Universal Basic Income and Progressive Consumption Taxes

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Abstract

We provide a comprehensive quantitative evaluation of Universal Basic Income (UBI), evaluating different degrees of generosity and the fiscal alternatives to finance it. Replacing existing targeted transfers with a UBI of equal fiscal cost results in widespred welfare losses. In contrast, a combination of generous UBI (at least $15,000 per household) with a switch to progressive consumption taxation could be beneficial from the perspective of ex-ante expected welfare in the long run. However, the quantitative analysis of the transitional dynamics reveals non-trivial transitional costs for most current households.

Keywords: Incomplete market, Heterogeneous agents, Consumption tax, Universal basic income, Transitional dynamics

JEL classification: E2 , D52, H21

1 Introduction

This paper provides a quantitative evaluation of the impact of Universal Basic Income (henceforth UBI) for macroeconomic aggregates, inequality and welfare. The key distinguishing feature of our analysis is to evaluate different levels of UBI generosity, paired with different strategies to finance government policies. As such, we quantify the efficiency-equity trade-off jointly on the expenditure side and the revenue side of the government budget. Our results suggest that a combination of generous UBI with a switch to progressive consumption taxation could be beneficial from the perspective of ex-ante expected welfare in the long run. Yet, the quantitative analysis of the transitional dynamics reveals non-trivial transitional costs for most current households.

The current US welfare state consists of different public programs that target different segments of the population and usually provide transfers (cash or in-kind) that are means tested. This arrangement allows to target resources to those individuals most in need, at the expense of introducing substantial distortions and disincentives at the bottom of the income distribution (see Moffitt (2002)). UBI is viewed in several political and academic circles as an alternative to means-tested transfers. Its universal nature eliminates the large effective marginal tax rates at the bottom of the distribution introduced by means-tested programs, but it raises the fundamental question of how to pay for it and its impact on overall economic performance. Surprisingly, there are very few quantitative evaluations to inform this debate, and our exercise contributes by providing a thorough analysis of the implications of different levels of UBI generosity and alternative financing schemes.

In order to perform this policy exercise, we use an overlapping generations model where households face uninsurable idiosyncratic labor productivity risk in the spirit of Huggett (1993) and Aiyagari (1994). An additional contribution of this paper is to provide direct measures of productivity risk by age and education levels without relying on ad-hoc functional forms. Households in the model choose hours worked and savings, so that a system of taxes and transfers introduces potential distortions on both margins. One crucial departure of our analysis is the distinction between two types of consumption goods. Basic consumption goods are subject to a minimum consumption level, while the rest of consumption goods are not. This feature introduces the possibility of progressive consumption taxes, and our analysis will also tackle how to optimally tax differently these two types of goods.

UBI is not a new idea, and it connects back to the discussion by Friedman of a Negative Income Tax (NIT). UBI is in sharp contrast with the current targeted welfare transfers, provoking heated debates in policy and academic circles, for example Yang (2018), Stern (2016) and Van Parijs and Vanderborght (2017). Hoynes and Rothstein (2019) provide an excellent overview of the different proposals and pilot programs around the world, and argues that a UBI generous enough to make a difference for the poor would be too costly. The paper closer to our approach is Lopez-Daneri (2016), who provides a quantitative evaluation of a NIT (which is equivalent to UBI within the context of our approach) in a model environment similar to ours. His analysis is constrained to revenue-neutral reforms financed with proportional income taxes, and finds support for a NIT system instead of targeted transfers. In our analysis we do not impose revenue-neutrality and we allow for a much wider set of alternatives in both the expenditure and the revenue side, including progressive consumption taxation.

There is a long tradition advocating for expenditure taxation instead of income taxation that goes back to at least Kaldor (1955). In the recent literature, quantitative macroeconomic models similar to ours have been used to quantify the impact of different types of reforms. Exercises quantifying the macroeconomic impact and inequality implications of consumption taxation and flat-tax reforms in the spirit of Hall and Rabushka (1995) can be found in Krusell et al. (1996), Ventura (1999), Altig et al. (2001), or Correia (2010), among others. While Conesa et al. (2019) evaluates progressive consumption taxes in isolation, it turns out to play a key role in financing UBI schemes in this paper.

Our first policy exercise consists of eliminating all existing targeted transfers and providing all these resources as UBI instead. The resulting UBI consists of an annual transfer slightly below $2,500 for each working-age household. Such a policy is revenue neutral, but still requires some fiscal adjustments since households change behavior in response to the policy change, affecting other sources of fiscal revenues. Overall, such a policy implies a redistribution of resources from the poor to the rich and welfare is negatively affected. If, in addition, we switch to progressive consumption taxes efficiency improves, output increases and the welfare losses of the low-skilled households are reduced at the same time that the high-skilled experience moderate welfare gains.

Next, we explore the macroeconomic and welfare implications of different levels of UBI generosity combined with progressive consumption taxes. It turns out that the welfare of low-skilled households increases with the generosity of UBI, while it decreases for the high-skilled. There is a range, roughly between $10,000 and $20,000, where both types of households experience welfare gains relative to the benchmark scenario. Average welfare across these two groups is maximized for even more generous UBI (around $35,000), but that implies a welfare loss of 4.7 percent for the high-skilled and a welfare gain of 11.2 percent for the low-skilled.

While a combination of UBI and progressive consumption taxes has the potential to generate welfare gains in the long run, the transitional dynamics ask for more caution. We compute the level of UBI that maximizes average welfare gains over the population in the benchmark economy, and it corresponds to $25,000. Yet, this reform only generates welfare gains for 23.5 percent of the population. This result casts doubts on the desirability of such a reform.

The paper is organized as follows. Section 2 describes the model. Section 3 discusses the calibration strategy. Numerical experiments of revenue natural reforms can be found in Section 4. Section 5 experiments with more generous UBI. Section 6 concludes.

2 The model of the benchmark economy

2.1 Demographics

Time is discrete and the economy is populated by J_1 overlapping generations. In each period a continuum of new households is born, whose mass grows at a constant rate n. Each household works J_0 years and lives up to a maximum of J_1 years. Each household faces a positive probability of survival to next period. Let $\phi_j = Prob(alive\ at\ j+1 | alive\ at\ j)$ denote the conditional survival probability from age j to age $j+1$. At age J_1 households die with probability one, i.e., $\phi_{J_1} = 0$.

We denote the mass of population as $\psi : A \times \Xi \times \Theta \times J \rightarrow \mathbb{R}_+$, where A, Ξ, Θ, J are the state spaces for financial assets a, ability level ξ, labor efficiency θ and age j. Define $\tilde{\Psi}_j : A \times \Xi \times \Theta \rightarrow \mathbb{R}_+$ as the conditional cumulative distribution function of financial asset, ability level and labor efficiency for a given age j; $\tilde{\Psi}_{\xi,j} : A \times \Theta \rightarrow \mathbb{R}_+$ as the conditional cumulative distribution function of financial asset and labor efficiency for a given ability level ξ and age j ; and $\psi_j : J \rightarrow \mathbb{R}_+$ as the marginal density function of age.

2.2 Endowments

Upon entering the labor market, each household receives an innate ability level, which is assumed to be deterministic throughout the life cycle. Besides, households are also endowed with one unit of time in each period. At working age, time is divided between work and leisure; after retirement, households enjoy leisure full-time. Households enter the market with no financial assets. We assume that households have no bequest motives, but there are accidental bequests that are equally distributed among the surviving population.

2.3 Preferences

Households derive utility from basic consumption c_1, other consumption c_2 and disutility from labor l. The future utility is discounted by the factor β and conditional survival probability ϕ_j. The objective function of a newborn household is

$$E\sum_{j=1}^{J_1}\beta^j\left(\Pi_{s=1}^{j}\phi_s\right)u(c_{1,j},c_{2,j},l_j).$$

2.4 Earnings

During working age, households receive a labor income consisting of a wage w, a deterministic age and ability dependent labor productivity $e_{\xi,j}$, an idiosyncratic shock $\theta_{\xi,j}$, which also depends on age and ability, and hours worked l.

After retirement, households receive a social security benefit pen_ξ, with a replacement ratio of b_ξ. Note, pension is based on households' permanent income, which is determined by one's ability level, so the replacement is also ability dependent.

The earning function for workers and retirees is as follows:

$$y_j^{earn} = \begin{cases} we_{\xi,j}\theta_{\xi,j}l_j, & j \leq J_0 \\ pen_\xi, & j > J_0. \end{cases}$$

2.5 Welfare transfers

Each period, households receive welfare transfers $tr(y^{inc})$ from the government. The welfare transfers are means tested, and they are assumed to depend on pre-tax income, denoted by y^{inc}, which consists of capital income ra and labor earnings.

2.6 Production

There is a representative firm renting capital K and labor L to produce output Y, which is used for basic consumption C_1, other consumption C_2, capital investment I, as well as government spending G. The firm's maximization problem is

$$\max_{K,L} F(K,L)-\delta K-rK-wL$$

where r and w are factor prices, and δ is the depreciation rate of capital. The law of motion of capital accumulation is $K'=(1-\delta)K+I$.

2.7 Government and fiscal policy

Each period, the government collects its revenue through income taxes. This paper focuses on federal-level fiscal reforms, so we ignore the taxes at the state and local level. There are two categories of income taxes: a capital income tax, and a labor income tax. The capital income tax is assumed to be proportional to the capital income ra and is taxed at the rate of τ_a. The labor income tax function is denoted by $T(\cdot)$. For working households, the taxable income includes earnings y^{earn} and one half of social security tax contributions ss, where $ss = \tau^{ss}\min\{y^{earn}, \bar{y}\}$ with $\bar{y}$ being the social security cap and τ_{ss} being the social security tax rate.[1] According to the current tax system, pensions and social security benefits of retirees are also treated as taxable labor income.

The tax that a household pays to the government is

$$Tax = \begin{cases} \tau^a ra + T\big(y^{earn} - 0.5ss\big) & j \leq J_0 \\ \tau^a ra + T\big(y^{earn}\big) & j > J_0 \end{cases}$$

Government revenue is used to finance a stream of exogenously given government consumption, G, and Tr is used for welfare transfers. Throughout the paper, we assume that the social security system is self-financed.

2.8 Equilibrium

Definition: Given an exogenous government policy, a stationary equilibrium is a collection of household decision rules $c_1(a,\xi,\theta,j)$, $c_2(a,\xi,\theta,j)$, $a'(a,\xi,\theta,j)$ and $l(a,\xi,\theta,j)$; taxes paid to the government $Tax(a,\xi,\theta,j)$, social security tax $ss(a,\xi,\theta,j)$, welfare transfer received $tr(a,\xi,\theta,j)$ and social security benefits pen_ξ; factor prices r and w; aggregate basic consumption C_1, aggregate other consumption C_2 , aggregate capital K, and aggregate labor L; ; and a measure $\psi : A\times\Xi\times E\times J \to \mathbb{R}_+$, a conditional cumulative distribution function for a given age $\tilde{\Psi}_j : A\times\Xi\times E \to \mathbb{R}_+$; a conditional cumulative distribution function for a given ability and age $\tilde{\Psi}_{\xi,j} : A\times E \to \mathbb{R}_+$, and a marginal density function of age $\psi_j : J \to \mathbb{R}_+$ such that:

[1]Here, we abstract from the double taxation problem of capital income and summarize the overall capital taxes paid by households and firms into a single tax on the net return of capital.

1. Given prices and tax policies, $\{c_1, c_2, a', l\}$ solve the households' maximization problem:

$$V(a,\xi,\theta,j) = \max_{\{c_1,c_2,a',l\}} u(c_1,c_2,l) + \beta\phi_{j+1}EV(a',\xi,\theta',j+1)$$

$$\text{s.t. } c_1 + c_2 + a' = \begin{cases} (1+r)a + y^{earn} - Tax - ss + tr, & j \leq J_0 \\ (1+r)a + y^{earn} - Tax + tr, & j > J_0 \end{cases}$$

$$y^{earn} = \begin{cases} we_{\xi,j}\theta_{\xi,j}l, & j \leq J_0 \\ pen_\xi, & j > J_0 \end{cases}$$

$$Tax = \begin{cases} \tau^a ra + T\big(y^{earn} - 0.5ss\big), & j \leq J_0 \\ \tau^a ra + T\big(y^{earn}\big), & j > J_0 \end{cases}$$

$$ss = \tau^{ss}\min\{y^{earn}, \bar{y}\}$$

$$c_1, c_2 > 0, a' \geq 0, 0 < l \leq 1$$

2. The firm maximizes its profit according to

$$\max_{\{K,L\}} F(K,L) - \delta K - rK - wL$$

3. Markets clear:

   (a) The goods markets clear

$$C_1 + C_2 + K' - (1-\delta)K + G = Y$$

$$C_1 = \sum_{j=1}^{J_1} \psi_j \int_{A\times\Xi\times\Theta} c_1 d\tilde{\Psi}_j(a,\xi,\theta)$$

$$C_2 = \sum_{j=1}^{J_1} \psi_j \int_{A\times\Xi\times\Theta} c_2 d\tilde{\Psi}_j(a,\xi,\theta)$$

   (b) The capital markets clear

$$K' = \sum_{j=1}^{J_1} \psi_j \int_{A\times\Xi\times\Theta} a' d\tilde{\Psi}_j(a,\xi,\theta)$$

   (c) The labor markets clear

$$L = \sum_{j=1}^{J_1} \psi_j \int_{A\times\Xi\times\Theta} e_{\xi,j}\theta_{\xi,j} l d\tilde{\Psi}_j(a,\xi,\theta)$$

4. Fiscal policy is such that:

    (a) The government general budget constraint is satisfied:

$$\sum_{j=1}^{J_1} \psi_j \int_{A\times\Xi\times\Theta} Tax d\tilde{\Psi}_j(a,\xi,\theta) = \sum_{j=1}^{J_1} \psi_j \int_{A\times\Xi\times\Theta} tr d\tilde{\Psi}_j(a,\xi,\theta) + G$$

    (b) The social security budget constraint is satisfied:

$$pen_\xi = \frac{bw \sum_{j=1}^{J_0} \psi_j \int_{A\times\Theta} e_{\xi,j}\theta_{\xi,j} l d\tilde{\Psi}_{\xi,j}(a,\xi,\theta)}{\sum_{j=1}^{J_0} \psi_j \int_{A\times\Theta} d\tilde{\Psi}_{\xi,j}(a,\xi,\theta)}$$

$$pen_\xi \sum_{j=J_0+1}^{J_1} \psi_j \int_{A\times\Theta} d\tilde{\Psi}_{\xi,j}(a,\xi,\theta) = \tau_{ss} w \sum_{j=1}^{J_0} \psi_j \int_{A\times\Theta} e_{\xi,j}\theta_{\xi,j} l d\tilde{\Psi}_{\xi,j}(a,\xi,\theta)$$

5. The measure over the state space evolves according to the Markovian transition matrix:

$$\psi(a',\xi,\theta',j+1) = \phi_j \psi(a,\xi,\theta,j)\Pi_{\xi,j}(\theta,\theta')\mathbf{1}_{a'}(a,\xi,\theta,j)$$

    where $\mathbf{1}(\cdot)$ denotes the indicator function that takes value 1 if $a' = a'(a,\xi,\theta,j)$ and 0 otherwise.

3 Calibration

This section presents the calibration strategy and model validation. One period in the model is the equivalent of four natural years. The reason for doing so is to make sure that the sample size for estimation of productivity processes is sufficiently large (see Section 3.5). Some parameters are determined exogenously, others are jointly calibrated in equilibrium to match the data.

3.1 Demographics

We assume that households enter the market without any financial asset, i.e. $a_0 = 0$. The annual population growth rate is set to 1.2 percent, which means that the four-year population growth rate is $n = 4.9\%$. The conditional survival probabilities ϕ_j are obtained from Bell and Miller (2002). In Bell and Miller (2002), they provide conditional cohort probabilities of survival at age 0, 30, 60, 65, 75 and 100. We interpolate the conditional survival probabilities at each age, then multiply the consecutive four years as the conditional survival probability of our model time interval, Figure 1 shows the interpolated probabilities that we use in the model.

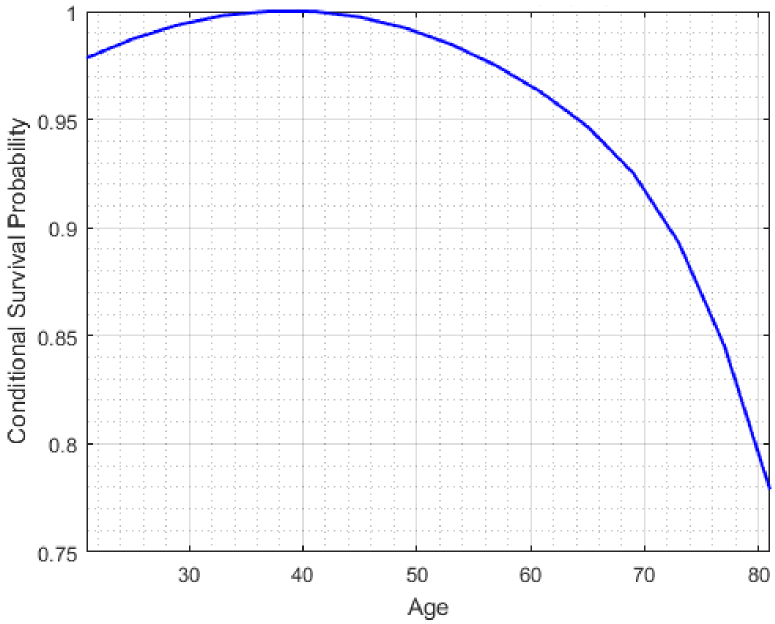


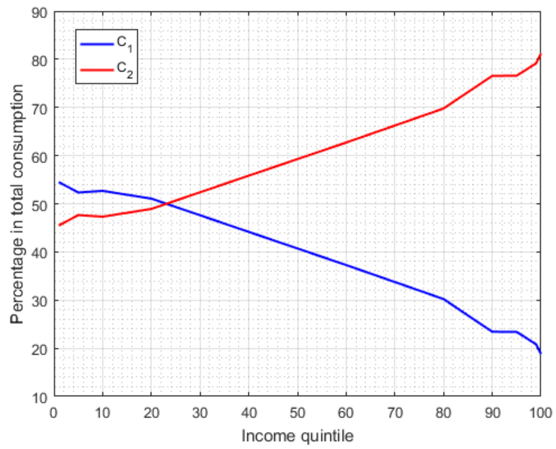
Figure 1: Conditional survival probability, interpolated

3.2 The definition of basic consumption: Expenditure patterns in the CEX

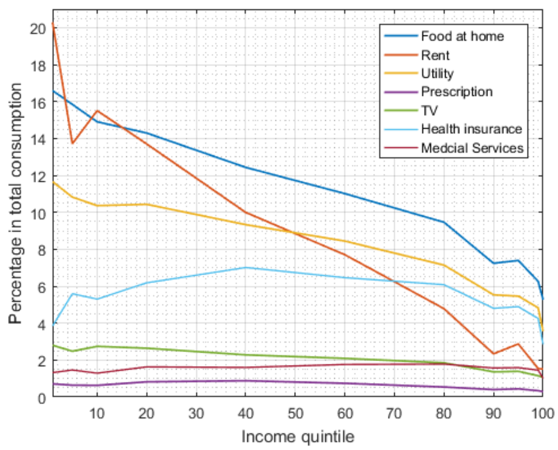
In order to determine the distinction between basic goods and non-basic goods we look at the composition of consumption in relation to income in the Consumption Expenditure Survey (CEX) 2017. The consumer unit is one household, the expenditure profile is constructed according to income. We restrict our sample to households whose household head is between 21 and 65 years old and participates in the labor force. We consider basic goods those categories for which their share in total consumption decreases with income. Based on this criterion we label as basic goods food at home, rent, utility, prescription medicine and television. We also include health insurance and medical services as basic goods.[2] Notice there is a substantial overlap between those categories and the goods that are usually subject to either reduced rates or exemptions from taxation. All other expenditure categories are labeled as non-basic consumption goods. See the Appendix for a more careful description of the data and the procedure we use to construct consumption shares.

Figure 2a shows the relationship between expenditure shares and earnings for the largest categories of consumption in the CEX. Figure 2b lists the items of basic consumption, whereas examples of non-basic consumption are presented in Figure 2c.

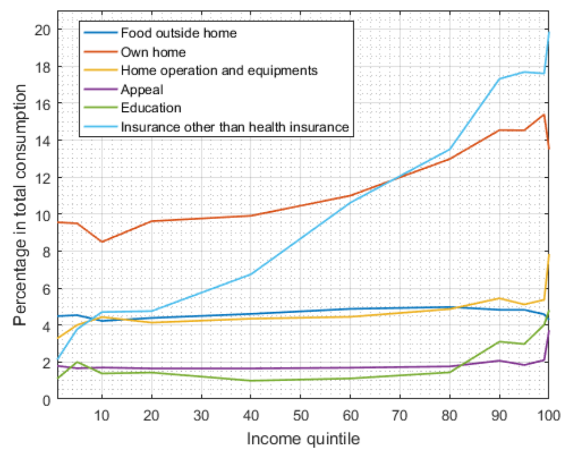
[2]A large number of papers find that bad health is a big obstacle to participate in labor market and financial market, and eventually leads to low income (De Nardi et al. (2017), Currie and Madrian (1999), Poterba et al. (2017) and De Nardi et al. (2010) etc.).



(a) Share of C_1 and C_2 in total C by pre-tax income quintile, in %



(b) Items in C_1 as a percentage of total C by pre-tax income quintile, in %



(c) Items in C_2 as a percentage of total C by pre-tax income quintile, in %

Figure 2: Items of consumption as a percentage in total consumption by income quintile, in %

Basic consumption goods (the group of categories with a declining consumption share as income increases) takes up 54.5 percent of total consumption for households whose income is at the bottom 1 percent and only consists of 18.8 percent of total consumption for households at the top 1 percent.

The share of food at home and rent declines the most with income: from 16.6 and 20.3 percent for the bottom 1 percent, to 5.3 and 1.5 percent for the top 1 percent, respectively. Utility payments also appear to decrease rapidly with income, with a highest share of 11.7 percent at the bottom of of the income distribution. On the other hand, expenses on insurance other than health insurance and on own home (interest on mortgage payment is not included) exhibit increasing patterns with income.

3.3 Preferences

The utility function is:

$$u(c_1, c_2, l) = \frac{\left(\left(\gamma(c_1 - \underline{c})^\nu + (1-\gamma)c_2^\nu\right)^{1/\nu}\right)^{1-\sigma}}{1-\sigma} - B\frac{l^{1+\frac{1}{\chi}}}{1+\frac{1}{\chi}}$$

We set σ equal to 2. Parameter γ governs the share of basic consumption in total consumption. Under the assumption that the minimum consumption $\underline{c}$ is irrelevant for households at the top of the income distribution, γ is the share of basic consumption in total consumption at the top of the distribution, which is 0.21. The elasticity of substitution between c_1 and c_2, $\frac{1}{1-\nu}$ is assumed to be 1 in the benchmark case. That is $\nu = 0$ and utility takes the Cobb-Douglas form. Following Chetty et al. (2012), the Frisch elasticity of labor supply $\chi = 0.75$.

The minimum consumption $\underline{c}$ is chosen to target the ratio of aggregate $C_1/C_2 = 0.5$. Parameter B is calibrated such that average hours worked are one third of available time.

3.4 Life-cycle profiles of labor productivity

We use PSID data from 1969 to 2017 to form a household panel at four-year intervals. The Appendix gives a more detailed description of the data treatment. Basically, we keep in the sample households that: 1. are in the non-immigration sample; 2. whose head is between 21 and 65 years old; 3. whose head's annual hours worked is above 260 hours; 4. whose earnings are not completely from self-employment; 5. whose wage rate (household total earning over total hours worked) is above one half of the minimum wage rate. We split the sample into two ability levels: non-college and college graduates. The deterministic life-cycle profiles are obtained by regressing logarithm wage rate on age, age squared, cohort dummies, and year dummies, which capture the time fixed effects. This estimation is done for non-college graduates and college graduates separately. Figure 3 presents the life cycle profile for non-college and college households respectively.

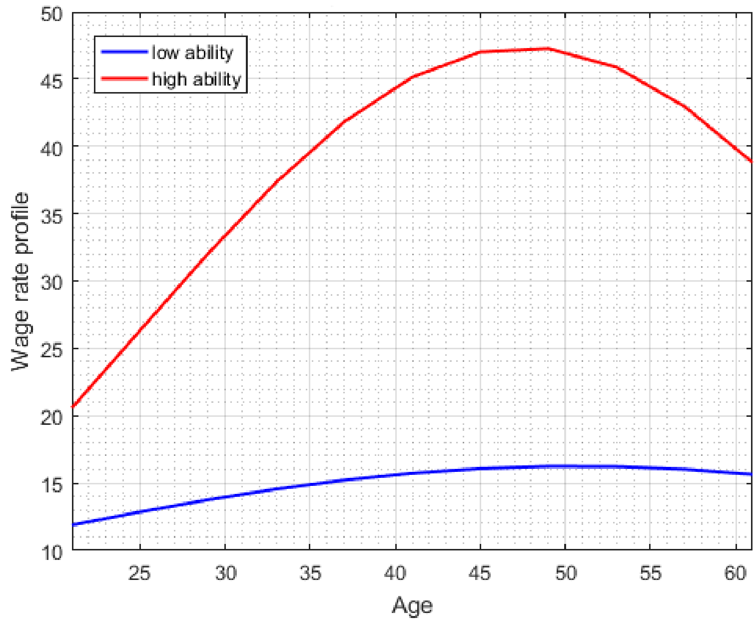


Figure 3: Life cyce wage profile, in 2017 $

3.5 The stochastic process of labor productivity

The stochastic component of labor productivity is taken directly from the data. In the spirit of De Nardi et al. (2019), our procedure is to compute age-education dependent Markov processes that impose no constraints on the stochastic properties of the shocks. In particular, our parameterization allows for the type of deviations from log-normality emphasized in Guvenen et al. (2019).

Taking the residuals from the regression that provides the deterministic life-cycle profiles, we split households for each educational class according to 11 age groups within a 4-year interval; within each age and education group, residuals are categorized into 11 shocks corresponding to the percentiles of the Lorenz curve of the distribution of residuals. The age and education-dependent realization of the shock θ takes the median value for each group.

For the transition matrix, we simply compute age-education dependent transitions over four year intervals as the probability of a household moving from one percentile group this period to another group next period. We use order probit regressions to estimate those probabilities. The reason for doing so is to tackle the small sample problem of some age-education groups.

The procedure we have used for obtaining the age-dependent states and transition matrices is somewhat similar to De Nardi et al. (2019). In their paper, after removing the life-cycle profile, they split the residuals into a persistent component and a white noise component, and then estimate the persistence and variances. Using the estimation results, they simulate each component and construct a set of artificial residuals. Then they perform the same exercise as we described above to obtain transition probabilities. In their procedure, they inevitably assume a functional form for the distribution of residuals, whereas in our approach we do not need to impose any restriction on the structure of shocks.

3.6 Technology

The aggregate production function is assumed to be Cobb-Douglas, with a capital income share of 0.33. The annual capital depreciation rate is set to be 0.059, to match investment ratios in the steady state of the benchmark economy to averages in the data. This means that the capital depreciation rate for four years is 0.218.

3.7 Fiscal policy in the benchmark economy

3.7.1 Income Taxation

We assume that the capital income tax is proportional to net earnings from wealth, with a marginal tax rate of $\tau_a = 0.396$ (see Domeij and Heathcote (2004)). The labor income tax follows Gouveia and Strauss (1994) and takes the form:

$$T(y^{earn}) = \kappa_0(y^{earn} - ((y^{earn})^{-\kappa_1} + \kappa_2)^{-1/\kappa_1})$$

where y^{earn} is labor earnings, κ_0 is the marginal tax rate at the top of the earnings distribution, and κ_1 governs the degree of progressivity (how fast the marginal tax rate increases from 0 to κ_0). Following Anagnostopoulos et al. (2012) we set $\kappa_0 = 0.414$ and $\kappa_1 = 0.888$. Finally, κ_2 is calibrated to match a total government spending to GDP ratio of 20%.

3.7.2 The Structure of Consumption Taxation

In the benchmark economy, we assume no consumption tax because our exercise concerns the federal budget. In our policy experiments we allow for differential tax treatment between basic consumption goods and other categories, as is commonly done at the U.S. state and local level and in countries with a VAT system. Notice that this allows for a consumption tax scheme that is potentially progressive, by taxing more non-basic goods than basic goods.

In the U.S., the majority of the states have adopted state and local level sales tax.[3] Most of the states apply reduced tax rates and exemptions on different categories. Grocery food is exempted in 31 out of 46 states that have sales taxes, and subject to reduced rates in the other states. Medical prescriptions are exempted in 42 states, and there are usually exemptions on newspapers and periodicals, and several services including transportation. The average tax ranges from 4 percent in Alabama to 7.5 percent in California.

In contrast to the US, many other countries use a Value Added Tax (VAT) system. VAT is a broad-based tax on consumption by households, that taxes the sale to the final consumer through a staged payment process along the supply chain. Firms collect VAT (and pay it to the tax authority) on their sale revenues net of the VAT on the cost of their purchases of inputs and intermediate goods. Similar to sales taxes in US states, the VAT consists of a standard tax rate, together with several categories of reduced rates and exemptions. [4]

3.7.3 Welfare transfer programs

The government provides a variety of means-tested welfare programs to help families with low income and protect them against hardship. Congressional Research Service (CRS) identifies 83 overlapping federal welfare programs, classified into ten categories: cash assistance, medical, food, housing, energy and utilities, education, training, services, child care and child development, and community development. Presented in Table 1 are the proportions of major welfare transfers in total federal outlays and in total GDP constructed from the White House Office of Management and Budget Historical tables.

Table 1: Major welfare transfers as a fraction of government outlays, averaging between 1997 and 2016, in %

Medicaid	UI	SNAP	TANF	SSI	EITC	HA	CTC	CNSM	CHI	WIC	LIHEA	Average
7.37	1.85	1.56	0.80	1.41	1.47	1.49	0.44	0.51	0.19	0.20	0.09	**17.39**

[3]Pennsylvania was the first state to introduce a sales tax in 1921. Around half of the states introduced their own sales taxes during the 1920s and 1930s, and the rest of them introduced them in the period between the late 1940s and the 1960s. The exception are the states that still have not introduced sales taxes as of today: Alaska, Delaware, Montana, New Hampshire, and Oregon.

[4]The standard VAT rates vary across countries. In countries with VAT, the tax rate ranges from 4.5 percent in Andorra to as high as 27 percent in Hungary. Within the OECD the average rate was 19.2 percent in 2014. EU member states are bound by common rules that set the minimum level of the standard rate at 15 percent. The average VAT rate of EU member states is 21.7 percent.

Averaging over 1997 to 2015,[5] the largest welfare programs are: 1. Medicaid (7.3% in the total federal outlays); 2. Unemployment Insurance (UI, 1.8%); 3. Supplemental Nutrition Assistance Program (SNAP, 1.6%); 4. Housing Assistance (1.5%); 5. Earned Income Tax Credit (EITC 1.5%); 6. Supplemental Security Income (SSI, 1.4%); 7. Temporary Assistance for Needy Families (TANF, 0.8%); 8. Children's Nutrition Program (0.5%); 9. Child Tax Credit (0.5%); 10. Women, Infants, and Children (WIC, 0.2%); 11. Children's Health Insurance Program (CHIP, 0.2%); 12. Low Income Home Energy Assistance (LIHEA, 0.1%). Summing up, the total share of these welfare programs in federal outlays is 17.4 percent.

We recover the distribution of overall welfare transfers from multiple datasets, including PSID, CEX and MEPS. PSID is a thorough survey on households' income sources and it keeps records on welfare transfers, like food stamps, TANF, SSI, energy assistance, unemployment compensation, etc. Unfortunately, PSID does not included tax credits and Medicaid, so we obtain information about EITC and child tax credit from CEX, and Medicaid from MEPS. As with the CEX, we only include households from PSID and MEPS whose head of household is between 21 and 65 years old and belongs to the labor force, having hours worked exceeding 260 hours per year, as well as the household wage rate being more than half of the minimum wage.

Because of the differences in data samples, survey frequency and survey questions, there are several inconsistencies in the outcomes. For example, the average earnings in MEPS is roughly 80 percent of the averge earning in PSID and CEX; PSID has the earnings at the top 1 group almost twice as that in MEPS. We adhere to PSID earnings' data for its thoroughness, and interpolate EITC and child tax credits in CEX and Medicaid in MEPS to PSID earning level. The original data and the interpolation algorithm are shown in the Appendix.

Because all these welfare programs are means-tested, requiring earnings and/or assets tests, the families at the bottom of the income distribution do not necessarily receive the highest transfers. For example, only \$453 of EITC transfers go to the bottom 1 percent due to the fact that many of these households do not have a job, whereas households with slightly more income at the bottom $1 \sim 5\%$ are the biggest recipients of EITC. Overall, the welfare transfers decline with income. The average welfare transfer is $\$2,488$, with households whose income is at $1 \sim 5\%$ receiving the most.

In the model, we split welfare transfers into EITC and other transfers. For each category, we choose a piece-wise linear function to describe the welfare transfers as a function of income. That

[5] The reason we begin with 1997 is that TANF was implemented from Jan. 1st, 1997. The Appendix provides the data for each year.

is

$$eitc = \sum_{i=1}^{11} \mu_i^{eitc} I_{y \in income\ group\ i} \times EITC$$
$$other = \sum_{i=1}^{11} \mu_i^{eitc} I_{y \in income\ group\ i} \times Other$$

where I is an indicator that takes value 1 if the criterion is satisfied, y denotes income, *eitc* is the amount of EITC transfers, *other* refers to other transfers. Income groups are the same ones corresponding to the Lorenz curve for productivity: the bottom 1%, $1 \sim 5\%$, $5 \sim 10\%$, $10 \sim 20\%$, $20 \sim 40\%$, $40 \sim 60\%$, $60 \sim 80\%$, $80 \sim 90\%$, $90 \sim 95\%$, $95 \sim 99\%$ and the top 1%. The parameters $\{\mu_i\}_{i=1}^{7}$ are the ratio of a transfer received by this income group to the average welfare transfer. These ratio are directly taken from data except for μ_{11}, which is adjusted endogenously such that the EITC takes up 1.46 percent of the government revenues, and other welfare transfers account for 15.92 percent.

The parameters that we feed in the benchmark model are shown in Table 2 and Table 3.

Table 2: Parameters

Parameter	Targets	Values
Demographics		
g	Annual population growth rate	1.2%
ϕ_j	Conditional survival probability	see text
Preferences		
β	$K/Y = 3$ annually	0.999
σ		2.000
γ	C_1/C_2 at top income percentile	0.210
$\underline{c}$	Average $C_1/C_2 = 0.5$	0.518
ν	Elasticity of substitution between c_1 and c_2	0.000
B	Average hours worked = 0.33	11.339
ξ	Elasticity of labor supply	0.750
Technology		
α	Capital share of income	0.360
δ	Annual capital depreciation rate	0.069
Fiscal policy		
τ_a	Capital income tax rate	0.396
κ_0	Average level of labor income tax	0.258
κ_1	Progressivity of labor income tax	0.786
κ_2	$G/Y = 0.2$	0.999
τ_{c1}	basic consumption tax rate	0.000
τ_{c2}	Other consumption tax rate	0.000
τ_{ss}	Social security tax rate	0.126
$y^{e\bar{a}rn}$	Ratio of social security tax cap to average earnings	2.460
b	Replacement ratio for self-financed SS system	0.487

Table 3: Parameters, contd

EITC transfers		
μ_1^{eitc}	Ratio of EITC received to total EITC transfers at bottom 1% income group	1.129
μ_2^{eitc}	$1 \sim 5\%$	3.624
μ_3^{eitc}	$5 \sim 10\%$	3.462
μ_4^{eitc}	$10 \sim 20\%$	3.082
μ_5^{eitc}	$20 \sim 40\%$	1.443
μ_6^{eitc}	$40 \sim 60\%$	0.355
μ_7^{eitc}	$60 \sim 80\%$	0.068
μ_8^{eitc}	$80 \sim 90\%$	0.052
μ_9^{eitc}	$90 \sim 95\%$	0.034
μ_{10}^{eitc}	$95 \sim 99\%$	0
μ_{11}^{eitc}	1%	0
Other welfare transfers		
μ_1^{oth}	Ratio of other transfer to total at bottom 1% income group	3.810
μ_2^{oth}	$1 \sim 5\%$	3.518
μ_3^{oth}	$5 \sim 10\%$	2.611
μ_4^{oth}	$10 \sim 20\%$	2.434
μ_5^{oth}	$20 \sim 40\%$	1.089
μ_6^{oth}	$40 \sim 60\%$	0.683
μ_7^{oth}	$60 \sim 80\%$	0.454
μ_8^{oth}	$80 \sim 90\%$	0.340
μ_9^{oth}	$90 \sim 95\%$	0.185
μ_{10}^{oth}	$95 \sim 99\%$	0.352
μ_{11}^{oth}	1%	0.624

3.8 Model validation

Given those parameter values we compute the equilibrium in our benchmark economy. Now we turn to the comparison of the benchmark economy to the data. Figure 4 presents basic consumption C_1 as a proportion of aggregate consumption C for all income levels. The model generates a pattern of C_1/C as a function of income that is comparable with the data.

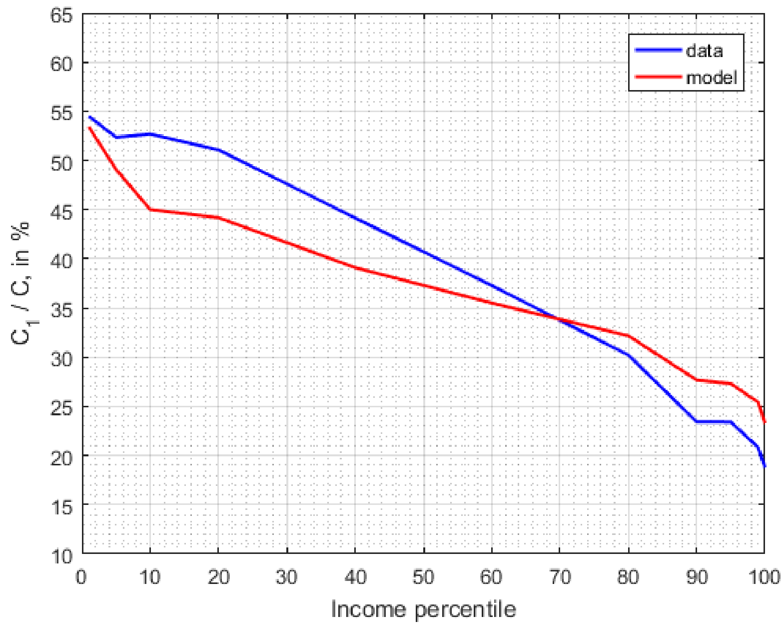


Figure 4: Data vs Model: C_1 as percentage of total consumption by income quintile, in %

Table 4 compares the unconditional distributions between model and data. Table 5 shows the distribution conditional on income of the model versus that of data. Of these variables, only the distribution of EITC transfer and other welfare transfers are directly targeted through calibration. Of course, the welfare transfers match the data almost perfectly, this is attributable to the piece-wise linear function we assumed for the transfer functions. We can see that the model generates a distribution of earning that matches fairly well with data, except that the Gini of earning is slightly larger in the model, because the concentration of earnings at the top is a bit larger in the model than in the data.

Table 4: Data vs Model: Distribution of earning, consumption and welfare transfers, in %

	Gini	Bottom%			quintile					Top%		
		1	$[1,5]$	$[6,10]$	Q1	Q2	Q3	Q4	Q5	$[91,95]$	$[96,99]$	$[99,100]$
						Earnings						
Data	0.431	0.060	0.520	1.000	4.600	9.550	15.020	23.170	47.658	10.960	12.160	8.020
Model	0.536	0.000	0.000	0.000	0.028	7.017	15.163	23.727	54.064	12.173	15.753	8.526
						Wealth						
Data	0.780	-0.219	-0.038	0.000	-0.220	1.333	5.250	13.448	80.190	14.107	25.674	25.794
Model	0.598	0.000	0.000	0.023	0.444	4.265	11.207	23.333	60.751	14.815	17.312	8.124
						Income						
Data	0.439	0.059	0.512	1.017	4.578	9.431	14.592	22.600	48.799	11.020	12.668	8.623
Model	0.381	0.123	0.713	1.541	6.474	11.123	15.510	21.676	45.218	10.440	12.734	6.813
						Basic Consumption C_1						
Data	0.254	0.248	1.461	2.346	9.721	14.291	18.024	22.582	35.382	8.694	8.902	3.491
Model	0.145	0.472	2.856	3.620	14.568	16.494	18.429	21.307	29.202	7.267	6.783	2.592
						Other Consumption C_2						
Data	0.401	0.065	0.620	1.146	4.977	10.175	15.962	23.637	45.249	11.077	12.074	4.993
Model	0.272	0.234	1.660	2.412	9.840	13.413	17.084	22.446	37.216	9.242	9.295	3.893

Table 5: Data vs Model: Distribution of taxes and transfers by pre-tax income quintile, in %

	Bottom%			quintile					Top%		
	1	$[1,5]$	$[6,10]$	Q1	Q2	Q3	Q4	Q5	$[91,95]$	$[96,99]$	$[99,100]$
Tax pre-transfer by income quintile											
Data	-0.003	0.034	0.294	1.514	5.979	10.942	20.498	61.067	13.863	21.465	9.672
Model	0.097	0.613	1.413	5.371	10.127	14.928	22.487	47.087	11.389	13.058	6.298
Tax post-transfer by income quintile											
Data	-0.029	-0.628	-0.583	-1.665	4.130	10.315	21.214	66.005	15.044	23.320	10.478
Model	-0.499	-1.435	-0.703	-1.020	8.699	15.058	24.279	52.984	12.881	14.801	7.136
EITC transfer by income quintile											
Data	0.613	14.113	17.391	61.102	29.314	7.527	1.371	0.685	0.166	0.000	0.000
Model	1.098	13.714	16.454	59.773	29.035	8.949	1.578	0.665	0.162	0.000	0.000
Other welfare transfer by income quintile											
Data	3.867	14.130	12.938	48.870	22.197	13.697	9.208	6.027	1.032	0.582	0.622
Model	3.530	12.799	12.074	50.264	21.789	13.394	8.562	5.992	0.887	1.271	0.610

The model falls short of matching the distribution of wealth. It is typical for this type of models to fall short in generating as much concentration of wealth as in the data. As a result the model generates a lower concentration of consumption and tax burdens as well, especially at the top of the distribution. Notice that we have used top-coded PSID data to construct our measures of labor productivity and that we have abstracted from self-employment. While the model performs well relative to the earnings distribution as measured in the PSID, it falls short of accounting for the wealth distribution as measured in the CPS. This type of model can generate much larger wealth inequality by introducing super-star productivity realizations as in Kindermann and Krueger (2014), or explicitly modelling entrepreneurship, see Quadrini (2009).

4 Substituting existing targeted transfers with UBI

The first exercises we perform replace targeted transfers with UBI, and explore different alternatives for the adjustment of the rest of the tax system. The objective is to quantify the efficiency-equity trade-off taking into consideration both the expenditure side (UBI v.s. targeted transfers) and the revenue side (consumption v.s. income taxes). We do so both in the long run (steady state results) and in the short run (by computing the transitional dynamics).

4.1 Steady State

We first consider the long-run impact of distributing equally among all working-age households the average amount of targeted transfers in the benchmark economy. A key question regarding the implementation of UBI is how the rest of the tax system adjusts. In Table 6 we report the macroeconomic and welfare implications of introducing UBI under four different policy scenarios: 1. Adjusting upward capital income taxes, 2. Adjusting upward labor income taxes, 3. Introducing consumption taxes keeping income taxes fixed, and 4. Removing income taxes and switching to a consumption-based tax system. In alternatives 3 and 4 we obtain the combination of taxes on basic and non-basic goods that maximizes the ex-ante expected welfare of a newborn. Keeping income taxes unchanged, adjusting consumption tax rates to balance the government budget (alternative 3) yields a long run optimal combination of $\tau_{c1} = -0.20$ and $\tau_{c2} = 0.13$, introducing consumption tax progressivity. Eliminating income taxes (alternative 4) results in an optimal combination of consumption taxes that is also very progressive, with $\tau_{c1} = 0.10$ and $\tau_{c2} = 0.49$.

In all these cases, capital shock falls with the exception of alternative 4, in which the elimination of income taxes encourages capital accumulation. All these policies stimulate labor supply, especially for the non-college group. There are two reasons for that. First, under the targeted transfer system of the benchmark these households receive an annual transfer as high as $4,838, if they fall into the first quintile. However, UBI only pays them $2,488 per year. This negative income effect drives low educated households to supply more labor. Second, since UBI is not income tested the distortion on labor supply at the bottom of the distribution is eliminated. In contrast, college educated households adjust their labor supply slightly, and in different directions depending on the different policy scenarios.

Essentially, switching from targeted transfers to UBI results in a redistribution of income from low income households to high income ones. Non-college educated households experience substantial welfare losses in all policy alternatives (between 7.7 and 10.9 percent).[6] College educated households also experience welfare losses in the first three cases. In contrast, eliminating income taxes while introducing substantially progressive consumption taxes generates the lowest welfare losses for non-college households and even some welfare gains for college households. However, these welfare gains

[6]We measure welfare changes in consumption equivalent units. The Appendix provides the definitions of all our welfare measures, as well as the definition of the decomposition between the aggregate and the redistribution component.

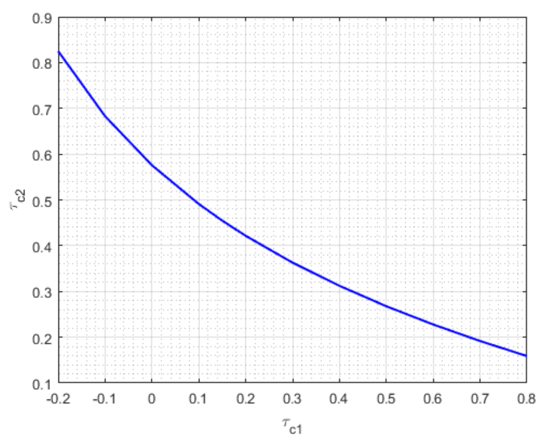
are attributable to the elimination of income taxes rather than UBI per se. [7]

Table 6: 1 × UBI, steady state results

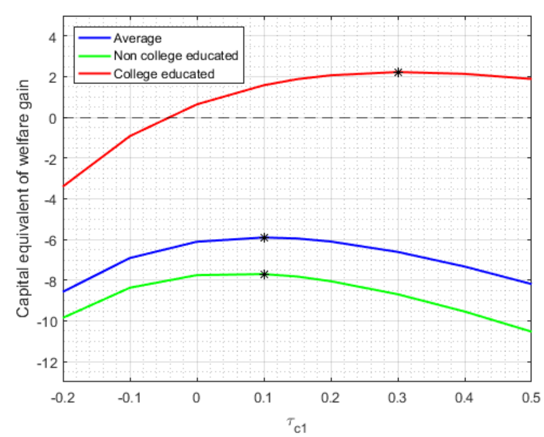
	Benchmark	adjust τ_a		adjust κ_2		adjust τ_{c1} and τ_{c2}, optimal			
						keep income tax long run optimal		remove income tax long run optimal	
			%		%		%		%
τ_a	0.390	0.392		0.390		0.390		0.000	
κ_0	0.258	0.258		0.258		0.258		0.000	
κ_1	0.768	0.768		0.768		0.768		0.000	
κ_2	0.998	0.998		1.058		0.998		0.000	
τ_{c1}	0.000	0.000		0.000		-0.200		0.100	
τ_{c2}	0.000	0.000		0.000		0.129		0.491	
b	0.487	0.489		0.489		0.488		0.489	
Y	6.077	6.084	0.110	6.080	0.050	6.050	-0.441	6.784	11.633
K	5.007	5.002	-0.082	5.006	-0.011	4.996	-0.220	6.952	38.859
H	0.330	0.347	5.284	0.347	5.123	0.341	3.384	0.341	3.492
H_{low}	0.346	0.369	6.685	0.368	6.517	0.361	4.397	0.363	5.004
H_{high}	0.292	0.296	1.412	0.296	1.273	0.294	0.584	0.290	-0.687
L	6.777	6.792	0.218	6.783	0.084	6.739	-0.565	6.692	-1.264
C_1	1.149	1.150	0.076	1.151	0.168	1.326	15.447	1.330	15.746
$C_{1,low}$	1.049	1.048	-0.147	1.049	-0.052	1.197	14.065	1.196	13.914
$C_{1,high}$	1.379	1.386	0.473	1.387	0.560	1.626	17.902	1.641	19.000
C_2	2.309	2.313	0.143	2.316	0.315	2.109	-8.690	2.206	-4.485
$C_{2,low}$	1.937	1.932	-0.300	1.935	-0.107	1.766	-8.857	1.835	-5.298
$C_{2,high}$	3.177	3.201	0.7732	3.206	0.9150	2.908	-8.453	3.071	-3.3281
K/Y	0.824	0.822	-0.192	0.823	-0.061	0.826	0.221	1.025	24.389
$gini_k$	0.598	0.625		0.625		0.628		0.639	
$gini_{earn}$	0.536	0.521		0.521		0.525		0.521	
$gini_{c1}$	0.145	0.154		0.154		0.169		0.169	
$gini_{c2}$	0.272	0.288		0.288		0.283		0.283	
Average welfare gain			-9.42		-9.08		-8.29		-5.90
Low Skill			-10.85		-10.51		-9.33		-7.70
High Skill			-3.55		-3.23		-4.15		1.58
Aggregate component			-5.09		-4.78		-5.07		-1.77
Redistribution component			-4.56		-4.52		-3.39		-4.20

[7] We have explored the impact of switching to progressive consumption taxation in detail in an infinite horizon framework in Conesa et al. (2019).

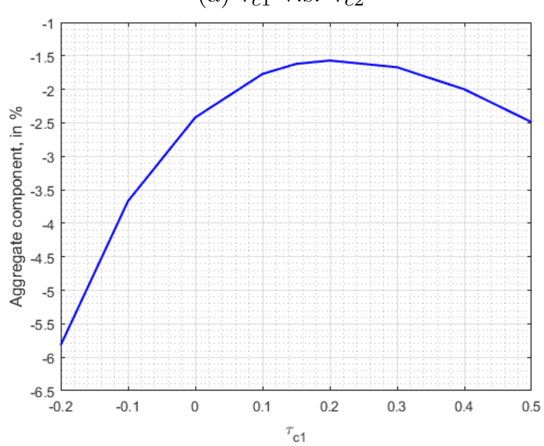
In order to understand better the role of progressive consumption taxes, we report in Figure 5 the long run welfare implications of a UBI reform with a complete shift of government finances toward consumption taxes. The top left panel plots the equilibrium relation between the two consumption tax rates. The top right panel presents the welfare gain of a newborn in terms of consumption equivalents, for low educated households and for high educated households, as a function of the tax on basic consumption. Households with college degrees benefit as long as τ_{c1} is not very negative. In contrast, non-college households always experience welfare losses, but those are minimize at $\tau_{c1} = 0.1$. Finally, in the bottom two pannels we show that while the aggregate component of welfare changes is hump-shaped, the redistribution component is systematically falling.



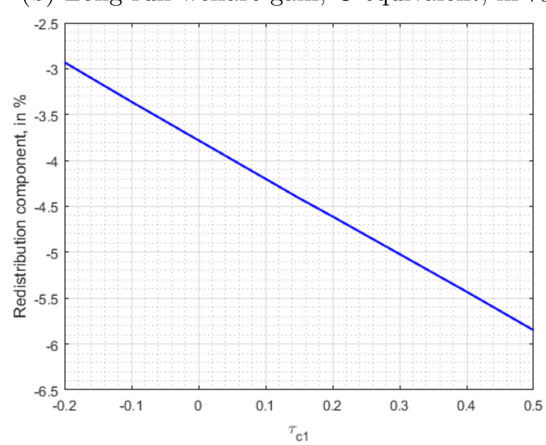
(a) τ_{c1} v.s. τ_{c2}



(b) Long run welfare gain, C equivalent, in %



(c) Aggregate component, in %



(d) Redistribution component, in %

Figure 5: UBI long run welfare gain

4.2 Transitional dynamics

We have seen in Table 6 that switching to consumption taxes is the best policy alternative. We further explore this alternative by computing the transitional dynamics associated to such a reform.

If we look at the transition we find that, from the perspective of the current population, the optimal tax system almost entirely eliminates the progressivity of consumption taxes, i.e., $\tau_{c1} = 0.30$ and $\tau_{c2} = 0.36$. The reason is that the current population involve a large fraction of middle age households, who have already accumulated some wealth and look forward to the consumption of c_2. Therefore, a smaller τ_{c2} with a larger τ_{c1} is preferable to the current population. Still, the optimal short run combination of consumption taxes delivers a significant welfare loss of 11.3 percent in terms of consumption equivalent on average, with low productive households losing 12.8 percent and high productive ones losing 5 percent. The aggregate component of the welfare gain is -8.6 percent and redistribution component is -2.7 percent.

The transition paths of variables of interest are reported in Figure 6. The reform induces a large increase in capital accumulation and output that results in a continuous increase in basic consumption (except for the initial period) and a substantial decrease of non-basic consumption during the initial periods of the transition. Hours worked increase substantially, especially at the beginning of the reform.

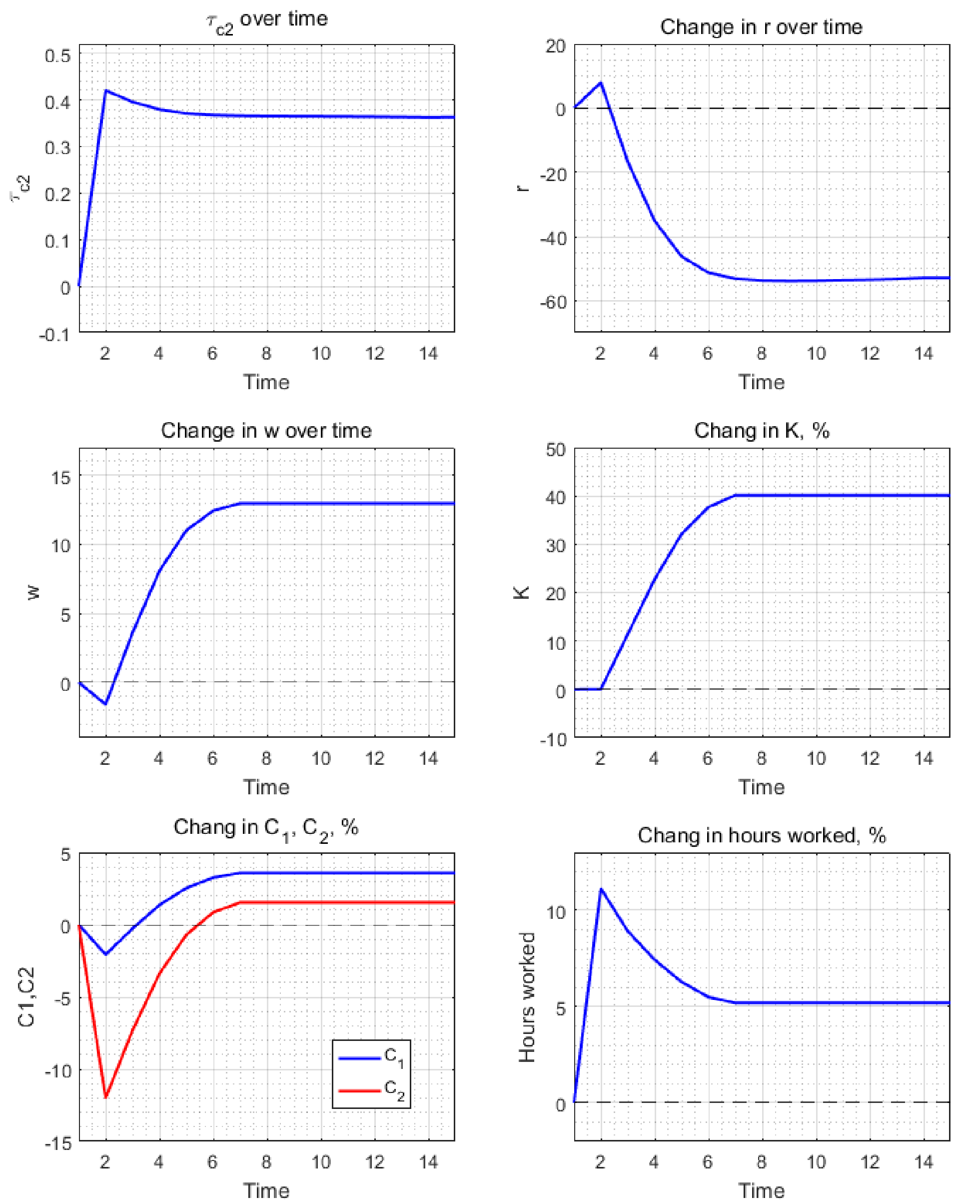


Figure 6: UBI : SR optimal, transition paths

Figure 7 shows welfare changes for all individuals in the benchmark economy as a function of age, asset holdings and labor productivity. Notice that welfare losses are increasing in assets due to the lower return to capital, so most current households lose with the reform. Only young college educated with high productivity benefit from such a reform, but those with low productivity realizations also experience welfare losses.

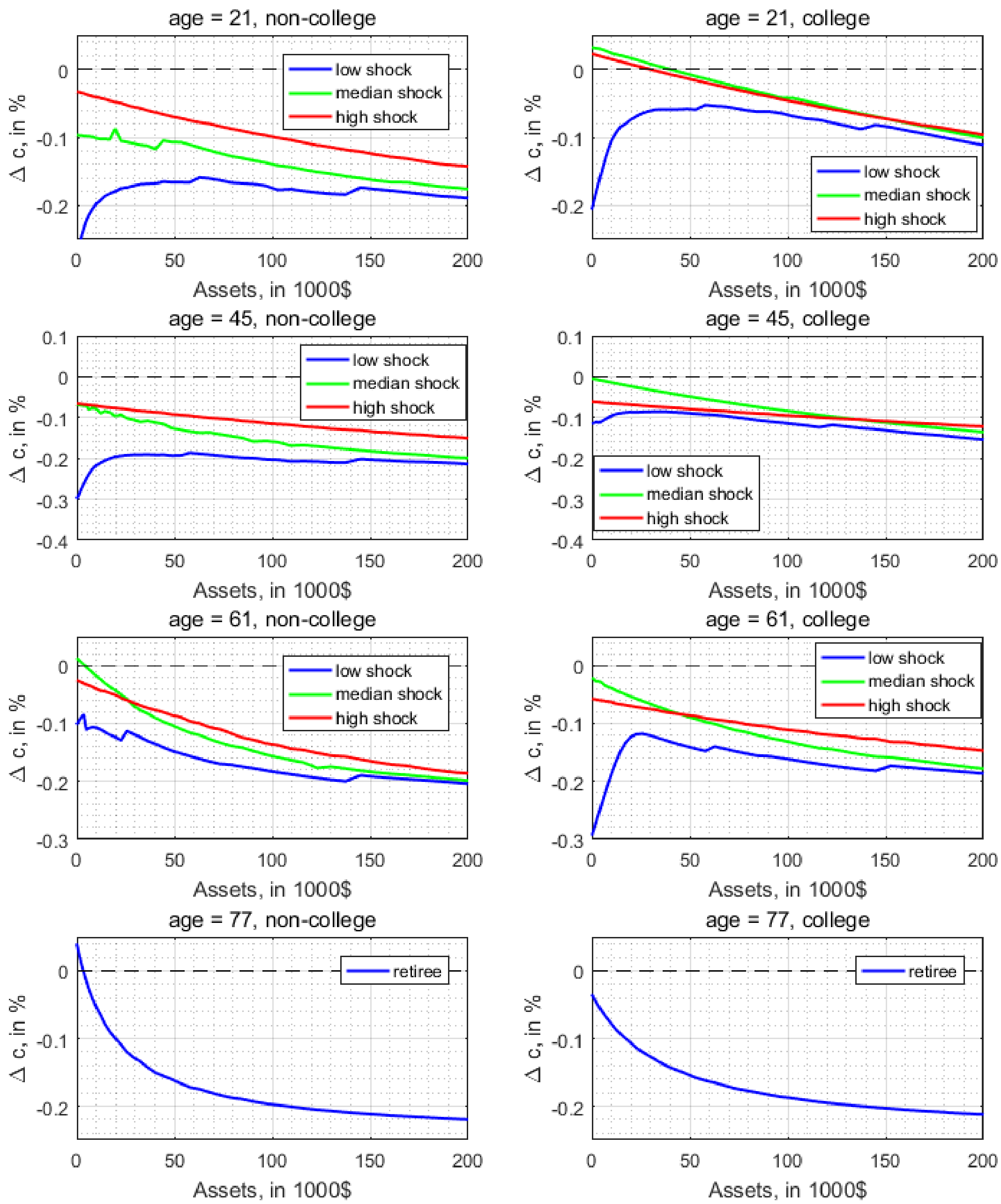


Figure 7: UBI:SR optimal welfare gain by assets, age and education

We conclude that substituting targeted transfers with UBI at the current average level of transfer shifts resources from low income to high income families and results in generalized welfare losses.

Overall, with the optimal financing scheme the fraction of current households that experience welfare gains is only 5.3 percent (0.7 percent of the non-college educated and 16.1 percent of the college educated).

4.3 Robustness

This section explores the robustness of these results to two key parameters: The elasticity between basic consumption and other consumption goods $\frac{1}{1-\nu}$, and the elasticity of labor supply ξ. For every value of these two parameters, we recalibrate B such that average hours worked are 0.33, adjust β in order to keep the capital output ratio at 0.825 (annually 3.3), $\underline{c}$ is reset to have $C_1/C_2 = 0.5$, and κ_2 and the replacement rate b are recalibrated to maintain $G/Y = 0.2$ and a self-financed social security system. We report the long run optimal reforms. The recalibrated parameters are shown in the first part of Table 7, where each column presents the optimal long run outcome of switching to a UBI system with progressive consumption taxes.

4.3.1 Changing the elasticity of substitution between C_1 and C_2

The first important observation is that for all levels of the elasticity parameters, the optimal financing scheme always implies consumption taxes alone and no income taxes.

The benchmark case is $\nu = 0$ (the Cobb-Douglas case with an elasticity of substitution of 1). As ν increases/decreases, the substitutability between C_1 and C_2 increases/decreases. In our experiment with $\nu = 0.5$ (a elasticity of substitution of 2), the aggregate C_1 increases by 21.7 percent, whereas the aggregate C_2 decreases by 10.3 percent. The optimal tax scheme becomes even more progressive, with a tax on basic goods of $\tau_{c1} = -4\%$, and a tax on other goods of $\tau_{c2} = 61.1\%$. In this scenario the welfare losses for the non-college are slightly larger than in the benchmark, and the welfare gains for the college educated turn into losses.

In contrast, when the elasticity of substitution decreases to 0.5 ($\nu = -1$), c_1 and c_2 become more complementary, and the progressivity of consumption taxes disappers, both types of goods are taxed at 34 percent. In this case the change in welfare is slightly more favorable than in the benchmark case for both type of households.

4.3.2 Changing the elasticity of labor supply

We also experiment with the elasticity of labor supply, ranging from 0.25 to 1.25, with the benchmark case being 0.75. A higher ξ increases the disutility of labor supply, thus the parameter B, which governs hours worked, decreases with ξ. The higher the labor supply elasticity the greater the increase in hours worked of low skilled households when a UBI system substitutes for the benchmark system of targeted transfers.

Table 7: Robustness, long run welfare gain with different parameters

	Elasticity between C_1 and C_2					Elasticity of labor				
	Recalibrated parameters for initial steady state					Recalibrated parameters for initial steady state				
ν	-1.000	-0.500	0.000	0.200	0.500	0.000	0.000	0.000	0.000	0.000
ξ	0.750	0.750	0.750	0.750	0.750	0.250	0.500	0.750	1.000	1.250
B	7.759	8.730	11.339	13.249	16.834	241.396	26.579	11.339	7.947	6.095
β	0.994	0.996	0.999	1.001	1.005	1.038	1.017	0.999	0.986	0.975
$\underline{c}$	0.017	0.205	0.535	0.696	0.943	0.536	0.518	0.535	0.526	0.537
κ_2	0.962	0.972	0.998	0.993	1.003	0.986	1.002	0.998	1.004	0.996
Optimal financing scheme										
income taxes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
τ_{c1}	0.340	0.220	0.100	0.050	-0.040	0.050	0.080	0.100	0.100	0.120
τ_{c2}	0.340	0.407	0.491	0.533	0.611	0.525	0.503	0.491	0.493	0.480
Percent change of work hours and consumption, in %										
H	4.754	4.652	3.492	2.583	0.245	1.793	2.912	3.492	3.872	4.218
H_{low}	6.614	6.464	5.004	3.883	1.055	2.769	4.269	5.004	5.460	5.844
H_{high}	-0.091	-0.160	-0.687	-1.091	-2.132	-0.710	-0.732	-0.687	-0.600	-0.426
C_1	3.224	8.474	15.746	18.876	21.650	19.863	17.349	15.746	15.643	14.173
$C_{1,low}$	2.081	7.271	13.914	16.487	18.306	16.898	15.127	13.914	13.992	12.758
$C_{1,high}$	4.910	10.362	19.000	23.426	28.854	24.837	21.205	19.000	18.614	16.747
C_2	3.250	0.239	-4.485	-7.029	-10.286	-5.514	-4.950	-4.485	-4.821	-4.192
$C_{2,low}$	2.096	-0.831	-5.298	-7.643	-10.494	-6.843	-5.945	-5.298	-5.485	-4.750
$c_{2,high}$	4.940	1.793	-3.328	-6.167	-9.998	-3.808	-3.589	-3.328	-3.852	-3.365
Welfare gains, consumption equivalent, in %										
Average	-4.42	-5.10	-5.90	-6.22	-6.64	-5.96	-5.99	-5.90	-5.98	-5.99
Low Skill	-6.29	-7.01	-7.70	-7.87	-7.82	-7.65	-7.76	-7.70	-7.77	-7.80
High Skill	3.06	2.67	1.58	0.73	-0.63	1.77	1.64	1.58	1.29	1.24

The results suggest that both the sign and magnitude of the welfare changes are not significantly affected by the labor supply elasticity. This contrasts with the much more significant role played that the elasticity of substitution between both consumption goods. Nevertheless, our previous conclusion still holds that UBI in place of targeted transfers results in significant welfare losses for low skilled households.

5 More generous UBI

So far we have seen that substituting targeted transfers with UBI results in generalized welfare losses for the low skilled. Since the policy experiment is revenue neutral, UBI provides by construction a smaller transfer to low income households. In our previous experiments this policy boils down to a UBI transfer slightly below $\$2,500$ a year per working-age households. As such it is normal that this policy decreases welfare for most households, especially for those at the bottom of the distribution. The immediate question is whether that would still be true with a much more generous UBI scheme. At the same time, the debate in the policy arena is also talking about much more generous UBI. For example, democratic candidate Andrew Yang has mentioned magnitudes around $\$1,000$ per adult per month, which implies (depending on how many adults per household there are) 7-10 times larger magnitudes than the UBI we have so far considered.

We follow the same structure as in the previous section and we evaluate the impact of such reforms both in the long-run (Steady State) and in the short-run (Transitional dynamics).

5.1 Steady State

Table 8 reports the results of an experiment where UBI is 10 times larger than the existing targeted transfers. In this table, each column represents a different tax structure that can finance the generous UBI scheme. Namely, we experiment with different degrees of consumption tax progressivity while keeping income taxes unchanged, and in the final column we eliminate income taxes and display results for the consumption tax combination that maximizes ex-ante expected utility of newborns.

Table 8: Impact of a 10 $\times$ UBI. Steady State

Benchmark		Keeping Income Taxes										Only Cons. Taxes	
			%		%		%		%		%		%
τ_a	0.390	0.390		0.390		0.390		0.390		0.390		0.000	
κ_0	0.258	0.258		0.258		0.258		0.258		0.258		0.000	
κ_1	0.768	0.768		0.768		0.768		0.768		0.768		0.000	
κ_2	0.998	0.998		0.998		0.998		0.998		0.998		0.000	
τ_{c1}	0.000	0.300		0.500		0.650		0.800		1.000		0.850	
τ_{c2}	0.000	1.006		0.834		0.730		0.641		0.539		1.091	
b	0.487	0.472		0.473		0.474		0.474		0.476		0.478	
Y	6.077	5.480	-9.8	5.489	-9.7	5.506	-9.4	5.528	-9.0	5.565	-8.4	6.251	2.9
K	5.007	4.726	-5.6	4.722	-5.7	4.731	-5.5	4.739	-5.3	4.758	-5.0	6.500	29.8
H	0.330	0.266	-19.4	0.268	-18.7	0.270	-18.0	0.273	-17.2	0.277	-15.9	0.284	-13.8
H_{low}	0.346	0.268	-22.4	0.271	-21.6	0.274	-20.7	0.277	-19.8	0.283	-18.3	0.292	-15.5
H_{high}	0.292	0.259	-11.2	0.260	-10.9	0.261	-10.6	0.262	-10.1	0.264	-9.4	0.265	-9.2
C_1	1.149	1.238	7.8	1.130	-1.6	1.067	-7.1	1.015	-11.6	0.958	-16.6	1.139	-0.9
$C_{1,low}$	1.049	1.146	9.2	1.051	0.1	0.996	-5.1	0.950	-9.5	0.900	-14.3	1.050	0.05
$C_{1,high}$	1.379	1.451	5.2	1.313	-4.8	1.233	-10.6	1.166	-15.5	1.093	-20.7	1.345	-2.5
C_2	2.309	1.714	-25.8	1.831	-20.7	1.910	-17.3	1.981	-14.2	2.069	-10.4	2.010	-13.0
$C_{2,low}$	1.937	1.491	-23.1	1.589	-18.0	1.655	-14.6	1.713	-11.6	1.785	-7.9	1.716	-11.4
$C_{2,high}$	3.176	2.235	-29.6	2.396	-24.6	2.504	-21.2	2.604	-18.0	2.730	-14.1	2.695	-15.1
K/Y	0.824	0.862	4.7	0.860	4.4	0.859	4.3	0.857	4.1	0.855	3.8	1.040	26.2
$gini_k$	0.598	0.666		0.665		0.663		0.662		0.660		0.672	
$gini_{earn}$	0.536	0.572		0.569		0.568		0.566		0.563		0.554	
$gini_{c_1}$	0.145	0.122		0.115		0.111		0.106		0.101		0.126	
$gini_{c_2}$	0.272	0.216		0.220		0.223		0.226		0.230		0.239	
Average Welfare Gain			-2.04		-1.07		-0.89		-1.10		-1.73		5.96
Low Skill			2.64		3.43		3.42		3.00		2.05		8.20
High Skill			-16.47		-15.06		-14.41		-14.05		-13.83		-1.74
Aggregate Component			-5.56		-4.12		-3.55		-3.35		-3.42		0.67
Redistribution Component			3.73		3.18		2.77		2.33		1.75		5.25

A generous UBI scheme that keeps income taxes intact discourages labor supply and capital accumulation, and as a consequence output drops between 8 and 10 percent. The reduction in labor supply is larger for the low skilled (around 20 percent compared to 10 percent for the high skilled), indicating the importance of a substantial positive income effect together with a substitution effect making consumption much more expensive relative to leisure. In contrast, the financing scheme involving the elimination of income taxes (last column) implies smaller reductions in labor supply and a 30 percent increase in capital accumulation. As a result output even increases, by 2.9 percent.

A generous UBI together with a reform switching from income taxes to a system of consumption taxes alone would result in a welfare gain on average of 6 percent, with the low skilled increasing welfare by 8 percent and the high skilled experiencing a welfare loss equivalent to 2 percent less consumption.

At the bottom of the table there is a decomposition between the aggregate and the redistributive component. Notice that a generous UBI always generates a gain through the redistribution component, but the additional consumption taxes generate an even larger welfare loss through the efficiency component. In contrast, the elimination of income taxes compensates for the efficiency losses, at the same time that it increases the welfare gains accrued by redistribution.

Given these results, we now experiment with different levels of UBI, ranging from the case of the previous section ($1 \times UBI$) to 20 times the size of targeted transfers, each of them financed exclusively with the combination of consumption taxes that achieves the highest expected welfare of a newborn.

Table 9 shows that welfare gains for the low skilled are increasing in the generosity of UBI, while they are decreasing for the high skilled. That should not come as a surprise since a generous UBI substitutes for a progressive tax system. Interestingly, around $6 \times UBI$ both types of households experience welfare gains relative to the benchmark, while average welfare would be maximized at $14 \times UBI$. This range of UBI generosity includes the case we considered before, of $10 \times UBI$. Finally, decomposing the average welfare gains, we see that the redistributive component is uniformly increasing in the generosity of UBI, becoming positive at around $6 \times UBI$. The last block of Table 9 shows that a more generous UBI calls for a larger tax collection, which compromises efficiency and results in a lower aggregate component. On the other hand, a more generous UBI always enables redistribution towards low income households.

Table 9: Long run welfare gain at the optimal tax mix of different levels of UBI, financed with consumption taxes, consumption equivalent, in %

	1 × UBI	2 ×	4 ×	6 ×	8 ×	10 ×	12 ×	14 ×	16 ×	18 ×	20 ×
τ_{c1}	0.100	0.150	0.400	0.500	0.650	0.850	1.050	1.250	1.500	1.750	1.950
τ_{c2}	0.491	0.571	0.632	0.809	0.962	1.091	1.229	1.374	1.497	1.627	1.793
Average Welfare Gain	-5.90	-3.80	-0.32	2.54	4.54	5.96	6.90	7.43	7.40	7.17	6.83
Low Skill	-7.70	-5.10	-0.84	3.04	5.96	8.20	9.91	11.16	11.94	12.46	12.87
High Skill	1.58	1.49	1.17	0.70	-0.52	-1.74	-3.15	-4.68	-6.16	-7.66	-9.29
Aggregate comp.	-1.77	-1.01	0.43	0.93	0.89	0.67	0.14	-0.63	-1.54	-2.50	-3.62
Redistribution comp.	-4.20	-2.82	-0.75	1.59	3.61	5.25	6.75	8.12	9.08	9.92	10.85

Summing up, a combination of generous UBI and switching to consumption taxation can increase average welfare and also the welfare of both types of households at the same time. Remember, though, that all of these results only apply to the long run. In order to determine the potential desirability of such reforms we still need to discuss the transitional dynamics.

5.2 Transitional dynamics

In this subsection, we compute the average welfare gain (in consumption equivalent units) for all levels of UBI transfers and all possible combinations of consumption taxes. The highest possible average welfare gain among all individuals in the benchmark economy corresponds to a policy of 10 times the current transfer, financed with $\tau_{c1} = 1.20$ and $\tau_{c2} = 0.89$. It is remarkable that the size of the best possible UBI along the transition is the case we evaluated in the previous section (of a magnitude similar to Yang's proposal).

An important difference between the transitional dynamics and the long run results is that the desire for a progressive tax system is mitigated. Coupled with the fact that a generous UBI also substitutes for the progressivity of a tax system to some extent, Table 10 shows a regressive consumption tax system with τ_{c1} being greater than τ_{c2}. Nevertheless, the optimal tax schedule still induces a short run welfare loss of 6.6 percent on average, with a much larger welfare loss for the high skilled.

Table 10: Optimal short run welfare gain
consumption equivalent Δ_c, in %

variables	10 × UBI
τ_{c_1}	1.200
τ_{c_2}	0.892
Average Welfare Gain	-6.57
Low Skill	-4.89
High Skill	-12.64
Aggregate component	-12.66
Redistribution component	7.17

Figure 8 reports the transitional dynamics. This reform generates a substantial increase in capital accumulation due to the removal of income taxes, but much lower hours worked. Overall this reform results in a reduction in basic and non-basic consumption both in the short run and in the long run.

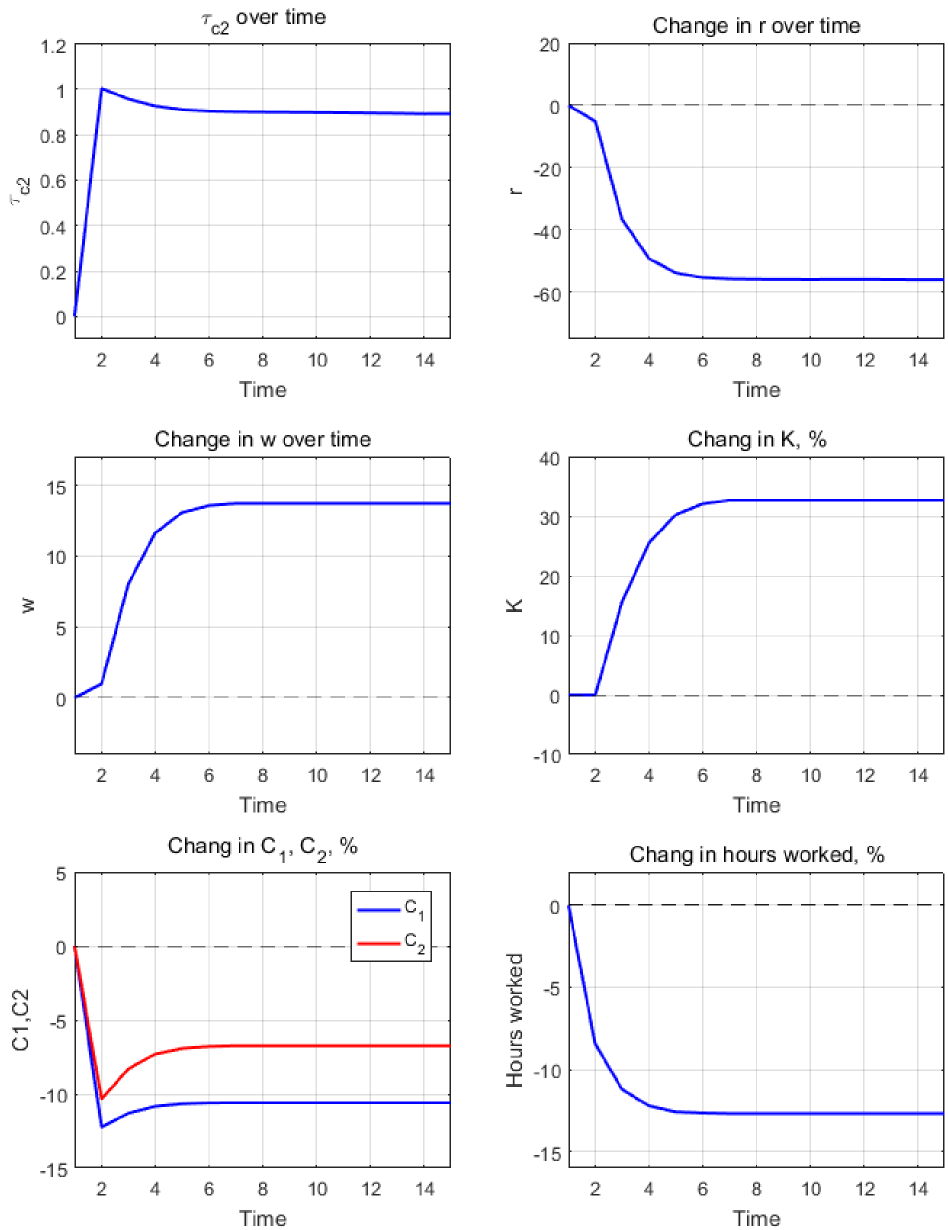


Figure 8: UBI : SR optimal, transition paths of UBI = 10 × current transfer

Figure 9 reports the distribution of welfare gains over the state space. As before, welfare gains decrease (or welfare losses increase) with assets holdings. Households with low labor productivity benefit more from the reform than their high productivity counterparts. Overall, the fraction of households that experience welfare gains is 23.5 percent, 33.2 percent of the non-college group and 1 percent of the college educated.

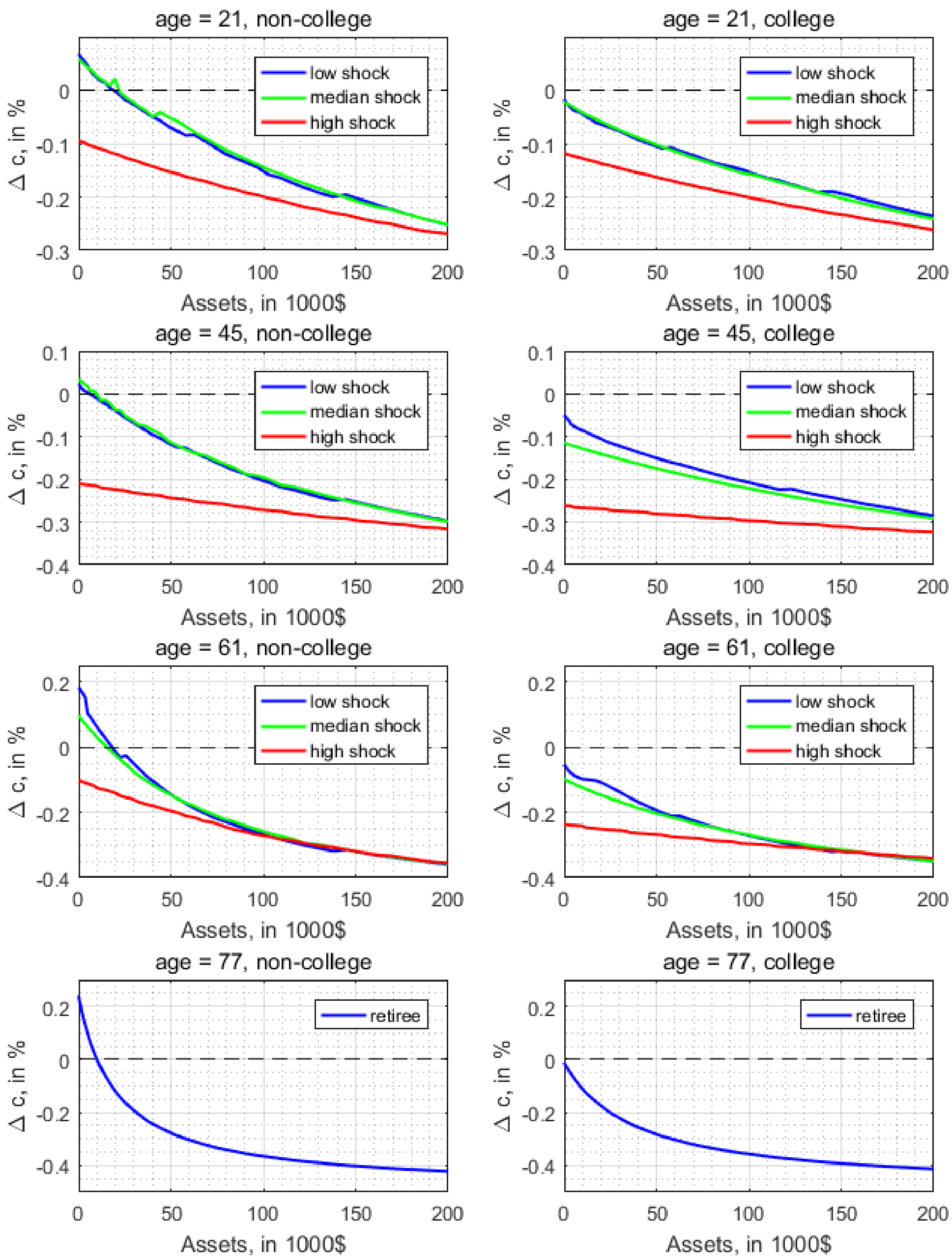


Figure 9: A generous UBI:SR optimal welfare gain by assets, education and age

6 Conclusion

Advocates for UBI argue that there are multiple gains from eliminating the complex and inefficient existing network of welfare programs. Our results provide mixed partial support for such a view. When substituting for existing targeted transfers, UBI must be generous enough in order to prevent substantial welfare losses at the bottom of the income distribution. But such a program would require large tax increases that would negatively affect economic efficiency. Only when combined with a comprehensive efficiency-enhancing tax reform (in our case a switch from income taxation to progressive consumption taxes) such alternatives have a chance at generating welfare gains in the long run. But still, the analysis of the transitional dynamics suggest that most households would experience welfare losses on impact.

Our analysis has focused on the distortions for labor and savings decisions inherent in means-tested welfare programs, but we have abstracted from a wide range of issues that are also part of the debate. We abstract from the discussion regarding new technologies and their impact on employment opportunities for the less skilled. We do not include in the analysis the administrative costs of existing welfare programs and the potential savings of UBI along this margin. Another potential margin is that in frictional labor markets UBI would change the incentives to search for and retain jobs. Finally, we have decided to leave other government programs out of the exercise, in particular we have considered only UBI for working-age households and we have left pensions as in the benchmark economy.

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A The measurement of welfare changes

A.1 Long run welfare gains

The welfare gain and the decomposition of the welfare gain are defined in the same way as in Domeij and Heathcote (2004), except that we have overlapping generations and that the long-run and short-run welfare gain take different forms.

Specifically, the long run average welfare gain is defined as how much the consumption bundle in excess to consumption floor $\underline{c}$: $\big(\gamma(c_{1,j}-\underline{c})^{\nu}+(1-\gamma)c_{2,j}^{\nu}\big)^{\frac{1}{\nu}}$ need to be given to newborns in the future in order for them to be indifferent about the reform. Let $c_{1,j}^{NR}$, $c_{2,j}^{NR}$ and $c_{1,j}^{R}$, $c_{2,j}^{R}$ are pre- and post-reform basic consumption and non-basic consumption of a newborn household at age j, similarly, l_j^{NR} and l_j^{R} are the hours worked (note that hours worked becomes 0 after retirement age J_0), then the long run average welfare gain Δ^{LR} is the solution to the following equation,

$$\int_{A\times E} E\sum_{j=1}^{J_1}\beta^j\big(\Pi_{s=1}^{j}\phi_s\big)\Big(\frac{\big((\gamma(c_{1,j}^{R}-\underline{c})^{\nu}+(1-\gamma)(c_{2,j}^{R})^{\nu})^{\frac{1}{\nu}}\big)^{1-\sigma}}{1-\sigma}-B\frac{(l_j^{R})^{1+1/\chi}}{1+1/\chi}\Big)d\hat{\Psi}_1^{R}(a,\epsilon)$$
$$=\int_{A\times E} E\sum_{j=1}^{J_1}\beta^j\big(\Pi_{s=1}^{j}\phi_s\big)\Big(\frac{\big((1+\Delta^{LR})(\gamma(c_{1,j}^{NR}-\underline{c})^{\nu}+(1-\gamma)(c_{2,j}^{NR})^{\nu})^{\frac{1}{\nu}}\big)^{1-\sigma}}{1-\sigma}-B\frac{(l_j^{NR})^{1+1/\chi}}{1+1/\chi}\Big)d\hat{\Psi}_1^{NR}(a,\epsilon),$$

where $\hat{\Psi}_1^{NR}(a,\epsilon)$ and $\hat{\Psi}_1^{R}(a,\epsilon)$ are the conditional cumulative distribution function over assets a and labor efficiency ϵ at age 1 pre- and post-reform.

Define $\hat{c}_{1,j}^{R}=\hat{c}_{1,j}^{NR}\frac{C_1^R}{C_1^{NR}}$, where C_1^{NR} and C_1^{R} are the aggregate basic consumption pre- and post-reform. Similarly, $\hat{c}_{2,j}^{R}=\hat{c}_{2,j}^{NR}\frac{C_2^R}{C_2^{NR}}$ and $\hat{l}_j^{R}=\hat{l}_j^{NR}\frac{H^R}{H^{NR}}$, where H^{NR} and H^{R} are aggregate hours worked pre- and post-reform. The aggregate component of the short run welfare gain Δ_{agg}^{LR} is the solution to the following equation

$$\int_{A\times E} E\sum_{j=1}^{J_1}\beta^j\big(\Pi_{s=1}^{j}\phi_s\big)\Big(\frac{\big((\gamma(\hat{c}_{1,j}^{R}-\underline{c})^{\nu}+(1-\gamma)(\hat{c}_{2,j}^{R})^{\nu})^{\frac{1}{\nu}}\big)^{1-\sigma}}{1-\sigma}-B\frac{(\hat{l}_j^{R})^{1+1/\chi}}{1+1/\chi}\Big)d\hat{\Psi}_1^{R}(a,\epsilon)$$
$$=\int_{A\times E} E\sum_{j=1}^{J_1}\beta^j\big(\Pi_{s=1}^{j}\phi_s\big)\Big(\frac{\big((1+\Delta_{agg}^{LR})(\gamma(c_{1,j}^{NR}-\underline{c})^{\nu}+(1-\gamma)(c_{2,j}^{NR})^{\nu})^{\frac{1}{\nu}}\big)^{1-\sigma}}{1-\sigma}-B\frac{(l_j^{NR})^{1+1/\chi}}{1+1/\chi}\Big)d\hat{\Psi}_1^{NR}(a,\epsilon),$$

The redistribution component Δ_{dist}^{LR} is

$$\Delta_{dist}^{LR}=(1+\Delta^{LR})/(1+\Delta_{agg}^{LR})-1.$$

A.2 Short run welfare gains

The short-run welfare gain is defined in terms of the consumption equivalent of the current population. Let Δ^{SR} denote the immediate average welfare gain of the current population in terms of the consumption equivalent, then it is the solution to the following equation

$$\sum_{j=1}^{J_1}\psi_j\int_{A\times E}E\sum_{t=j}^{J_1}\beta^{t-j}\big(\Pi_{s=j+1}^{t}\phi_s\big)\Big(\frac{\big(\gamma(c_{1,t}^R-\underline{c})^\nu+(1-\gamma)(c_{2,t}^R)^\nu\big)^{\frac{1}{\nu}}\big)^{1-\sigma}}{1-\sigma}-B\frac{(l_t^R)^{1+1/\chi}}{1+1/\chi}\Big)d\hat{\Psi}_j^R(a,\epsilon)$$

$$=\sum_{j=1}^{J_1}\psi_j\int_{A\times E}E\sum_{t=j}^{J_1}\beta^{t-j}\big(\Pi_{s=j+1}^{t}\phi_s\big)\Big(\frac{\big((1+\Delta^{LR})(\gamma(c_{1,j}^{NR}-\underline{c})^\nu+(1-\gamma)(c_{2,j}^{NR})^\nu\big)^{\frac{1}{\nu}}\big)^{1-\sigma}}{1-\sigma}-B\frac{(l_t^{NR})^{1+1/\chi}}{1+1/\chi}\Big)d\hat{\Psi}_j^{NR}(a,\epsilon$$

Define $\hat{c}_{1,j}^R=\hat{c}_{1,j}^{NR}\frac{C_1^R}{C_1^{NR}}$, where C_1^{NR} and C_1^R are the aggregate basic consumption pre- and post-reform. Similarly, $\hat{c}_{2,j}^R=\hat{c}_{2,j}^{NR}\frac{C_2^R}{C_2^{NR}}$ and $\hat{l}_j^R=\hat{l}_j^{NR}\frac{H^R}{H^{NR}}$, where H^{NR} and H^R are aggregate hours worked pre- and post-reform. The aggregate component of the short run welfare gain Δ_{agg}^{SR} is the solution to the following equation

$$\sum_{j=1}^{J_1}\psi_j\int_{A\times E}E\sum_{t=j}^{J_1}\beta^{t-j}\big(\Pi_{s=j+1}^{t}\phi_s\big)\Big(\frac{\big((\gamma(\hat{c}_{1,t}^R-\underline{c})^\nu+(1-\gamma)(\hat{c}_{2,t}^R)^\nu\big)^{\frac{1}{\nu}}\big)^{1-\sigma}}{1-\sigma}-B\frac{(\hat{l}_t^R)^{1+1/\chi}}{1+1/\chi}\Big)d\hat{\Psi}_j^R(a,\epsilon)$$

$$=\sum_{j=1}^{J_1}\psi_j\int_{A\times E}E\sum_{t=j}^{J_1}\beta^{t-j}\big(\Pi_{s=j+1}^{t}\phi_s\big)\Big(\frac{\big((1+\Delta^{LR})(\gamma(\hat{c}_{1,t}^{NR}-\underline{c})^\nu+(1-\gamma)(\hat{c}_{2,t}^{NR})^\nu\big)^{\frac{1}{\nu}}\big)^{1-\sigma}}{1-\sigma}-B\frac{(l_t^{NR})^{1+1/\chi}}{1+1/\chi}\Big)d\hat{\Psi}_j^{NR}(a,\epsilon$$

At last, the redistribution component Δ_{dist}^{SR} is

$$\Delta_{dist}^{SR}=(1+\Delta^{SR})/(1+\Delta_{agg}^{SR})-1.$$

B The construction of consumption shares

The CEX is a rotating panel, conducted four times a year. During each interview, households are asked to report the income of the past twelve months, and the consumption of both the previous and current quarter. For example, if the interview is conducted in May 2016, then households report their income between May 2015 and April 2016; the consumption of the previous quarter is consumption during February and March, and the current quarter consumption only takes into account April consumption. Thus, we construct consumption for the past three months by adding up the previous and current consumption.

Next, we select households who stay in the survey for four consecutive quarters. We add up their consumption over the four interviews as the consumption for the past twelve months, and take the income reported during the last interview as the income for the past twelve months. This process roughly leaves us with 3,000 households (12,000 observations) per wave.

We use data for the waves of 2014, 2015, 2016 and 2017, and express all in 2015 dollars. we limit the sample to households whose head is between 21 and 85 years old. Eventually, we get 12,016 households in our sample.

In order to construct consumption shares we use gross income, that is the income before any welfare transfers or taxation. Specifically, we subtract "FINCBTXM" by "FSSIXM", "WELFAREM", JFS-AMTM", "OTHREGXM" and "OTHRINCM", leaving only salary, self-employment income, Social Security and Railroad Retirement income, retirement income, interest and dividend income, royalty income and rent income.

Table 11: Consumption share according to income distribution, in %

PSID	1%	1 ∼ 5%	6 ∼ 10%	Q1	Q2	Q3	Q4	Q5	91 ∼ 95%	96 ∼ 99%	1%	Ave
Total expenditure	100	100	100	100	100	100	100	100	100	100	100	100
C_1	54.50	52.34	52.68	51.07	44.16	37.28	30.22	23.43	23.41	20.83	18.79	33.09
Food at home	16.59	15.84	14.90	14.29	12.43	11.01	9.46	7.24	7.39	6.26	5.26	9.75
Rent	20.29	13.71	15.50	13.70	9.99	7.70	4.78	2.34	2.87	1.54	1.51	5.89
Utility	11.66	10.82	10.36	10.43	9.33	8.44	7.14	5.53	5.46	4.83	3.56	7.36
health insurance	3.84	5.59	5.30	6.18	7.01	6.46	6.08	4.80	4.89	4.25	2.85	5.80
medicine services	1.32	1.46	1.29	1.63	1.60	1.76	1.78	1.57	1.59	1.45	1.01	1.66
Prescriptions	0.71	0.64	0.63	0.82	0.88	0.74	0.54	0.40	0.44	0.34	0.29	0.59
medical supplies	0.20	0.19	0.19	0.22	0.25	0.18	0.22	0.18	0.20	0.17	0.13	0.20
TV	2.80	2.48	2.74	2.64	2.28	2.09	1.85	1.36	1.39	1.15	1.06	1.84
C_2	45.49	47.65	47.32	48.93	55.84	62.71	69.78	76.57	76.58	79.16	81.21	66.91
food out	4.48	4.53	4.22	4.38	4.60	4.87	4.97	4.82	4.82	4.58	4.28	4.79
alcohol	1.06	0.64	0.59	0.63	0.70	0.81	0.89	0.91	0.87	0.98	1.01	0.83
own dwelling	9.55	9.49	8.49	9.61	9.90	10.99	12.97	14.53	14.52	15.38	13.48	12.49
other dwelling	0.36	1.02	0.64	0.92	1.07	0.92	1.35	2.27	2.23	2.65	4.76	1.54
house operation	1.73	1.77	2.29	1.98	2.05	2.06	2.29	2.92	2.60	2.97	5.28	2.43
home equipment	1.54	2.23	2.14	2.15	2.29	2.38	2.57	2.52	2.51	2.39	2.56	2.44
appeal	1.79	1.66	1.70	1.65	1.65	1.69	1.76	2.07	1.84	2.10	3.72	1.84
transportation	9.33	13.97	15.51	14.95	17.70	18.20	17.65	15.76	16.29	14.71	12.23	16.79
entertainment fee	0.56	0.72	0.80	0.73	0.73	0.94	1.27	1.92	2.02	2.13	2.60	1.33
other entertainment	0.72	1.12	1.20	1.16	1.34	1.39	1.93	1.87	1.62	1.62	2.18	1.66
personal care	0.49	0.51	0.52	0.54	0.65	0.60	0.65	0.65	0.68	0.63	0.56	0.63
reading	0.15	0.13	0.17	0.16	0.19	0.19	0.18	0.19	0.20	0.19	0.26	0.18
education	1.10	2.00	1.38	1.43	0.99	1.11	1.44	3.10	2.97	4.01	4.80	1.94
tobacco	2.48	1.59	1.36	1.30	0.94	0.73	0.53	0.26	0.26	0.14	0.07	0.59
contribution	3.89	3.17	2.53	2.90	3.76	3.28	3.21	4.57	3.57	7.06	5.68	3.77
insurance	2.13	3.77	4.70	4.75	6.74	10.61	13.49	17.30	17.67	17.59	19.85	12.71

In Table 11, each column reports the share of consumption in one specific income group. For example, the cell "food at home" in quintile 2 means that for households whose income are in the second quintile, their expenditure on "food" at home takes 14.3 percent of total consumption of households in quintile 2.

The last column is the average consumption share in total consumption. For example, the overall expenditure on“food at home” is 9.75% of the total consumption expenditure. Because of the structure of our statistics, the summation of each column from line “food at home” to the last line is exactly 100%.

C PSID, life cycle profile and wage process

C.1 Data selection

We obtain data of earnings from the PSID covering the years 1968 to 2016. The definition of earnings includes wage income, labor income from farm, labor income from business, bonuses, overtime payments, tips, commissions, professional income, extra job income and others. The households earnings is the earnings summed over all household members.

We restrict sample according to the following criterion. 1. The sample is restricted to the non-immigration sample; 2. The head of household is between 21 and 64 years old; 3. The hours worked by the head of household is more than 260 hours per year; 4. The hourly wage rate by the household (household total earnings divided by total hours worked) is more than half of the minimum wage; 5. Not all earnings are from self-employment.

C.2 Life cycle profiles

With the aid of ”Cross-year individual data” provided by PSID, we are able to form household panels. We define one period as four years, thus the panel can form 11 age groups, 24 cohorts and 12 year groups. We split the sample into two educational groups: with a bachelor degree and more, and no college degree.

Within each educational group, we regress log hourly wage on age, age square, cohort dummies and year dummies to get the deterministic life cycle profile. The gap between the log wage profile at 21 is around 0.5, implying that upon entering the labor market, the average hourly wage of college graduates and more is roughly 1.58 times the hourly wage of non college graduates. This process leaves us with 19,844 observations in the non-college sample, and 6,852 observations in the college sample.

C.3 The estimation of the wage process

After we obtain the residuals from the above regression, we stack all households and select the households who have stayed for two consecutive periods or more. For example, if a household stays in the sample during the first and second period, then we keep this household; if a household stays in the sample for period 1, period 2 and period 3, then we treat this household as two observations: one observation from period 1 to period 2, the other observation from period 2 to period 3; if a household stays in the sample for period 1 and period 3 only, then we drop this household.

The goal of this procedure is to obtain as many pairs of household who stay in the sample for two consecutive period as possible. Eventually, we are left with 12,268 pairs of observation for the non-college sample, and 4,757 pairs for the college sample.

For each age group, we divided the sample into 11 bins according to the size of the residuals. The 11 bins are the bottom 1%, $1 \sim 5\%$, $5 \sim 10\%$, $10 \sim 20\%$, $20 \sim 40\%$, $40 \sim 60\%$, $60 \sim 80\%$, $80 \sim 90\%$, $90 \sim 95\%$, $95 \sim 99\%$ and top 1%. The age-dependent realization of the shock is the median of each bin. The transition probability is the percentage of households that move from one bin in the current period to another bin in the next period.

D Welfare transfers as a fraction of government outlays

Table 12: Major welfare transfer as a fraction of government outlays, in %

	Medicaid	UI	SNAP	TANF	SSI	EITC	HA	CTC	CNSM	CHI	WIC	LIHEA	Year average
1997	5.97	1.29	1.43	0.94	1.59	1.37	1.72	0.00	0.52	0.00	0.24	0.08	15.14
1998	6.13	1.19	1.22	0.94	1.59	1.41	1.73	0.00	0.52	0.00	0.24	0.07	15.02
1999	6.35	1.26	1.12	0.99	1.58	1.51	1.59	0.03	0.52	0.03	0.23	0.07	15.27
2000	6.59	1.16	1.02	1.03	1.66	1.46	1.60	0.05	0.51	0.07	0.22	0.08	15.45
2001	6.95	1.50	1.03	1.17	1.40	1.40	1.60	0.05	0.51	0.20	0.22	0.12	16.14
2002	7.34	2.52	1.10	1.13	1.47	1.38	1.63	0.25	0.51	0.18	0.22	0.09	17.82
2003	7.44	2.52	1.17	1.07	1.42	1.48	1.63	0.30	0.50	0.20	0.21	0.09	18.03
2004	7.69	1.85	1.25	0.94	1.37	1.45	1.59	0.39	0.49	0.20	0.21	0.08	17.50
2005	7.35	1.31	1.32	0.86	1.43	1.40	1.52	0.59	0.48	0.21	0.20	0.09	16.76
2006	6.80	1.17	1.30	0.79	1.30	1.36	1.43	0.58	0.47	0.21	0.19	0.10	15.70
2007	6.99	1.19	1.28	0.77	1.21	1.40	1.43	0.59	0.48	0.22	0.20	0.09	15.84
2008	6.75	1.43	1.32	0.73	1.28	1.36	1.33	1.14	0.47	0.23	0.21	0.09	16.34
2009	7.13	3.39	1.58	0.63	1.18	1.21	1.42	0.69	0.43	0.22	0.18	0.13	18.19
2010	7.89	4.54	2.04	0.64	1.27	1.58	1.67	0.66	0.48	0.23	0.19	0.13	21.31
2011	7.63	3.25	2.16	0.59	1.38	1.55	1.51	0.63	0.48	0.24	0.19	0.12	19.72
2012	7.08	2.57	2.27	0.57	1.25	1.55	1.33	0.63	0.52	0.26	0.19	0.11	18.32
2013	7.68	1.95	2.39	0.61	1.46	1.67	1.32	0.63	0.56	0.27	0.19	0.10	18.82
2014	8.60	1.22	2.17	0.58	1.47	1.71	1.33	0.61	0.56	0.27	0.18	0.10	18.80
2015	9.48	0.86	2.06	0.54	1.42	1.63	1.27	0.56	0.57	0.25	0.17	0.09	18.90
Program average	7.37	1.85	1.56	0.80	1.41	1.47	1.49	0.44	0.51	0.19	0.20	0.09	**17.39**

In the table "SNAP" is the Supplemental Nutrition Assistant Program (usually refereed to as food stamps), "TANF" denotes Temporary Assistance for Needy Families; "SSI" is the Supplemental Security Income program, "EITC" is the Earned Income Tax Credit, "HA" denotes Housing Assistance, "CTC" is the Child Tax Credit, "CNSM" stands for Child Nutrition and Special Milk program, "CHI" is Children Health Insurance, "WIC" is supplemental feeding programs and "LIHEA" is the Low Income Home Energy Assistance program. "Program average" is the average of each program over years, "Year average" is the average over programs in a given year.

E Welfare transfer in PSID, CEX and MEPS data

Table 13: Earnings v.s. welfare transfers in different datasets, in $

PSID	B1%	B1 ∼ 5%	B6 ∼ 10%	Q1	Q2	Q3	Q4	Q5	T91 ∼ 95%	T96 ∼ 99%	T99 ∼ 100%	average
income	5468	11872	18852	21244	43629	67834	104395	226031	204954	293528	778382	92642
PSID welfare	1771	1721	1192	1068	315	195	63	9	5	0	0	330
CEX	B1%	B1 ∼ 5%	B6 ∼ 10%	Q1	Q2	Q3	Q4	Q5	T91 ∼ 95%	T96 ∼ 99%	T99 ∼ 100%	
income	4202	11985	18341	20291	42247	64481	96064	201006	203056	284369	457396	84889
EITC	255	1473	1435	1267	608	156	28	14	14	0	0	414
child tax credit	0	213	393	412	597	637	508	133	0	0	0	457
MEPS	B1%	B1 ∼ 5%	B6 ∼ 10%	Q1	Q2	Q3	Q4	Q5	T91 ∼ 95%	T96 ∼ 99%	T99 ∼ 100%	
income	3480	11198	17801	19810	41396	64910	94732	177071	177376	238434	366748	79603
medicaid	3200	2416	2004	2145	1630	953	916	777	555	407	727	1284

Table 14: Interpolated welfare transfers according to PSID earnings, in $

PSID	B1%	B1 ∼ 5%	B6 ∼ 10%	Q1	Q2	Q3	Q4	Q5	T91 ∼ 95%	T96 ∼ 99%	T99 ∼ 100%	Average
income	5468	11872	18852	21244	43629	67834	104395	226031	204954	293528	778382	92642
EITC	453	1456	1391	1238	580	143	27	21	13	0	0	402
child tax credit	35	210	398	420	600	623	478	305	0	0	0	485
medicaid	2998	2374	2078	2111	1566	950	900	818	488	974	727	1269
PSID welfare	1771	1721	1193	1069	315	195	64	16	6	0	0	332
Total welfare	5257	5761	5059	4838	3060	1911	1469	1160	507	974	727	2488

Table 15: Ratio of EITC and other welfare transfer to their average

	B1%	B1 ∼ 5%	B6 ∼ 10%	Q1	Q2	Q3	Q4	Q5	T91 ∼ 95%	T96 ∼ 99%	T99 ∼ 100%
EITC	1.129	3.624	3.462	3.082	1.443	0.355	0.068	0.052	0.034	0	0
other welfare	3.810	3.518	2.611	2.434	1.089	0.683	0.454	0.340	0.185	0.352	0.624

Because the income in each quintile is different across datasets, we interpolate income as well as other welfare programs according to PSID earnings. For example, quintile 3 in PSID has the income of $67,834, which is between the income of quintile 3 ($64,480) and quintile 4 ($96,064) in the CEX. Therefore, the third income quintile in the PSID has the EITC transfer constructed as a linear combination of the EITC in CEX quintile 3 and CEX quintile 4.

The ratio of welfare transfers in each earnings group to the average welfare transfer is shown in Table 15. In this table, the ratio of the first percentile to the fourth quintile is the model parameter μ_1 to μ_7.