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ARTICLE

Negative income tax and universal basic income in the eyes of Aiyagari

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Abstract
We compare two welfare programs: the universal basic income (UBI) and negative income tax (NIT). Under *a linear* income tax system, we show that (i) the NIT can replicate the allocation of the UBI exactly by providing an identical marginal effective tax schedule, and (ii) the budget of the NIT is *always* smaller than that of the UBI. According to our quantitative model, which is calibrated to approximate the income and wealth distributions in the United States, the optimal UBI is to pay everyone 7.2% of the average income. We also show that the NIT can achieve a similar average welfare with a much smaller budget (2.3% of the GDP) by providing a subsidy that is generous to the very poor and quickly phases out as income increases.

Keywords: Negative income tax; redistribution; universal basic income

1. Introduction

We compare two welfare programs that are popular in public and political debates: the universal basic income (UBI) and a means-tested negative income tax (NIT). Mankiw (2021) illustrated that *within the class of linear* income tax-and-transfer system, the NIT can replicate the same allocation as the UBI by providing an identical marginal effective tax schedule. According to Mankiw (2021), "The two policies are equivalent because the net payment—that is, taxes less transfers—is identical under the two policies . . . The difference is only a matter of framing." However, Mankiw (2021) was not explicit about the total amount of the budget of the policy. The size of the budget differs vastly between the two programs. Although the two programs can generate an identical allocation, we analytically show that the total budget of the NIT is *always* smaller than that of the UBI.

Based on a standard heterogeneous agents general equilibrium model [*a la* Aiyagari (1994)], calibrated to approximate the income and wealth distributions in the United States, we perform quantitative analyses on various versions of the UBI and NIT (within the class of linear income tax). While the UBI that pays everyone 20% of the average income costs about 15.4% of the GDP, the NIT (that replicates the identical outcome) costs only 3.8% of the GDP. Neither program improves the average welfare significantly in the long run (in fact, it decreases slightly by 0.27% in consumption-equivalence units), as the reduction in capital and labor (owing to a tax distortion and a weakened motive for precautionary savings and work) roughly offsets the insurance benefit. Furthermore, the aggregate output, capital, and hours worked decrease by 12%, 22%, and 10%, respectively, in the long run.

Among the UBI programs (within the class of a linear income tax schedule), the economy achieves the highest average welfare when everyone receives 7.2% of the average income (and pays 8% of their income as tax). The average welfare improves slightly (0.4%) compared with a *laissez-faire* economy. An NIT can perform nearly as well (actually slightly better) with a much smaller budget, that is a mere 2.3% of the GDP. This (optimal) NIT program features a piecewise linear effective marginal tax schedule: an 8% tax rate above the 45th income percentile, and a subsidy that is generous to the very poor (i.e. 19.5% of the average income for those with zero income) and quickly diminishes (at a 27% phase-out rate) with income.

We simulate the political outcome of introducing a welfare program. While the three welfare programs we consider (UBI with a 20% income tax rate, optimal UBI, and optimal NIT) easily win the majority votes (with approval rates of 70% or higher), the simulation reveals the interesting heterogeneous impacts of the welfare programs across workers. In general, the proportion of the workers in favor of a welfare program decreases with wealth. However, extremely rich workers may also be in favor of a redistribution policy owing to so-called pecuniary externalities [e.g. Dávila et al. (2012)], according to which a welfare program often raises the equilibrium interest rate by reducing the aggregate supply of capital (via a weakened precautionary savings motive).

Our analysis makes a modest contribution to the literature on optimal income taxation [e.g. Conesa and Krueger (2006), Corbae et al. (2009), Heathcote et al. (2017), Chang et al. (2018, 2022), Heathcote and Tsujiyama (2021), Wu (2021)]. The literature examined comprehensive income tax-and-transfer systems and highlighted that it is the effective marginal income tax schedule that matters for household decisions. Our study distinguishes itself from previous studies in two ways. First, our analytical analysis shows (i) the equivalence between the UBI and NIT regardless of particular macroeconomic models or specific parameterization and that (ii) the government budget is always smaller under the NIT. Second, we numerically find an optimal UBI and NIT using a quantitative general equilibrium model.

The remainder of this paper is organized as follows: Section 2 analytically shows that the NIT can *always* replicate the allocation of the UBI with a smaller budget within the class of a linear income tax system, Section 3 lays out a benchmark model economy for the quantitative analysis and computes the optimal UBI and (means-tested) NIT, Section 4 provides the sensitivity analyses, and Section 5 summarizes the study.

2. Analytical analysis

For the analytical analysis, we formalize and generalize Mankiw (2021), with an explicit consideration of the government budget constraint [which is missing in Mankiw (2021)].

UBI program:

Suppose the total (capital and labor) income is $\mathbf{y}$. This total income is subject to a constant tax rate of τ. When the lump-sum transfer for everyone (i.e. UBI) is $\bar{T}$, the disposal income is:

$$(1-\tau)\mathbf{y}+\bar{T}.$$

NIT program:

A means-tested transfer of T_0 goes to those with zero income ($y=0$). The transfer is phased out at rate ϕ: that is, the recipients lose ϕ fraction of every dollar they earn. Such transfers are financed through the taxation of households whose income is above a pivotal income $\hat{y}$ at a constant tax rate of $\hat{\tau}$. The disposable income is:

$$\begin{aligned} T_0+(1-\phi)\mathbf{y}, &\quad \text{if} \quad \mathbf{y}\leq\hat{\mathbf{y}} \\ \mathbf{y}-\hat{\tau}(\mathbf{y}-\hat{\mathbf{y}}), &\quad \text{if} \quad \mathbf{y}>\hat{\mathbf{y}}. \end{aligned}$$

From the point of view of households, both programs are identical under assumptions 1 and 2 below.[1]

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1. The transfer paid to households with zero income under the NIT is the same as the basic income in the UBI: $T_0 = \bar{T}$.
2. The phase-out rate and the income tax rates are identical: $\hat{\tau} = \phi = \tau$
3. The government runs a balanced budget.

Proposition 1. *Under a linear tax-and-transfer system, a means-tested NIT system can exactly replicate the UBI program by providing an identical effective marginal income tax schedule.*

Proof. *Let $\bar{\mathbf{y}}$ be the economy-wide average of the taxable income. By setting $\hat{\mathbf{y}} = \bar{\mathbf{y}}$, we balance the government budget, and it follows immediately that the disposable income of a households under both programs is equal to* $(1-\tau)\,\mathbf{y} + \tau\bar{\mathbf{y}}$. □

The households with taxable income below the economy-wide average are the net recipients, whereas those with taxable income above the economy-wide average are the net contributors in the tax-and-transfer system. Although both programs are identical from a household's point of view, very different budgetary implications may exist. Proposition 2 below shows that the program budget of the NIT (which achieves the same allocation as the UBI) is *always* smaller than that of the UBI.

Proposition 2. *Under a linear tax-and-transfer system, the size of the program budget of a means-tested NIT program is always smaller than that of the UBI (which achieves the identical allocation).*

Proof. *The total budget of the UBI is $\tau\bar{y}$. Under the NIT with $\hat{\mathbf{y}} = \bar{\mathbf{y}}$, the government's budget constraint is: $\int_0^{\bar{\mathbf{y}}} \left(T_0 - \phi\mathbf{y}\right)\psi(\mathbf{y})\, d\mathbf{y} = \hat{\tau}\int_{\bar{\mathbf{y}}}^{\infty}\left(\mathbf{y}-\bar{\mathbf{y}}\right)\psi(\mathbf{y})\, d\mathbf{y}$, where the left-hand side is the total expenditure, and the right-hand side is the total tax revenue, and $\psi(\mathbf{y})$ denotes the cross-sectional distribution of income. With $\hat{\tau} = \phi = \tau$ and $T_0 = \bar{T} = \tau\bar{\mathbf{y}}$, the total expenditure under the NIT is consistently smaller than that under the UBI: $\int_0^{\bar{\mathbf{y}}} (\tau\bar{\mathbf{y}} - \tau\mathbf{y})\psi(\mathbf{y})\, d\mathbf{y} = \mu\tau\bar{\mathbf{y}} - \tau\int_0^{\bar{\mathbf{y}}} \mathbf{y}\psi(\mathbf{y})\, d\mathbf{y} < \tau\bar{\mathbf{y}}$, where $\mu \in [0, 1]$ is the population share of the households with an income below the average.* □

While the budget of the NIT is *always* smaller than that of the UBI, the difference between the two depends on the particular shape of the taxable income distribution $\psi(\cdot)$. In the next section, we provide a quantitative analysis of the UBI and NIT based on a model calibrated to approximate US income distribution.

3. Quantitative analysis

3.1. Model economy

The model economy (which will serve as a laboratory for various quantitative analyses) extends the model developed by Aiyagari (1994) to the endogenous labor supply.

Households: A continuum (measure one) of workers (households) with identical preferences exists and faces an idiosyncratic productivity shock x, which evolves over time according to the Markov process with a transition probability distribution function $\pi_x(x'|x) = \Pr(x_{t+1} \le x'|x_t = x)$. When a worker with labor productivity x_t chooses to work h_t hours, its labor income is $w_t x_t h_t$, where w_t is the wage rate per efficiency unit of labor. The workers hold assets, a_t, which yield the real rate of return, r_t. The total (labor and capital) income, $\mathbf{y}_t = w_t x_t h_t + r_t a_t$, is subject to a constant tax rate τ, and the workers receive $T(\mathbf{y}_t)$, which is a transfer from the government. A household maximizes its lifetime utility given as follows:

$$\max_{\{c_t,h_t\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{{c_t}^{1-\sigma}-1}{1-\sigma} - B\frac{{h_t}^{1+1/\gamma}}{1+1/\gamma} \right\}$$

subject to

$$c_t + a_{t+1} - a_t = (1-\tau)(w_t x_t h_t + r_t a_t) + T(\mathbf{y}_t),$$
$$a_{t+1} \geq \underline{a},$$

where c_t represents consumption. Three parameters govern the preferences: σ represents the relative risk aversion, B denotes the relative weights on the disutility from working, and γ denotes the (Frisch) labor supply elasticity.

Capital markets are incomplete in two senses. (i) Physical capital is the only available asset for households to insure against idiosyncratic productivity shocks. (ii) Households face an exogenous borrowing constraint $\underline{a}$: $a_{t+1} \geq \underline{a}$ for all t. The households differ *ex post* with respect to their productivity x_t and asset holdings a_t, whose cross-sectional joint distribution is characterized by the probability measure $\mu_t(a_t, x_t)$.

Firms: The representative firm produces output according to a constant-returns-to-scale Cobb-Douglas production function in capital K_t and effective units of labor $L_t = \int x_t h_t d\mu$. Capital depreciates at rate δ in each period:

$$Y_t = F(L_t, K_t) = {L_t}^{\alpha} {K_t}^{1-\alpha}.$$

Government: The government operates a tax/transfer system. The government runs a balanced budget in each period:

$$\tau \int \left(w_t x_t h(a_t, x_t) + r_t a_t\right) d\mu(a_t, x_t) = \int T(\mathbf{y}(a_t, x_t))\, d\mu(a_t, x_t).$$

Recursive representation: It would be useful to consider a recursive representation. Let $V(a, x)$ denote the value function of a household with asset holdings a and productivity x. Then, V can be expressed as follows:

$$V(a, x) = \max_{c,h} \left\{ \frac{c^{1-\sigma} - 1}{1-\sigma} - B \frac{h^{1+1/\gamma}}{1+1/\gamma} + \beta \mathbb{E}\left[V(a', x')|x\right] \right\}$$

subject to

$$c + a' = a + (1-\tau)(wxh + ra) + T(\mathbf{y}(a, x)),$$
$$a' \geq \underline{a},$$
$$\mu'(a, x) = \mathbf{T}(\mu(a, x)).$$

Equilibrium: A stationary equilibrium consists of a value function, $V(a, x)$; a set of decision rules for consumption, asset holdings, and the labor supply, that is, $c(a, x)$, $a'(a, x)$, and $h(a, x)$, respectively; aggregate input K and L; and the invariant distribution of the households $\mu(a, x)$, such that:

1. Individual households optimize: Given w and r, the individual decision rules $c(a, x)$, $a'(a, x)$, $h(a, x)$, and $V(a, x)$ solve the Bellman equation.
2. The representative firm maximizes its profits:
$$w = \alpha (K/L)^{1-\alpha}$$
$$r = (1-\alpha)(K/L)^{-\alpha} - \delta.$$
3. The goods market clears:
$$\int \left\{a'(a, x) + c(a, x)\right\} d\mu(a, x) = F(L, K) + (1-\delta)K.$$

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Table 1. Parameters of the benchmark economy

Parameter	Value	Description
α	0.64	Labor share in production function
δ	0.10	Depreciation rate of captial
σ	1.00	Relative risk aversion
γ	0.50	Labor supply elasticity
β	0.948	Time discount factor
B	22.5	Disutility from working
ρ	0.91	Persistence of idiosyncratic productivity
σ_x	0.21	SD of innovation to productivity shock

4. The factor markets clear:

$$L = \int xh(a,x)d\mu\ (a,x)$$
$$K = \int ad\mu\ (a,x)\ .$$

5. The government balances the budget:

$$\tau \int \big(wxh(a,x) + ra\big)\ d\mu(a,x) = \int T(\delta(a,x))\ d\mu(a,x).$$

6. Individual and aggregate behaviors are consistent: For all $A^0 \subset A$ and $X^0 \subset X$,

$$\mu(A^0, X^0) = \int_{A^0, X^0} \left\{ \int_{A,X} \mathbf{1}_{a'=a'(a,x)} d\pi_x(x'|x) d\mu \right\} da' dx'.$$

3.2. Calibration

As the Aiyagari-type model is widely used in various macroeconomic analyses, we adopt the standard values for most of the parameters. The time unit is 1 year, the labor income share α is 0.64, and the annual depreciation rate of capital δ is 10%. The workers are not allowed to borrow, so $\underline{a} = 0$. As is common in the macroeconomic literature, we assume the relative risk aversion σ to be one (i.e. the log utility in consumption) to be consistent with the balanced growth path.[2]

We set the Frisch elasticity of the labor supply γ to 0.5, close to the estimates in the literature [e.g. Chetty et al. (2011), Keane (2011)]. We assume that individual productivity x follows an AR(1) process: $\ln x' = \rho \ln x + \varepsilon_x$, where $\varepsilon_x \sim N(0, \sigma_x^2)$. We assume that $\rho = 0.91$, which is a commonly used value. The chosen value for σ_x is 0.21, which is an estimate provided by Floden and Lindé (2001) based on the Panel Study of Income Dynamics (PSID). In the benchmark economy, there are no taxes and transfers. Finally, we set the time discount factor β so that the real interest rate is 4%, which is the average real rate of return to capital in the United States in the post-World War II period. We also choose the disutility from working B to generate the average number of hours worked of 0.33 in the steady state. Table 1 summarizes the parameter values of the benchmark model economy.

Table 2 reports the income and wealth distributions of the benchmark economy. The Gini coefficients of income and wealth are 0.33 and 0.64, respectively. Although the model exhibits significant dispersion in income and wealth, they are considerably smaller than those in the data (e.g. 0.53 and 0.76 according to the PSID and 0.63 and 0.78 according to the Survey of Consumer Finances). This outcome is inevitable given that the model is driven by a single source of heterogeneity (i.e. an idiosyncratic productivity shock). It is well known [see, Diaz-Gimenez et al. (1997)]

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Table 2. Distributions of income and wealth

	Model	US
Median income	0.346	$61,937
Mean income	0.435	$87,864
Mean–median ratio	1.26	1.42
Income Gini	0.33	0.53
Wealth Gini	0.64	0.76

Table 3. Steady states

	(1) Benchmark	(2) UBI	(3) NIT	(4) UBI	(5) NIT
Tax rate (τ)	0	0.2	0.2	0.08	0.08
Phase-out rate (ϕ)	–	–	0.2		**0.249**
Pivotal income ($\hat{y}$)	–	–	**0.392**	–	**0.308**
Transfer at $y=0$ (T_0)	–	0.078		0.033	0.080
(relative to $\bar{y}$)		(0.2)		(0.079)	(0.195)
Output	0.585	0.510		0.557	0.545
Capital	1.520	1.186		1.380	1.333
Hours worked	0.332	0.301		0.320	0.310
Effective labor	0.344	0.317		0.334	0.330
Wage rate	1.089	1.029		1.067	1.058
Interest rate	4.00%	5.48%		4.52%	4.73%
Income					
Mean ($\bar{y}$)	0.435	**0.392**		0.419	**0.412**
Median	0.346	0.307		0.332	0.327
Before-tax Gini	0.324	0.341		0.331	0.349
After-tax Gini	0.324	0.273		0.304	0.307
Wealth Gini	0.640	0.657		0.646	0.677
Tax/GDP	0	0.154	0.038	0.060	0.023
Welfare (CEV)	–	−0.27%		0.41%	0.47%

that this type of model cannot account for the concentration found in the upper 1% of the income or wealth distribution. However, accounting for the likes of Bill Gates is not our primary concern so we do not focus on the extreme upper part of the wealth distribution. We compare the UBI and NIT in a simple heterogeneous agent model. In the United States, the median and mean household incomes (as of 2018) are $61,937, and $87,864, respectively. In our benchmark economy, the median and mean incomes are 0.346 and 0.435, respectively. Thus, the mean–median income ratio in the model (1.26) is not far from that in the data (1.42).

3.3. Comparison between UBI and NIT

In this subsection, we consider the UBI and NIT programs that are similar to Mankiw (2021) where the income tax rate and phase-out rate are 20%: $\tau = \hat{\tau} = \phi = 0.2$. We also assume that the households with zero income receive 20% of the pivotal income $T_0 = 0.2 \times \hat{y}$ in the NIT. To guarantee the balanced budget, we set the pivotal income in the NIT to the average income $\hat{y} = \bar{y}$. Table 3 reports the steady states of the model economy.

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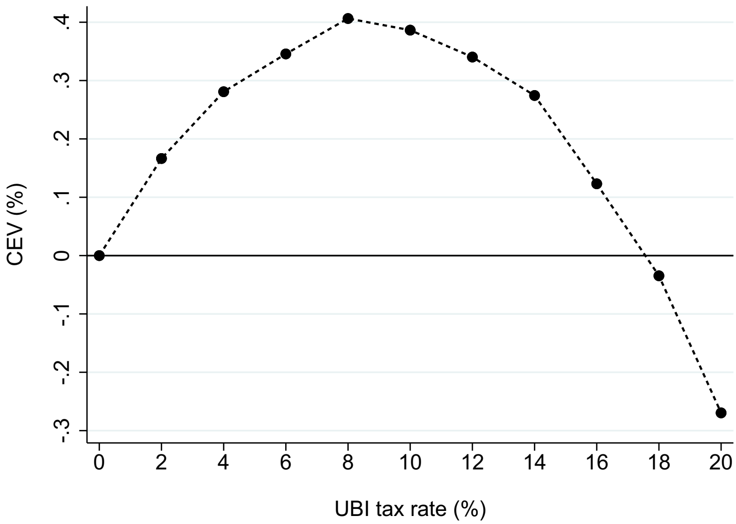

Figure 1. Welfare gains of UBI under various tax rates.

Column (1) is the benchmark economy where no tax and subsidy exist. Columns (2) and (3) are the steady states under the Mankiw-like program described above. By construction, the UBI and NIT provide the same incentives to the households, resulting in an identical allocation. The aggregate output decreases by 13% (from 0.585 to 0.511) in the long run, capital and labor decrease by 22% and 9%, respectively. Two forces can explain the decrease of factor inputs. First, the introduction of a welfare program reduces the motive for precautionary savings and the labor supply. Second, the imposition of an income tax reduces the incentive to work and save. As capital decreases more than labor, the capital-labor ratio falls, and the equilibrium interest rate rises to 5.48% (and the wage rate falls by 6%), which slightly increases the Gini coefficients of wealth (from 0.640 to 0.657) and before-tax income (from 0.324 to 0.341). Owing to the redistribution policy, the after-tax income Gini drops to 0.273. As the aggregate output decreases significantly, the average income also falls. The UBI program requires 15.4% of the GDP, whereas the tax-to-GDP ratio under the NIT is only 3.8%. Overall, the average welfare slightly decreases (−0.56% in consumption-equivalence units).[3] In this particular case (of 20% effective marginal tax rate on income), the cost of distortion from taxes outweigh the insurance benefit of the subsidy.

3.4. Optimal UBI and NIT

In the above analysis, we assume that the tax rate is fixed at $\tau = 0.2$ and the transfer amount for the households with zero income ($\bar{T}$ or T_0) is 20% of the average income. We drop these assumptions and look for an optimal UBI amount $\bar{T}$ (still under a linear income tax schedule) along with a tax rate that balances the government budget.

Figure 1 plots the average welfare gains (in consumption-equivalence units) for a range of tax rates: $\tau \in [0.02, 0.2]$. We compute the welfare gains relative to the benchmark economy with no welfare program ($\tau = 0$). The figure clearly illustrates the trade-off (between the insurance benefit and efficiency costs) in the UBI programs. As the size of the UBI increases, the inefficiency from high taxes starts to dominate the insurance benefit. According to our model, the highest social welfare (0.41% in consumption-equivalence units) is achieved at a tax rate of 8% ($\tau = 0.08$). Under this tax rate, everyone in this economy receives 7.9% ($= \frac{0.033}{0.419}$) of the economy-wide average income as the basic income. The detailed statistics of the steady state under this optimal UBI tax rate $\tau = 0.08$ are reported in column (4) of Table 3.

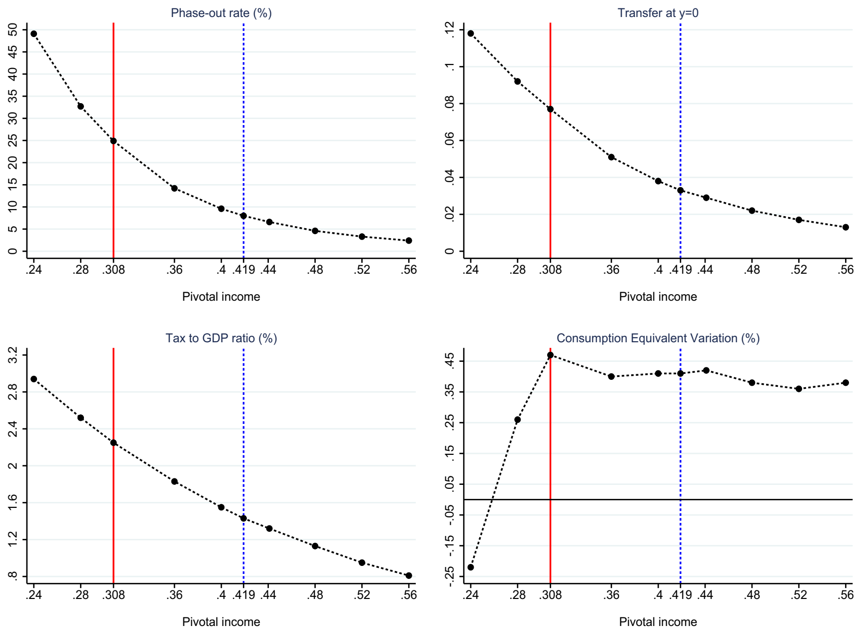

Figure 2. Welfare gains of NIT under various pivotal income.

In Section 3.3 above, we assume that the pivotal income in the NIT is the same as the economy-wide average income ($\hat{y}=\bar{y}$), and the phase-out rate is identical to the tax rate ($\phi=\tau$). While this assumption easily guarantees a balanced budget, in practice, the government has a more leeway to choose from various combinations of these parameters. Now we allow the government can choose one of the two parameters ($\hat{y}$ or ϕ), and the other parameter is set to maintain the balanced budget of the NIT program. For a direct comparison with the optimal UBI of $\tau=0.08$ (which we just derived), we assume that the tax rate above the pivotal income remains at 8%.

The first panel of Figure 2 shows the combinations of pivotal income $\hat{y}$ (ranging from 0.24 to 0.56 in x-axis) and the phase-out rate ϕ (decreasing from 49% to 2.4% in y-axis) which achieve the balanced budget of the NIT. Note that the income tax rate above the pivotal income remains the same at $\tau=0.08$. Since the phase-out rate is not necessarily the same as the income tax rate, the effective marginal income tax schedule is potentially piece-wise linear. The second and third panels show the subsidy amount for a zero-income household (T_0) and tax-to-GDP ratio, respectively.

Looking at the last panel, we obtain the highest welfare (CEV of 0.47%) when the pivotal income is 0.308—marked by red vertical line—which is the 45th percentile of the income distribution. (We also mark the NIT program that replicates the optimal UBI (of $\tau=\phi=0.08$) by the dotted vertical line in the figure for comparison). The phase-out rate under the optimal NIT (that achieves the balanced budget) is 0.249. Thus, the phase-out rate is much steeper than the income tax rate of 8% above the pivotal income. This optimal NIT features a subsidy that is generous to those with very little income and phases out quickly, providing a strong insurance to the very poor. Column (5) in Table 3 reports the detailed statistics of the steady state of this optimal NIT.

The households with zero income receive more than twice the subsidy than under the optimal UBI: $T_0=0.08$ in Column (5) versus 0.033 in Column (4) of Table 3. This results in a lower aggregate capital and labor in the long run (via a weaker motive for precautionary savings). While the aggregate hours fall by 7%, the efficiency units of labor decrease by 4.4% only because the decrease in the labor supply stems largely from the low-productivity workers. As the government collects

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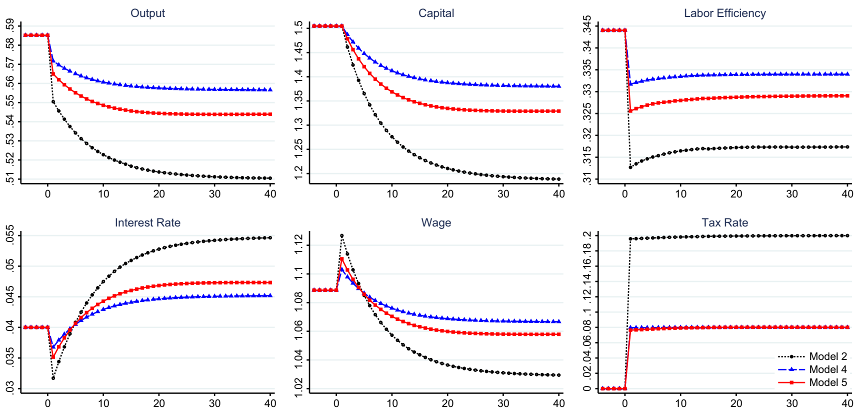

Figure 3. Transition dynamics.

taxes only from those above the 45th percentile, the tax-to-GDP ratio is a mere 2.3% in Column (5) (compared to 6% under the optimal UBI in Column (4)). Thus, the NIT can perform nearly as well as (actually slightly better than) the UBI with a much smaller budget.

3.5. Transition dynamics

So far, we have focused on the steady states only. In this subsection, we consider the transition dynamics between the steady states. Suppose that the economy is in the steady state without any welfare program (i.e. Column (1) of Table 3) in period 0. We assume that a redistribution program is introduced in year 1. During the transition to a new steady state, we assume that the government chooses the tax rates to achieve a period-by-period budget balance. For example, the government introduces a fixed-amount UBI and chooses a sequence of income tax rates (τ_t's) to achieve a balanced budget each year. In the case of the NIT, the government announces a fixed phase-out rate and pivotal income in period 1 (along with a sequence of tax rates in the future to balance the budget in each period until the economy reaches the new steady state).

Figure 3 plots the transition dynamics of the economy for 40 years for three cases: Columns (2), (4), and (5) of Table 3 which we label as Models (2), (4), and (5), respectively. In all three scenarios, the model economy (nearly) converge to new steady states in 30 years. The half-life of convergence is about 10 years. In all three cases, there are periods of overshooting (i.e. temporary increase in wages and decrease in interest rates) because the economy's current capital stock will be much higher than its new steady state when the government just introduced the welfare program.

3.6. Political support for redistribution program

Finally, we compute the approval rate for each welfare program. Figure 4 illustrates the winners (in blue) and losers (in red) in each of the three scenarios: Columns (2), (4), and (5) of Table 3. The horizontal axis represents the asset holdings, and the vertical axis denotes the average labor income ($w x \bar{h}$). For illustrative purposes, we convert the model units into dollars so the average income in the benchmark model coincides with the per capita GDP in 2018 ($62,805).[4] All three policies easily gain the majority, which is not surprising, because the benchmark economy ($\tau = 0$) does not provide any social insurance at all. In Model (2), 70.7% of the workers are in favor of introducing a redistribution policy (either the UBI or NIT) with an income tax rate of 20%. The approval rate increases to nearly 81.9% for an optimal UBI (Model (4)). The optimal NIT obtains 74.4% (Model (5)). Compared with the UBI, the approval rate falls among the lower-middle asset

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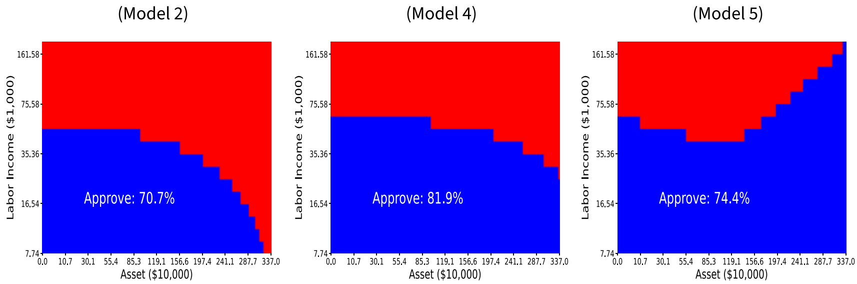

Figure 4. Political support for introducing redistribution program.

and income households (where the population density is high given the skewed income and asset distributions), because the subsidy phases out quickly under this NIT.

In general, the workers with low productivity and low assets are in favor of introducing a redistribution policy. According to Model (2), among the households with asset holdings below \$853,000, those with annual labor income less than \$50,000 are better off from the introduction of a redistribution program whereas those with the labor income higher than \$50,000 are against the UBI. As the asset holdings increase, the fraction of workers in favor of the redistribution policy diminishes. When the asset holdings reach \$3 million, no one is in favor of an introduction of the UBI financed by a 20% income tax rate. However, in Models (4) and (5), quite a few rich households are in favor of a redistribution program, owing to so-called pecuniary externalities [e.g. Dávila et al. (2012)]. On the one hand, redistribution is bad for wealthy households. On the other hand, redistribution raises the returns to capital in equilibrium because of the decreased supply of the aggregate capital (owing to a weak motive for precautionary savings).

4. Sensitivity analysis

The optimal degree of redistribution depends on the trade-off between efficiency costs and insurance benefits. In our model, three parameters are particularly important for this trade-off: the elasticity of the labor supply γ and uncertainty about the future income (ρ_x and σ_x, which govern the stochastic process of individual productivity shocks). The benchmark model assumes that $\gamma = 0.5$, $\rho_x = 0.92$, and $\sigma_x = 0.21$. We consider two additional cases with respect to the elasticity of labor supply: inelastic ($\gamma = 0.25$) and elastic ($\gamma = 1$). We also consider two variants of the model with respect to the stochastic process of productivity shocks: highly persistent shocks ($\rho = 0.96$) and a larger SD ($\sigma_x = 0.31$). Both specifications result in a 50% larger uncertainty about the future income and thus strengthen the insurance benefit of redistribution policies. In all four specifications, we re-calibrate two preference parameters, that is, the discount factor β and the relative weight on the disutility from working B, to match the real interest rate of 4% and average work hours of 0.33 in the steady state, as in the benchmark. Table 4 summarizes the parameter values of these four additional specifications.

The left panel in Figure 5 shows the welfare gains/costs (in consumption-equivalence units in the steady state) for three values of the labor supply elasticity (for $\tau \in [0, 0.2]$). When the labor supply is inelastic ($\gamma = 0.25$), the optimal UBI tax rate will increase to 12% (from 8%), as the efficiency cost from the labor supply distortion is small, and vice versa, with an elastic labor supply ($\gamma = 1$).

The right panel in Figure 5 shows the welfare gains/costs for the alternative specifications of the model with respect to the stochastic process of idiosyncratic productivity shocks. Both alternative specifications, that is, a higher persistence and a larger SD of innovation, increase the uncertainty

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Table 4. Sensitivity analysis

	Benchmark	Labor supply		Productivity shock	
		Inelastic	Elastic	Persistent	Larger SD
γ	0.50	**0.25**	**1.00**	0.50	0.50
ρ_x	0.91	0.91	0.91	**0.96**	0.91
σ_x	0.21	0.21	0.21	0.21	**0.31**
β	0.948	0.949	0.945	0.941	0.935
B	22.5	210.0	7.5	23.5	22.0

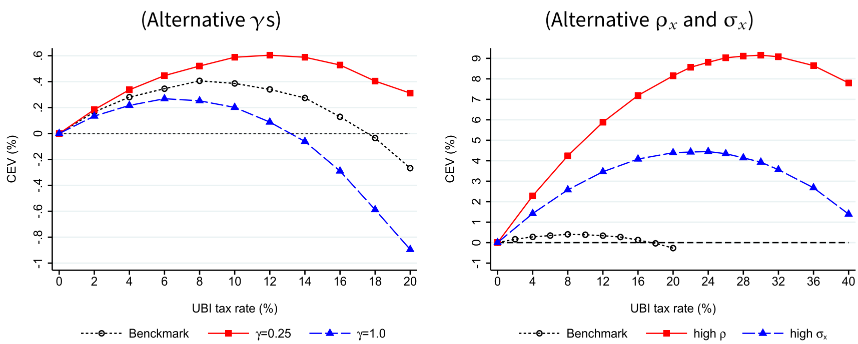

Figure 5. Welfare gains of UBI under alternative specifications.

Table 5. Optimal UBI and NIT under alternative specifications

	Benchmark	$\gamma = 0.25$	$\gamma = 1$	$\rho_x = 0.96$	$\sigma_x = 0.31$
Optimal UBI					
Tax rate (τ)	0.08	0.12	0.06	0.30	0.24
CEV (%)	0.41%	0.60%	0.27%	9.20%	4.45%
Average income	0.419	0.413	0.424	0.369	0.388
Optimal NIT					
Tax rate (τ)	0.08	0.12	0.06	0.30	0.24
CEV (%)	0.43%	0.63%	0.40%	9.20%	4.46%
Average income	0.411	0.415	0.416	0.368	0.389
Pivotal income ($\hat{y}$)	0.3	0.5	0.3	0.36	0.4
Percentile of $\hat{y}$	(43)	(70)	(43)	(65)	(65)
Phase-out rate (ϕ)	0.28	0.07	0.20	0.32	0.22
Tax-to-GDP ratio	0.023	0.014	0.012	0.089	0.063

about the future income by 50%, thereby strengthening the insurance benefit of the welfare program. The optimal UBI tax rate significantly increases in both cases: 30% and 24% for $\rho_x = 0.96$ and $\sigma_x = 0.31$, respectively.

Table 5 summarizes the tax rate, welfare gains (CEV), and the average income of the optimal UBI in each specification. The welfare gains are the smallest under an elastic labor supply (0.27% under $\gamma = 1$) and largest (9.2%) when the productivity shocks are highly persistent ($\rho_x = 0.96$).

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Next, we look for an NIT program that will maximize the average welfare. Similar to the benchmark case, we assume that the tax rate above the pivotal income is the same as that in the optimal UBI under an each alternative specification of the model economy. Given the tax rate, we vary the pivotal income and the corresponding phase-out rate (ϕ), which will balance the NIT budget. The bottom half of Table 5 reports the optimal NIT policies and their outcomes. We also report the income percentile of the pivotal income in equilibrium. When the labor supply is inelastic ($\gamma = 0.25$), owing to a high tax rate of 12%, the optimal NIT can afford a high pivotal income ($\hat{y} = 0.5$, which falls upon the 70th percentile in the income distribution) and low phase-out rate ($\phi = 7\%$). With an elastic labor supply, the opposite occurs. With a lower income tax of 6%, the pivotal income returns to 0.3 (which falls upon the 43rd percentile), with a 20% phase-out rate. With a larger uncertainty, the optimal UBI tax rate increases to 30% and 24% for $\rho_x = 0.96$ and $\sigma_x = 0.31$, respectively. The optimal NIT exhibits higher pivotal incomes (0.35 and 0.4 in the 65th percentile in both cases) and steeper phase-out rates (32% and 22%).

5. Summary

We compare two welfare programs: the UBI and NIT. Within the class of a linear income tax-and-transfer system, the NIT can replicate the allocation of the UBI exactly by providing an identical effective marginal tax schedule. However, the total budget of the NIT is *always* smaller than that of the UBI. Using a quantitative general equilibrium model calibrated to approximate the income and wealth distributions in the United States, we compute an optimal UBI and NIT. Under a flat tax rate of 20%, the UBI program costs about 15.4% of GDP in the steady state, whereas the NIT (which generates an identical allocation) costs 3.8% of the GDP. Neither program improves social welfare significantly in the long run. The reduction in capital and labor owing to a distortion from taxes and weakened motive for precautionary savings and work roughly offsets the insurance benefit. In fact, the average welfare decreases slightly by 0.56%, in terms of consumption-equivalence units. The aggregate output, capital, and hours worked decrease by 12%, 22%, and 10%, respectively, in the long run. Among the UBI programs with a linear income tax, the model economy achieves the highest social welfare with a moderate amount of basic income, that is, 7.2% of the average income and an 8% tax rate. The average welfare improves slightly (by 0.4%) compared with a *laissez-faire* economy. Under the same income tax rate of 8%, the NIT can perform nearly as well (actually slightly better) with a much smaller budget (a mere 2.3% of the GDP). This (optimal) NIT program features a piece-wise linear effective marginal tax schedule: an 8% tax rate above the 40th income percentile, and a subsidy that is generous to the very poor (i.e. 19.5% of the average income for those with zero income) and quickly diminishes (at a 27% phase-out rate) as income rises.

We end this summary by raising a warning flag in applying our results in the real world. We conducted our analysis under two restrictive assumptions: (i) all taxes are collected under a linear or piece-wise linear income tax schedule, and (ii) no administrative costs exist in collecting taxes and providing transfers. In a realistic environment, the two policies will generate different outcomes depending on the exact nature of the administrative costs. For example, the UBI typically requires a budget that is four times as large as that of a comparable NIT, but it does not need to distinguish the recipients (and their payments) across households.[5]

Notes

1 We add the government budget constraint in the assumption 3, which is missing in Mankiw (2021).

2 See Chetty (2006) who found that a mean estimate of the risk aversion is close to one.

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3 Following Aiyagari and McGrattan (1998), we look for a compensating differential (Δ) to make a consumer indifferent to living between two economies.

$$\int \left\{ \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \left\{ \frac{[(1+\Delta)c_1(a_t, x_t)]^{1-\sigma} - 1}{1-\sigma} - B\frac{h_1(a_t, x_t)^{1+1/\gamma}}{1+1/\gamma} \right\} \right] \right\} d\mu_1(a_t, x_t)$$
$$= \int \left\{ E_0 \left[\sum_{t=0}^{\infty} \beta^t \left\{ \frac{c_0(a_t, x_t)^{1-\sigma} - 1}{1-\sigma} - B\frac{h_0(a_t, x_t)^{1+1/\gamma}}{1+1/\gamma} \right\} \right] \right\} d\mu_0(a_t, x_t).$$

where c_0, h_0, and μ_0 are consumption, the labor supply, and the steady-state distribution in the benchmark economy, and c_1, h_1, and μ_1 are those in a new tax system.

4 The x-axis (asset holdings) stops at \$3.4 million for illustrative purposes.

5 For example, the administrative cost of collecting taxes is 1.1% of the net tax revenue, on average, across the OECD countries [OECD (2013)]. Eurostat (2012) reported that the administrative cost of social welfare programs is about 3% of the total budget.

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