From Means-Tested Programs to Universal Basic Income - The Role of Endogenous Participation in Transfer Programs

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Abstract

Take-up of the means-tested transfer programs in many countries is generally incomplete – that is, not all eligible individuals or households receive benefits. For example, 5 million eligible households(22% of total) for Earned Income Tax Credit (EITC) benefits in the US do not receive them. Given this reality, would a Universal Basic Income scheme, which features complete participation by design, be preferable? Extending social insurance benefit to these individuals would be a big advantage of UBI. However, current UBI reform literature typically abstract from this program participation margin. I address this question using incomplete-market life-cycle general equilibrium model augmented with the household's decision to take up EITC benefit. I calibrate two versions of the model, which differ in EITC's participation setup (full or incomplete), to the U.S economy and conduct a UBI reform. I find that the welfare effect of replacing EITC with a generous UBI as often proposed ($12,000 annually) is negative because of the large tax increase to finance the program, which is highly distortive. Endogenous program participation amplifies this negative effect. In contrast, the much smaller optimal UBI program (~ $3500 annually) produces a welfare gain, but only under incomplete participation. When participation is complete, I reproduce the literature's typical result that an optimal UBI reform generates a welfare loss. I conclude that the key benefit of a properly sized UBI program is in extending benefits to a broader share of the eligible population.

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1 Introduction

Nowadays, Universal Basic Income (UBI) has drawn more public attention because of rising income inequality.[1] It is a policy proposal that offers condition-free, non-taxable cash transfer to a large proportion of the population. Most recently, due to the pandemic, many countries have implemented semi-universal policies to assist people in need (e.g., CERB in Canada; CARES Act in the U.S.). There were still 12 million Americans not receiving their benefit during the pandemic (Marr et al., 2020). Such incomplete participation has existed in other transfer programs and countries for a long time (Ko and Moffitt, 2022).

The current transfer programs are characterized by means-tested, where the eligibility and benefit amount depend on the type and level of the income (e.g., earnings, investment income, etc.). The design of means-tested aims to efficiently redistribute resources towards the targeted people or families; however, not all eligible people apply for or receive their benefits. For instance, Goldin et al. (2022) shows that only 78% of the eligible people take up their Earned Income Tax Credit (EITC) benefit. The 22% who are eligible but do not participate make up 5 million low-income people. In addition, the participation in other cash transfer programs is even lower.[2]

The existing macroeconomic literature mostly assumes the program participation is complete - that is, all eligible people definitely get their benefits. This full-participation setup can overstate the effectiveness of the transfer program since it assumes that the transfer program assists all people in need. In addition, the full-participation setup cannot capture the knock-on effects of changes in participation due to program reforms.

For instance, a generous reform (e.g., raising the benefit level) can attract more people to participate, which naturally divides the post-reform participants into two groups. The first group consists of people who stay as participants in both pre- and post-reform programs (defined as *stayers*). The other group includes people who were eligible but did not participate in the pre-reform program, and they switched to take part in the post-reform program (defined as *switchers*). The full-participation setup can

[1] In the past three decades, the income inequality in the U.S. has gotten worse: For instance, the top 1% income share almost doubled from 1980 to 2014 (World Bank Dataset). In addition, Real median income in the U.S. increased by less than 1% between 2000 and 2016 (Semega et al., 2017)

[2] According to the Center on Budget and Policy Priorities (CBPP), the lowest participation rate of the cash transfer programs in the U.S (TANF) is 23% in the fiscal year 2017. That is, only 23% of the eligible needy family participate in the program

only capture the stayers' behavioural change and their effect on price (e.g., increase in tax burden). The ignored switchers, however, matter not only in contributing more to the tax burden but also in altering aggregate response through compositional channels. Therefore, the full-participation setup cannot capture these two channels by switchers even though they are essential in evaluating the reform.

Given limited participation in existing means tested programs, it is a natural question whether Universal Basic Income (UBI), which features full participation by design, would be preferable?[3] This paper addresses this question by both empirical and quantitative analysis. The empirical analysis uses micro-survey data to study the incompleteness of the program participation and identifies *who* are the eligible (non)participants of the means-tested program. These empirical findings discipline the quantitative modelling of endogenous participation. The quantitative analysis rationalizes the empirical findings into a structural model. Using the calibrated model, I evaluate the worthiness of the UBI reform along changes in the aggregates, welfare, and inequality. In particular, the quantitative analysis highlights the role of the program participation margin. To my best knowledge, this is the first paper that analyzes UBI reform with endogenous program participation margin.

The empirical analysis explores the participation patterns of the Earned Income Tax Credit (EITC), which is the largest cash transfer program in the U.S after the medical and pension programs (Crandall-Hollick et al., 2021a). The primary dataset is the 2013-2016 Annual Social and Economic Supplements of Current Population Survey (ASEC-CPS), an annual survey of U.S households on their income, transfer program receipt, and demographic characteristics. These data indicate incomplete participation in the EITC, with an overall participation rate of 82.3% that is close to the rate of 79.5% reported by the Internal Revenue Service (IRS). The data also show incomplete participation across the earning distribution. Even at the earning region that corresponds to the maximum benefit level, the participation rate is only 85%. Participation declines in earnings, which can be partially attributed to the decreasing benefit.

To gain a better understanding of the participation pattern, I further explore the data on the economic factors that correlate with the program (non)participation among

[3]Extending social insurance benefit to those eligible nonparticipants would be a advantage of UBI. An alternative reform is increasing participation of the current program by reducing application hassles or effectively informing. The effectiveness of these experiments has shown to be limited and small (Goldin et al., 2022).

eligible families. I find the likelihood of participation positively correlates with the education level and the expected benefits given earnings and assets. The intuition is straightforward: given the existence of participation friction, people who qualified for a higher benefit find it is more worthy to participate. In addition, people with higher education can tackle the application hassle (e.g., filing tax forms) more easily. Meanwhile, people with higher investment income and productivity (measured by wage rate) are less likely to take up the benefit. All of the empirical findings are essential and used to discipline modelling of endogenous program participation in the quantitative analysis.

The quantitative analysis uses a standard incomplete-market life-cycle heterogeneous-agent general equilibrium model (Aiyagari (1994); İmrohoroglu et al. (1995)) augmented with an endogenous program participation. During working age, households face idiosyncratic productivity shock and make their consumption-saving decision. In addition, households make labor choices along both intensive and extensive margins. Both margins are relevant for the evaluation of welfare programs. For instance, EITC has significant effects on encouraging work, especially along the extensive margin (Kleven, 2019). In contrast, a generous UBI can destroy the incentivizing design of EITC due to the income effect of a generous non-labor benefit.

The means-tested transfer program in the model closely mimics the average EITC in terms of the benefit scheme and eligibility requirements. I assume that participating into the program involves a utility cost, which varies with education. This setup replicates the empirical pattern that more educated people are more likely to participate, which translates to lower participation friction in the model. Depending on the income type and level, eligible households decide whether to take up the transfer benefit by comparing the cost of participation and entitled benefit. After households retire, they live off their pension income and wealth, and the cash transfer program is not available for them.

The model parameters are calibrated to replicate the US economy in the 2010s. In particular, the participation cost parameters are calibrated to the participation rates across the benefit scheme, as computed in the empirical analysis. To understand the effects of the program participation margin in detail and contrast my findings with the existing literature, I also calibrate a model that assumes full program participation to the same economic moments except for the program participation rate.[4] Overall, both setups perform well in terms of targeted and untargeted moments. In particular, the incomplete-setup generates qualitatively similar program participation patterns along wealth and productivity dimensions compared to the empirical findings. The full participation setup definitely cannot capture such program participation pattern as there is no variation in program participation within eligible group.

Using the calibrated models, I conduct counterfactual reforms that replace the benchmark EITC program with UBI. I assume UBI has complete participation. I considered two levels of UBI in the counterfactual analysis. The first UBI is worth \$1,000 monthly (or \$12,000 annually) after tax, which is a generous level that is widely discussed in the literature.[5] The second UBI reform is the one that maximizes social welfare. It turns out that the optimal UBI involves much lower transfer payments of \$313 monthly (\$3,750 annually) and \$275 monthly (\$3,300 annually) under incomplete and full participation setup respectively.

Replacing EITC with generous UBI has large distortionary effects. The tax burden significantly increases to finance the universal benefit. Meanwhile, agents' behaviours also got distorted. Labor supply decreases along both intensive and extensive margins due to the income effect of generous benefit and the removal of the EITC's labor-incentivizing design. In addition, agents save less in response to the higher tax, and both aggregate consumption and output decreases. In terms of equity-efficiency, the declines in aggregates are sufficiently large so that aggregate welfare declines, despite a reduction in inequality of disposable income.

The program participation margin matters for the effects of the generous UBI reform. Comparing results across two participation setups, the extent of response is mostly larger under the incomplete participation setup. Such comparison, however, mix many factors' change at the same time (e.g., prices change, different groups' responses etc.). To better explore the role of program participation margin, I decompose the aggregate responses into two groups under partial equilibrium, where I fix the prices, tax, and stationary distribution as in the pre-reform economy. The first group consists of the households who take part in both EITC (pre-reform) and UBI (post-reform),

[4]This is the typical assumption in the literature on quantitative analyses of welfare reforms.

[5]This reform is costly due to both universality and generosity of the benefit. An annual transfer of \$12,000 corresponds to 28.6% of the mean disposable income in the U.S (~ \$42,000 annually). It is much higher than the average EITC benefit of about \$2,500 annually.

which I denote as *stayers*. The second group consists of households who were eligible but did not participate in the EITC program, which I denote as *switchers* as they switch to participate after the reform.

The partial equilibrium decomposition provides some intuitions for the larger distortionary response under incomplete participation setup. On the one hand, some stimulating effects from eliminating the means-tested designs[6] got attenuated by the partial take-up. On the other hand, switchers take effects on aggregates responses through both general equilibrium and compositional channels. Government needs more tax to balance their budget since switchers' benefit increase from zero (pre-reform) to \$12,000 (post-reform). Moreover, switchers' responses are in the same direction as stayers, which amplifies the aggregate responses.

I also compute the optimal UBI reform in each setting. Social welfare declines for optimal level under full participation setup. In contrast, under incomplete participation setup, switching to a moderate UBI generates a gain in aggregate welfare. To investigate the reasons for the opposite pattern, I decompose the welfare change along several dimensions.

Regarding of different groups' welfare change, some stayers under full participation setup suffer both benefit loss and the distortionary effect of a higher tax. On the contrary, under incomplete participation setup, the optimal UBI can redistribute resources to those benchmark eligible non-participants, which is welfare-improving. The removal of participation friction contributes positively to stayers' welfare change but the magnitude is small. Therefore, I conclude that the program participation margin matters for evaluating the policy reform, and the key benefit of a properly sized UBI program is in extending benefits to a broader share of the eligible population with moderate increase in the tax burden.

Related literature: This paper contributes to two strands of literature. First, it contributes to the growing UBI literature.[7] Hoynes and Rothstein (2019) provided a comprehensive descriptive analysis of UBI. In the empirical literature, Jones and Marinescu

[6]For instance, saving is expected to increase after removing the asset means-tested design, since individuals need not to save less to be eligible for the program.

[7]This paper mainly focuses on US-related literature. There are also many empirical papers that analyzed similar programs in other countries: Hanna and Olken (2018); Banerjee et al. (2019); Boccanfuso et al. (2020)

(2018) analyzed Alaska Permanent Fund (APF)[8] and found no effect on employment along extensive margin but an increase in part-time work (intensive margin). Pilkauskas et al. (2022) analyzed the short-term unconditional Child Tax Credit and found improvement in economic wellbeing but no effects on labor supply.

There is a growing amount of work that quantitatively analyzes the effects of replacing existing schemes with UBI. These papers have different emphases from this paper, and none allows for endogenous program participation. Fabre et al. (2014) focus on comparing UBI and unemployment insurance. Conesa et al. (2020) and Ferriere et al. (2022) study the optimal financing scheme for the UBI, where the former focus on the consumption tax and the latter focus on the progressivity. Daruich and Fernandez (2020) focus on the effect of UBI reform on human capital investment, and Santos and Rauh (2022) study how UBI reform affects the labor market using the search-matching framework. There are also many papers analyzing the macroeconomic effect of the UBI on aggregates and inequality (Lopez-Daneri (2016); Luduvice (2021); Guner et al. (2021); Chang et al. (2021a); Jaimovich et al. (2022)). These papers typically find welfare losses even at the optimal level of UBI. This is in line with my findings when assuming full participation. However, none of these papers considers the participation margin of the current programs.

Second, this paper contributes to the empirical literature on EITC's incomplete take-up. Most of the recent studies only focus on aggregate participation rates (Hoynes (2019); Crandall-Hollick et al. (2021b); Chang et al. (2021b)). Two exceptions are Plueger (2009) and Jones (2013). They show participation rates by benefit region before and after the EITC reform in 2009. My paper updates their estimates.

The remainder of the paper is organized as follows: Section 2 contains an empirical analysis of EITC participation. Section 3 formulates the quantitative model, followed by calibration in section 4. In section 5, I assess the performance of the benchmark model by comparing untargeted moments and analyze counterfactual program reforms in section 6. Section 7 concludes.

[8]APF is financed through oil revenue, and the benefit is around $1,000 annually, which is far from the basic income level to live on. Moreover, APF is financed by oil tax, which does not take benefit away progressively from high-income people

2 Empirical Analysis

I conduct the empirical analysis in this section to study the participation status of a representative transfer program. The analysis aims to provide empirical evidence for incomplete program participation, which matters for modeling participation friction and checking model performance in the latter quantitative section. I first describe the Earned Income Tax Credit (EITC), which is the existing means-tested program of this paper's interest. Then, I describe the dataset construction and the sample selection for the final empirical analysis.

2.1 Earned Income Tax Credit (EITC)

EITC is an annual refundable tax credit and is the largest non-medical/pension cash transfer program in the U.S. [9] In addition to the sizable benefit, EITC also features i) a flexible benefit scheme containing both phase-in and phase-out design and ii) means-tested eligibility requirements similar to the other transfer programs.

The eligibility requirements consist of both economic and demographic restrictions. In terms of the economic requirements, both investment income and earned income have to be less than some limits.[10] In particular, the investment income limit is the same across demographic status, but the earned income limit is demographic-specific. The demographic requirements consist of

1. Number of eligible child(ren): child(ren) lived with the claimer and is younger than age 19; If the child(ren) is younger than 24 and is a full-time student, he/she is also counted as one eligible child.

2. Claimer's age: If one does not have an eligible child, the claimer's age should be between 25 and 64. Otherwise, there is no age restriction as long as the eligible child(ren) is younger than the claimer.

Once the individual/family is eligible, given demographic status, they face a trapezoid benefit scheme based on their earned income as shown in Figure 1. There are three

[9] For 2018 (i.e., 2018 tax returns filed in 2019), 26.5 million taxpayers (17% of all taxpayers) received a total of $64.9 billion from the EITC (Crandall-Hollick et al., 2021a)

[10] Investment income consists of Interest, dividends, rental income, and capital gain; while earned income consists of wage/salary, self-employment income(business or farm).

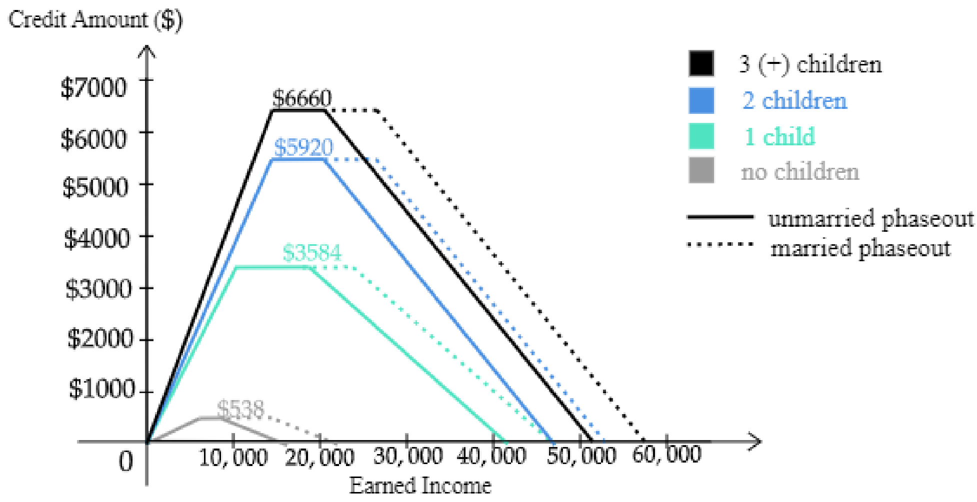

Figure 1: EITC Benefit Scheme

benefit regions. The benefit first increases with earned income in the *phase-in* region and is fixed at a maximum level in the *flat* region. As earned income keeps rising, the benefit decreases in the *phase-out* region. As is shown in Figure 1, The benefit scheme also varies across demographic characteristics. If the applicant is married or has more dependent children, then the spread of the trapezoid got expanded. In particular, the benefit at each earned income level rises with the number of kids.

To get the EITC benefit, one needs to i) file the tax form 1040 and schedule EIC form using the information on W-2 tax form, and ii) check the EITC claiming box in the form 1040. Thus, the reason for not taking up the benefit can be either not filing tax forms or not claiming the benefit. As Goldin et al. (2022) pointed out, almost two–thirds of the eligible non-participants of EITC are non-filers.[11] As a result, only 78% of eligible people take up the EITC benefit, while the other 22% eligible non-participants account for 5 million low-income people (Goldin et al., 2022).

2.2 Sample Description

To investigate who are the eligible non-participants and the participation pattern, I used the 2013 - 2016 Annual Social and Economic Supplements of Current Population Survey (ASEC-CPS). The dataset provides detailed information on tax filing status, received

[11] The main reason for not filing tax form is due to filing cost instead of information friction (Chetty and Saez (2013); Guyton et al. (2016); Linos et al. (2020)). Goodman et al. (2022) estimates the average filing cost is around 387$ for nonfilers without filing obligation and 1528$ for nonfilers with filing obligation. Given the average EITC benefit is around 2,500$, the cost is significant.

EITC benefit amount, and income. To build the correct tax units, I first construct the sample at the family level by marital status, family relationship, and age.[12] Economic variables (e.g., earnings) and program participation are then aggregated within the family.[13]

I apply the standard sample selection criteria as in literature: i) working-age (25-64) families with(out) children and young (21-24) families with children; ii) hourly wage rate is higher than half of the federal minimum wage (3.625$/hour); iii) work at least 260 hours annually; After the sample selection, I keep in total 39280 eligible observations for the EITC programs.

The dataset provides the received EITC benefits amount for participants. However, the potential eligibility for EITC and qualified EITC benefit level of the eligible non-participants are not available. To fill this gap, I imputed eligibility based on income and demographic characteristics. I then calculated the potential benefit of each eligible family (regardless of the recorded participation status) following closely the official information.

To verify the quality of the imputation, I check whether the imputed eligible group covers all participating families, who have recorded positive EITC benefits. In terms of the imputed benefits (B^{own}), I regress it on the counterpart from the raw data (B^{raw}) among recorded participants. How close the estimated coefficient is to one indicates how close these two identities are. The imputed eligible group indeed includes all recorded participants, and the imputed benefits are close to the raw data for participants. As shown in Table 1, the correlation is close to one with a high R^2 of 0.949.

[12] For example, person A, B, and C live in the same household, (A & B) are a couple, and C is their children aged 25+. So we got two families in this household ({A&B} and {C}). For households consist of more than two generations, I set that eligible children can only be claimed as dependent by their parents, or grandparents if their parents are missing.

[13] For example, $earnings_{A\&B} = E_A + E_B$; $hours_{A\&B} = H_A + H_B$; $wage_{A\&B} = earnings_{A\&B}/hours_{A\&B}$. The family participate in the transfer program if at least one of the member does so

	B^{own}
B^{raw}	1.006***
	(0.001)
R^2	0.949
Obs	32844

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 1: Benefit Comparison: Imputed v.s. Recorded

2.3 Partial Participation along Benefit Scheme

Using the sample described above, I calculated the participation rate (PR) across three benefit scheme regions to assess the incompleteness of program participation.

$$PR_i = \frac{(Size\ of\ participants\ group)_i}{(Size\ of\ eligible\ group)_i};\ i \in \{\text{Overall, Phase-in, Flat, Phase-out}\}$$

PR_i measures which proportion of eligible families at benefit region i participate in the program. The upper bound is one, which means every eligible family takes up their benefit, and the lower bound of zero refers to no participation. Thus, the incompleteness of participation increases when PR decreases.

Benefit Region	Overall	Phase-in	Flat	Phase-out
PR	0.823	0.895	0.84	0.79

Table 2: Participation Rates across Benefit Scheme

As seen in Table 2, the overall participation rate of EITC is 82.3%. This means that 82.3% of the eligible families in the survey take up their benefit. The calculated overall PR is close to the official level around 79.5%, which ensures my computation is reasonable. [14]

[14] To further validate the empirical method, I apply the imputation and PR computation to the 2006 ASEC-CPS, and get close results as Plueger (2009) and Jones (2013). The four PR levels (as in Table 2) in their papers are {0.75(±2%),0.65(±3%), 0.8(±3%), 0.79(±2%)}. My results are close to theirs: {0.74,0.59, 0.84, 0.8}.

The last three columns of Table 2 show the participation rate in the three benefit regions. Partial program participation exists across the scheme since all *PR* are less than 1. In addition, the incompleteness of the participation exhibits an increasing trend as we move along the benefit scheme (phase-in →flat→phase-out). This trend can be partially attributed to a decreasing benefit in the phase-out region. However, the participation rate is still far from 1 in the flat region, where the benefit is maximized for a given demographic group. Therefore, benefit level is not the only factor that drives partial participation.

2.4 What Drives (Non)Participation?

To better understand what factors correlate with the (non)participation, I first compared the mean of some variables of interest in Table 3.

	Eligible non-participants	Participants
#Children	1.237	1.329
	(1.003)	(1.054)
$\mathbb{1}(Married)$	0.255	0.277
	(0.436)	(0.448)
EITC Benefit	1847.4	2263.2
	(1643.4)	(1799.5)
Years of Educ.	12.64	12.53
	(2.348)	(2.5)
Invest. Income	89.6	50.75
	(357.2)	(261.7)
Wage rate	13.14	11.29
	(6.285)	(5.708)
$\mathbb{1}(Other\ welf)$	0.240	0.381
	(0.427)	(0.486)
Obs	6436	32844

Table 3: Summary Statistics

Compared to the eligible nonparticipants, participants have more children on average and are more likely to be married, which aligns with more generous benefits. Conversely, participants feature lower education, hourly wage rate and less investment income. In addition, participants are more likely to receive other welfare benefits, which reflects their sophistication in applying for social benefits.

However, the summary statistics are not fully comparable since they mix several factors simultaneously. To analyze the effect of the relevant factors more compactly, I then estimate the following Probit model among eligible groups.

$$Pr(\mathbb{P}_{it} = 1 | edu_{it}, ra_{it}, B_{it}, X_{it}) = \Phi(\beta_1 edu_{it} + \beta_2 ra_{it} + \beta_3 B_{it} + X'_{it}\gamma)$$

where the dependent variable $\mathbb{P}_{it} \in \{0, 1\}$ indicates whether the eligible family i in year t participate in EITC. Key regressors $\{edu, ra, B\}$ refer to the years of schooling, investment income and potential benefit respectively. The control set (X) includes:

1. benefit-related variables: marital status, number of eligible children.
2. demographic variables: age, state of residence.
3. economic variable: hourly wage rate, other welfare receipt status, other income.[15]

Variable	Average Semielasticity		
Invest.Income	-0.003***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)
Hourly Wage	-0.078***	-0.072***	-0.074***
	(0.005)	(0.006)	(0.006)
Education	0.025*	0.032*	0.043***
	(0.012)	(0.012)	(0.012)
Benefit	0.034***	0.043***	0.033***
	(0.002)	(0.004)	(0.004)
Benefit-factor control	N	Y	Y
Other controls	N	N	Y
Obs	39280	39280	39280
Pseudo R^2	0.024	0.032	0.049

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Program Participation Pattern

Table 4 shows the estimated average semi-elasticity. Eligible families with higher investment income or hourly wage rates are less likely to participate. For example, if investment income increases by 1%, then the likelihood of participating in EITC decrease by 0.3 percentage points. This negative effect can be due to higher hassle costs

[15]One might worry the wage rate and EITC benefit are closely correlated. However, due to the trapezoid (non-linear) scheme and hours worked, such multicolineariry issue not happened.

arisen from specifying all types and levels of earned income in tax forms. In contrast, the likelihood of participation is higher for families who qualified for a higher benefit or are more educated. The former entails benefit seeking motive since larger benefit compared to the hassle cost makes EITC more attractive. The latter implies that the participation cost is lower for educated people as it is easier for them to handle the application process.

In summary, the empirical analysis provides evidence of incomplete program participation by computing the participation rate across the benefit scheme. In addition, I use Probit analysis and identify the some factors that correlate with (non)participation. According to the existing literature and my empirical findings, I conclude the participation friction of EITC works as hassle cost, as people need to specify demographic and income information correctly while filing several tax forms.[16]

3 The Model

To analyze the quantitative effect of replacing EITC with UBI in a more realistic setup that features incomplete program participation, I build an incomplete market heterogenous-agent life-cycle dynamic general equilibrium model (Aiyagari (1994); İmrohoroglu et al. (1995)) with program participation margin. Moreover, the model features the labor supply adjustment along both intensive and extensive margins. It is important to have comprehensive endogenous labor supply for analyzing the reform as Kleven (2019) shows EITC has significant effects on encouraging work, especially along the extensive margin. In contrast, one of the critical concerns of UBI is lowering working incentives or labor force participation due to the large income effect. In the model economy, there are three sets of agents: heterogeneous households, a representative firm, and a government.

3.1 Household Problem

The economy consists of a continuum of agents that are heterogeneous in age (j), wealth (a), skill (η), and productivity(ϵ). Agents are born with zero assets ($a_{j=1} = 0$)

[16] Financial cost cannot work here due to the incomplete participation at flat region, which stands for maximum benefit.

and permanent skill level (η). The time endowment in each period is one, from which agents choose hours of work and leisure. Agents work until the mandatory retirement age J_r and live until age J.

During working age ($j = 1 \dots J_r - 1$), agents face an uninsurable idiosyncratic labor productivity shock every period, which follows a finite-state Markov-Chain $\Pi(\epsilon'|\epsilon)$. With the realized productivity and other endowments, agents can have a pre-tax income as a sum of salary and investment income ($y = w\eta\epsilon\tilde{h} + ra$), where w is the market wage rate per efficiency labor, and r is the market interest rate. $\tilde{h}$ denotes the labor service agent supply, which is a kinked function of hours of work (h) (Prescott et al. (2009); Chang et al. (2019)):

$$\tilde{h} = \max\{0, h - \zeta\}, h \in [0, 1]$$

where ζ denotes the time commuting cost. This kinked mapping gives rise to labor supply adjustment along both intensive and extensive margins: larger ζ raises marginal cost and lowers the marginal benefit of working simultaneously, which undermines the value of working. Both labor income and investment income are subject to a progressive income tax, and I use the log-linear approximation for the post-tax disposable income y^d (Heathcote et al., 2017).

Another component of the disposable income is the non-taxable transfer benefit $B(ra, w\eta\epsilon\tilde{h})$. Based on the income type and level, agents can check their eligibility for the transfer program and decide whether to participate ($\mathbb{P} \in \{0, 1\}$) if eligible. Participants get the transfer benefit but pay a utility participation cost $\kappa(\eta)$.[17] I set the utility participation cost as a decreasing function of skill (η), which is inspired by the positive effect of education on program participation from empirical analysis:

$$\kappa(\eta) = \frac{\nu_1}{1 + exp(\nu_2\eta - \nu_3)}, \quad \kappa'(\eta) < 0; \quad \nu_i > 0, i \in \{1, 2, 3\}$$

The justification for this setting is: it is relatively easier for a more educated individual to file tax forms or learn the application process, which translates into a lower

[17] Finn and Goodship (2014) summarized the reasons for non-participation into four categories: i) stigma (Friedrichsen et al. (2018);Moffitt (1983)); ii) unawareness of the program(Coady et al. (2013), Bhargava and Manoli (2015)); iii) transaction cost(Gray (2019), Gray et al. (2019), Homonoff and Somerville (2019), Grogger (2002)) and iv) expected benefit. I choose univariant heterogeneous utility cost, which is justified based on program pattern in empirical analysis.

participation friction.

Agents then allocate the disposable resources to consumption(c) and savings(a'). In summary, the working-age household problem is:

- **Working-age households** ($j < J_r$) value consumption, dislike working and discount future utility using a discount factor $\beta \in (0,1)$. Taking the tax scheme, market prices (w, r), and aggregate distribution (Γ) as given, agents maximize the expected discounted utility by choosing how much to consume(c), save(a'), hours of work(h) and whether to participate in the transfer program ($\mathbb{P}$). The formulation of the working-age households' problem is:

$$
\begin{aligned}
V(j, a, \eta_i, \epsilon_k) &= \max_{c,a',h,\mathbb{P}} \frac{c^{1-\sigma}}{1-\sigma} - \theta \frac{h^{1+\psi}}{1+\psi} - \kappa(\eta_i)\mathbb{P} + \beta \sum_{l=1}^{N_\epsilon} \pi_{kl} V(j+1, a', \eta_i, \epsilon_l) \\
s.t. \quad & c + a' \leq a + y^d(w\eta_i\epsilon\tilde{h} + ra) + B(ra, w\eta_i\epsilon_k\tilde{h})\mathbb{P}; \\
\tilde{h} &= \max\{0, h-\zeta\}, h \in [0,1] \\
a' &\geq 0; \;\; c \geq 0; \;\;\; \mathbb{P} \in \{0,1\}
\end{aligned}
$$

  where π_{kl} is the transition probability of productivity $Pr(\epsilon' = \epsilon_l | \epsilon = \epsilon_k)$ and $y^d(.)$ denotes disposable income. In addition, at the last working age ($J_r - 1$), the agent's problem becomes a bit different since there is no uncertainty in productivity next period due to retirement. With the same constraint set, the Bellman equation becomes:

$$
V(j, a, \eta_i, \epsilon_k) = \max_{c,a',h,\mathbb{P}} \frac{c^{1-\sigma}}{1-\sigma} - \theta \frac{h^{1+\psi}}{1+\psi} - \kappa(\eta_i)\mathbb{P} + \beta V^R(j+1, a', \eta_i, \epsilon_k)
$$

After agents retire ($j \geq J_r$), the taxable income consists of investment income and a fixed amount of pension payment ($pen = pw\eta\epsilon^{J_r-1}\bar{h}$). I assume pension payment depends on the fixed replacement rate p and the labor efficiency level at one year before retirement ($\eta\epsilon^{J_r-1}$). The transfer program is not available for retirees, which mimics the age limits of the EITC. Therefore, retirees decide on consumption and savings under a deterministic setting. The formulation of the retirees' problem is:

$$
\begin{aligned}
V^R(j, a, \eta_i, \epsilon_k) &= \max_{c,a'} \frac{c^{1-\sigma}}{1-\sigma} + \beta V^R(j+1, a', \eta_i, \epsilon_k) \\
& s.t. \quad c + a' \leq a + y^d(ra + pw\eta_i\epsilon_k\bar{h}); \;\; c \geq 0; \;\; a' \geq 0
\end{aligned}
$$

At the last age ($j = J$), agents consume everything on hand and does not save($a'_{j=J} = 0$).

3.2 Government

The government levies a progressive income tax on households, and uses the tax revenue to pay i) autonomous expenditure, which is modeled as a fixed proportion of output ($G = gY$); ii) EITC transfer payments for the working-age participants, and iii) pensions for all retirees. I employ the log-linear tax function (Benabou (2002);Heathcote et al. (2017)) to represent the U.S progressive tax system. Denote y, y^d as the taxable income and disposable income respectively. Total tax revenue ($\mathcal{T}$) is:

$$
\begin{aligned}
\mathcal{T}(\lambda, \tau) &= \int_{s \in \mathcal{S}} y(s) - y^d(s) d\Gamma(s) = \int_{s \in \mathcal{S}} y(s) - \lambda y(s)^{1-\tau} d\Gamma(s) \\
where\ y &= \begin{cases} w\eta\epsilon\tilde{h} + ra & if\ j \leq Jr - 1 \\ pw\eta\epsilon^{J_r - 1}\bar{h} + ra & if\ j \geq Jr \end{cases}
\end{aligned}
$$

where $(j, a, \eta, \epsilon) = s \in \mathcal{S}$ demotes a state vector; $\tau \in (0, 1]$ governs the progressivity of the tax system, and λ controls the average tax rate.

The transfer program in the model mimics the average EITC benefit scheme closely in terms of means-tested requirements and benefit scheme. Similar to the EITC in the real world, the eligibility requirement consists of both earning ($\bar{E}$) and investment income limits($\bar{d}$). The eligibility region ($\mathcal{E}$) becomes:

$$
\mathcal{E} = \{(j, \eta, \epsilon, a) | j < J_r;\ w\eta\epsilon\tilde{h} \leq \bar{E};\ ra \leq \bar{d}\}
$$

For computational convenience, I abstract the benefit scheme from variations in marital status and number of children. Instead, I use one trapezoid scheme to represent the average EITC benefit, where the average is taken over the number of children. Figure 2 visualizes the benefit scheme as a trapezoid mapping of the earnings ($e = w\eta\epsilon\tilde{h}$), and the benefit modeling follows.

$$B(ra, w\eta\epsilon h) = \begin{cases} s_1 e & e \in [0, E_1) \\ \bar{b} = s_1 E_1 & e \in [E_1, E_2) \\ s_2(\bar{E} - e) & e \in [E_2, \bar{E}] \end{cases}$$

where $s_1 > 0$ refers to the phase-in rate and $s_2 > 0$ is the phase-out rate. The earning level E_1 correspond to the end point of the phase-in and E_2 is the starting point of phase-out.

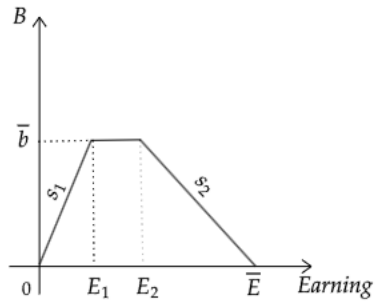

Figure 2: EITC Scheme in Model Economy

Overall, the government adjusts average tax parameter λ to keep the following budget balanced:

$$\underbrace{g * Y}_{G} + \int_{s \in \mathcal{S}} \underbrace{\mathbb{1}(j \geq Jr) pen(s)}_{Pension} + \underbrace{(1 - \mathbb{1}(j \geq Jr)) B(s) \mathbb{P}(s)}_{EITC} d\Gamma(s) = \mathcal{T}(\lambda, \tau)$$

where $\mathcal{T}(\lambda, \tau)$ is the aggregate tax revenue from individual tax payment.

3.3 Firm

A representative firm produces a consumption good with Cobb-Douglas technology in a competitive market. Taking the production factor prices (w, r) as given, the firm solves a static profit maximization problem by choosing how much efficiency labor to hire (L) and how much capital to rent (K).

$$\max_{K,L} F(K, L) - \delta K - rK - wL; \ where \ F(K, L) = K^{\alpha} L^{1-\alpha}$$

The first order conditions of the firm are:

$$F_K(K,L) = \alpha\left(\frac{K}{L}\right)^{\alpha-1} = r + \delta$$
$$F_L(K,L) = (1-\alpha)\left(\frac{K}{L}\right)^{\alpha} = w$$

3.4 Welfare Measure

The utility function is additively separable in consumption(c), labor(h) and participation friction(κ). Following Bakis et al. (2015) closely, I compute the certainty equivalence of consumption($\hat{c}$) and hours($\hat{h}$) net of participation friction for each state bundle $s \in \mathcal{S}$.[18] Denote $V(s) = V^c(s) - V^h(s) - V^\kappa(s)$ as the value of state bundle s, the certainty equivalent levels of consumption and labor solve the following equations (Bakis et al., 2015):

$$\begin{aligned} V^c(s) &= E\sum_{t=0}^{J}\beta^t\frac{c(s)^{1-\sigma}}{1-\sigma} = \frac{1}{1-\beta}\frac{\hat{c}(s)^{1-\sigma}}{1-\sigma} \\ V^h(s) &= \theta E\sum_{t=0}^{J}\beta^t\frac{h(s)^{1+\psi}}{1+\psi} = \frac{\theta}{1-\beta}\frac{\hat{h}(s)^{1+\psi}}{1+\psi} \\ V^\kappa(s) &= V(s) - V^c(s) + V^h(s) \end{aligned}$$

The social welfare ($\mathcal{W}_i$) is defined as the weighted sum of the agents' value function:

$$\mathcal{W}_i = \int_{s\in\mathcal{S}} V_i(s)d\Gamma_i(s) = \int_{s\in\mathcal{S}}\left(V_i^c(s) - V_i^h(s) - V_i^\kappa(s)\right)d\Gamma_i(s); \quad i \in \{0,1\}$$

where subscript $i = 0$ denotes the pre-reform economy and $i = 1$ for the post-reform economy.

One of the criteria to evaluate the policy reform is the change in social welfare, which is computed using consumption equivalence variation (CEV). The aggregate welfare change ($\%\mathcal{W}$) is the sum of each agent's CEV weighted by the post-reform stationary distribution. Like value function decomposition above, I separate the aggregate welfare change into consumption ($\%\mathcal{W}^c$), labor ($\%\mathcal{W}^l$) following closely Conesa et al. (2009). Denote a state bundle as $s \in \mathcal{S}$, I compute the CEVs using the following

[18] Compute certainty equivalence of consumption and labor twice. The first time attribute participation friction in consumption while the second time in labor. Thus, the utility of participation friction is obtained by contrasting two versions of certainty equivalence of either consumption or labor.

equations:

$$
\begin{aligned}
\textit{Aggregate} \quad &: \quad v(\hat{c}_1(s), \hat{h}_1(s)) = v((1 + \%\mathcal{W}(s))\hat{c}_0(s), \hat{h}_0(s)) \\
\textit{Consumption-only} \quad &: \quad v(\hat{c}_1(s), \hat{h}_0(s)) = v((1 + \%\mathcal{W}^c(s))\hat{c}_0(s), \hat{h}_0(s)) \\
&\Rightarrow \quad \%\mathcal{W}^c(s) = \left(\frac{\hat{c}_1(s)}{\hat{c}_0(s)}\right) - 1 \text{ by additive separable} \\
\textit{Labor-only} \quad &: \quad v(\hat{c}_1(s), \hat{h}_1(s)) = v((1 + \%\mathcal{W}^l(s))\hat{c}_1(s), \hat{h}_0(s)) \\
&\Rightarrow \quad \%\mathcal{W}^l(s) = \left[1 - \frac{\chi}{1+\psi}\left(\frac{\hat{h}_1(s)^{1+\psi} - \hat{h}_0(s)^{1+\psi}}{u(\hat{c}_1(s))}\right)\right]^{1/(1-\sigma)} - 1
\end{aligned}
$$

In addition to the welfare change arisen from consumption and labor, program participation margin affects welfare change through elimination of participation friction ($\%\mathcal{W}^{\kappa}$). Thus, by the additively separable of the three component in the value function, the decomposition of the aggregate welfare change is:

$$\%\mathcal{W} = \%\mathcal{W}^c + \%\mathcal{W}^l + \%\mathcal{W}^{\kappa}$$

4 Calibration

In this section, I describe how I calibrate the model to replicate US economy in the 2010s. To contrast with the existing literature and assess the role of program participation margin, I also formulate another version of model without participation friction, which generates full EITC participation. I calibrate both versions, which differ in the EITC's participation (full or incomplete), to target the same moments of the U.S economy. Doing so makes the two versions of the model start at the same points and makes the latter responses towards the reform comparable.

To quantify the formulated models, I first set some parameters' values to the levels that are widely used in the literature. Then, I calibrate the remaining parameters to match the moments from the data. The following calibration strategies apply to both versions.

4.1 Demographic and Preference

The model period is one year. Agents born at age 21, retire at age 45 and live until age 80. The preference parameter set includes a discount factor (β), the coefficient of relative risk aversion (σ), the inverse elasticity of labor supply (ξ), the disutility of work (θ), time commuting cost (ζ) and three utility program participation cost ($\nu_{1,2,3}$).

I set the σ equal to 1.5, which is a standard level in the literature. The curvature parameter of labor utility ψ is set to 1.2, which implies a Frisch elasticity of 0.83 (Kaymak et al., 2020). After anchoring the utility curvature, I can uniquely calibrate three participation friction parameters ν_is to match the participation rates in three benefit scheme regions (phase-in/out, flat) computed in the empirical analysis (Table 2). The remaining preference parameters (θ, ζ, β) are jointly calibrated to match average hours of work, labor force participation, and the capital-output ratio, respectively (See Table 5).

4.2 Productivity Process

I assume that the total labor efficiency (ω) consists of both permanent (η) and stochastic (ϵ) elements. Furthermore, I assume the stochastic element follows a first-order autoregressive process with white noise ξ, which follows a standard normal distribution with the standard deviation of σ_ξ:

$$\ln \omega = \ln \eta + \ln \epsilon; \quad where \ \ln \epsilon \sim AR(1, \rho, \sigma_\xi)$$

I use the panel data on the hourly wage from Survey of Income and Program Participation (SIPP) 2014 series to estimate the productivity parameters. The sample covers year 2013-2016 and follows the same sample selection as in section 2.2. I estimate the following regression to decompose the permanent and stochastic components:

$$\ln w_{it} = \gamma_t + f(3, edu_{it}) + \epsilon_{it}$$

where γ_t denotes the year fixed effect and $f_{it} = f(3, edu_{it})$ is the cubic polynomial of the years of schooling for family i at time t. The predicted $\hat{f}_{it}$ captures the permanent component of labor efficiency ($\ln \eta$), and I use the its quartile levels as the skill grid in the model.

Residual ϵ_{it} represents the stochastic component of labor efficiency. To quantify the parameters of the AR(1) process, I estimate the persistence ρ and the variance σ_ξ using the minimum distance method as in Kim (2022). Lastly, I employed the Tauchen algorithm to discretize the stochastic productivity space and get the transition matrix $\Pi(\epsilon'|\epsilon)$.

4.3 Production, Tax, Transfer

According to National Income and Product Account (NIPA), I set the capital income share (α) equal to 0.35, and calibrate the deprecation rate (δ) to match the annual risk-free interest rate around 4%.

The pension replacement rate (p) is set to 0.4. The tax progressivity is set to be 0.137 as what Wu (2021) estimated. The government expenditure ratio (g) is calibrated to match the income-weighted average tax rate of 0.34 as in Heathcote et al. (2017).

Figure 3 shows the average EITC benefit for 14 earning groups from the data, where the width of each bar represents 3500$ (e.g., the first bar represents earned income between 0 and 3500$). The average benefit scheme preserves the trapezoid shape, and I calibrate the scheme parameters to capture the characteristics of the fitted average EITC benefit scheme.

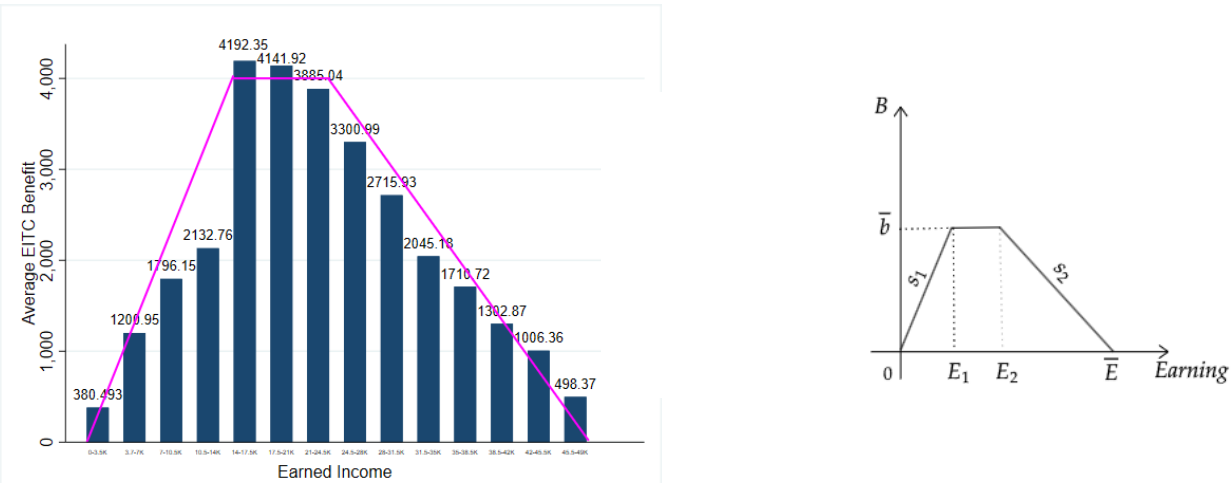

Figure 3: Average EITC Benefit Scheme

According to the left diagram, the phase-in scheme ends around the fourth bar, which corresponds to the earnings of 14,000$. The average benefit reaches at the maximum level around 4,000\$, which implies the phase-in rate of $\frac{4,000}{14,000} = 0.285$. The benefit starts phasing out after the seventh bar, which corresponds to the earnings of 24,500\$. Mapping these stylized facts into the model, E_1 denotes the earning level terminating phase-in and E_2 denotes the earning level at which phase-out starts. I calibrate these two parameters to match the corresponding ratios of threshold and average earnings. Assuming average earnings is 60,000\$, (E_1, E_2) are calibrated to match $(\frac{14,000}{60,000}, \frac{24,500}{60,000})$ respectively.

Table 5 summarizes the endogenously calibrated parameter values for two versions of the model, which differ in the participation setup of the means-tested program. The difference between two set of calibrated parameters is relatively small. In addition, The model generated moments under both incomplete (IP) and full participation(FP) setup are close to the counterparts in the data (the last two columns of the Table 5). Therefore, both setups have similar starting points of the benchmark economies and both can be used as labs for analyzing the latter reforms' effects are comparable.

Parameter	Description	Value	Targeted moment	$Moments^{Data}$	$Moments^{Model}$
β	discount rate	0.9618*(0.963)*	Cap-output ratio	3	3.01*(3)*
θ	labor disutility	8.9*(8.18)*	Avg. Hours	0.33	0.33*(0.32)*
ζ	time commuting cost	0.31*(0.33)*	Emp.Rate	0.8	0.81*(0.8)*
g	G/Y	0.195*(0.19)*	Avg.Tax.Rate	0.34	0.32*(0.32)*
E_1	End of Phase-in	0.14*(0.14)*	$E_1/\bar{Earnings}$	0.23	0.24*(0.24)*
E_2	Start of Phase-out	0.23*(0.23)*	$E_2/\bar{Earnings}$	0.41	0.41*(0.41)*
δ	Depreciation	0.076*(0.076)*	r^*	4%	4.01%*(4.02%)*
v_1, v_2, v_3	participation cost	0.916,3.75,3.112	$PR_{\{in,flat,out\}}$	{0.895,0.84,0.79}	{0.895,0.87,0.65}

Notes: calibrated parameters value in brackets correspond to full-participation setup; Three participation rates correspond to three scheme regions (phase-in, flat, phase-out)

Table 5: Endogenous Calibrated Parameters

5 Benchmark Economy

In this section, I assess the model performance by comparing some untargeted model-generated moments with their counterpart in data. I begin with the comparison of economy aggregates followed by assessments of the distributions' fitness. In addition, I also compare the labor elasticities between the model and data, which is essential for the behavior response toward the UBI reform. Lastly, I check whether the program participation pattern is consistent between the model and data.

5.1 Aggregates and Distribution

In Table 6, I compare some untargeted aggregates from the model with the counterpart from real data. The model-generated consumption-output ratio (C/Y) is consistent with the US data under both participation setups. Investment-output ratio (I/Y) is coherent with data due to the calibration of the capital-output ratio and interest rate. As I only targeted the average hours of work in the calibration stage, I further checked the untargeted variation in work hours to ensure the validity of the labor supply decision. Overall, the untargeted aggregates are consistent with US data.

	Data	Model(IP)	Model(FP)	Source
C/Y	0.67	0.575	0.58	FRED
I/Y	0.18	0.229	0.23	FRED
CV_H	0.27	0.23	0.234	Bakis et al. (2015)
$Gini_{Y^{pre}}$	0.595	0.516	0.527	CBO
$Gini_{Y^{post}}$	0.423	0.438	0.441	CBO
$Gini_{Wealth}$	0.7	0.628	0.648	Luduvice (2021)
Share of 0 wealth	0.08	0.12	0.136	Kim (2022)

Notes: The abbreviations corresponds to consumption-output ratio(C/Y); investment-output ratio(I/Y); Coefficient of variation of hours (CV_H); Gini coefficient for income (Y) and wealth (K)

Table 6: Untargted Aggregates

The transfer programs screen out eligible people by means-tested scheme and redistribute resources toward low-income people. Thus, the untargeted distributions of income and wealth matter since they contain information on the mass of people in need and the inequality of the economy, both of which have implications for the worthiness of UBI reform. I use the Gini coefficient of pre-and post-tax income to represent the income distribution. In terms of wealth distribution, I checked both the Gini coefficient of wealth and the share of zero assets. All these untargeted measurement of distributions align with the data as shown in Table 6. Overall, both versions of model performs well in terms of the untargeted aggregates and distributions.

5.2 Labor Supply Elasticity

One of the key concerns of a generous reform is the distortionary effect on labor supply. The extent of the distortion depends on the labor elasticity and the benefit scheme changes. As I already calibrate the benefit scheme before, the remaining labor supply elasticity is another set of critical moments.

Using model-generated data, I obtain the labor elasticities by running a log-log regression. The dependent variable is the log of hours of work, and the regressors are the log of wealth ($\ln a$), the log of hourly efficiency ($\ln \omega$), and age. I approximate the non-labor income elasticity using the estimated coefficient of $\ln a$ and the substitution elasticity using the estimated coefficient of $\ln \omega$.

	Data	Model(IP)	Model(FP)	Source
Income elasticity	-0.1 to 0	-0.044	-0.042	McClelland and Mok (2012)
Substitution elasticity	0.1 to 0.3	0.101	0.07	McClelland and Mok (2012)
Frisch elasticity	0.68 to 0.96	0.83	0.83	Blundell et al. (2016)

Table 7: Labor Supply Elasticity

Table 7 compares three relevant labor elasticities between literature and model-generated ones. The Frisch elasticity is targeted while the other two are not. The substitution and income elasticities matter for this paper by the potential effects of transfer program on labor supply. EITC's phase-in/out designs alter participants' behaviour mainly through substitution effect while the UBI program has large income effect. As shown in Table 7, all three elasticities are consistent with empirical studies. In addition, the magnitudes of the elasticity are close to range of empirical estimates.

5.3 Program Participation

In the calibration stage, the model with the incomplete participation setup only targets the participation rates across trapezoid benefit scheme while leaving the participation pattern and participation sensitivity free. Both untargeted moments identify who are the eligible (non)participants of the means-tested program, and are essential for validating the incomplete program participation modeling. This section assesses the program participation pattern from the model with the incomplete participation setup.

Probit Model Estimates		
	Invest.income	Wage
Data	-0.003***	-0.079***
	(0.001)	(0.006)
Model	-0.054***	-0.133***
	(0.006)	(0.016)

Table 8: Model v.s. Data: Average Semielasticity

Using the model-generated data, I run a simple probit model of EITC participation on two variables: investment income (ra) and hourly efficiency ($\omega = \eta * \epsilon$). I also re-run the Probit model with these two regressors using survey data. Table 8 presents the estimated average semielasticity of the two variables. The results are qualitatively consistent between model and data: agents with higher investment income or more productive, which is approximated by higher hourly wage rate in the survey data, are less likely to participate. This qualitative consistency ensures the model captures the right identity of the eligible (non)participants, which enhances the model's validity.

The model's results are, on average, 0.05 larger in absolute value. Relatively speaking, this difference of 0.05 matters less along the hourly efficiency dimension but is a large jump along the investment income dimension. One possible reason for this can be attributed to plenty of families with zero or tiny investment income in the data, which biases the estimates. However, the magnitude of the elasticity is the second priority since the counterfactual reform eliminates the participation friction and there is no intensive adjustment in (non)participation.

Overall, the calibrated models with two participation setups perform well in terms of both targeted and untargeted moments. Next, I will analyze the effects of UBI-reform using the well-perform models.

6 Program Reforms

In this section, I use the two versions of the calibrated models to analyze the effect of the counterfactual program reforms. The reform removes all means-tested features (eligibility screening, trapezoid benefit) of the EITC. In addition, the program participation friction also gets eliminated under the incomplete participation setup, which ensures the universality property of UBI.

I conduct two UBI reforms that differ in benefit size. The first one is worth 12,000$ annually, which is the one from public debate. The second UBI reform is the one that maximizes social welfare. It turns out that this involves much lower transfer payments of 3,750$ annually and 3,300$ annually under incomplete and full participation setup respectively.

6.1 Generous UBI reform

The first non-taxable UBI benefit is worth 12,000$ annually, which is a level that is widely discussed in the literature and public debate. This benefit size is generous. Note that the EITC's average maximum benefit is around 4000$, and the average EITC benefit is 2,500$. Thus, the generous UBI benefit is almost five times of EITC's average benefit. On a broader level, 12,000$ is approximately 28.6% of the average disposable income in the U.S, and it is close to the poverty line. Thus, the first reform should raise more fiscal pressure.

Analyzing this generous reform is necessary: On the one hand, the analysis checks whether my results under the full-participation setup are consistent with the literature. On the other hand, the analysis enables me to assess the role of program participation margin by comparing the responses between two participation setups.

6.1.1 General Equilibrium (GE) Response

Figure 4 shows the aggregate responses toward generous UBI under the general equilibrium. The yellow bars correspond to the incomplete participation setup, and the blue bars refer to the full participation setup, which is the setup widely used in the literature. The responses are qualitatively consistent between the two setups. Under generous UBI, the average tax rate increases significantly to finance the reform, which is due to the benefit's universality and generosity. Such general equilibrium effect distorts the agent's behaviors. The aggregate saving decreases as higher tax reduces the marginal return of savings.

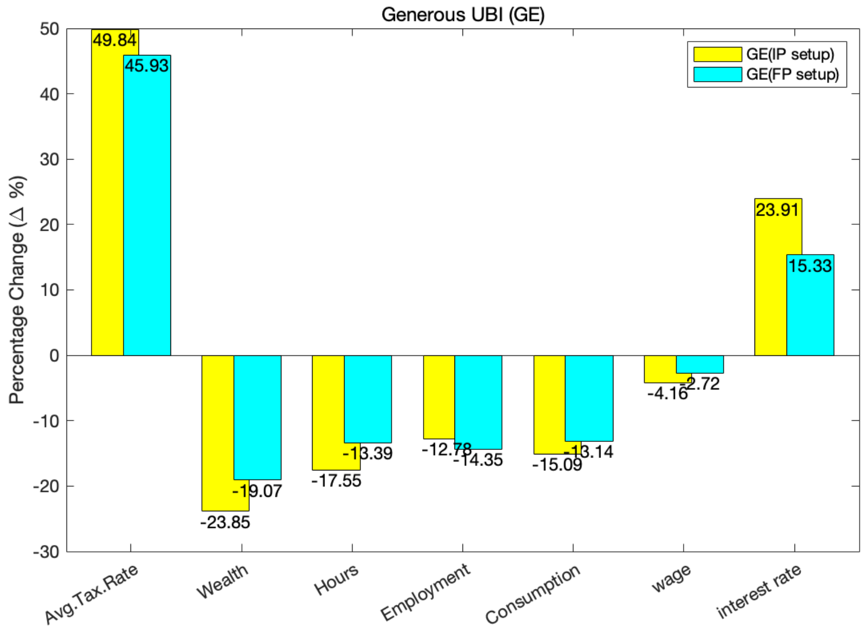

Figure 4: General Equilibrium Response Comparison

In addition to the general equilibrium effect, labor supply was also affected by the change in the benefit scheme. The labor supply decreases along both intensive and extensive margins. On the one hand, the significant income effect of UBI reduces the labor supply. On the other hand, removing EITC's incentivizing design (phase-in) also discourages agents from working. As a result of the distortions, the aggregate consumption and output also decrease, which contribute negatively to the aggregate welfare change. Lastly, the larger savings decline translates into an interest rate increase, and the wage decreases a bit by the complementary relationship between capital and labor. Overall, the generous UBI reform is costly in terms of financing pressure and distortionary effect on agents' behaviors.

Although the responses are in the same direction across two participation setups, the magnitudes are mostly larger under the incomplete participation setup. This pattern can be attributed to the program participation margin, which is the critical distinction between the two setups.

Figure 5 visualizes the compositional differences between two setups. Green indicates participants, while gray is for nonparticipants. The EITC eligibility and take-up status divide the populations into three groups. By EITC eligibility, we have eligible (located in the red box) and non-eligible groups. By EITC take-up status, we can further divide the eligible group into two groups.

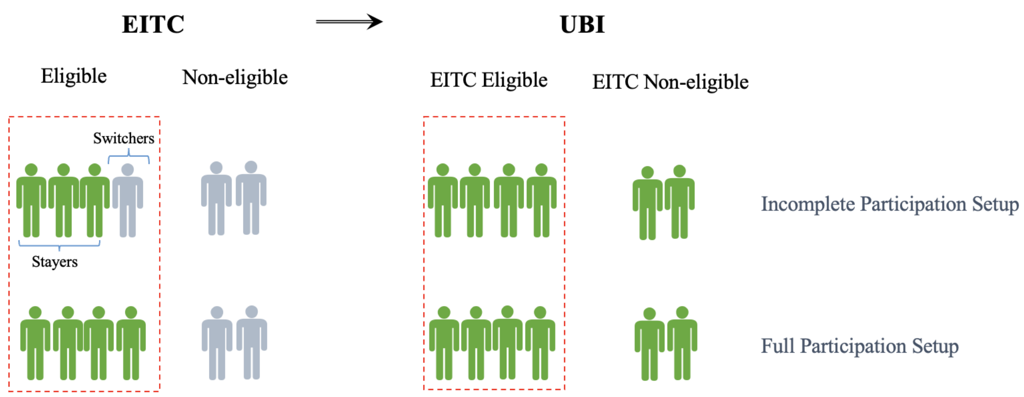

Figure 5: Difference between Two Setups

All eligible agents take up the EITC benefits without any friction under the full participation setup (second row of Figure 5). In contrast, participating in EITC is costly under the incomplete participation setup. Thus, some eligible agents take up the EITC benefit but pay the participation cost, while others choose not to participate due to a relatively high participation friction. After UBI reform, everyone turns green, and we can define two other groups by the transitions of the take-up status. Agents, who stay participating in both pre-and post-reform programs, are denoted as stayers. I denote the other eligible agents as switchers, since they were eligible nonparticipants under EITC but switch to take up the UBI benefit after reform.

Since general equilibrium results mix many changes simultaneously, I then conduct the partial equilibrium analysis to study the effects of the program participation margin, excluding the other factors change (e.g., prices change).

6.1.2 Partial Equilibrium (PE) Analysis

The partial equilibrium analysis, which fixes prices, taxes and distribution as of the pre-reform steady state, solely investigates the behaviour effects of changing the benefit scheme on the benchmark eligible group. I focus on the eligible group in this stage, since it reflects the key differences between two setups. The non-eligible group shares similar feature across two setups due to the means-tested screening. Figure 6 shows the behavior responses under the incomplete participation setup. Following the previous classification, I decompose the responses into stayers' (red bar), switchers' (green bar). The benchmark eligible group's response (yellow bar) is a weighted sum of stayers' and switchers'.

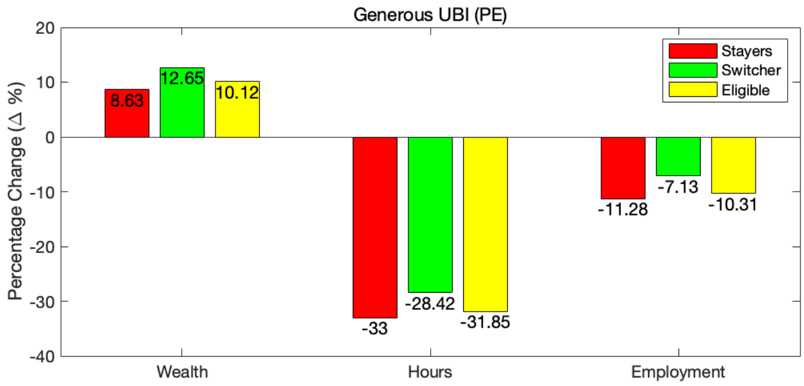

Figure 6: Behaviour Response under Partial Equilibrium

Stayers and switchers respond to the reform in the same direction. Both of them increase the savings arisen from the consumption-smoothing motive. The working-age resource increase due to the generous UBI benefits. Agents save more for their retirement to smooth their consumption over the life-cycle. The increase in switchers' savings is larger than stayers, which can be attributed to a larger increase in resources. Switchers take no transfer benefit before the reform, and their benefit amount jumps from zero to a generous level after the reform. With more increment in the resource, the saving is expected to rise more.

On the contrary, the generous benefit discourages labor supply of both stayers and switchers. The hours of work decreases around 24%, and the employment rate decreases around 10%.[19] In addition, the change in benefit scheme reduces stayers' labor supply more along extensive margins. Unlike switchers, some stayers' benchmark labor participation is incentivized by the EITC's phase-in design. Thus, the stayers' employment is expected to declines more due to this scheme change channel.

Responses of the benchmark eligible group are the weighted sum of the stayers' and switchers', where stayers take a weight of 75% and 25% for switchers. Although switchers' response amplifies stayers' as they react in the same direction, the amplification extent is constrained by a lower share. As a result, the eligible group's response magnitude is dominated mainly by stayers' response.

Figure 7 compares the eligible group's responses across two participation setups. The yellow bars correspond to the incomplete participation (IP) setup, and the blue bars are for the full participation (FP) setup. The difference in behavioral changes

[19]The large extent of response is driven by the large reform, as the untargeted labor elasticity fits in reasonable range.

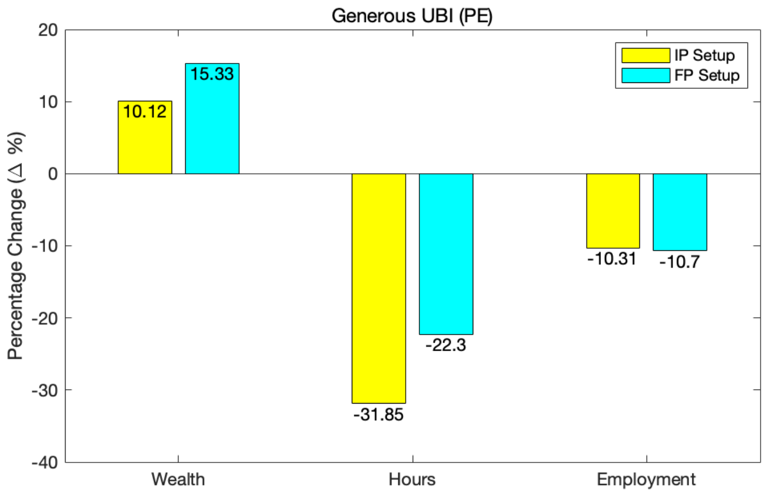

Figure 7: Behaviour Response of Eligible Group: Incomplete v.s. Full Participation

between the two setups exhibits a non-unified pattern. Eligible agents in the FP setup raise savings more than IP's, while the decline in labor supply is more dramatic under the IP setup. This pattern can be due to the compositional difference of the benchmark eligible group between two setups.

By construction, all eligible agents take up EITC benefits and are subject to all means-tested designs under the FP setup. In contrast, only partial eligible agents are affected by the scheme design under IP setup. Such attenuation in the benchmark means-tested effects is reflected in the eligible group's responses. First, the IP setup attenuates the effect of the asset means-test (AMT) in the benchmark. Facing AMT of the EITC program, agents can dissave a bit to become eligible and take up the benefit. Therefore, the savings are expected to rise after eliminating the AMT. This stimulating effect gets attenuated under the IP setup, which reflects as a less increase in savings under IP setup.

In contrast, the decline in hours of work is less under the FP setup, which can be due to the full-response towards the removal of the phase-out. Among the eligible group, most agents located in the phase-out benefit region, and only 65% of are affected by the scheme under IP setup in contrast to 100% under FP setup. As noted before, phase-out design works as an implicit tax on labor, discouraging labor supply along the intensive margin in the benchmark economy. Therefore, after removing phase-out, the decline in hours of work should be less under the FP setup due to the full mitigation effect from disincentive-removal channel.

The above comparison between IP and FP setup highlights the compositional effect of the program participation margin. On the one hand, switchers react in the same direction as stayers, amplifying the aggregate response (e.g., hours of work). On the other hand, the IP setup attenuates the expected effect of removing the means-tested scheme since only part of the eligible agents take up the benefit in the benchmark.

Comparing Figure 4 (GE) and Figure 7 (PE), we can infer how the program participation margin takes effect through another channel – general equilibrium channel. According to the PE responses, the tax base declines more under the IP setup, which is mainly driven by the decline in labor supply. Most importantly, the existence of the switchers raises the tax demand for financing larger increments in transfer benefits. Both forces lead to a larger increase in the average tax rate under the IP setup, and it reverses the response direction of savings under PE.

In summary, the generous UBI reform distorts behaviors under both participation setups. Moreover, the distortion is larger under the IP setup due to the compositional and general equilibrium effect from switchers – the key reflection of the two participation setups' differences. Next, I will evaluate this reform by investigating the welfare change and the redistributive effect.

6.1.3 Equity-Efficiency Analysis

This section analyzes the changes in welfare ($\mathcal{W}$) and redistributive effect ($\mathcal{RE}$) under two participation setups after implementing the generous UBI reform.

I define the $\mathcal{RE}$ of a given redistributive program as the percentage change in Gini coefficient of income before and after the tax-transfer. The more negative $\mathcal{RE}$ implies more reduction in inequality. I then take percentage point difference between $\mathcal{RE}^{UBI}$ and $\mathcal{RE}^{EITC}$ to infer whether UBI has larger redistributive effect than EITC.

As noted before, I decompose the aggregate welfare change($\%\mathcal{W}$) into three dimensions: consumption($\%\mathcal{W}^c$), leisure($\%\mathcal{W}^l$), and removal of participation friction($\%\mathcal{W}^\kappa$). The positive number of the welfare change implies a welfare gain and vice versa.

Setup	$\Delta\mathcal{RE}$	$\%\mathcal{W}$	$\%\mathcal{W}^c$	$\%\mathcal{W}^l$	$\%\mathcal{W}^\kappa$
Incomplete	-13.97	-1.02	-2.62	1.44	0.16
Full	-12.29	-1.77	-2.97	1.2	-

Notes: $\Delta\mathcal{RE} = \{\Delta\%Gini_{pre}^{post}\}_{ubi} - \{\Delta\%Gini_{pre}^{post}\}_{EITC}$

Table 9: Changes in Welfare and Inequality

The first row of Table 9 corresponds to the IP setup, and the second row stands for the FP setup. The equity-efficiency results under both setups share the same patterns. The generous UBI reduces inequality more significantly than EITC but accompanies with aggregate welfare loss. The welfare decreases along the consumption dimension but increases along leisure. The former is consistent with the decline in the aggregate consumption, and the latter aligns with the decrease in labor supply (or increase in leisure). Despite the qualitative consistency, the results are of quantitative differences between two participation setups.

Column two shows that the UBI's effectiveness in reducing inequality is larger under the IP setup. Under the IP setup, EITC does not redistribute resources to all eligible agents. Such shortage in redistributive effect got improved as we switche to UBI, which redistribute resources more progressively as a result of generous benefit for low-income agents and taxing away from the high-income people.

Column three illustrates a lower aggregate welfare loss under the IP setup. Although the removal of participation friction can contribute positively to welfare change, the main mitigating forces are from the welfare change along consumption(c) and leisure(l). To separately evaluate equity and efficiency concerns, I further decompose the welfare change along consumption and leisure into the level and distribution changes following Conesa et al. (2009).

$$\%\mathcal{W}^i = \%\mathcal{W}^i_{level} + \%\mathcal{W}^i_{distribution} \quad i \in \{c, l\}$$

Take $\%\mathcal{W}^c$ as an example. The aggregate consumption level decreases more under the IP setup (see Figure 4), which implies $\left(\%W^c_{level}\right)^{IP} < \left(\%W^c_{level}\right)^{FP}$.[20] Meanwhile, the welfare loss arising from consumption change is less under IP setup. Thus, under IP

[20]Note that $\left(\%W^c_{level}\right)$ is negative here. This relation shows the decline in welfare, which arisen from consumption level decreases, is larger under IP setup

setup, the lower welfare loss along consumption benefits from the equity improvement. In addition, the equity advantage complements a larger increase in leisure under IP setup, which results in a larger welfare gain along leisure dimensions.

The equity-efficiency analysis shows the generous UBI reduces inequality more significantly than EITC but with welfare loss, which is in line with the literature. In addition, the program participation margin intensifies the equity advantage and mitigates the welfare loss, which makes quantitative differences between two participation setups. Overall, replacing EITC with the generous UBI is not desirable as it induces inefficiency in the economy.

6.2 Optimal UBI

As the UBI of annual $12,000 distorts behaviors and cannot improve social welfare, what is the optimal size of UBI that maximize social welfare? In addition, what would be the welfare change at the optimum – that is, can the optimal UBI generate welfare gain or welfare loss? This subsection addresses these questions. Denote the state bundle as $s \in \mathcal{S}$, the optimal benefit size (B^*) solves the following problem:

$$B^* = arg \max_b \int_{s \in \mathcal{S}} \%\mathcal{W}(b, s) d\Gamma_1(s)$$

where $\%\mathcal{W}(b, s)$ denotes the welfare change of the individual, who endowed with s, arisen from EITC to a UBI that is worth $b\$/year$. The optimal UBI size ($B^*$) maximizes the total welfare change, which is aggregated using the post-reform stationary distribution Γ_1.

Figure 8 plots the social welfare change against various UBI levels for two participation setups. The blue line corresponds to the incomplete participation (IP) setup and the red line is for the full-participation (FP) setup. The peak of the hump-shape locus idetifies the optimal size of UBI, which is $3,750 for IP setup and $3,300 for FP setup. Such optimal benefit sizes are less than both the generous UBI and the maximum benefit of the benchmark EITC program ($\bar{b} \simeq \$4000$). Therefore, some stayers (e.g., located close to the maximum benefit region) suffer benefit loss while replacing EITC with the optimal UBI.

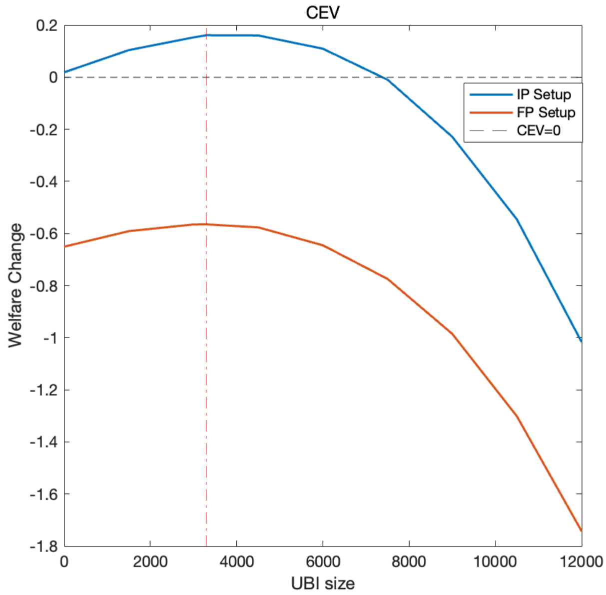

Figure 8: Welfare Change under Different UBI Size

Interestingly, at the optimal UBI level, the welfare change exhibits opposite pattern across two participation setups. This moderate UBI reform generates a welfare gain of 0.16% under the IP setup while a welfare loss of 0.57% under the FP setup. In addition, the optimal-loss pattern under the FP setup aligns with Guner et al. (2021), who uses full-participation setup and also find welfare loss under optimal UBI.[21] To explore the reasons for the opposite welfare change, I investigate the behavior responses and the welfare decomposition following similar procedures as in the last subsection.

6.2.1 Behaviour Responses under Optimal UBI

Figure 9 shows the general equilibrium responses toward optimal UBI reform under two setups. Like the generous UBI, the average tax rate increases to finance the universal benefit, but the magnitude is much less now. Moreover, under optimal UBI, most behavioral responses are opposite across the two participation setups. The savings decrease under the IP setup while increase under the FP setup. The former is mainly driven by the distortions of taxes, while the latter mixes several factors.

Under FP setup, two forces on savings work against each other. On the one hand, agents intend to save more due to eliminating the asset means-test and increment of

[21] One might think maybe zero UBI can be good under the FP setup, but this also eliminate EITC and the efficiency induced by the means-tested scheme.

the resource. On the other hand, the higher tax distorts the saving. However, as a result of a cheaper UBI, the extent of tax distortion under the FP setup is not large enough to reverse the positive effect on savings.

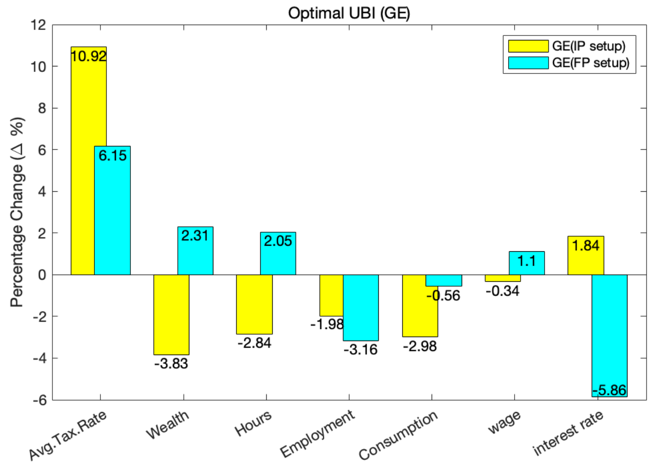

Figure 9: General Equilibrium Response Comparison (Optimal UBI)

In terms of labor supply, employment decreases under both setups, which is mainly driven by the reform's income effect and the elimination of the EITC's incentivizing design. However, the hours of work exhibit an opposite pattern in the two participation setups. In addition to fully responding to the removal of EITC's disincentive design (phase-out), some agents under FP setup suffer more benefit loss. Thus, the negative income effect also stimulates the labor supply along the intensive margin.

To isolate the general equilibrium effect, I investigate the pure effect of scheme reform on the stayers' and switchers' behaviours under the partial equilibrium. Table 10 shows the group-specific percentage change in savings, hours of work, and employment under IP setup only. The change in savings and employment shares the similar patterns and intuition as before but with a modest response magnitude. However, switchers now work against stayers' response of hours of work.

%Δ	Stayers	Switchers
Savings	2.2154	5.8743
Hours	0.2865	-5.3552
Emp.rate	-1.5405	-0.5797

Table 10: Behaviour Under Partial Equilibrium

Under the optimal UBI, we have two forces affecting stayers' labor supply in opposite directions. On the one hand, some stayers intend to work more due to either removing the phase-out design or the income effect arisen from benefit loss. On the other hand, some stayers can work less due to removing the phase-in design or benefit gain. These two forces work against each other and lower the aggregate stayers' labor response to 0.29%. In contrast, switchers lower their labor supply by five percent solely due to the income effect of the UBI.

Comparing the PE with GE results, we can infer that the distortionary effect through general equilibrium channel is more significant under the IP setup. To explain why there is a welfare gain under the IP setup, I decompose the welfare change along several dimensions for three groups of the working-age group: stayers, switchers, benchmark non-eligible.

6.2.2 Welfare Decomposition

Table 11 shows the welfare decomposition for three groups. In terms of aggregate welfare change($\%\mathcal{W}$), benchmark non-eligible agents suffer welfare loss in both participation setups[22]. On the contrary, eligible agents (stayers+switchers) have welfare gain under the IP setup while a welfare loss under the FP setup. I then investigate the reasons for these pattern along dimensions of consumption, leisure, and the removal of participation friction.

Optimal UBI					
Setup	Incomp. (3,750$/yr)			Full (3,300$/yr)	
Group	Stayers	Switchers	Non-elig	Stayers	Non-elig
$\%\mathcal{W}$	0.3192	0.3152	-0.4747	-0.3333	-0.2329
$\%\mathcal{W}^c$	0.1890	0.2852	-0.7094	-0.2397	-0.2702
$\%\mathcal{W}^l$	0.0039	0.0229	0.2327	-0.0936	0.0373
$\%\mathcal{W}^\kappa$	0.1263				

Table 11: Welfare Change by Benchmark Participation Status

[22]Non-eligible includes both working-age non-eligible agents and retirees. The welfare loss of this group is mainly driven by the retirees, who pay more taxes but not get the benefit. The working-age non-eligible agents actually have welfare gain, where more taxes is compensated by a moderate UBI benefit.

The welfare of stayers increases under the IP setup, which is mainly driven by the increase in the resources complemented by the removal of participation costs. The welfare change along leisure is tiny, which can be attributed to the competing effects on labor supply arising from changes in scheme and benefit level. On the contrary, stayers under FP setup lose welfare. In addition to squeezing leisure time for more working, the welfare loss is mainly driven by the welfare loss along consumption. The optimal UBI size under FP setup is lower, which hurts those benchmark participants with higher EITC benefit.

Switchers in the incomplete setup derive welfare gain mainly from higher consumption complemented with more leisure due to the income effect of the universal benefit. Lastly, the aggregate welfare losses of the benchmark non-eligible agents is larger under the IP setup. Moreover, other welfare components' changes are larger under IP setup as well. We can infer the reason for this pattern is due to the tax difference between two setups, which affects the resource level and the behavioural incentives. To verify the above intuitions, I decompose the welfare change along wealth - productivity joint distribution.

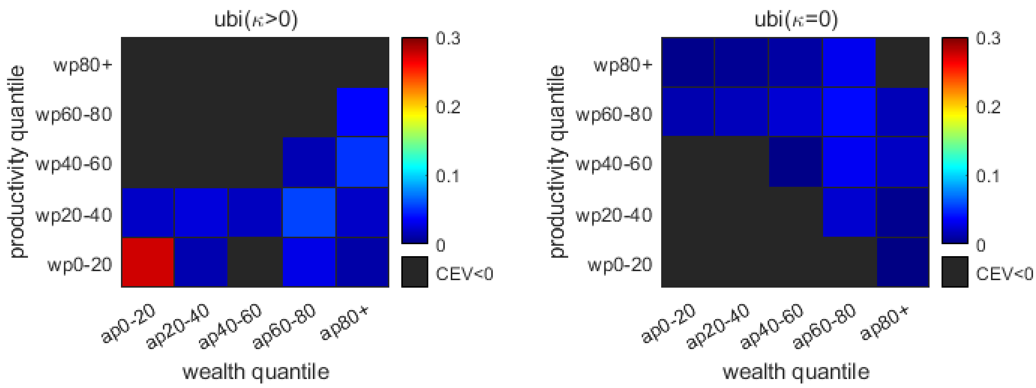

Figure 10: Welfare Decomposition along (a, ω) Distribution

In Figure 10, I divide the cells based on the pre-reform stationary distribution and use various colors representing the direction and extent of welfare change. The lighter blue indicates more welfare gain, and black areas indicate welfare loss. Beneficiaries mainly concentrate at the low productivity region under IP setup while the opposite appears in FP setup. This *symmetric* distribution pattern aligns with the difference in the redistribution. As a result of switchers' contributions and higher taxes, IP setup redistributes the resources from rich people to low-income group. In contrast, the FP setup exploit resource from low-income people (benchmark participants) by lowering the benefit.

Under the IP setup, some stayers experience a benefit loss but compensated by elimination of participation cost. Most importantly, switchers benefit from the significant increment in the resources. EITC is means-tested and well designed, but it does not reach all people in need due to participation friction. Overall the redistributive effect of UBI is higher and the tax pressure concentrate at more productive group. The opposite happens under FP setup, where some benchmark participants experience benefit loss without any compensation. Thus, the redistributive effect is less and people works more due to negative income effect. Poor people suffer welfare loss due to less social assistance while rich people are compensated by the universal benefit.

7 Conclusion

In this paper, I documented the incomplete take-up of the EITC, which the largest non-medical/pension cash transfer program in the U.S., and investigated the incompleteness and the relevant factors of the program participation using ASEC-CPS data. I then rationalized the empirical findings into an standard incomplete market life-cycle dynamic general equilibrium model (Aiyagari (1994); İmrohoroglu et al. (1995)). I calibrated the benchmark models of two setups, which differs in the means-tested program take-up (incomplete or full), to the U.S. economy and conducted two UBI-replacement reforms. In each reform, I analyze the general equilibrium effects on aggregate behaviour responses and compare them across two participation setups. To better distinguish the mechanisms of the program participation margin, I then decompose the response into stayers' and switchers' under partial equilibrium to isolate the pure reform effect on behaviours excluding prices and distribution changes. Contrasting GE and PE results enable us to infer the how program participation margin takes effect through general equilibrium channel.

In the case of generous UBI ($1,000 monthly), I find the reform reduces inequality significantly but with welfare loss. The program participation margin makes the quantitative difference and takes effect through both compositional and general equilibrium channels. On the one hand, switchers react in the same direction as stayers, which amplifies the aggregate response. On the other hand, the existence of switcher enlarges the tax demand to finance the increase in the transfer benefit, which induces more distortions in the economy. In terms of the welfare change, both setups generate welfare loss while the loss under incomplete participation setup got mitigated by a more equal distribution and elimination of participation cost.

I also solved for the optimal size of UBI that maximizes the social welfare for both participation setups, and the optimal size of UBI is less than the generous UBI and the maximum amount of benefit in benchmark EITC. Replacing benchmark EITC with the optimal level of UBI generates opposite behavioural responses across two setups. Moreover, the welfare change are opposite at the optimum. The program participation margin sheds light on this opposite pattern as it assists switchers by large increments in the benefit, which is missing under the full participation setup.

Therefore, considering the program participation margin makes both qualitative and quantitative differences in terms of behaviour response to the reform, price adjustments and efficiency-equity analysis. To summarize, replacing means-tested program with a generous UBI is not a good idea, as it is expensive and distorts the behaviours. However, a properly sized UBI program can be a good idea and the key is in extending benefits to a broader share of the eligible population.

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