. Bureau of Labor Statistics and the U.S. Census Bureau, the CPS provides national representative households and individual characteristics like demographic characteristics, place of birth, and year of immigrant,

etc. Additionally, the FSS data in December also has information about household FS, food expenditures, and ways to cope with FI. Household level FS is assessed using an 18-item scale developed by the Food and Nutrition Service of the US Department of Agriculture (USDA) to measure limited or uncertain access to food due to insufficient resources. Finally, household's FS status is then defined as food secure, low food secure, very low food secure. In our analysis, we define household food secure status with a discrete variable: 0 for food secure, and 1 for food insecure (including both low food secure, very low food secure).

The data used for assessing a household's time allocation is the ATUS with approximately 11,000 individuals per year. This data measures the amount of time people spend doing various activities, such as paid work, household production, food acquisition and meal production. In each ATUS sample household unit, one individual who is selected to be the "designated person" reports sequentially the length of time spent on activities from top-level categories into sub-categories for their single designated diary day (24 hours). To reduce variability in response rates across the week, the preassigned survey day of the week is randomly assigned to each designated person with 50% of the sample reporting about the weekdays and 50% reporting about weekend. Our study focuses on six activities related to food production: meal preparation, grocery shopping, purchasing food (not groceries), eating time, travel related food preparation and travel related eating or drinking.

There are three limitations with using ATUS data to conduct time analysis (David and You, 2010a; Berning et al., 2023). First, the ATUS data only collect time use for one day of the week. In this case, time spent of food production activities on the other six days of the week is unavailable. As such, certain activities such as shopping may not be observed resulting in undercounting of that activity. Second, only one individual in the household survey reports time spent on activities so the time spent by other household members such as spouses cannot be directly observed. This may

be less of an issue with single households but may cause significant bias for married households. And the direction of the bias which is determined by whether spousal time is a substitute or complement (Leeds & Allmen, 2004) is not clear a priori. Third, the "designated person" in the ATUS sample household may not be the person who is primarily in charge of household food production. In this case, we will expect that the reported food production time is underestimated.

Following the time imputation strategies proposed by You & Davis (2019) and Berning et al. (2023), we solve the first two challenges in ATUS data. We impute time use for non-survey days separately for married and single households. For single households, the only problem is that its respondents only report time use for one day of the week. So, we employ a two-part model to solve this issue by using the observed time use of household respondents across different food production activities on their "designated diary day" to predict the time use on specific activities for the unobserved six days in the week since the ATUS sample is randomized by day over the week. Specifically, using data from respondents *r*, the first part is the estimate the probability of a survey respondent *i* engaging in food production activity *j* on day *d* from a probit model, such that $Pr^r(FP_{ijd} > 0|X^r, D = d;\ \hat{\theta}^r)$, where FP_{ijd} is the time spent on food production activity *j* on day *d;* X^r is a set of covariates; $\hat{\theta}^r$ is the predicted values from the respondents. Then the expected time of day-specific imputed food production activity *j* on day *d* for a household *i* will be written as: $E^r(FP_{ijd}|X^r, D = d;\ \hat{\theta}^r) = Pr^r(FP_{ijd} > 0|X^r, D = d;\ \hat{\theta}^r) * E^r(FP_{ijd}|FP_{ijd} > 0, X^r, D = d;\ \hat{\theta}^r)$, where $E^r(FP_{ijd}|FP_{ijd} > 0, X^r, D = d;\ \hat{\theta}^r)$, the second part, is the conditional expected value of time in food production for household *i* on day *d* based on a conditional exponential model. Now we will get six predicted daily time use and one actual reported daily time use for food production activity *j* in one week for household *i*. Finally, we get the weekly estimated time use of

food production activity *j* for single household *i* by summing six predicted values and one observed value.

For married households, we not only predict the time use on specific activities for the unobserved six days in the week but also predict their non-respondent spousal time use. Like the time use imputation for single household, we first employ the two-part methods to predict day-specific values for respondent *r*, the $Pr^r(FP_{ijd} > 0|X^r, D = d;\ \theta^r)$ and $E^r(FP_{ijd}|FP_{ijd} > 0, X^r, D = d;\ \theta^r)$. But these two parts Pr^r and E^r are gender specific for married household. Now by multiplying the Pr^r and E^r, we could get the expected time of day-specific imputed food production activity *j* on day *d* for the respondent of a married household *i,* $E^r(FP_{ijd}|X^r, D = d;\ \hat{\theta}^r)$. Second, the expected day-specific non-respondent spousal time use for food production activity *j* is predicted based on their covariates (X^s) and predicted values from our respondents ($\hat{\theta}^r$), $E^s(FP_{ijd}|X^r, D = d;\ \hat{\theta}^r) = Pr^r(FP_{ijd} > 0|X^s, D = d;\ \hat{\theta}^r) * E^r(FP_{ijd}|FP_{ijd} > 0, X^r, D = d;\ \hat{\theta}^r)$. Third, we get the weekly estimated time use of food production activity j for the respondent and non-respondent spouse of married household i by summing their six predicted daily values and one observed daily value separately. Finally, we impute total household food production time for married households by summing up the weekly time use of respondent and non-respondent spouse.

Summary Statistics of the Matched Dataset

Our dataset linking CPS-FSS data with ATUS data has 47,486 matched households. Berning et al. in 2023 compared the ATUS, CPS-FSS and matched samples and found that the composition of the three datasets appeared to be relatively similar, implying that the statistical analysis using matched data will be not biased. Since the matched dataset does not have prescribed weights to

make the data representative, summary statistics do not use population weights. The demographic information is taken from the FSS reporting.

Table 1 shows the descriptive statistics of the matched households across immigration status (native/immigrant non-citizen and immigrant citizen) separately for single and married households. Of the matched households, 24,526 (52%) are household head with spouse—married households, and 22,960 (48%) are single head households. Immigrant households are defined as the households whose both head and spouse are not born in the US for married households and only head is not born in US for single households. Native households with spouses are treated similarly. We exclude households with mixed nativity marriages—one native and one immigrant spouse—as they may encounter unique production challenges compared to households where both partners are immigrants. Such households potentially access a broader array of resources and networks from both native and immigrant communities, which could influence their FS differently. Since previous literature finds citizen status of immigrants as a strong predictor of FI (kalil & Chen, 2008), we further assign the immigrant households to two citizenship subgroups: immigrant without citizenship (both no for married households; head no for single households) and immigrant with citizenship (at least one individual yes for married households； head yes for single households). For single households, there are 20,265 (88.3%) native households, 1,216 (5.3%) immigrant noncitizens and 1,479 (6.4%) immigrant citizens. Married households consist of 21,065 (85.9%) native households, 1,657 (6.7%) immigrant noncitizens and 1,804 (7.4%) immigrant citizens. Overall, there are more immigrant noncitizens in single households than married households. Immigrant citizens have longer time since immigration, around 13 years, than immigrant noncitizens. Single immigrant citizens have longer time since immigration than married

households. And for married or single households, there are larger proportion of white across different immigrant groups.

Immigrant households tend to have a higher number of children under 18 years old and usually have larger household size, particularly for immigrants without citizenship. Immigrant households especially immigrants with citizenship are more likely to live in metropolitan cities than natives. Single immigrant households tend to live in metropolitan cities more than married immigrant households. More than half of single households are female headed households for native and immigrant groups. Married households are more likely to have a male as the head. The household head in single households are older than the head in married households. And no matter in married or single households, immigrants without citizenship are the youngest. Immigrant households tend to have a bimodal distribution in education achievement, similar to existing literature (Budiman et al., 2020). Specifically, for both married and single households, immigrant noncitizens and citizens have both higher rates of "below high school degree" (low-skilled) and "master's degree and above" (high-skilled) than natives. It also shows that immigrants with citizenship have higher rates of earning higher level degrees than immigrant noncitizens, except for "below high school degree". Both immigrant households with citizenship and without citizenship have larger proportions of unemployed and employed but lower proportions in "Not in labor force" and "Armed forces". And relative to married households, single households are more likely to be employed.

In examining weekly expenditures and time use in food production, it is observed that single immigrant households, regardless of citizenship status, incur higher weekly food expenditures and greater food production times compared to their native counterparts. In contrast, among married households, the expenditures of native and noncitizen immigrant households are similar, while those of citizen immigrant households are higher. Furthermore, immigrant

households, both noncitizens and citizens, allocate more time to food production than native households, with married households displaying a more significant overall time commitment.

Furthermore, over our entire study period from 2003-2019, US immigrant non-citizens persistently have the highest rate of FI over time, followed by immigrant citizens and natives (Figure 1). FI of native households is also more relatively stable across time than immigrant households. Immigrant households with no citizenship who have less access to government support programs such as SNAP have the biggest proportion of FI, especially during the recession from 2007-2009. But they recover sooner than the other groups perhaps because they are more likely to engage in various forms of contingent and flexible employment (Liu & Kolenda, 2012). Meanwhile, immigrant citizens experience slightly higher FI relative to natives but with larger fluctuations.

In Table 2, we additionally analyze weekly food expenditures across various groups, taking into account their FS status and marital situation, distinguishing between immigrants and natives. Food secure households on average spend more on weekly food expenditures than food insecure household no matter single or married households, which is consistent with existing literature (Gundersen & Ribar 2005). Notably, both non-citizen and citizen immigrant households generally have higher costs for food production compared to native households. The exception to this trend occurs within the subset of married and food-secure households, where natives' spending surpasses that of immigrant non-citizens, yet remains below the expenditure of immigrant citizens. Additionally, within the food-secure category, both single and married non-citizen immigrants tend to spend less on food than their citizen counterparts. Conversely, in the context of FI, non-citizen immigrants' food expenditures are higher than those of citizen immigrants. An intriguing trend is observed when assessing the variance in food expenditures between food-insecure and

food-secure households: immigrant non-citizens demonstrate the smallest disparity, whereas immigrant citizens show the greatest. This suggests that food expenditures among immigrant non-citizens remain relatively stable regardless of their FS status. This was unexpected since immigrant noncitizens usually have higher rate of FI and are more likely to experience economic hardship than immigrant citizens (U.S. Census Bureau 2018a; Van Hook & Balistreri 2006).

Among these different groups categorized by immigrant status, marital status and FS status, we continue to compare the differences in mean imputed weekly food production time in Table 3. Similar to food expenditures, food secure households spend more time on household food production than food insecure households, no matter single or married, except for single, non-citizen households. And there are slight differences (less than a half hour) in the weekly food time between food insecure and food secure immigrant households. Immigrant households, both citizens and noncitizens, usually spend more time in food production than natives, especially in food insecure households. Meanwhile, food secure and married, immigrant noncitizen households spend almost the same food time as immigrant citizens. Married households spend almost twice as much time on food production as single households.

We further decompose the distribution of imputed food production time use across different food production activities. Food secure households spend more time on every category of food production, except for food preparation. This may be explained that food insecure households with economic hardship may choose to use less money to buy cheaper unprepared food, which results in spending more time on preparing food. Immigrant households spend more time on every category of food production, mainly in food preparation and secondly in grocery/nongrocery shopping, which may be explained by their efforts to maintain their cultural food preferences and traditional eating habits (Cantarero et al.,2013). Surprisingly, immigrant

citizens who have more years of immigration also have similar but slightly lower food preparation time than immigrant noncitizens.

Altogether, these unconditional means show that immigrant households invest more time and money in food production than natives, yet they still face more probability of being FI. We next estimate how immigrant households use time and expenditures to produce food and manage their household FS relative to natives separately for married and single households with a set of control variables.

3. Empirical Methods

3.1 Empirical Models

To estimate the effect of intrahousehold food time and expenditure (or money) allocation on FI among immigrants relative to natives, we begin by examining how time spent on food production and food expenditures is associated with household FI through the specification of a general household food production model (Becker 1965, Davis & You 2013). Our benchmark regression model takes the form:

$$y_{hst} = \alpha + \beta T_{hst} + \gamma M_{hst} + \delta_{imm}^{noncit} Imm_{hst}^{noncit} + \delta_{imm}^{cit} Imm_{hst}^{cit} + \delta_x X_{hst} + \theta_s + \eta_t + \epsilon_{hst}, \quad (1)$$

where the dependent variable y is a binary FI status variable for household h, in state s and year t that takes a value of 1 if the household is food insecure and 0 if the household is food secure. T is weekly total food production time in hours. M is weekly total food expenditures in dollars[1]. Because of the role of citizenship as a symbol of eligibility for to receive food assistance (Kalil &

[1] To enhance the interpretability of the coefficients, we change the unit of food production time to 10 hours and food expenditure to 100 dollars in our tables of results.

Chen, 2008), Imm_{hst}^{noncit} and Imm_{hst}^{cit} are dummy variables for immigrant non-citizen and immigrant citizen. Both dummy variables use native as the base group. *X* is a vector of household and individual demographic characteristics including household head gender, age, race, education level, employment status, metro status, children under 18, household size and years since immigration. State and year fixed effects (θ_s and η_t) are included to absorb time and spatially invariant unobservable variations in the outcome variable y. The scalar α and vectors β, γ, δ_{imm}, and δ_x are the estimated parameters with the error term of ϵ_{hst}. We are primarily interested in $\hat{\beta}$ and $\hat{\gamma}$ which respectively represent the associations of time and money with FI.

Similar to the estimations of Chapter 1 models, we estimate the LPM for Equation (1) using the matched ATUS + CPS-FSS sample, as LPM estimates have the advantage of being easy to interpret, representing the ceteris paribus marginal effects of each covariate on the probability of FI. Since there is no weight available for the matched sample, we do not use weight for the benchmark analysis. To account for the effects of different household structures on food production, we separately estimate models for all households, single headed households, and married households.

Next, our primary concern is the different FI challenges faced by immigrants and natives by comparing the associations of their food time and expenditure investments with FI. To comparing these different associations across immigrant and US native households, we further add interaction terms between time or expenditure allocations and immigrant citizenship status to Equation (1), such that:

$$y_{hst} = \alpha + \beta_1 T_{hst} * \left(1 - Imm_{hst}^{noncit}\right) + \beta_2 T_{hst} * Imm_{hst}^{noncit} + \beta_3 T_{hst} * Imm_{hst}^{cit}$$
$$+\gamma_1 M_{hst} * \left(1 - Imm_{hst}^{noncit}\right) + \gamma_2 M_{hst} * Imm_{hst}^{noncit} + \gamma_3 M_{hst} * Imm_{hst}^{cit}$$
$$+\delta_x X_{hst} + \theta_s + \eta_t + \epsilon_{hst}, \qquad (2)$$

Where Imm_{hst}^{noncit} and Imm_{hst}^{cit} are still dummy variables for immigrant non-citizen and immigrant citizen. Now $\widehat{\beta_1}$, $\widehat{\beta_2}$ and $(\widehat{\beta_1} + \widehat{\beta_3})$ estimate the marginal returns of food production time on FI for natives, immigrant non-citizens and immigrant citizens. The difference in the associations of time with FI between immigrant non-citizens (immigrant citizens) and natives is given by $\widehat{\beta_2} - \widehat{\beta_1}$ and $\widehat{(\beta_3)}$. The estimated $\widehat{\gamma_1}$, $\widehat{\gamma_2}$ and $(\widehat{\gamma_1} + \widehat{\gamma_3})$ represent the associations of food expenditure on FI for natives, immigrant non-citizens and immigrant citizens. And $\widehat{\gamma_2} - \widehat{\gamma_1}$ captures the difference in the different association of food expenditure with FI between immigrant non-citizens and natives. $\widehat{\gamma_3}$ is the difference between immigrant citizens and natives. Consistent with Equation (1), this Equation (2) also will be estimated separately for all households, single headed households, and married households.

3.2 Identification Strategy

After controlling for household-level, individual level controls and fixed effects in our empirical specification, there may still be factors that bias the estimates of the effect of food production time and food expenditure on household FI. First is the potential measurement error issue of time and expenditures in food production. Food production time taken from the ATUS 24-hour diary may be a poor indicator of a household's actual long-run time use which is the true time variable of interest for our analysis of household FI (Frazis & Stewart, 2012). Even though we impute other six days' time use and spousal's time use to get the weekly household time use, the predicted weekly time use also remain measure error with the short reference period relative to the year survey period for household FI. Therefore, as suggested by Frazis and Stewart (2012), a concern is that our measure of weekly food production time in the short run may have little effect on household FI for 12-month periods so that there will be downward bias. Similarly, our weekly food expenditures may be measured with some error.

Additionally, there are potential endogeneity concerns. First, time and expenditures vary with household demographic composition. For example, elderly households spend more time in meal preparation and eating time than younger households (Berning et al., 2023). Households with higher educational attainment (diet-health knowledge) spend more money on food expenditure (Blisard et al., 2003). So, unobserved shocks on households with particular demographic profiles could also affect these particular households' food time and expenditure inputs. Second, unobserved state-specific economic shocks may simultaneously affect both household time, expenditures, and FS. For example, a trade war leading to higher food prices may affect both FI status and time or expenditures. Third, FS status may also affect a household's allocation of time and expenditures, resulting in reverse causality. For instance, food insecure households may spend more time on work and decrease food production time and even food expenditure to get through economic hardship.

To address these estimation concerns, we aggregate households' food production time and money at the cell level based on observed characteristics (for example, by age and marriage status) and then use cell-level mean values as instruments (IV) for time and expenditures (Hanushek et al., 1996). We illustrate the details in constructing these cell-level aggregations below. Using aggregated cell-level values to predict household values can help reduce measurement error resulting from the deviation between short-period values and long-run true values (Frazis & Stewart, 2012). Furthermore, cells can be treated as a sensible measure of the labor market the same demographic characteristics belong to, so we also include cell-level fixed effects to serve the purpose of controlling for any unobservable factors that may exists between these different labor markets (Farré et al., 2018). We make full use of intra-cell variation, allowing the average

probability of FI to vary across cells. Finally, the IV approach has the added advantage to mitigate the reverse causality problems.

To construct the aggregated time and money as IVs for food time, we first divide each household into 13 age-cohort groups with 5-years interval from 20-85 years old as the cells for food time. This is because previous literature suggests that there are strong life-cycle variations in food production time by age (Faberman, 2015). Then we calculate three year moving average values of other time use (total time spent except for food production time) across each age cohort cell at a national level by marriage status (married or single) on a sample-weighted basis. We use total other time because other time affects FI only through the food time. We separately calculate the aggregated values by marriage status due to the strong correlation between household composition and time use, which is also true for food expenditures (Berning et al, 2023). Altogether, cells are defined by marital status (married or single head) and age-cohort resulting in $2 \times 13 = 26$ cells. Figure 2 illustrates that there are significant cross-age and cross-marriage status variations in the use of predicted weekly time for food production and total other activities. For both single and married households, the time spent on food production steadily increases across age cohorts, while the corresponding total other time steadily decreases across age cohorts. Notably, married households significantly spend more time on food production than single households but spend less total other time than single households. Constructing values at national level, not at state level, avoids potential unobserved correlation with state-trend factors that could bias our household estimates. The instrument (IV_FT_{cst}) for food production of households at cell level *c* in state *s* and year *t* is given as:

$$IV\_FT_{cst} = Mean\_other\ time_{c,t=3} \tag{3}$$

For our expenditure instruments, we create cells based on household characteristics that capture variation in food expenditures—marriage status (household composition), age, education attainment and race (Blisard et al., 2003). Figure 3 shows the distribution of food expenditure for these different characteristics used to construct the cells. We find a clear variation in household food expenditure across age groups, showing an inverted U-shape. Moreover, even within the same age group, there are variations in food expenditure across different demographic characteristics, particularly for married households, households with higher education degrees and white households who have higher household expenditure. Cells *c* for household food expenditures are divided by marital status, age-cohort group, educational attainment (below high school, high school, associates, bachelors, advanced degree) and race (white or non-white) resulting in $2 \times 13 \times 5 \times 2 = 260$ cells. We create the instrument for food expenditures using a three-year moving average by cell at the national level on a sample-weighted basis. The aggregate food expenditures at the cell level are not driven by cell-specific characteristics and their change over time does not vary by demographic characteristics like marriage status, age, education, race.

The instrument for food production IV_FE_{hcst} of households at cell level *c* in state *s* and year *t* is given as:

$$IV\_FM_{cst} = \text{Mean}\_FoodExpenditures_{c,t=3} \quad (4)$$

We use IV_FT_{cst} and IV_FM_{cst} as instruments for household level food time and expenditures to separately estimate Equations (1)-(2) via two stage lease square (2SLS). To clearly explain the identification process, we use Equation (1) as the main model. Then the first-stage regressions for time and money include both the two IVs in each model with other controls identical to those in Equation (1), as follows:

$$T_{hst} = \lambda_0 IV_F T_{cst} + \lambda_1 IV_F M_{cst} + \lambda_{imm}^{noncit} Imm_{hst}^{noncit} + \lambda_{imm}^{cit} Imm_{hst}^{cit}$$

$$+\lambda_x X_{hst} + {\theta_s}^T + {\eta_t}^T + \zeta_c + {\mu_{hst}}^T \quad (5)$$

$$M_{hst} = \omega_0 IV_F M_{cst} + \omega_1 IV_F T_{cst} + \omega_{imm}^{noncit} Imm_{hst}^{noncit} + \omega_{imm}^{cit} Imm_{hst}^{cit}$$

$$+\omega_x X_{hst} + {\theta_s}^M + {\eta_t}^M + \zeta_c + {\mu_{hst}}^M \quad (6)$$

The relevance assumption suggests the cell-level food time and expenditures cause the variations in individual values, which means $\widehat{\lambda_0}$ and $\widehat{\omega_0}$ are statistically different from zero in Equation (5) and (6). Exclusion restrictions require conditional on controls, the instruments IV_FT_{cst} and IV_FM_{cst} only affect household FI status through their individual food time and expenditure but not through other factors. In other words, these instruments should not correlate with the error term in main Equations (1 & 2).

The relevance assumption of the cell-level instruments is credible because the cell mean values as instruments (IV) for time and expenditure are calculated as the aggregated values at the cell-level based on the household demographics. Intuitively, our instruments capture household variation in time and expenditures across the household characteristics.

The exclusion restrictions are also plausible. On one hand, the new cell level IVs for time and expenditures accounts for within-cell variation, which addresses the concern that both FS and food time and expenditures vary with household demographic composition. On the other hand, using the mean cell level for other time as an instrumental variable for food production time will intuitively only affect FS through food production time. Additionally, aggregated cell-levels IVs based on characteristics at the national level also reduce the omitted variable bias introduced by the cell-level and state-trend unobserved factors that will affect both household FI and food time and expenditures. Moreover, adding cell-fixed effects ζ_c (marriage-age-education-race cells) will help control for the unobservable difference that may exists between these different labor markets or different cells with the same demographic characteristics (Farré et al., 2018).

3.3 Strength of the Cell-level Instruments for Time and Money

Once we construct the cell-level mean values as instruments (IV) for household-level time and expenditures using Equations (3) and (4), the relevance of our cell-level instruments could be examined by reporting the first-stage regression results from Equations (5) and (6). The binned scatter plot of residualized instruments against residualized time or money input in Figure 4 respectively represents the first stage effect of the cell-level instruments on food production time or food expenditure for all households in our sample. The residualization is generated by running full multivariate regressions on a full set of controls including household and individual demographic characteristics as well as year and state fixed effects. It shows that there are tight relationships between food production time or expenditure and its corresponding instruments, even when control variables are included. We further plot these first stage effects for single and married households separately in appendix Figure A. The dispersion of the binned scatter around the red regression line in Figure A suggests that there are still statistically significant relationships between cell-level instruments and time or expenditure on food production, regardless of whether the household is single or married. Therefore, the relevance assumption of cell-level mean values as instruments (IV) in predicting time and expenditures is valid.

4. Results

We first regress household FI on time and expenditures to get the marginal products of time and expenditures on FS across all households, single and married households. Then we introduce interaction terms between time and expenditures and immigrant status in the models to estimate the differential effects of food production time and food expenditures on FI between immigrants and natives.

4.1 Estimates of the Effects of Food Time and Expenditure on FI

All Households

We examine the effects of food time and expenditures on household FI by estimating Equation (1) for all households (Table 4). Column (1)-(3) report the results of linear probability model (OLS) with standard errors clustered at state level using different sets of controls. To make the coefficients interpretable, we adjust the unit of food production time to 10 hours and the unit of food expenditure to 100 dollars in our results. When there are not any controls, we find 10 hours increase in weekly time spent on food production are associated with an 6.2% decrease in the probability of FI. Alternatively, 100 dollars increases in weekly food expenditure are associated with a 2.2% decrease in the probability of FI. We also find that noncitizen immigrants are about 11% more likely to be food insecure than natives and citizen immigrants are about 2% more likely to be food insecure than natives. When adding state and year fixed effects, the estimated results do not change meaningfully. This suggests that unobserved state and year factors may not affect the association between food production time and expenditures and FI.

With all controls including the household demographics, the association between food production time and FI decreases to 2%. But the association between food expenditures and FI increases slightly to 3.3%. This is consistent with Tables 2 and 3 which show food secure households on average spend more time and money on food production. In this same specification, immigrant noncitizens are still 3% more likely to be food insecure than natives, while immigrant citizens and natives are not statistically different in FI. This is consistent with Figure 1 showing that immigrant non-citizens have the highest rate of FI and immigrant citizens almost have similar food insecure rate with natives.

The 2SLS estimates for all households using cell-level aggregated time and expenditure as instruments are reported in columns (4)-(7). Columns (4)-(6) have the same sets of controls as the

OLS estimates. Column 7 adds cell fixed effects (constructed as marriage-age-education-race) to control for the unobserved shocks for households with those particular demographics. After using IVs to control for endogeneity and correct for measurement error, the effects of food time and expenditure on FS increase relative to the OLS estimates. Models without controls in column (4) and with only state- and year- fixed effects in column (5) have almost the same estimates, showing that each additional 10 hours spent on food production reduces the likelihood of household FI by 9.2%, compared to a reduction of 6.2% as estimated by the OLS model. But the corresponding 2SLS estimates of the effect of food expenditures is not statistically significant. At the same time, the inequalities in the likelihoods of FI between immigrant noncitizens and native, and between immigrant citizens and natives are similar to the OLS estimates, at about 11% and 2% respectively.

After adding household demographic characteristics in column (6), our estimates suggest that an additional 10 hours and $100 spent on food production will respectively decrease the likelihood of household FI by 5.1% and 15.9%, which are larger than the OLS estimates with the same controls. Further, we find only immigrant noncitizens are statistically more likely to be food insecure than natives. Finally, estimates including additional cell fixed effects in column (7) do not change much and suggest that every 10 hours spent on food production statistically decreases the likelihood of household FI by 3.6%, and every $100 spent on food production decreases the likelihood of household FI by 22.6%. But there is no statistical difference in FI likelihood between immigrants and natives after adding cell fixed effects.

Single Households

Next we report the effects of food time and expenditures on household FI by estimating Equation (1) for single households (Table 5). We report the OLS estimates in columns (1) to (3). Time and expenditures are correlated with a decrease in the likelihood of FI. And the associations between

time or expenditure and FI for single households are higher than those for all households in Table 4. Specifically, when there are no controls or only state and year fixed effects, spending 10 hours or $100 on food production is correlated with an 8.7%-9.7% decrease in the probability of FI. The likelihood of FI for non-citizen immigrants is 6% higher than natives, but not significantly different for citizens. After adding household demographic characteristics, the association between food production time and FI decreases to 3.3%, while the association between food expenditures and FI increases to 4%. Our findings indicate that for single households, there are no statistical differences in the likelihood of FI between immigrants (both citizens and noncitizens) and natives.

Columns (4)-(7) report the 2SLS results for single households. When there are no demographic controls in columns (4) and (5), spending 10 hours on food production decreases the single households' FI probability by 18.5%, but food expenditures do not have a statistically significant effect. In these models, only immigrants without citizenship are at higher likelihood of FI than natives but not for immigrant without citizenship. After controlling for household demographics and cell-level fixed effects in columns (6) and (7), the time spent on food production does not statistically affect the likelihood of FI. However, spending $100 on food statistically decreases the probability of FI for single households by 18.6%-26.5%. Consistent with the OLS results, there are no statistical differences between immigrants (both citizens and non-citizens) and natives in terms of FI probability after including covariates.

Married Households

Table 6 reports the OLS and 2SLS results for married households. Consistent with the OLS estimates for all households and single households, we find that both more food production time and food expenditure inputs are statistically associated with a decrease in the probability of FI. Adding household demographics as controls, the association between time and FI decreases from

6.8% to 3%, and the association between food expenditures and FI is stable around 2%. In these models, both immigrant non-citizens and immigrant citizens are statistically more likely to be food insecure than natives, especially immigrant non-citizens with almost twice the probability.

The 2SLS estimates report that only more time investment in food production significantly decreases the married households' likelihood of FI. The estimates without households' demographics in column (4) and (5) show that both time and expenditure in food production decrease the likelihood of FI for married households. But when we add household demographic characteristics and cell fixed effects, the effect of food expenditure is not statistically significant. Whereas time still reduces the likelihood of FI by 14.6%-10.5%, which are higher than the estimates in OLS models. In married households, immigrants without citizenship or with citizenship are more vulnerable to be food insecure than natives, even including all the controls in the model. And immigrant non-citizens are at the highest likelihood of FI, 10.4% higher than natives. By contrast, immigrant citizens are 0.7% more likely to be food insecure.

Overall, in all cases across all households, single and married households, our cell-level instrumental variables for food production time and expenditure which attempts to correct for endogeneity and measurement error perform well with a high F-statistics reported in the last rows in columns 4-7 from Table 4 to Table 6 (Stock & Yogo, 2002). With the IV approach, time and expenditures inputs have a significant impact on household FI. We also find there are different effects of time and expenditures for all households, single and married households. For all households, more time and expenditures investment have statistically negative marginal effects on FI. For single households, only food expenditure investment has a statistically negative effect on FI, whereas for married households, only food time has a statistically negative effect on FI.

4.2 Comparing the Effects of Food Time and Expenditure on FI Between Immigrants and Natives.

We compare the effects of time and expenditure investment in food production on FI between immigrants and natives by estimating Equation (2) with the interacted terms of food time/expenditure and immigrant status, separately for all households, single households, and married households in Tables 7-9. We report both OLS and 2SLS estimates in each case.

All households

We first compare the effects of time and expenditures on FI between immigrant citizens and natives for all households in Table 7. Columns (1)-(3) report the OLS results. When comparing the differences in the association between time and FI among various immigrant groups and natives, we surprisingly find that time spent on food production is statistically associated with a greater reduction in the probability of FI for natives than noncitizen immigrants. Similarly, more time spent on food production is statistically related to a greater reduction in the likelihood of FI for natives than citizen immigrants. Specifically, more time spent on food production is associated with a decrease in the probability of FI for natives from 2.8% to 7.1% with different sets of controls. But there are positive but non-statistical associations between time input and the likelihood of FI for immigrant non-citizens and citizens.

We then compare the differences in the effects of expenditures between the different immigrant groups and natives. The results indicate that there is no difference in the effect of food expenditure when comparing non-citizen immigrants and native households. But an additional $100 spent on food production decreases the probability of FI more for immigrant citizens about 2% than natives, which is very stable even with adding different controls. To be specific, an extra $100 spent on food production is statistically associated with a decrease in the probability of food

expenditure at 3.1% for natives, 2.4% for immigrants without citizenship, and 4.8% for immigrants with citizenship after controlling for all covariates. Using different sets of control variables in columns (1) to (3), these correlations between food expenditures and FI are not very different, with a maximum increase of 4.8% after including all covariates.

The 2SLS estimates in column (4)-(7) show similar but slightly larger results. Comparing the different effects of food time across different immigrant groups, it appears that more time spent on food production leads to a greater reduction in the probability of FI for natives than noncitizen immigrants with more controls in the models (9.8%-6.1%). The same is true for the difference between immigrant citizens and natives (8.2%-6.5%). If we look at the effect of time input on household FI separately for these different groups, spending an additional 10 hours on food production time statistically decreases the likelihood of FI for natives by 5% - 10.6% but is not significant for both noncitizen and citizen immigrants under all controls.

Finally, an extra $100 in food production causes a greater decrease in the likelihood of FI for both immigrant non-citizens (at 7.4% with 10% significant level) and citizens (at 7% with 1% significant level) than natives with all controls. Specifically, an additional $100 spent on food production decreases the likelihood of FI by about 26% for both immigrant noncitizens and immigrant citizens and by 19.4% for natives including all controls in the model.

Single households

We compare the effects of time and expenditure between immigrants and natives for single households (Table 8). Column (1)-(3) show the OLS estimates on each group. Comparing the associations between immigrant groups and natives in single households shows that more time invested in food production is associated with a 5% (at 10% significant level) greater reduction in the likelihood of FI for natives than for non-citizen after controlling all variates (column 3). There

is the same difference between single immigrant citizens and single natives. Specifically, every additional 10 hours invested in food production is associated with a 4.6% statistical decrease in the probability of FI for single natives under all control variables. However, for both immigrant noncitizens and citizens, the associations are positive but not statistically significant at the 5% significance level. Furthermore, the effects of food expenditures on FI are not statistically different between immigrants, including both citizens and non-citizens, and natives. An additional $100 spent on food production is statistically associated with a 3.9% decrease in the probability of FI for single natives, a 3% decrease for single immigrant noncitizens, and a 5.1% decrease for single immigrant citizens.

Compared to the OLS results, the 2SLS estimations show higher effects of time and money investment in food production for single households. Under different sets of covariates, we find additional 10 hours investment in food production leads to 26%-13.9% greater reduction in the likelihood of FI for single natives than single immigrant non-citizens, and 15.7%-12.1% greater reduction in the likelihood of FI for single natives than single immigrant citizens. When we look at the impact of time input on FI for each group, one hour spent on food production helps native households statistically decrease the probability of being FI by 22.8-5.4%. But time spent on food production increases the probability of FI for immigrants without citizenship at 10% significant level and for immigrants without citizenship at 5% significant level. These results reveal that time spent in food production does not narrow the FI gap between immigrants and natives but could actually widen the gap. This is probably because immigrants have already invested more time in food production than natives from the very beginning shown in Table 3.

However, based on our 2SLS results, more dollar spending will statistically cause the same decrease of the likelihood of FI among immigrants including both citizen and noncitizens and

natives around 26.5-31.8%. Nevertheless, an extra $100 input could lead to 5.3% more decrease the likelihood of FI for single immigrant citizens than single native households but at 10% significant level. This may align with the fact that there is larger gap in food production between food insecure with single immigrant citizens and food secure with single immigrant citizens households in Table 2. So, more money input will help immigrant citizens decrease the likelihood of FI and narrow the FI gap with natives.

Married households

We compare the effects of food time and expenditures on FI between immigrants and natives for married households (Table 9). The OLS estimates (column 1 to 3) show that even though more time input in food production is statistically associated with a decrease in the probability of being food insecure by 3% for natives, by 5.8% for immigrant noncitizens and is not significant associated for immigrant citizens with all controls, these effects are not statistically different. For food expenditure, higher expenditures are statistically associated with a decrease in the probability of being food insecure for both natives and immigrants. The decrease is 2.3% for married natives, 2.1% for noncitizen immigrants, and 4.2% for citizen immigrants, with all controls included. By comparing with natives, more money input is statistically associated with 1.9% greater reduction of the probability of FI for married immigrant citizen.

The effects of time and expenditure for married households estimated by 2SLS are shown in column (4)-(7) of Table 9 which there are different results from OLS estimations. For the effect of time estimated including all covariates and fixed effect, additional 10 hours in food production statistically causes a 15.6% greater decrease in the probability of FS for married native households than married immigrant citizens, but not for married immigrant noncitizens relative to natives. For the effects for each group, the married native households have the largest negative and significant

effect of food production time on FI at 13.1% but married native households including both noncitizens and citizens do not have statistical effect of money input on FI. These results are consistent with descriptive comparisons in Table 3 that married immigrant households have spent more time than their corresponding native households. Unlike the 2SLS results from all households and single households, an additional $100 input in food production could not statistically decrease the probability of FI for any households including natives and immigrants.

5. Discussion

Given the higher likelihood of FI faced by immigrants, this study examines how immigrant households use time and expenditures to produce food and manage their household FS relative to natives. Aggregated cell means of food production time and expenditures are employed as instruments separately to address potential measurement errors and endogeneity of household level time-use and expenditures. Using these instruments, we determine the impact of time and expenditures on household FI, while existing studies mainly focus on correlations and consider only one input. Next, we compare the different effects of food time and expenditure investments for immigrants and natives to explore whether these different effects contribute to the disparity in FI faced by immigrants and natives.

We examine the effects of time and money inputs for all households, single and married headed households separately and get different results between 2SLS estimates and OLS estimates. The OLS estimates across all households, single and married headed households consistently indicate that more time and expenditures are associated with a decrease in the probability of FI, which is consistent with the literature and our descriptive analysis.

The 2SLS results suggest that adjusting for endogeneity and measurement error is important. For all households, more time and expenditure investment have negative effects on FI.

In single households, only food expenditures have a negative effect on FI, whereas only food time has a negative effect on FI of married households. Beatty et al (2014) explore how FI status is associated with time spent on food-related activities. But their findings differ from ours in that single households' FI are associated with 20% more time in meal preparation and 13% less time eating while married households' FI is associated with 17% less time eating and 14% less time in grocery shopping.

The varying effects of time and money investment in food production across different types of households suggests household structure matters with managing FI. The impact of food expenditure in single households reflects the well-established fact that single headed households make less than their married peers and may not enjoy the marriage benefits of lower food expenditure due to household scale economies (Lazear & Michael, 1980; Bütikofer & Gerfin 2017). The benefits of time for FS of married households reveal the limited time spent on household food production as married people are torn between the demands of work and child rearing (Flood & Genadek, 2016) and emphasize the importance of complementarities in consumption of food production time for married households (Mansour & McKinnish, 2014). These results may also indicate that it is difficult to substitute time for money to manage FI (Davis and You, 2013). Married households with sufficient money may still need more time input to keep food secure. Similarly, single households with sufficient time may require more resources to increase their expenditures on food production.

The comparison of the different effects of food time and expenditures for immigrants and natives under different household structures helps explain whether the different effects contribute to their disparity in likelihoods of FI. Our causal analysis suggests that time spent in food production improves the FS of natives but does not improve the likelihood of FI for immigrants,

either single households or married households. This could be that immigrant households regardless of citizens and noncitizen, have already spent more time on food production than natives. It may be that immigrants have to invest more time in food production to maintain cultural food preferences while facing limited access to culturally appropriate foods and resources (Vahabi and Damba, 2013). In contrast, food expenditures are helpful for both natives and immigrants in single households to maintain FS but are less impactful for married households. As we discussed before, marriage may provide other benefits through bargaining and sharing of internal resources such that food expenditures are not a limiting resource.

The differences we find between immigrants and natives further confirms that more time input does not narrow the FI gap between immigrants and natives and may actually exacerbate the gap for both single immigrants with and without citizenship and married immigrants with citizenship who already spend more time than natives on food production. Nevertheless, more food expenditure could be used to significantly narrow the FI gap between immigrant and natives, especially between married immigrant citizens and married natives. Surprisingly, immigrant citizens found to be less likely to report hardship than the native-born population (Iceland, 2021) were better able to benefit from food expenditure in terms of FI. But this is consistent with the descriptive findings that married immigrants with citizenship who have higher education levels tend to spend more money on food and be more food secure.

The fact that less time is required in food production for immigrants who have already invested more time in food production may be a reflection of high cost of time in food production and its high opportunity cost measured by the market wage rate (Davis & You, 2010). Additionally, more money required in food production not only indicates the fact that immigrants are experiencing economic hardship in maintaining their FS and but also may reveal the situation that

immigrants work harder than natives to get more paid. Empirical studies have examined that immigrants are working harder than natives, are more likely to work unusual hours (Dramski, 2017) and their job are risker and physically more arduous (Orrenius & Zavodny 2009; Zavodny 2015).

The findings that less time input and more money required for immigrants also suggest that developing ways to support the acquisition and preparation of culturally relevant foods in food assistant programs or local communities (i.e., food preparation, sharing, and consumption; food-ways), could help create time savings and increase immigrants' FS (Alonso et al. 2018). Allowing to buy prepared food items with an EBT card from SNAP which could help participants reduce food production time could also be a way to improve their FS.

6. Conclusions

Our findings elucidate marked disparities in the effects of time and money investments in food production among diverse immigrant cohorts, delineated by household composition. Targeted fiscal support for food expenditures in single-person households could mitigate economic distress and diminish the prevalence of FI. Conversely, for married households, increased access to ready-made meals via food assistance initiatives may yield time savings in food preparation and a corresponding reduction in FI. Single immigrants, particularly those dedicating additional time to preserve cultural dietary practices, may benefit from increased monetary subsidies and access to culturally appropriate pre-prepared meals. Programs aimed at bolstering immigrant household welfare should consider addressing the barriers to availability, access, and stable utilization of traditional foods—accounting for food preparation, sharing, and consumption norms (food-ways). For instance, enabling cultural-specific grocers to accept Electronic Benefit Transfer (EBT)/Food Stamp payments could be beneficial. Notably, H-MART, the preeminent Asian supermarket chain in the United States, accepts EBT in its California, Georgia, Illinois, Maryland, Michigan, Texas,

and Virginia locations. Our insights and subsequent policy recommendations are in concordance with the core objectives of the United States Department of Agriculture (USDA) regarding food and nutrition security, which advocate for the acknowledgment of structural disparities in the allocation of financial and temporal resources for food production between native-born and immigrant households, underscoring the imperative of applying an equity lens to these efforts.

As with all studies, ours has several limitations. First, the limited sample size in our matched dataset, especially for immigrants, doesn't allow us to divide the households into single or married households with different numbers of children and income levels and further explore the effects of time and money inputs for these household subgroups. Second, future studies about food production could consider the different strategies of different household structures to maintain their FI, especially for the married households. For example, how complementary are couples in household food production? Third, future studies could consider the cost of time input in food production measured by wage rates using the opportunity cost approach like Davis & You (2010), which will help to illustrate the tradeoff between home production and labor market opportunity. Fourth, we now assume there are the linear relationships between time/expenditure and FS. Future studies may try to explore nonlinear analysis.

Tables and Figures

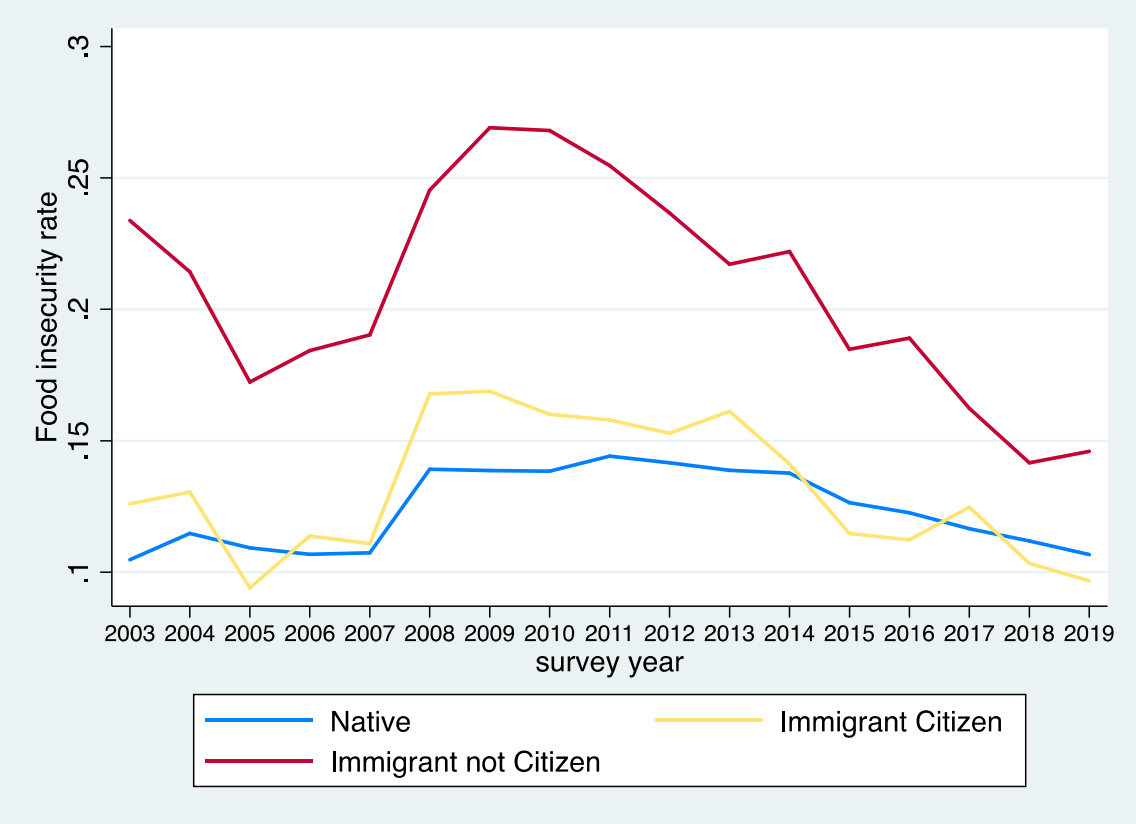
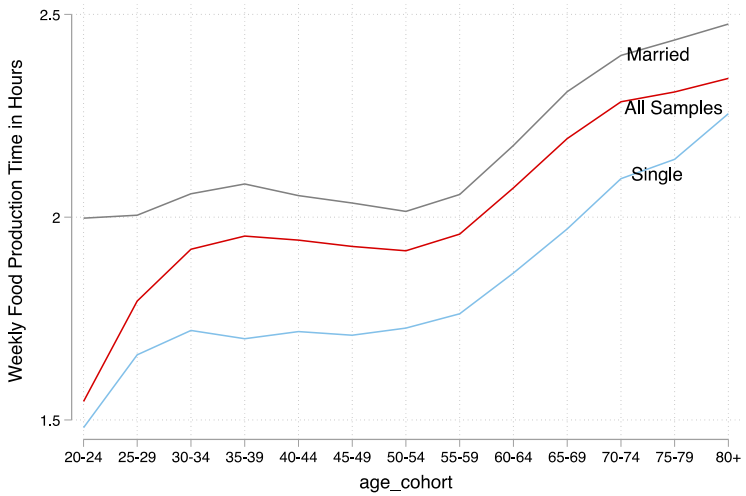
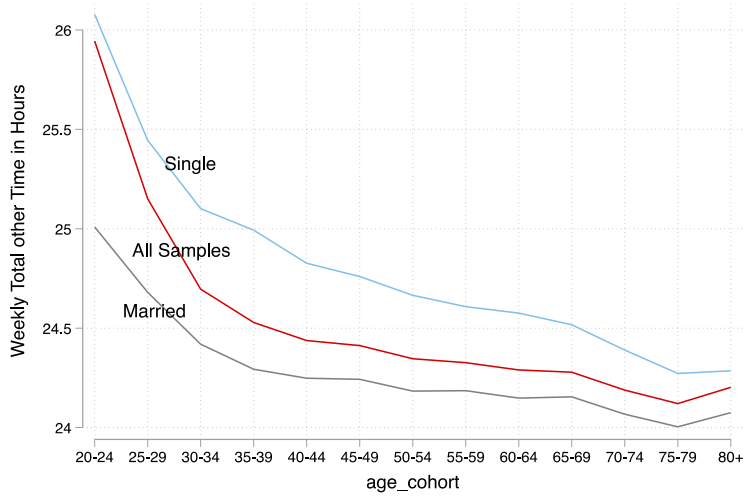


Figure 1. FI Rates Change Over Time Across Different Groups.



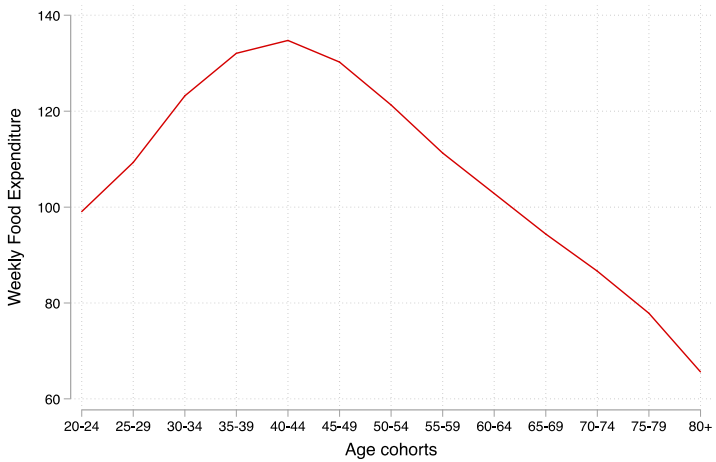
a. Average Weekly Food Production Time Changes Across Age Cohorts



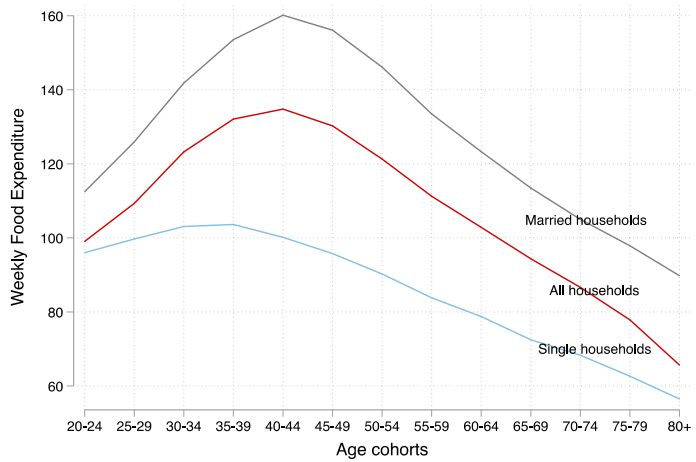
b. Average Weekly Total Other Time use Changes Across Age Cohorts

Figure 2. Variation in Time Use across Subgroups

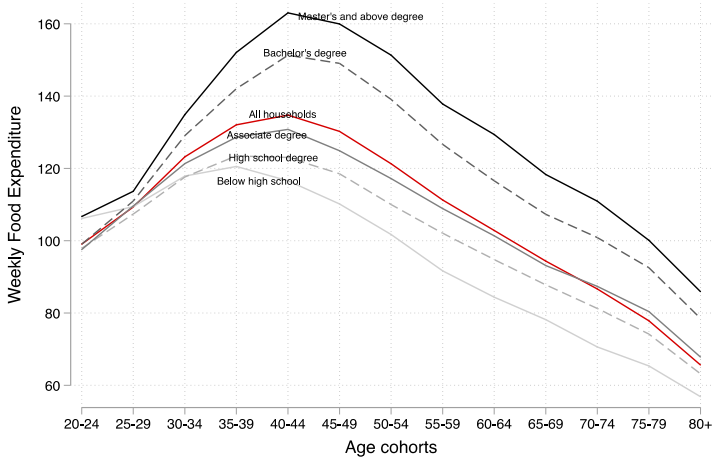
Note: These two figures present two charts illustrating the variations in average weekly time spent on food production and other activities across different age cohorts, categorized by marital status, using the raw data of ATUS without a time imputation strategy.
Source: Authors' calculations, Current Population Survey, and American Time Use Survey



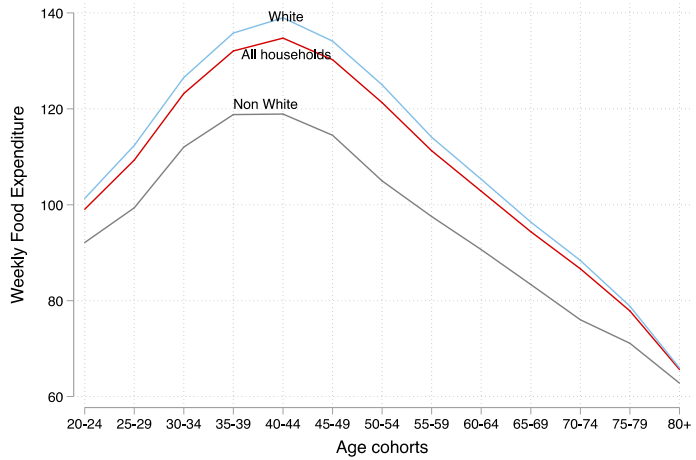
a. Average Weekly Food Expenditure Across Age Cohorts



b. Average Weekly Food Expenditure Across Marriage Status

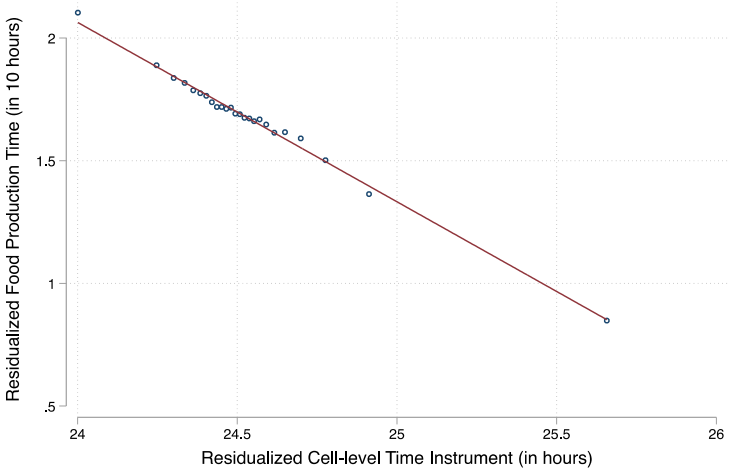


c. Average Weekly Food Expenditure Across Education Level

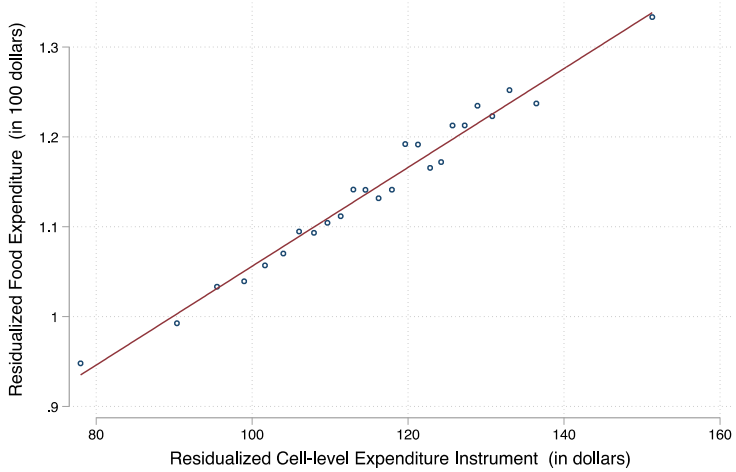


d. Average Weekly Food Expenditure Across Race

Figure 3. Variation of Food expenditure Across Subgroups



A. First Stage Effect of cell-level Instrument on Food Production time



A. First Stage Effect of cell-level Instrument on Food Expenditure

Figure 4. First Stage Effects of Cell-level Instruments on Weekly Time and Money use

Note: The figure is a visual representation of the first stage regressions about the residualized cell-level instruments and weekly food production time (Figure 4A) and food expenditure (Figure 4B) for all households. The residualized y- and x-axis variables are generated by the regression of predicted weekly food production time or food expenditure on its corresponding cell-level instrument for all households with full set of the same control variables as in the IV estimations of the effect of time and money inputs on household FI. We then group the values of residualized cell-level instruments for time and money into equal sized bins, compute the mean of instruments and time (or money) residuals within each bin, and create a scatterplot of these data points. Finally, the red lines are the plotted the best linear fit lines for time and money inputs, constructed from the OLS regressions of the y-residuals on the x-residuals. The slopes of the fit lines match the first-stage regression coefficients on the cell-level instruments.
Source: Authors' calculations, Current Population Survey, and American Time Use Survey

Table 1. Descriptive Statistics of Households by Native and Immigrant from Matched Dataset, 2003-2018

	Single HHS			Married HHS		
	Native	Immigrant Noncitizen	Immigrant Citizen	Native	Immigrant Noncitizen	Immigrant Citizen
Weekly Food Expenditure (in 100 dollars)	0.86 (0.61)	1.04 (0.68)	1.05 (0.75)	1.38 (0.76)	1.34 (0.76)	1.44 (0.81)
Weekly Food Production Time (in 10 hours)	1.00 (0.26)	1.02 (0.37)	1.08 (0.40)	2.29 (0.39)	2.36 (0.41)	2.38 (0.39)
Characteristics						
Children under 18						
Yes	22.36%	40.87%	29.48%	55.49%	80.81%	61.47%
Metro or not						
Metropolitan	81.66%	96.38%	96.01%	79.65%	94.15%	95.18%
Household size	1.83 (1.26)	2.79 (1.80)	2.42 (1.70)	3.24 (1.26)	3.96 (1.36)	3.57 (1.32)
Gender for head						
Male	37.87%	46.71%	40.43%	60.94%	61.07%	64.75%
Age for head	54 (17.57)	43 (14.18)	53 (16.18)	49 (14.83)	40 (10.56)	49 (13.61)
Education for head						
High school degree-Some college	48.88%	33.31%	38.95%	41.88%	26.43%	32.04%
Associate degree	10.40%	4.52%	8.92%	11.05%	3.80%	7.15%
Bachelor's degree	18.87%	12.01%	19.95%	25.82%	17.56%	25.50%
Master's degree	8.15%	8.06%	10.21%	11.33%	12.25%	13.36%
Above Master's degree	2.73%	3.29%	4.60%	4.30%	5.79%	5.99%
Employment status for head						
Employed	56.12%	69.57%	65.31%	67.47%	70.31%	70.40%
Not in labor force	40.40%	25.25%	30.43%	29.57%	25.71%	25.50%
Armed force	0.10%	0.00%	0.14%	0.82%	0.12%	0.39%
Years of immigration for head	--	15.12 (12.05)	29.51 (14.38)	--	12.19 (9.37)	25.73 (13.05)
Race for head						
White	76.80%	74.42%	66.73%	89.73%	72.42%	63.25%
Sample size	**20265**	**1216**	**1479**	**21065**	**1657**	**1804**

Note: Standard deviations in parentheses. The food production time represents the estimated weekly time use, determined using the imputation strategy, for both single and married households.

Table 2. Comparisons of Mean Weekly Food Expenditure (in 100 dollars) Among Subgroups.

	Mean	Std. dev
FS/Single		
Native	0.871	0.614
Immigrant citizen	1.072	0.766
Immigrant not citizen	1.048	0.688
FI/Single		
Native	0.792	0.615
Immigrant citizen	0.899	0.622
Immigrant not citizen	1.018	0.661
FS/Married		
Native	1.396	0.756
Immigrant citizen	1.468	0.822
Immigrant not citizen	1.362	0.773
FI/Married		
Native	1.183	0.730
Immigrant citizen	1.194	0.632
Immigrant not citizen	1.268	0.675

Note: The table presents mean weekly food expenditure in units of 100 dollars, with standard deviations for different subgroups based on their FS status (FS - Food Secure, FI - Food Insecure), marital status (Single, Married), and immigration status (Native, Immigrant citizen, Immigrant not citizen).

Table 3. Comparisons of Mean Weekly Food Production Time (in 10 hours) Among Subgroups.

	Food preparation	Eating	Grocery shopping	Non-grocery shopping	Travel related food preparation	Travel related eating/drinking	Total
FS/Single							
Native	0.259	0.618	0.062	0.012	0.003	0.055	1.010
	(0.132)	(0.164)	(0.038)	(0.009)	(0.006)	(0.044)	(0.261)
Immigrant citizen	0.300	0.647	0.066	0.013	0.003	0.057	1.085
	(0.214)	(0.200)	(0.045)	(0.010)	(0.006)	(0.054)	(0.394)
Immigrant not citizen	0.294	0.595	0.057	0.013	0.003	0.053	1.015
	(0.210)	(0.187)	(0.042)	(0.010)	(0.011)	(0.038)	(0.375)
FI/Single							
Native	0.299	0.530	0.057	0.011	0.002	0.041	0.940
	(0.144)	(0.133)	(0.038)	(0.010)	(0.005)	(0.048)	(0.239)
Immigrant citizen	0.348	0.598	0.061	0.011	0.002	0.039	1.059
	(0.206)	(0.254)	(0.043)	(0.007)	(0.004)	(0.022)	(0.429)
Immigrant not citizen	0.362	0.558	0.060	0.010	0.002	0.041	1.034
	(0.362)	(0.168)	(0.051)	(0.007)	(0.005)	(0.033)	(0.359)
FS/Married							
Native	0.634	1.385	0.129	0.025	0.009	0.116	2.297
	(0.205)	(0.256)	(0.048)	(0.012)	(0.039)	(0.060)	(2.297)
Immigrant citizen	0.748	1.364	0.146	0.025	0.007	0.097	2.387
	(0.249)	(0.239)	(0.055)	(0.012)	(0.028)	(0.047)	(0.380)
Immigrant not citizen	0.822	1.294	0.149	0.024	0.008	0.084	2.381
	(0.276)	(0.232)	(0.057)	(0.011)	(0.031)	(0.039)	(0.410)
FI/Married							
Native	0.706	1.177	0.123	0.021	0.008	0.081	2.115
	(0.261)	(0.252)	(0.048)	(0.012)	(0.026)	(0.053)	(0.430)
Immigrant citizen	0.870	1.227	0.144	0.019	0.010	0.076	2.346
	(0.319)	(0.212)	(0.053)	(0.009)	(0.041)	(0.044)	(0.424)
Immigrant not citizen	0.879	1.177	0.148	0.018	0.013	0.067	2.301
	(0.292)	(0.198)	(0.066)	(0.009)	(0.078)	(0.028)	(0.418)

Note: This table displays the average weekly hours (in unit of 10 hours) spent on food-related activities among different subgroups categorized by FS (FS) status, marital status, and citizenship. Activities include food preparation, eating, grocery shopping, non-grocery shopping, and travel related to food. The last column represents the total time spent on all activities combined.

Table 4. The Effects of Food Time and Expenditure on Household FI for All households.

	OLS			2SLS			
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Food time in 10 hours	-0.062***	-0.059***	-0.020***	-0.092***	-0.087***	-0.051***	-0.036***
	(0.004)	(0.004)	(0.003)	(0.006)	(0.006)	(0.006)	(0.006)
Food expenditure in 100 dollars	-0.022***	-0.023***	-0.033***	0.015*	0.008	-0.159***	-0.226***
	(0.002)	(0.002)	(0.002)	(0.009)	(0.009)	(0.024)	(0.030)
Immigrant not citizen	0.106***	0.104***	0.031***	0.107***	0.106***	0.018**	0.015
	(0.009)	(0.010)	(0.009)	(0.009)	(0.010)	(0.009)	(0.010)
Immigrant citizen	0.021**	0.022**	0.008	0.020**	0.023***	0.006	0.010
	(0.009)	(0.008)	(0.015)	(0.009)	(0.009)	(0.014)	(0.015)
Constant	0.240***	0.246***	0.353***	0.247***	0.260***	0.313***	0.409***
	(0.009)	(0.008)	(0.021)	(0.009)	(0.008)	(0.026)	(0.075)
Observations	45,778	45,778	45,778	45,774	45,774	45,774	45,774
R-squared	0.032	0.039	0.1090	0.024	0.033	0.050	-0.018
Demographic characteristics	NO	NO	YES	NO	NO	YES	YES
Cell FE	NO	NO	NO	NO	NO	NO	YES
State FE	NO	YES	YES	NO	YES	YES	YES
Year FE	NO	YES	YES	NO	YES	YES	YES
F-statistics for food time	--	--	--	5153.50	4258.68	2909.65	3644.48
F-statistics for food expenditure	--	--	--	3532.66	3680.67	432.71	381.92

Note: Food production time compositions is in units of 10 hours and food expenditure is in units of 100 dollars. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 5. The Effects of Food Time and Expenditure on Household FI for Single households.

	OLS			2SLS			
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Food time in 10 hours	-0.097***	-0.087***	-0.033***	-0.185***	-0.183***	-0.006	-0.018
	(0.013)	(0.013)	(0.008)	(0.027)	(0.028)	(0.022)	(0.022)
Food expenditure in 100 dollars	-0.022***	-0.023***	-0.040***	0.006	-0.005	-0.186***	-0.265***
	(0.004)	(0.003)	(0.004)	(0.008)	(0.010)	(0.034)	(0.038)
Immigrant not citizen	0.062***	0.062***	-0.010	0.058***	0.058***	-0.021	-0.018
	(0.016)	(0.017)	(0.014)	(0.015)	(0.016)	(0.013)	(0.014)
Immigrant citizen	-0.012	-0.009	-0.028	-0.010	-0.007	-0.031*	-0.018
	(0.010)	(0.010)	(0.018)	(0.010)	(0.010)	(0.016)	(0.017)
Constant	0.277***	0.280***	0.285***	0.340***	0.351***	0.276***	0.430***
	(0.0151)	(0.0177)	(0.0336)	(0.027)	(0.028)	(0.035)	(0.120)
Observations	22,050	22,050	22,050	22,049	22,049	22,049	22,049
R-squared	0.009	0.019	0.110	0.003	0.013	0.065	0.014
Demographic characteristics	NO	NO	YES	NO	NO	YES	YES
Cell FE	NO	NO	NO	NO	NO	NO	YES
State FE	NO	YES	YES	NO	YES	YES	YES
Year FE	NO	YES	YES	NO	YES	YES	YES
F-statistics for food time	--	--	--	835.51	638.49	280.62	295.89
F-statistics for food expenditure	--	--	--	545.52	636.26	86.27	77.68

Note: Food production time compositions is in units of 10 hours and food expenditure is in units of 100 dollars. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 6. The Effects of Food Time and Expenditure on Household FI for Married households

	OLS			2SLS			
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Food time in 10 hours	-0.066***	-0.068***	-0.030***	-0.191***	-0.187***	-0.146***	-0.105***
	(0.006)	(0.006)	(0.008)	(0.013)	(0.013)	(0.021)	(0.027)
Food expenditure in 100 dollars	-0.021***	-0.022***	-0.025***	-0.035***	-0.043***	0.023	0.055
	(0.003)	(0.003)	(0.003)	(0.006)	(0.006)	(0.043)	(0.103)
Immigrant not citizen	0.139***	0.136***	0.074***	0.149***	0.135***	0.099***	0.104***
	(0.009)	(0.009)	(0.011)	(0.010)	(0.009)	(0.015)	(0.024)
Immigrant citizen	0.051***	0.049***	0.046**	0.064***	0.051***	0.064***	0.070***
	(0.010)	(0.010)	(0.019)	(0.011)	(0.010)	(0.019)	(0.021)
Constant	0.247***	0.253***	0.419***	0.550***	0.533***	0.610***	0.521***
	(0.015)	(0.014)	(0.027)	(0.030)	(0.028)	(0.063)	(0.150)
Observations	23,728	23,728	23,728	23,725	23,725	23,725	23,725
R-squared	0.031	0.040	0.100	-0.005	0.009	0.070	0.065
Demographic characteristics	NO	NO	YES	NO	NO	YES	YES
Cell FE	NO	NO	NO	NO	NO	NO	YES
State FE	NO	YES	YES	NO	YES	YES	YES
Year FE	NO	YES	YES	NO	YES	YES	YES
F-statistics for food time	--	--	--	1029.69	1055.87	488.65	688.74
F-statistics for food expenditure	--	--	--	1026.38	1211.94	80.20	42.30

Note: Food production time compositions is in units of 10 hours and food expenditure is in units of 100 dollars. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 7. Heterogenous Effects of Food Time and Expenditure on FI Between Immigrant and Natives for All households.

	OLS			2SLS			
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Food time×Native	-0.071***	-0.068***	-0.028***	-0.106***	-0.102***	-0.064***	-0.050***
	(0.003)	(0.003)	(0.005)	(0.006)	(0.006)	(0.005)	(0.006)
Food time×Immigrant not citizen	-0.013	-0.012	0.003	-0.008	-0.005	-0.006	0.011
	(0.010)	(0.010)	(0.011)	(0.020)	(0.020)	(0.017)	(0.017)
Food time× Immigrant citizen	-0.010	-0.010	0.014	-0.024**	-0.023*	0.005	0.015
	(0.010)	(0.010)	(0.009)	(0.012)	(0.012)	(0.011)	(0.010)
Food Expenditure×Native	-0.020***	-0.020***	-0.031***	0.029***	0.022**	-0.130***	-0.194***
	(0.002)	(0.002)	(0.002)	(0.009)	(0.009)	(0.024)	(0.031)
Food Expenditure×Immigrant not citizen	-0.019**	-0.020**	-0.024**	-0.106**	-0.116***	-0.208***	-0.268***
	(0.009)	(0.009)	(0.010)	(0.044)	(0.044)	(0.038)	(0.039)
Food Expenditure × Immigrant citizen	-0.038***	-0.039***	-0.048***	-0.038*	-0.042**	-0.212***	-0.264***
	(0.008)	(0.008)	(0.008)	(0.020)	(0.020)	(0.029)	(0.029)
Immigrant not citizen	0.003	0.004	-0.032	0.096***	0.103***	0.014	0.002
	(0.025)	(0.026)	(0.023)	(0.029)	(0.030)	(0.032)	(0.032)
Immigrant citizen	-0.064***	-0.059***	-0.048**	-0.043*	-0.036	-0.010	-0.014
	(0.017)	(0.017)	(0.023)	(0.024)	(0.023)	(0.031)	(0.031)
Constant	0.251***	0.258***	0.359***	0.255***	0.268***	0.322***	0.418***
	(0.009)	(0.007)	(0.021)	(0.010)	(0.008)	(0.027)	(0.075)
Diff:							
Food time×Immigrant not citizen- Food time×Native	0.057***	0.056***	0.031***	0.098***	0.096***	0.058***	0.061***
	(0.011)	(0.010)	(0.009)	(0.023)	(0.023)	(0.019)	(0.020)
Food time×Immigrant citizen- Food time×Native	0.061***	0.059***	0.042***	0.082***	0.078***	0.069***	0.065***

	(0.010)	(0.010)	(0.007)	(0.011)	(0.011)	(0.011)	(0.011)
Food Expenditure×Immigrant not citizen- Food Expenditure×Native	0.001	0.001	0.007	-0.135***	-0.139***	-0.077**	-0.074*
	(0.010)	(0.010)	(0.0102)	(0.048)	(0.047)	(0.039)	(0.038)
Food Expenditure×Immigrant citizen- Food Expenditure×Native	-0.019**	-0.018**	-0.016**	-0.067***	-0.065***	-0.081***	-0.070***
	(0.008)	(0.008)	(0.008)	(0.018)	(0.018)	(0.021)	(0.021)
Observations	45,778	45,778	45,778	45,774	45,774	45,774	45,774
R-squared	0.0336	0.0407	0.1099	0.020	0.029	0.061	0.006
Demographic characteristics	NO	NO	YES	NO	NO	YES	YES
Cell FE	NO	NO	NO	NO	NO	NO	YES
State FE	NO	YES	YES	NO	YES	YES	YES
Year FE	NO	YES	YES	NO	YES	YES	YES
F-statistics for							
"foodtime × Native"	--	--	--	.	3174.94	1709.33	2307.14
"foodtime × Imm noncitizen"	--	--	--	.	1292.08	1181.02	1097.84
"foodtime × Imm citizen"	--	--	--	.	2285.75	2389.04	2479.22
"foodexpenditure × Native"	--	--	--	.	1466.52	573.70	434.26
"foodexpenditure × Imm noncitizen"	--	--	--	.	58.67	102.44	88.00
"foodexpenditure × Imm citizen"	--	--	--	.	257.30	241.63	257.37

Note: Food production time compositions is in units of 10 hours and food expenditure is in units of 100 dollars. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 8. Heterogenous Effects of Food Time and Expenditure on FI Between Immigrant and Natives for Single households.

	OLS			2SLS			
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Food time×Native	-0.130***	-0.118***	-0.046***	-0.228***	-0.227***	-0.029	-0.054**
	(0.012)	(0.012)	(0.008)	(0.031)	(0.032)	(0.029)	(0.027)
Food time×Immigrant not citizen	0.040	0.043*	0.004	0.032	0.020	0.065	0.086*
	(0.026)	(0.026)	(0.025)	(0.056)	(0.053)	(0.050)	(0.048)
Food time× Immigrant citizen	-0.003	-0.001	0.004*	-0.071*	-0.070*	0.057*	0.067**
	(0.027)	(0.027)	(0.024)	(0.041)	(0.041)	(0.029)	(0.031)
Food Expenditure×Native	-0.021***	-0.022***	-0.039***	0.006	-0.006	-0.179***	-0.265***
	(0.004)	(0.003)	(0.004)	(0.009)	(0.011)	(0.035)	(0.039)
Food Expenditure×Immigrant not citizen	-0.014	-0.017	-0.030**	-0.018	-0.034	-0.190***	-0.271***
	(0.013)	(0.012)	(0.015)	(0.049)	(0.048)	(0.049)	(0.052)
Food Expenditure × Immigrant citizen	-0.036**	-0.037**	-0.051***	-0.037*	-0.044*	-0.245***	-0.318***
	(0.016)	(0.016)	(0.016)	(0.023)	(0.023)	(0.040)	(0.044)
Immigrant not citizen	-0.118***	-0.108***	-0.068***	-0.180**	-0.164**	-0.100	-0.150**
	(0.030)	(0.030)	(0.026)	(0.081)	(0.078)	(0.070)	(0.066)
Immigrant citizen	-0.131***	-0.119***	-0.066	-0.131**	-0.134**	-0.045	-0.083
	(0.040)	(0.040)	(0.044)	(0.057)	(0.058)	(0.058)	(0.058)
Constant	0.308***	0.306***	0.294***	0.383***	0.389***	0.286***	0.468***
	(0.014)	(0.017)	(0.035)	(0.032)	(0.033)	(0.039)	(0.125)
Diff:							
Food time×Immigrant not citizen- Food time×Native	0.170***	0.162***	0.050*	0.260***	0.246***	0.094*	0.139**
	(0.029)	(0.029)	(0.026)	(0.068)	(0.007)	(0.056)	(0.055)
Food time×Immigrant citizen- Food time×Native	0.126***	0.118***	0.050*	0.157***	0.156***	0.086*	0.121***
	(0.030)	(0.029)	(0.026)	(0.047)	(0.048)	(0.045)	(0.042)

Food Expenditure×Immigrant not citizen- Food Expenditure×Native	0.007	0.0051	0.008	-0.024	-0.028	-0.011	-0.005
	(0.014)	(0.014)	(0.015)	(0.052)	(0.050)	(0.036)	(0.039)
Food Expenditure×Immigrant citizen- Food Expenditure×Native	-0.015	-0.015	-0.012	-0.043*	-0.038	-0.066***	-0.053*
	(0.016)	(0.016)	(0.017)	(0.023)	(0.023)	(0.026)	(0.029)
Observations	22,050	22,050	22,050	22,049	22,049	22,049	22,049
R-squared	0.0111	0.0204	0.1106	0.005	0.015	0.065	0.008
Demographic characteristics	NO	NO	YES	NO	NO	YES	YES
Cell FE	NO	NO	NO	NO	NO	NO	YES
State FE	NO	YES	YES	NO	YES	YES	YES
Year FE	NO	YES	YES	NO	YES	YES	YES
F-statistics for							
"foodtime × Native"	--	--	--	.	390.39	126.38	190.07
"foodtime × Imm noncitizen"	--	--	--	.	48.26	55.39	43.55
"foodtime × Imm citizen"	--	--	--	.	36.57	46.84	53.29
"foodexpenditure × Native"	--	--	--	.	357.26	110.08	153.67
"foodexpenditure × Imm noncitizen"	--	--	--	.	56.03	83.56	80.54
"foodexpenditure × Imm citizen"	--	--	--	.	43.89	86.32	78.36

Note: Food production time compositions is in units of 10 hours and food expenditure is in units of 100 dollars. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.

Table 9. Heterogenous Effects of Food Time and Expenditure on FI Between Immigrant and Natives for Married households.

	OLS			2SLS			
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Food time×Native	-0.070***	-0.072***	-0.030***	-0.202***	-0.198***	-0.174***	-0.131***
	(0.006)	(0.007)	(0.008)	(0.015)	(0.015)	(0.026)	(0.035)
Food time×Immigrant not citizen	-0.069***	-0.071***	-0.058***	-0.076	-0.071	-0.047	-0.022
	(0.022)	(0.022)	(0.021)	(0.071)	(0.072)	(0.055)	(0.058)
Food time× Immigrant citizen	-0.0169	-0.019	0.008	-0.096 **	-0.094**	-0.029	0.024
	(0.026)	(0.026)	(0.023)	(0.048)	(0.048)	(0.588)	(0.054)
Food Expenditure×Native	-0.019***	-0.020***	-0.023***	-0.024***	-0.033***	0.049	0.079
	(0.003)	(0.003)	(0.003)	(0.006)	(0.006)	(0.043)	(0.108)
Food Expenditure×Immigrant not citizen	-0.023**	-0.022**	-0.021**	-0.270***	-0.274***	-0.081	-0.009
	(0.010)	(0.010)	(0.009)	(0.069)	(0.070)	(0.078)	(0.139)
Food Expenditure × Immigrant citizen	-0.040***	-0.041***	-0.042***	-0.075***	-0.077***	-0.008	0.026
	(0.012)	(0.011)	(0.010)	(0.028)	(0.027)	(0.051)	(0.109)
Immigrant not citizen	0.142***	0.138**	0.139**	0.182	0.159	-0.015	-0.023
	(0.050)	(0.052)	(0.054)	(0.155)	(0.153)	(0.123)	(0.129)
Immigrant citizen	-0.045	-0.045	-0.012	-0.115	-0.134	-0.185	-0.208*
	(0.066)	(0.065)	(0.053)	(0.127)	(0.127)	(0.126)	(0.121)
Constant	0.253***	0.259***	0.417***	0.562***	0.546***	0.662***	0.572***
	(0.015)	(0.014)	(0.028)	(0.034)	(0.032)	(0.077)	(0.157)
Diff:							
Food time×Immigrant not citizen- Food time×Native	0.001	0.001	-0.028	0.126	0.128	0.127*	0.109
	(0.023)	(0.023)	(0.022)	(0.078)	(0.078)	(0.065)	(0.068)

Food time×Immigrant citizen- Food time×Native	0.053**	0.053*	0.038	0.106**	0.104**	0.145**	0.156***
	(0.0263)	(0.0264)	(0.0227)	(0.0508)	(0.0501)	(0.0590)	(0.0580)
Food Expenditure×Immigrant not citizen- Food Expenditure×Native	-0.004	-0.003	0.002	-0.245 ***	-0.240***	-0.130**	-0.088
	(0.011)	(0.011)	(0.010)	(0.069)	(0.070)	(0.061)	(0.065)
Food Expenditure×Immigrant citizen- Food Expenditure×Native	-0.021*	-0.021**	-0.019**	-0.051*	-0.043*	-0.056**	-0.053**
	(0.011)	(0.010)	(0.009)	(0.026)	(0.026)	(0.023)	(0.021)
Observations	23,728	23,728	23,728	23,725	23,725	23,725	23,725
R-squared	0.0312	0.0408	0.1008	-0.035	-0.021	0.049	0.045
Demographic characteristics	NO	NO	YES	NO	NO	YES	YES
Cell FE	NO	NO	NO	NO	NO	NO	YES
State FE	NO	YES	YES	NO	YES	YES	YES
Year FE	NO	YES	YES	NO	YES	YES	YES
F-statistics for							
"foodtime × Native"	--	--	--	.	507.94	255.62	347.59
"foodtime × Imm noncitizen"	--	--	--	.	56.43	78.71	83.75
"foodtime × Imm citizen"	--	--	--	.	61.72	76.00	56.17
"foodexpenditure × Native"	--	--	--	.	536.95	136.73	84.16
"foodexpenditure × Imm noncitizen"	--	--	--	.	10.04	12.72	13.41
"foodexpenditure × Imm citizen"	--	--	--	.	77.04	89.32	84.60

Note: Food production time compositions is in units of 10 hours and food expenditure is in units of 100 dollars. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

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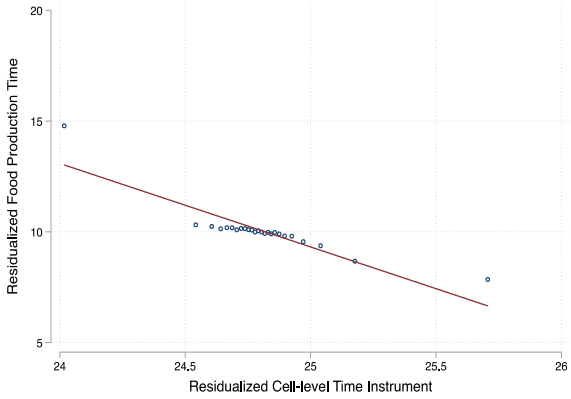
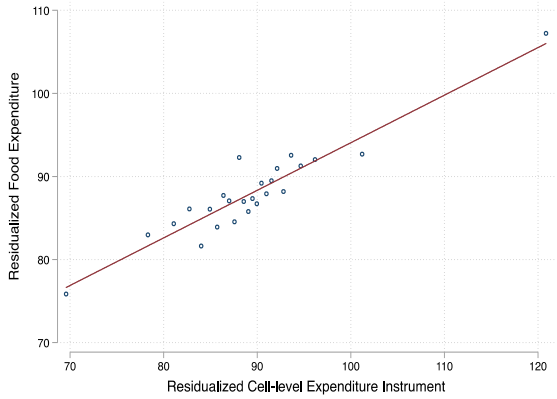
Appendix

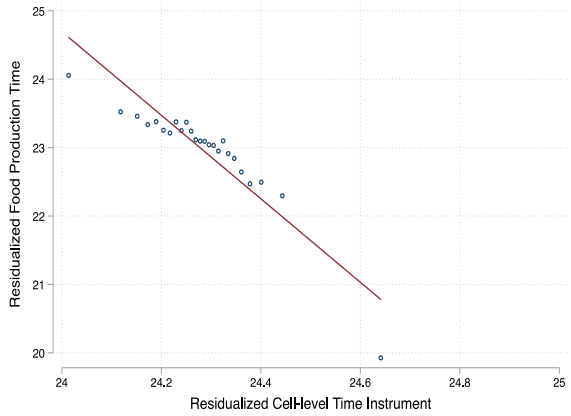
A. First Stage Effects of Cell-level Instruments on Weekly Time and Money Separately for Single and Married Households



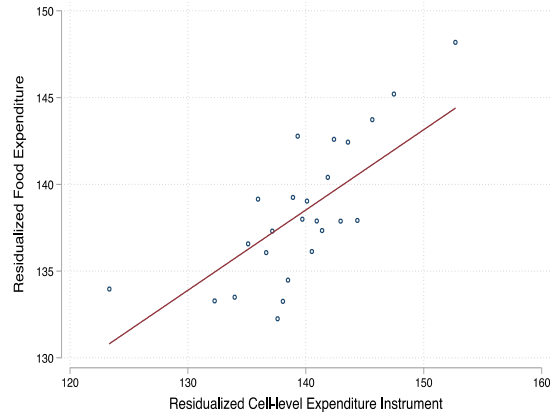
(1) First stage effect of cell-level Instrument on Food Production Time for Single Households



(2) First stage effect of cell-level Instrument on Food Expenditure for Single Households



(3) First stage effect of cell-level Instrument on Food Production Time for Married Household



(4) First stage effect of cell-level Instrument on Food Expenditure for Married Households

Figure A. First Stage Effects of Cell-level Instruments on Weekly Time and Money

Note: The figure is a visual representation of the first stage regressions about the residualized cell-level instruments and weekly food production time (Figure 6A) and food expenditure (Figure 6B) for single and married households separately. The residualized y- and x-axis variables are generated by the regression of predicted weekly food production time or food expenditure on its corresponding cell-level instrument for single and married households with full set of the same control variables as in the IV estimations of the effect of time and money inputs on household food insecurity. We then group the values of residualized cell-level instruments for time and money into equal sized bins, compute the mean of instruments and time (or money) residuals within each bin, and create a scatterplot of these data points. Finally, the red lines are the plotted the best linear fit lines for time and money inputs, constructed from the OLS regressions of the y-residuals on the x-residuals. The slopes of the fit lines match the first-stage regression coefficients on the cell-level instruments for single and married households.
Source: Authors' calculations, Current Population Survey, and American Time Use Survey