Comparing the Earned Income Tax Credit and Universal Basic Income in a Heterogeneous Agent Model*

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Abstract

This study quantitatively evaluates two redistributive policies: the earned income tax credit (EITC) and universal basic income (UBI). We construct a continuous time heterogeneous agent model calibrated to the US economy and compare the expansion of the EITC with the introduction of UBI. Both policy changes encourage low-income households' labor force participation and improve social welfare measured by consumption equivalents. Meanwhile, output declines as the policies discourage precautionary savings and reduce capital stock. Furthermore, they may widen wealth inequality because redistribution lowers income dispersion, and the marginal increase in the value of holding additional assets flattens out, as do consumption and savings.

Keywords: Mean Field Game, Heterogeneous Agents, EITC, Universal Basic Income, Labor Supply

JEL Codes: E02, E62, H24, I38, J22

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1 Introduction

The social issue of widening economic disparity is currently attracting attention in the US (Saez and Zucman (2016)). Its factors have been examined from a variety of perspectives; skill-biased technological progress is one of them (Acemoglu (2002)). Given the recent development of digital technology, inequality may continue to increase.

In March 2021, the Biden administration passed the $1.9 trillion American Rescue Plan to deal with the COVID-19 crisis, which includes an expansion of the earned income tax credit (EITC) besides expanding cash and unemployment benefits. The EITC is a type of tax credit with benefits for low- to moderate-income workers, especially those with children. Policymakers are considering making expanded EITC a permanent part of the American Families Plan released in April 2021, the budget for which is $124.9 billion over 10 years.[1]

While the EITC, which is tied to labor earnings, has been implemented, there are growing expectations for universal basic income (UBI) that would provide unconditional benefits to all citizens.[2] Andrew Yang, a candidate in the Democratic primaries for the 2020 US presidential election, pledged a "Freedom Dividend" of $1,000 per month distributed to US citizens over the age of 18 years to mitigate concerns over job losses due to advancements in AI.

Although both the EITC and UBI are redistribution policies, their effects on the labor supply seem to be contradictory. The EITC, which determines the amount of tax credits proportional to labor income up to a certain amount, encourages labor supply, while a main criticism of UBI is that unconditional benefits may suppress labor force participation. However, UBI has never been introduced on a nationwide basis, and its impact on labor supply is unclear.[3] Some, such as the non-profit research organization OpenResearch, have demonstrated the effects of UBI through randomized controlled trials, but there are limits to the scale and duration of these experiments. Since the introduction of the EITC in the 1970s, the amount of credit and eligibility have been expanded. Meanwhile, as income inequality widens, UBI has become a policy choice that cannot be ignored.

In considering future redistribution policies, it is meaningful to construct an economic structural model and compare the expansion of the EITC with the introduction of UBI.

[1] In the UK, Universal Credit, similar to the EITC in the US, was introduced in 2011.

[2] See Hoynes and Rothstein (2019) for a detailed overview and definition of UBI, as well as pilot programs and policy recommendations in various countries.

[3] At the state level, there are the Alaska Permanent Fund Dividend, which is similar to UBI in Alaska, and the distribution of casino revenue to the Eastern Cherokee Indians (Akee et al. (2018)).

For this purpose, we set up a heterogeneous agent model to quantitatively compare the effects on macroeconomic outcomes, social welfare, individual utility, and inequality when such policy tools are implemented. While several studies have quantitatively evaluated the policy effects of the EITC or UBI using heterogeneous agent models (e.g., Froemel and Gottlieb (2021), Conesa et al. (2023)), the main contribution of this paper is that we assume a generous EITC (gEITC) large enough to be compared with UBI and compare them in an Aiyagari-type model, which is relatively simple but includes necessary and sufficient elements.

This study obtains four results. First, both the EITC and UBI encourage labor force participation among low-income households. This result is natural for the EITC since it requires individuals to work for benefits, but even UBI, which is considered to suppress labor supply, encourages labor supply in our settings due to the existence of means-tested benefits. In the US, means-tested benefits such as the Supplemental Nutrition Assistance Program (SNAP) and Temporary Assistance for Needy Families (TANF) are provided to low-income households, which suppresses labor supply.[4] Replacing these benefits with UBI increases the labor participation rate of those who would have chosen not to work to receive them.

Next, in terms of the impact on macroeconomic outcomes, the introduction of the gEITC or UBI reduces output because both the policies, if introduced in a fiscally neutral manner, will increase the tax rates for high-income earners and reduce their labor participation rate. Furthermore, while households save precautionarily to smooth consumption against uninsured income shocks, redistributive policies reduce precautionary savings and discourage capital accumulation across the economy.

Third, both the gEITC and UBI improve social welfare measured by consumption equivalents, and the improvements are equivalent to more than 10% of consumption. However, the degree of improvement (deterioration) in utility at the individual level is not uniform. In both cases, the utility of households with above-average earnings worsens as a result of the tax hike, while the gEITC improves the utility of eligible households and UBI improves that of those with below-average incomes. Moreover, the UBI is the most preferred policy.

Finally, as redistributive policies, the gEITC and UBI reduce disposable income inequality but increase wealth inequality. This is because low-asset households reduce their

[4]Of course, the original purpose of the programs was to help households that are unable to participate in the labor force due to disability or poor health.

precautionary savings, but the equilibrium interest rate rises due to a decrease in the aggregate capital stock, which increases the capital income of high-asset households.

The rest of the paper is organized as follows. Section 2 provides a brief description of the related literature. Section 3 presents the model used in this study. In section 4, we calibrate the model parameters to the US economy. Section 5 reports the results, and section 6 discusses them. Section 7 presents the conclusions.

2 Related literature

A number of studies have empirically examined the impact of the EITC on labor supply. The EITC is most beneficial to low-income single-person households with child(ren) because the amount of the credit is determined by the household income and the number of children. Some studies showed that the expansion of the EITC positively impacts the employment rate of single mothers (Eissa and Liebman (1996), Meyer and Rosenbaum (2001), Meyer (2002), Meyer (2010)), while others showed that it reduces the labor force participation of married women (Eissa and Hoynes (2004), Eissa and Hoynes (2006)).

Based on these empirical facts, several studies have used heterogeneous agent models to simulate the expansion of the EITC as in this paper. Froemel and Gottlieb (2021) introduced the EITC into the Aiyagari (1994) model and found that its expansion positively impacts the labor supply. However, the expanded EITC in their simulation was much smaller than the UBI that is commonly proposed. They also assumed a small open economy and constant capital stock.[5] Ortigueira and Siassi (2022) revealed that US anti-poverty policies, including the EITC, distort the cohabitation and marriage choices of non-college-educated workers with children and Ortigueira and Siassi (2023) examined the optimal income support for single-parent families.

Empirical studies on UBI are limited, given that it is an unprecedented policy and difficult to test on a large scale. One notable exception is Jones and Marinescu (2022), who examined the impact of the Alaska Permanent Fund Dividend on labor supply. Their analysis showed that there is no clear negative effect of the introduction of permanent transfers on aggregate employment, although this might be attributed to the small amount of benefits ($1,000-2,000 per year), as they pointed out. In contrast, Bartik et al. (2024) exploited a randomized controlled trial (RCT) conducted by OpenResearch in which a

[5] As discussed in detail in section 5, redistributive policies reduce precautionary savings and raise the equilibrium interest rate through a reduction in capital stock. Moreover, the raised interest rate has a general equilibrium effect on capital income.

larger-scale cash benefit ($1,000 per month for three years) is paid. They found that substantial, temporary transfers increase short-term consumption and improve financial health but may not result in lasting improvements in the financial position of young, low-income households.

From the theoretical perspective, complex overlapping generations (OLG) or computable general equilibrium (CGE) models are used to study the implementation of UBI. Lopez-Daneri (2016) examined UBI as Friedman's negative income tax using a life-cycle model which takes individual heterogeneity into account and simulating the optimal negative income tax rate. Luduvice (2024) studied the effect of replacing means-tested benefits (EITC, SNAP, TANF, SSI) with unconditional benefits (UBI) without changing the budget size using an OLG model with idiosyncratic income risk. Daruich and Fernández (2024) used a similar model to investigate the long-run intergenerational consequences of UBI. Conesa et al. (2023) explored the size of UBI and its impact on macroeconomic outcomes using a heterogeneous OLG model. Meanwhile, Connolly et al. (2024) examined UBI using a dynamic CGE model combined with microsimulation, allowing for imperfect competition in the labor market.

Considering the binary choice between work and no work is essential to discussing income inequality. The indivisible labor model has been commonly adopted in heterogeneous agent models since it was proposed by Chang and Kim (2006) and Chang and Kim (2007). For example, Alonso-Ortiz and Rogerson (2010) examined the effect of changing the proportional labor income tax on welfare, and Nakajima and Takahashi (2020) studied the effect of changing the consumption tax rate on welfare, which they decomposed following the method of Flodén (2001). Furthermore, Yum (2018) demonstrated that the low employment rate of low-asset households can be replicated by assuming regressive income transfers.

Although the usefulness of heterogeneous agent models is obvious, the computational burden is high due to their complexity. Achdou et al. (2022) proposed a continuous time heterogeneous agent model based on the mean field game theory (Lasry and Lions (2007)), whose solution can be obtained relatively easily by solving partial differential equations numerically. Kaplan et al. (2018) is a seminal application of this approach, and we adopt it as well.

3 The baseline model

We set up a continuous time model based on an Aiyagari-type heterogeneous agent model, in which we assume continuous distribution of the productivity of heterogeneous households and adopt an indivisible labor model for labor supply (Chang and Kim (2006), Chang and Kim (2007)). In terms of taxation, we introduce a progressive income tax, the EITC, and means-tested benefits to capture actual labor participation rates.

3.1 The heterogeneous agent model

A continuum household indexed by $i \in [0,\ 1]$ faces the following constrained optimization problem:

$$\max_{\boldsymbol{c},\ \boldsymbol{h}}\ E_t\left[\int_t^{\infty} \exp(-\rho s) u(c_{is}, h_{is}) ds\right], \tag{1}$$

subject to $$\frac{da_{it}}{dt} = y_d(\exp(e_{it})w_t h_{it}) + y_{\text{EITC}}(\exp(e_{it})w_t h_{it}) + b_{\underline{a}}(\bar{h} - h_{it})\bar{y}_w \mathbb{1}_{\{\underline{a}\}}(a_{it}) + r_t a_{it} - c_{it}, \tag{2}$$

$$a_{it} \geq \underline{a}, \tag{3}$$

$$h_{it} \in \{0,\ \bar{h}\}, \tag{4}$$

$$de_{it} = -\eta e_{it} dt + \sigma dB_{it}, \tag{5}$$

where c_{it} is consumption, h_{it} is labor supply, a_{it} is asset holdings, e_{it} is the logarithm of productivity, w_t is the wage rate, and r_t is the real interest rate net of depreciation. ρ is the subjective discount rate and $u(\cdot, \cdot)$ is a utility function defined by

$$u(c, h) = \frac{c^{1-\theta} - 1}{1 - \theta} - \psi h, \tag{6}$$

where θ and ψ are the relative risk aversion and labor disutility weight, respectively. Equation (2) represents the budget constraint. $y_d(\cdot)$ is a function that returns after-tax labor income, $y_{\text{EITC}}(\cdot)$ is the EITC, $b_{\underline{a}}$ is the level parameter of means-tested benefits, and $\bar{y}_w$ is the theoretical value of the average wage, as mentioned below. As for labor supply, we adopt the indivisible labor model; that is, at each time period t, a household chooses to work or not to work, and the number of hours worked is a constant $\bar{h}$ when she works.[6]

[6] According to Meyer (2002) and Nichols and Rothstein (2016), the increase in labor supply due to an EITC expansion occurs mainly through an extensive margin; that is, it is not due to an increase in the number of working hours, but due to an increase in the labor participation rate.

For asset holdings, we assume a borrowing constraint $a_{it} \geq \underline{a}$. $\mathbb{1}_{\cdot}(\cdot)$ is an indicator function with $\mathbb{1}_A(x) = 1$ if $x \in A$ and $\mathbb{1}_A(x) = 0$ if $x \notin A$. $\mathbb{1}_{\{\underline{a}\}}(a_{it})$ is 1 if and only if $a_{it} = \underline{a}$, which implies that means-tested benefits are available only when asset holdings are at the lower bound. In the numerical simulation, we assume the lower bound on asset holdings as $\underline{a} = 0$ and normalize the number of hours worked at $\bar{h} = 1$. Equation (5) shows that the logarithm of the productivity of household i, e_{it}, follows an Ornstein-Uhlenbeck process with parameters η and σ.[7] B_{it} is a Wiener process, and in the steady-state, e_{it} is normally distributed; therefore, $\exp(e_{it})$ follows a lognormal distribution.

Following the progressive income tax approximation of Feldstein (1969), we assume the after-tax labor earnings function as

$$y_d(y_w) = y_w - \max\left\{y_w - \lambda\left(y_w/\bar{y}_w\right)^{1-\tau}\bar{y}_w,\ 0\right\}, \tag{7}$$

where $y_w = \exp(e)w\bar{h}$ represents before-tax labor earnings. The parameters are normalized with respect to the theoretical average earnings $\bar{y}_w = \exp\left(\sigma^2/4\eta\right)w\bar{h}$. $\lambda(\hat{y}_w)^{1-\tau}\bar{y}_w$ is after-tax labor earnings, and $y_w - \lambda(\hat{y}_w)^{1-\tau}\bar{y}_w$ is the labor income tax. τ is the parameter of the degree of progressivity; when it is zero, there is no progressivity, and as it increases, the degree of progressivity increases. The labor income tax is cut off to be positive; in the range where income tax rates are negative, that is, the tax credit is paid, we adopt Froemel and Gottlieb (2021)'s formulation of the EITC:

$$\begin{aligned} y_{\text{EITC}}(y_w) = \big[&\beta_{\text{in}}(y_w/\bar{y}_w)\mathbb{1}_{(0,\ y_w^1)}(y_w/\bar{y}_w) + \gamma\mathbb{1}_{[y_w^1,\ y_w^2]}(y_w/\bar{y}_w) \\ &+ \left\{\alpha_{\text{out}} + \beta_{\text{out}}(y_w/\bar{y}_w)\right\}\mathbb{1}_{(y_w^2,\ y_w^3)}(y_w/\bar{y}_w)\big]\bar{y}_w. \end{aligned} \tag{8}$$

The function $y_{\text{EITC}}(\cdot)$ represents the trapezoidal tax credit, and each parameter value and its shape is described in detail in section 4.

We adopt a simple setting for the firm, that is, we assume a constant return to scale production function with respect to capital K and labor L:

$$Y = F(K, L) = K^\alpha L^{1-\alpha}, \tag{9}$$

[7] While household productivity has only two states in Aiyagari (1994), we assume that it has a continuous distribution and stickiness as in Chang and Kim (2006) and Chang and Kim (2007).

and a competitive market. The factor prices are given by

$$w = F_L(K, L), \tag{10}$$

$$r = F_K(K, L) - \delta, \tag{11}$$

where δ is the depreciation rate. Since the baseline model includes the progressive labor income tax, EITC, and means-tested benefits, the government's budget constraint is

$$G_t = \int_0^1 [\exp(e_{it})w_t h_{it} - y_d(\exp(e_{it})w_t h_{it}) - y_{\text{EITC}}(\exp(e_{it})w_t h_{it}) - b_{\underline{a}}(\bar{h} - h_{it})\bar{y}_w \mathbb{1}_{\{\underline{a}\}}(a_{it})]di. \tag{12}$$

The model in this paper focuses only on taxes and benefits related to labor, and therefore, other taxes are omitted and the exogenous government expenditure G_t is assumed to be wasteful.[8] Finally, the market clearing condition is

$$dK_t = (Y_t - C_t - G_t - \delta K_t)dt, \tag{13}$$

where

$$K_t = \int_0^1 a_{it} di, \tag{14}$$

$$L_t = \int_0^1 \exp(e_{it}) h_{it} di. \tag{15}$$

3.2 The HJB equation and the Kolmogorov forward equation

The household's value function $V(a_{it}, e_{it}) = E_t \left[\int_t^\infty \exp(-\rho s) u(c_{is}, h_{is}) ds\right]$ can be written heuristically as

$$V(a_{it}, e_{it}) = \max_{\boldsymbol{c},\, \boldsymbol{h}} \left[u(c_{it}, h_{it})\Delta t + \frac{1}{1 + \rho \Delta t} E_t V(a_{i,t+\Delta t}, e_{i,t+\Delta t}) \right]. \tag{16}$$

[8]In the representative agent (complete market) model, lump-sum transfer is neutral because it does not affect factor prices and household behavior as the individual's budget constraint coincides with the country's resource constraint. However, in the heterogeneous agent model, it is not neutral because it plays the role of UBI and can have a large impact on each household's behavior. Therefore, we define government expenditure as residuals.

Multiplying both sides by $(1 + \rho\Delta t)/\Delta t$ and taking the limit of $\Delta t \searrow 0$, we obtain the Hamilton-Jacobi-Bellman (HJB) equation

$$\rho V(a_{it}, e_{it}) = \max_{c_{it}, h_{it}} [u(c_{it}, h_{it}) + s_{it}(c_{it}, h_{it})\partial_a V] - \eta e_{it}\partial_e V + \frac{1}{2}\sigma^2\partial_{ee}V + \partial_t V, \tag{17}$$

where savings $s_{it}(c, h) = \frac{da_{it}}{dt}$. Let $\hat{s}_{it}$ be the optimal savings. Define an infinitesimal operator $\mathcal{A}$ by

$$\mathcal{A}V(a_{it}, e_{it}) = \hat{s}_{it}\partial_a V - \eta e_{it}\partial_e V + \frac{1}{2}\sigma^2\partial_{ee}V; \tag{18}$$

Equation (17) can then be rewritten as

$$\rho V(a_{it}, e_{it}) = u(\hat{c}_{it}, \hat{h}_{it}) + \mathcal{A}V(a_{it}, e_{it}) + \partial_t V. \tag{19}$$

The transition of households' density $g(a_{it}, e_{it})$ follows the Kolmogorov forward equation

$$\partial_t g(a_{it}, e_{it}) = \mathcal{A}^* g(a_{it}, e_{it}), \tag{20}$$

where $\mathcal{A}^*$ is the adjoint operator of $\mathcal{A}$. The HJB and Kolmogorov forward equations can be solved numerically by using the finite difference method proposed by Achdou et al. (2022). As for grids used in the finite difference method, we set up a lattice consisting of 401 nodes from 0 to 150 at intervals of 0.375 for asset a and 101 nodes from -4 to 4 at intervals of 0.08 for log productivity e.

4 Calibration

4.1 Parameter settings

We calibrate the parameters of the model to replicate the US economy. Table 1 shows the parameter values for the baseline scenario. We assume the unit of time t to be a year and set the subjective discount rate ρ to 0.04. Due to the presence of precautionary savings in incomplete market models, the steady-state value of the real interest rate in the baseline model is 0.021.[9]

For the capital share α and depreciation rate δ, we use the values from Alonso-Ortiz

[9]The subjective discount rate is adjusted so that the real interest rate is 0.04 in Alonso-Ortiz and Rogerson (2010) and 0.03 in Froemel and Gottlieb (2021)

Parameter	Description	Value	Source/Target
ρ	Discount rate	0.04	–
θ	Relative risk aversion	2.0	Earnings and wealth distribution
ψ	Labor disutility weight	0.22	Labor participation rates
$b_{\underline{a}}$	Means-tested benefits	0.20979	Poverty line
α	Capital share	0.36	Alonso-Ortiz and Rogerson (2010)
δ	Capital depreciation rate	0.096	Alonso-Ortiz and Rogerson (2010)
η	Persistence of idiosyncratic shocks	0.018	Earnings and wealth distribution
σ	Standard deviation of shocks	0.15	Earnings and wealth distribution
$\underline{a}$	Borrowing limit	0	–
$\bar{h}$	Hours worked	1	–
τ	Progressivity of labor income tax	0.181	Heathcote et al. (2017)
λ	Tax level parameter	0.85	Average effective income tax rate
β_{in}	Phase-in, slope	0.34	Internal Revenue Service 2019
γ	Max, tax credit, plateau	$3526/\bar{y}^{\text{act}}$	Internal Revenue Service 2019
α_{out}	Phase-out, intercept	$7494/\bar{y}^{\text{act}}$	Internal Revenue Service 2019
β_{out}	Phase-out, slope	-0.16	Internal Revenue Service 2019
$\bar{y}^{\text{act}}$	Average household income	98088	Census 2019

Table 1: Parameter values for the baseline calibration.

and Rogerson (2010): 0.36 and 0.096, respectively. The relative risk aversion θ which represents the inverse of the elasticity of intertemporal substitution, the persistence of idiosyncratic shocks η, and the standard deviation of shocks σ are set to 2.0, 0.018, and 0.15, respectively, with reference to the joint distribution of labor earnings and wealth in the US (Table 2). By taking the forward difference, the Ornstein-Uhlenbeck process (5) becomes $e_{t+\Delta t} - e_t = -\eta e_t \Delta t + \sigma(B_{t+\Delta t} - B_t)$ and this can be written as

$$e_{t+\Delta t} = (1 - \eta \Delta t) e_t + \varepsilon_t, \tag{21}$$

where ε_t follows a normal distribution with mean 0 and variance $(\sigma \Delta t)^2$. Thus, $\eta = 0.018$ implies a quite persistent property of the productivity of each household.[10] The steady-state distribution of labor earnings is a lognormal distribution with mean $\exp(\sigma_e^2/2)$ and variance $\exp(\sigma_e^2)(\exp(\sigma_e^2) - 1)$ where $\sigma_e^2 = \sigma^2/2\eta$.

We set the labor disutility weight ψ to 0.22 so that the labor participation rates form an inverse U-shape with respect to asset holdings, as Yum (2018) noted. Since the income tax rate is progressive, an increase in ψ reduces the labor participation rate, especially of those with large assets.[11] The economy-wide labor participation rate in the baseline

[10] The persistence of idiosyncratic shocks has also been estimated to be relatively large in previous studies (e.g., Storesletten et al. (2004), Bayer et al. (2019)).

[11] The parameter of means-tested benefits, $b_{\underline{a}}$, has a large effect on the labor participation rate of those with few or no assets.

scenario is 0.927.

The parameter values for the tax system are also listed in Table 1. For the parameter of the degree of progressivity of the labor income tax rate, τ, we use the estimate of 0.181 from Heathcote et al. (2017).[12] The shift parameter λ in the tax function is set to 0.85 to match the average effective income tax rate. The lower the λ, the higher the average tax rate. However, in the range where the tax rates are negative, we use the EITC parameters.[13]

The amount of the EITC in the US to be calibrated depends on gross income, filing status, and the number of dependent children.[14] In this study, we assume a married household with one child who files a tax return together, following Froemel and Gottlieb (2021). According to the 2019 IRS Data Book, the payment is proportional to labor earnings in the phase-in until it reaches \$10,370, constant (γ) at \$3,526 until it reaches \$24,820, and diminishing in the phase-out until it reaches \$46,884, when the payment becomes zero. From above, the slope of the payment in the phase-in, β_{in}, is 0.34, and the intercept and the slope in the phase-out, α_{out} and β_{out}, are \$7,492 and -0.16, respectively. We use normalized values of γ and α_{out} by dividing by the average household income in 2019, $\bar{y}^{\text{act}}$(\$98,088). For the parameter $b_{\underline{a}}$, we use the poverty line \$20,578 for a family of three (one child) in 2019 divided by $\bar{y}^{\text{act}}$.[15] The tax credit schedule of the EITC expressed by the above parameters is shown in Figure 1(a), and the effective tax rates including the EITC are shown in Figure 1(b).

The joint distribution of wealth and earnings by quintile based on asset size in the steady-state of the model economy and the corresponding statistics estimated by An et al. (2009) from sample households in the PSID are shown in Table 2(a).[16] The steady-state distribution of assets and earnings in the model captures the actual US economy well.

[12]Heathcote et al. (2017) used the Panel Study of Income Dynamics (PSID) and the NBER's TAXSIM program to estimate the parameter values of the labor income tax rates in taking account of progressivity.

[13]If the estimate of τ based on the formulation of Heathcote et al. (2017) is used, the income tax rates for the lower-income group would be negative, which reflects the existence of other benefits such as child tax credits and TANF. In this study, however, to focus on the effect of the tax credit from the EITC, we adopt only the range where the income tax rates are positive and define the credit from the EITC separately.

[14]Strictly speaking, the EITC has a means test that determines households' eligibility for benefits based on their capital income; in 2019, the threshold was \$3,600. Our model does not consider this condition because the correlation between labor earnings and asset holdings is high and few households who receive the EITC earn capital income above the threshold.

[15]See US Department of Commerce, Bureau of Census, "Poverty Thresholds."

[16]It is well-known that the PSID does not adequately capture the wealth and earnings distribution of those with large assets. Further, the Aiyagari-type model cannot reproduce the upper tail of such distributions. Our study focuses on the redistributive effect on low-income groups. For generating the wealth distribution of the top 1% that follows a power law, models with human capital accumulation, for example, are suitable (e.g., Aoki and Nirei (2017)).

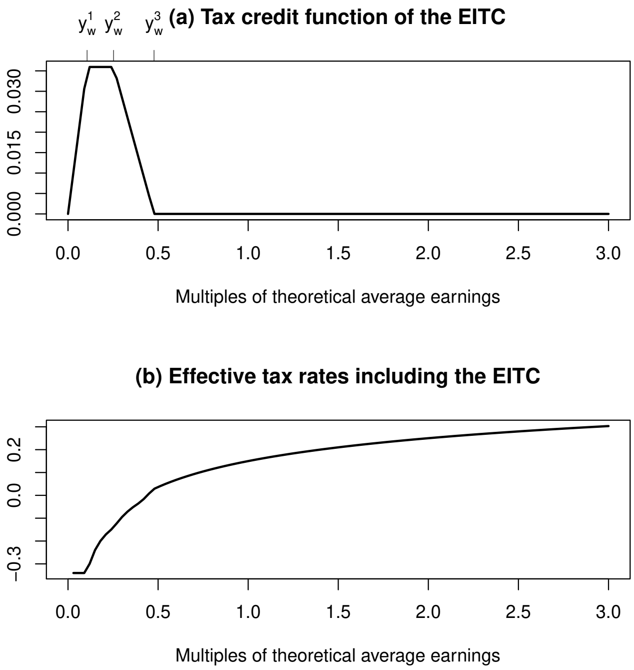


Figure 1: (a) Tax credit function of the EITC. (b) Effective tax rates including the EITC.

The difference between the distributions generated by the model and the actual data in each quintile is less than 1.17 percentage points. The average effective labor income tax rate faced by each household in each income quintile is shown in Table 2(b). The effective labor income tax rate of the households belonging to the first quintile is negative due to tax credits and means-tested benefits. The higher the quantile, the higher the effective labor income tax rate; but even in the fifth quintile, it is only 28.5% since the progressivity in the US is relatively low.[17] That for the whole economy is 17.9%.

Table 2(c) shows the labor participation rates by quintile based on asset size in the steady-state of the model economy and the corresponding statistics estimated by Yum (2018) from the Survey of Consumer Finances (SCF).[18] Yum (2018) pointed out that while asset holdings and labor participation rates are substantially uncorrelated in the data except for the first quintile, they have a strong negative correlation in a standard incomplete market model that does not take into account taxation or social security.[19] There is a difference of about 20 percentage points between the labor participation rate generated by the model and the data in the table, but the SCF used by Yum (2018)

[17] According to Holter et al. (2019), who compared the progressivity of labor income tax rates among OECD countries, progressivity is relatively low in the US and high in Nordic countries.

[18] We discuss this point in detail in the next section with reference to the policy function of labor supply.

[19] Yum (2018) used ad hoc transfers that decrease with respect to household productivity to reduce the labor participation rate in the model.

(a) Wealth and earnings distribution	Wealth quintile	1st	2nd	3rd	4th	5th
Wealth share (%)	Data	−0.52	0.50	5.06	18.74	76.22
	Baseline	0.00	0.40	4.89	17.57	77.14
Earnings share (%)	Data	7.51	11.31	18.72	24.21	38.23
	Baseline	8.36	10.56	18.18	24.79	38.12

(b) Effective labor income tax rates	Earnings quintile	1st	2nd	3rd	4th	5th
Effective labor income tax rates (%)	Baseline	−41.2	1.1	9.6	16.4	28.5

(c) Labor participation rates	Wealth quintile	1st	2nd	3rd	4th	5th
Labor participation rates (%)	Data	60.8	77.9	78.7	78.3	72.3
	Baseline	85.9	90.9	100.0	100.0	89.8

Table 2: (a) Wealth and earnings distribution. (b) Effective labor income tax rates. (c) Labor participation rates.

Note: The data on wealth and earnings distribution are obtained from An et al. (2009), who used the Panel Study of Income Dynamics. The labor participation rates are obtained from Yum (2018), who used the Survey of Consumer Finances. Effective labor income tax rates include the tax credit (EITC) and means-tested benefits.

considers it employment when the head of household works 1,000 hours per year (19 hours per week) and has a downward bias.[20]

4.2 Policy function of labor supply

Figure 2 shows the policy function of labor supply depending on two state variables, productivity and asset holdings, based on the baseline calibration. As we adopt an indivisible labor model, labor supply is a binary choice between work and no work. The figure reveals two groups whose labor participation rate is low: one on the lower-left side with zero assets and low labor productivity, and the other on the right side with high assets. The former does not participate in the labor market because the utility gained from consumption, which can be achieved with means-tested benefits, exceeds the utility gained from labor force participation. The latter supplies labor only if productivity is high enough. This is because the more their assets and, therefore, the higher their interest income, the higher their consumption level will be, as the marginal utility of consumption decreases and the reservation wage of whether they participate in the labor market or not becomes higher (Chang and Kim (2006)).

This can be seen in Figure 3, in which the vertical axis is the labor participation rate and the horizontal axis is labor productivity, and in Figure 4, in which the horizontal

[20]For example, according to the Current Population Survey data, in 2019, at least one person was employed in 97.5% of married households with children.

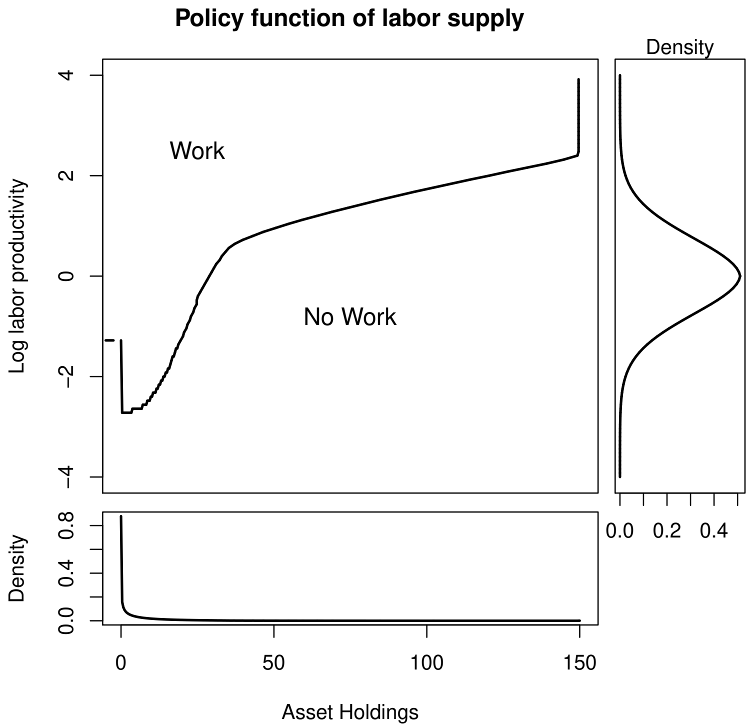


Figure 2: Policy function of labor supply.

Note: The horizontal axis indicates asset holdings, and the vertical axis represents log productivity. The bottom panel shows the marginal probability density of asset holdings, and the right-hand panel shows that of log productivity.

axis is asset holdings. The group with low labor productivity chooses zero assets and receives means-tested benefits, so they do not choose to participate in the labor force, but when the level of log labor productivity exceeds a threshold (-1.28), they participate in the labor force.[21] According to Figure 4, as asset holdings increase and exceed about 25, labor supply begins to decrease. Those with higher labor productivity, ceteris paribus, participate in the labor market, but since there is a strong correlation between labor productivity and asset holdings, the labor participation rate falls on average as labor productivity increases. The labor participation rate of those with moderate asset holdings, often accompanied by moderate labor productivity, is almost 100%.

[21]Figure 3 differs from a similar figure in Alonso-Ortiz and Rogerson (2010) (Figure 1), in which progressivity in the labor income tax rate is not introduced, and the labor participation rate falls as productivity becomes higher.

Figure 3: Labor participation rates (1).

Note: The horizontal axis indicates log productivity, and the vertical axis indicates labor participation rates. The bottom panel shows the marginal probability density of log productivity.

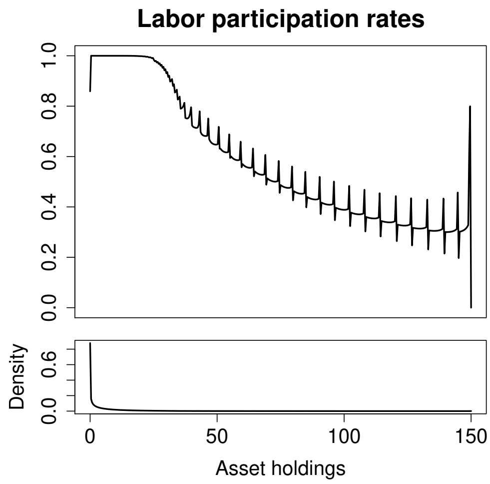


Figure 4: Labor participation rates (2).

Note: The horizontal axis indicates asset holdings, and the vertical axis indicates labor participation rates. The bottom panel shows the marginal probability density of asset holdings.

5 Alternative scenarios and counterfactual simulations

We now consider the gEITC an expansion of the current EITC, and UBI a larger unconditional income transfer.

5.1 Alternative scenarios: gEITC and UBI

In the gEITC scenario, we assume the tax credit is

$$y_{\text{gEITC}}(y_w) = \frac{1}{\pi} \sin(\pi y_w/\bar{y}_w)\bar{y}_w \mathbb{1}_{(0,\ 1)}(y_w/\bar{y}_w). \tag{22}$$

The gEITC provides benefits when labor earnings are in the range $y_w < \bar{y}_w$. Pre-tax disposable income is monotonically increasing, and the slope with respect to $y_w/\bar{y}_w$ is 2 if $y_w = 0$ and 1 if $y_w = \bar{y}_w$. While the current EITC schedule is trapezoidal in shape and is specified by four parameters, the formulation of equation (22) has the advantage that the tax credit schedule can be specified by the range of benefits $\mathbb{1}_{(0,\ 1)}$ and a level parameter set to $1/\pi$. This $1/\pi$ is the maximum benefit level that can maintain the monotonicity of labor earnings after tax credits, but the overall payments can be adjusted by reducing this value.

To maintain monotonicity, we include the gEITC in subjects to taxation; thus, the budget constraint is given by

$$\frac{da_{it}}{dt} = y_d\left(\exp(e_{it})w_t h_{it} + y_{\text{gEITC}}(\exp(e_{it})w_t h_{it}; \lambda_{\text{gEITC}})\right) + b_{\underline{a}}(\bar{h} - h_{it})\bar{y}_w \mathbb{1}_{\{\underline{a}\}}(a_{it}) + r_t a_{it} - c_{it}. \tag{23}$$

In addition, to keep the conditions the same as in the baseline scenario, we adjust the parameter λ for the labor income tax rate so that government spending G_t is at the same level as in the baseline scenario while keeping the degree of progressivity τ constant. Figure 5 shows the tax credit schedule of the gEITC and the gross labor earnings including the gEITC.

In the UBI scenario, we increase the labor income tax rate (decrease the shift parameter λ for the labor income tax rate) until UBI $b_{\text{UBI}}\bar{y}_w$ is equal to means-tested benefits $b_{\underline{a}}\bar{y}_w$ (i.e., until $b_{\underline{a}} = b_{\text{UBI}}$), given government spending G_t in the baseline scenario. The budget

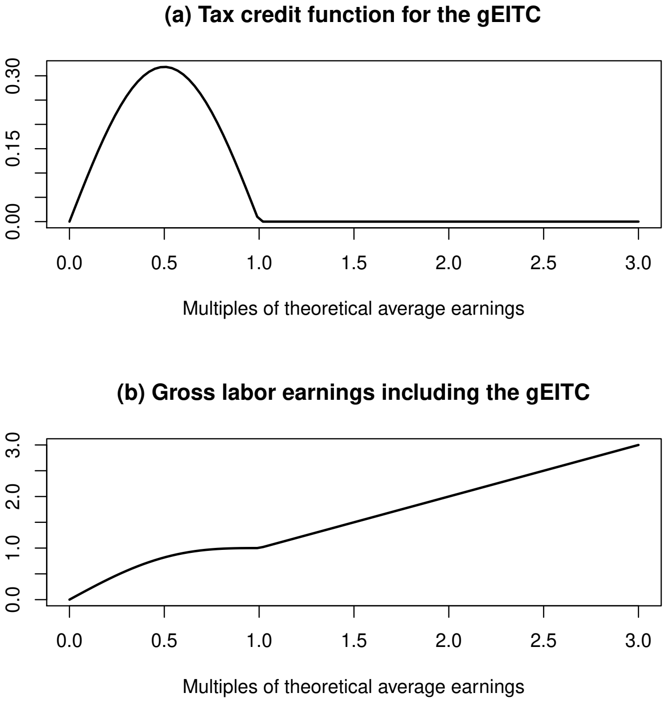


Figure 5: (a) Tax credit function for the gEITC. (b) Gross labor earnings including the gEITC.

constraint is given by

$$\frac{da_{it}}{dt} = y_d(\exp(e_{it})w_t h_{it}; \lambda_{\mathrm{UBI}}) + b_{\mathrm{UBI}}\bar{y}_w + r_t a_{it} - c_{it}. \tag{24}$$

It is clear from this that the progressive income tax is retained while the EITC (8) is removed.

In the following subsections, we compare the three scenarios in terms of (1) macroeconomic outcomes, (2) social welfare, (3) individual utility, and (4) inequality among individuals.

5.2 Macroeconomic outcomes

Table 3 summarizes the results for the main macroeconomic outcomes. From a macroeconomic perspective, output is largest in the baseline, gEITC, and UBI scenarios, in that order, which is due to the difference between effective labor L and capital accumulation K. The difference in labor supply in each case can be seen in Figure 6, which depicts the policy functions, and is more pronounced in the lower left side, which comprises those with low labor productivity and assets holdings. In the baseline and gEITC scenarios,

Variables / Scenarios	Baseline	gEITC	UBI
Output (Y)	2.483	2.386	2.352
Consumption (C)	1.466	1.434	1.408
Government expenditure (G)	0.284	0.284	0.284
Interest rate (r)	0.021	0.027	0.027
Wage (w)	1.204	1.169	1.169
Labor participation rate	0.927	0.957	0.951
Effective labor input (L)	1.325	1.327	1.287
Capital-labor ratio (K/L)	5.763	5.241	5.340
Consumption equivalence (Δ)	–	-0.107	-0.112
EITC/Y	0.003	0.101	–
UBI/Y	–	–	0.210
Tax level parameter (λ)	0.850	0.739	0.616

Table 3: Macroeconomic outcomes for all three scenarios.

Note: EITC/Y and UBI/Y represent the ratios of the total payment of the EITC and UBI to output, respectively.

households do not participate in the labor market when labor productivity is low because means-tested benefits are available when they hold no assets. However, labor force participation is a condition for the EITC to be paid, so those with lower labor productivity choose to work compared to the case in the baseline scenario (the region of "work" is relatively large). In the UBI scenario, households with zero assets choose labor supply independently of their labor productivity, because the utility from the additional consumption gained by labor supply exceeds the disutility from labor supply. The EITC, which is tied to labor supply, usually encourages labor supply more than UBI, which is unconditional. However, the latter in the UBI scenario has a more positive impact on labor supply than the former in the gEITC scenario because the UBI assumed here is introduced to remove means-tested benefits that constrain labor supply.

Meanwhile, as the UBI scenario has the largest benefits among the three scenarios, the increase in the labor income tax rate is also large, and as asset holdings increase, households will be less likely to participate in the labor market (i.e., the threshold of labor productivity between work or no work becomes higher). The labor participation rate of households with higher labor productivity that contributes more to production is the lowest in the UBI scenario (the labor participation rate of the fifth quintile of labor earnings is highest in the baseline, gEITC, and UBI scenarios, in that order). Therefore, the aggregated effective labor L is high in the gEITC, baseline, and UBI scenarios, in that order.

Regarding capital accumulation, the amount of capital stock in the whole economy

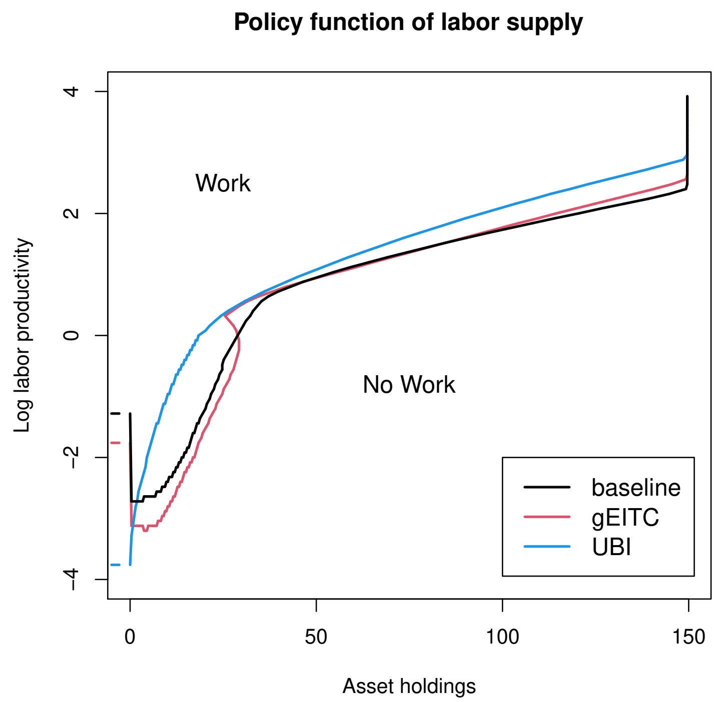


Figure 6: Policy function of labor supply for all three scenarios.

is largest in the baseline, gEITC, and UBI scenarios, in that order. Since there is no insurance against idiosyncratic shocks in this economy, households with few assets save precautionarily to smooth consumption. In the gEITC and UBI scenarios, precautionary savings are relatively small because the benefits play the role of insurance, and therefore, capital input in the baseline scenario is the largest.[22] This is also confirmed by the fact that the capital-labor ratio K/L is the highest in the baseline, UBI, and gEITC scenarios, in that order, while the real interest rate in the equilibrium follows the opposite order. As a result, the capital equipment ratio per worker and the real wage are the highest in the baseline scenario.[23]

The labor income tax rate faced by households with average income is $1 - \lambda$ by definition, which is 0.150 in the baseline scenario, 0.261 in the gEITC scenario, and 0.384 in the UBI scenario. Although the average labor income tax rate is the highest in the UBI scenario, the disposable income of those with average log productivity is slightly higher in the UBI scenario than in the gEITC scenario, because in the former, about 20% of the average income is unconditionally paid while households with average income are

[22] A similar result was reported in Lopez-Daneri (2016), who estimated the optimal negative income tax in a life-cycle model that considers individual heterogeneity.

[23] Froemel and Gottlieb (2021) reported that an increase in the EITC reduces precautionary savings. This is also consistent with the empirical findings of Weber (2016) that the EITC reduces incentives to save.

ineligible for the gEITC.

5.3 Social welfare

As the equilibrium of the heterogeneous agent model is not Pareto optimal, like that of the OLG model, redistributive policies can improve social welfare. If inequality is reduced while maintaining the size of the economy, social welfare will improve (Bénabou (2002)). The gEITC and UBI are examples of this.

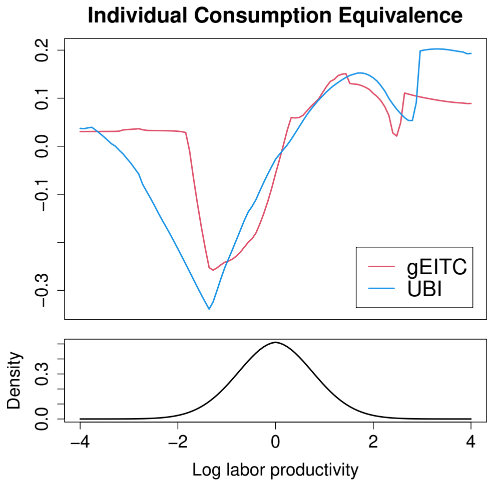
In this study, we measure social welfare by the consumption equivalence Δ that satisfies the following equation:

$$\frac{1}{\rho}\int_0^1 u(\hat{c}_{i,\text{ss}}, \hat{h}_{i,\text{ss}})di = \frac{1}{\rho}\int_0^1 u((1+\Delta)\hat{c}'_{i,\text{ss}}, \hat{h}'_{i,\text{ss}})di, \tag{25}$$

where $\hat{c}_{it}$ and $\hat{h}_{it}$ are the optimal consumption and labor supply, respectively. We place the optimal consumption and labor supply in the baseline scenario on the left-hand side and those in the alternative scenarios (gEITC and UBI) on the right-hand side, following Flodén (2001).[24] A negative Δ value implies that the transition to the new system will improve social welfare. It should be noted that such an evaluation of social welfare is based on the perspective of Benthamite utilitarianism as the utility of each household is aggregated with equal weight. In comparison with the baseline scenario, Δ_{gEITC} is -0.107 and Δ_{UBI} is -0.112. In other words, the implementation of the EITC and UBI will improve social welfare on average, and the improvement in social welfare corresponds to an increase in consumption by about 11% on average in both scenarios.

We do not discuss the optimal redistribution policy in this paper because there is no single social welfare index in heterogeneous agent models, unlike in representative agent models. The optimal taxation and transfer policies under heterogeneous agents are often measured with respect to certain social welfare in previous studies, but if the utility function of each agent is concave, the reduction in income inequality will lead to an improvement in social welfare if there were no general equilibrium effects. Meanwhile, even if social welfare improves in both the gEITC and UBI scenarios compared to the baseline, not all individuals' welfare is better off, that is, not Pareto improved.

[24]Lucas (1987) used consumption equivalence to measure the welfare loss suffered by the representative agent over business cycles.



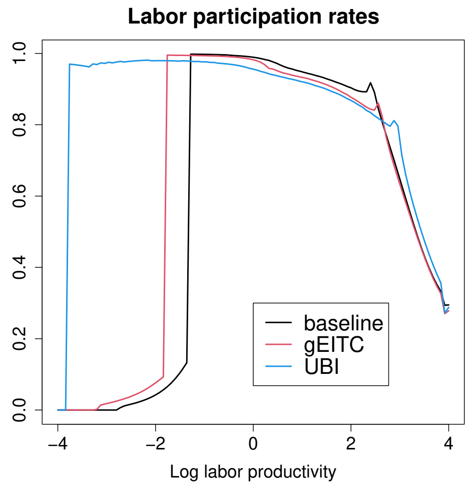


Figure 7: Individual consumption equivalence.

Note: The individual consumption equivalence of each scenario whose reference is the baseline are weighted averages for each productivity level. The bottom panel shows the marginal probability density of log productivity.

Figure 8: Labor participation rates for all three scenarios.

Note: The labor participation rates are weighted averages for each productivity level.

5.4 Individual utility

It is important to identify whose welfare will improve and whose will worsen. Figure 7 shows the steady-state welfare measured based on the individual consumption equivalence for each scenario (gEITC and UBI) compared to the baseline based on log labor productivity. Similar to the economy-wide consumption equivalence Δ in the previous subsection, we define the individual consumption equivalence Δ_i as

$$u(\hat{c}_{i,\text{ss}}, \hat{h}_{i,\text{ss}}) = u((1 + \Delta_i)\hat{c}'_{i,\text{ss}}, \hat{h}'_{i,\text{ss}}). \tag{26}$$

A negative Δ_i indicates an improvement in household i's utility. To draw the figure, we used the weighted averaged Δ_i for each productivity level based on density $g(a', e')$ after the transition from the baseline scenario.

If log labor productivity is low (<-1.3), the Δ_i of each scenario decreases monotonically. At the peak, the Δ_i of the gEITC scenario is approximately -0.25 and that of the UBI scenario exceeds -0.3. In the baseline scenario, households with low labor productivity do not choose to work to receive means-tested benefits; however, in the UBI scenario, the labor participation rate increases, and the consumption equivalence decreases dramatically because the benefits are unconditional (see Figure 8), whereas the gEITC improves the welfare of those who work with a relatively low wage rate directly.

When log labor productivity lies between -1.3 and 0, individual utility improves compared to the baseline; however, the degree of improvement decreases as labor productivity increases. This is because households in the baseline scenario begin to work when their log labor productivity exceeds -1.3 and their utility improves along with labor productivity, whereas in this range, the tax credit decreases in the gEITC scenario and the labor income tax rate rises in both the scenarios due to income tax progressivity.

For the same reason, the individual utility of households with high labor productivity decreases, but the trend in consumption equivalence is not monotonous because these households are affected not only by possible consumption but also by labor participation. Households with higher labor productivity have more assets, and therefore, tend to exit the labor market; that is, they are not subject to higher labor income rates. Moreover, as the gEITC and UBI reduce the precautionary savings of low-income households and raise the interest rate, productive households with large asset holdings have higher capital income.[25]

In this study, the proportion of households that prefer gEITC and UBI to the baseline is above the majority, at 54.7% and 60.1%, respectively. When comparing the UBI scenario with the gEITC scenario, the proportion of households whose welfare improves in the former is 51.2%. Thus, the UBI scenario is the most supported policy, albeit by a small margin.

5.5 Inequality among individuals

Table 4 shows the distributions of asset holdings and labor earnings by quintile based on asset size in the steady-state of all three scenarios. In terms of the distribution of disposable income after taxation and benefits, there is no significant difference between the gEITC and UBI scenarios. In both scenarios, the shares of the first, second, and third quartiles are larger, and the shares of the fourth and fifth quintiles are smaller than those in the baseline. In other words, the implementation of the gEITC or UBI, which provide credits or benefits to low-income households and tax high-income ones more heavily, reduces income inequality on a disposable income basis.

Meanwhile, in the gEITC and UBI scenarios, the wealth shares of the first through fourth quintiles of households are lower than those in the baseline. In particular, households in the first and second quintiles do not have any assets and spend all of their labor

[25] The consumption equivalence of those households in the upper tail (> 2.5) deteriorates again due to higher tax rates, but their share of the total population is limited.

	Wealth quintile	1st	2nd	3rd	4th	5th
Wealth share (%)	Baseline	0.00	0.40	4.89	17.59	77.14
	gEITC	0.00	0.00	1.08	12.45	86.48
	UBI	0.00	0.00	2.44	14.06	83.50

	Wealth quintile	1st	2nd	3rd	4th	5th
Disposal income share (%)	Baseline	6.11	11.49	15.79	22.56	44.06
	gEITC	8.22	14.88	16.46	20.57	39.87
	UBI	8.49	13.59	16.62	21.98	39.32

Table 4: Wealth and disposal income distributions in all three scenarios.

earnings on consumption. In the baseline scenario, households save precautionarily in case their labor productivity declines, but in the gEITC and UBI scenarios, generous benefits reduce the incentive to save in advance. Meanwhile, households in the fifth quintile, who hold more assets, can take advantage of the higher interest rate, and the share of their assets expands, which suggests that wealth inequality widens with the introduction of the gEITC or UBI.

6 Discussion

In this study, we compare the gEITC and UBI as income redistribution policies, but the policy to be adopted varies depending on the target. The model calibrated to the US economy reveals four findings: (1) If we want to maximize production, we should not adopt redistributive policies. (2) Both the gEITC and UBI can have equally desirable effects on social welfare. (3) UBI brings higher welfare improvement to low-income households than the gEITC. (4) The implementation of the gEITC or UBI will both increase wealth inequality. It is important to understand which income and asset groups will be affected by the policy and what the side effects will be. For this purpose, we need to understand in advance the mechanisms that bring about the policy effects through the model.

Particular attention should be paid to the impact on social welfare. In general, the EITC encourages labor supply, while UBI suppresses it.[26] The limited suppression of labor supply by UBI in our model is because its amount is set at a level that eliminates the distortions caused by means-tested benefits set at the poverty line. Generally, as the risk of suppression of the labor supply under UBI is considered to be high, it is desirable to

[26] The ad hoc transfers used by Alonso-Ortiz and Rogerson (2010) and Yum (2018) correspond to UBI in our model, which reduces labor force participation rates.

conduct a series of simulations using various models and settings. For example, according to Conesa et al. (2023), if the UBI is financed by a proportional income tax, there is an inverse U-shaped relationship between the size of the UBI and the labor participation rate. However, in Luduvice (2024), who studied transfer policies in an OLG model with idiosyncratic income risk, changing means-tested benefits to uniform ones (i.e., UBI) slightly raises the labor supply in the whole economy because under UBI, there is no need to adjust the intensive margin to be covered by means-tested benefits. However, although low-productivity households are susceptible to switching from means-tested benefits to UBI, their contribution to the aggregate output is limited, and it may not require much attention.

It is obvious that redistributive policies favor low-income households, but our study reveals that the gEITC and UBI raise the interest rate as a result of reduced precautionary savings and are beneficial to high-income households since the effect of tax hikes is offset to some extent.[27] The key to introducing a redistributive policy is to convince high-income earners, who will bear a higher tax burden, that besides the direct effect of higher taxes, there will be a general equilibrium effect of the higher interest rate increasing capital income. It should also be noted that the implementation of the gEITC or UBI will both increase wealth inequality. Redistribution lowers the dispersion of income, and the marginal increase in the value of holding additional assets, $\partial_a V$, flattens out, as do consumption and savings. In other words, wealth inequality widens since households save less when they have fewer assets and save more when they have more assets.

7 Conclusions

We study the expansion of the EITC and introduction of UBI using a general equilibrium model with heterogeneous agents, in which we adopt indivisible labor so that the extensive margin determines labor supply. The parameter values are calibrated to reproduce the joint distribution of labor earnings and wealth in the actual US economy, and means-tested benefits replicate the inverted U-shape of the labor participation rate relative to assets holdings.

We find that both the expansion of the EITC and introduction of UBI will encourage

[27]In general, redistributive policies raise the real interest rate because the concavity of the utility function decreases the average marginal utility. The decline in the marginal utility of those who receive transfers (low-income households) is larger than the increase in the marginal utility of those who pay tax (high-income households).

labor force participation among low-income households and increase the overall labor participation rate in the economy. Simultaneously, these redistribution policies will reduce precautionary savings, leading to a decrease in capital stock. In addition, if a redistributive policy is introduced in a fiscally neutral manner, the average labor income tax rate will rise, and high-income earners with high productivity will exit the labor market, resulting in a decrease in effective labor and output. Both these policies will improve social welfare, but there is no uniformity in whose agents' utility will increase, which depends on the income and asset holdings of each household. The expansion of the EITC and introduction of UBI will reduce disposable income inequality, but a decrease in precautionary savings and a rise in the equilibrium interest rate will increase wealth inequality. Whether wealth inequality should be reduced and, if so, what policies are needed is not discussed in this paper; we leave it for future research.

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