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The Macroeconomic Effects of Universal Basic Income Programs

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Abstract

What are the consequences of a nationwide reform of a transfer system based on means-testing toward one of unconditional transfers? I answer this question with a quantitative model to assess the general equilibrium, inequality, and welfare effects of substituting the current US income security system with a universal basic income (UBI) policy. To do so, I develop an overlapping generations model with idiosyncratic income risk that incorporates intensive and extensive margins of the labor supply, on-the-job learning, and child-bearing costs. The tax-transfer system closely mimics the US design. I calibrate the model to the US economy and conduct counterfactual analyses that implement reforms toward a UBI. I find that an expenditure-neutral reform has moderate impacts on agents' labor supply response but induces aggregate capital and output to grow due to larger precautionary savings. A UBI of $1,000 monthly requires a substantial increase in the tax rate of consumption used to clear the government budget and leads to an overall decrease in the macroeconomic aggregates, stemming from a drop in the labor supply. In both cases, the economy has more equally distributed disposable income and consumption. The UBI economy constitutes a welfare loss at the transition if it is expenditure-neutral and results in a gain in the second scenario.

Keywords: Universal Basic Income, Social Insurance, Overlapping Generations, Labor Supply
JEL Classifications: E21, H24, J22

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1 Introduction

A universal basic income (UBI) is an unconditional transfer given to all citizens of a given region or country. Over the last few years, pilot programs and experiments have been proposed, launched, or are ongoing in countries such as Canada, Brazil, Finland,[1] Kenya, Switzerland, Uganda, and the United States.[2] The idea is far from new in economics as similar concepts have been proposed by James Meade, Milton Friedman - with the negative income tax - and Anthony Atkinson, among others (Meade, 1935; Friedman, 1962; Atkinson, 1995) and has long been discussed by thinkers across all traditions of the political spectrum (Van Parijs and Vanderborght, 2017). In a nationwide context, the span of proposed policies is fairly broad: from large, one-time grants at the beginning of the working age on top of the already existing programs to an entire substitution of the welfare system, including Social Security and health benefits (Murray, 2006; Thigpen, 2016).

The return of the UBI concept to the policy debate and, more recently, to the economics literature is due to both the economic incentives intrinsic to its simple design and to the recent set of trends in inequality, public finance, and the labor market that have been attracting economists' attention. On the incentives side, the UBI can potentially reduce inefficiencies at the microeconomic level. First, as it is a lump-sum transfer, it does not distort individuals' decisions and avoids threshold traps that might be induced by any means testing. Second, it is untargeted and can yield a 100 per cent take-up rate as it avoids stigma or any other latent frictions for program eligibility and applications. It also does not require any monitoring or bookkeeping and can reduce the government's operational costs.

Over the last 20 years, there has been a steady growth of both federal spending and participation in means-tested income security programs such as the Earned Income Tax

[1] The Finnish experiment has already been concluded. The program ran through 2017-18 and the preliminary results for the first year can be found in the recently released report (link).

[2] A few examples are the Y Combinator randomized control trial, the Stockton Economic Empowerment Demonstration in California, and the Democratic candidate Andrew Yang's "freedom dividend" proposal. A longstanding program of unconditional transfers in the US is the Alaska Permanent Fund dividend, which will be discussed in detail later in this text.

Credit (EITC) or the Supplemental Nutrition Assistance Program (SNAP). The eligibility requirements of such programs yield phase-out effects that generate discontinuities in after-tax income, with effective marginal tax rates on the order of 30-39 percent, for more than 50 percent of low- and moderate-income households (CBO, 2013, 2015). At the same time, income inequality has sharply risen as the top 1 percent of households earn today 24.1 times the median household income, a figure that was 8.6 in 1976 (Nakajima, 2017). While such growth at the very top is often addressed in the literature, the catching-up of the bottom when accruing its share of national income is a redistribution matter in which the UBI is often raised as a competitive instrument. Finally, the observed decline in labor force participation, especially among young men, when paired with the current and expected rise of automation, has triggered a concern about how to adapt the welfare system in an economic environment with pervasive joblessness (Michaels, 2017; Lowrey, 2018; Acemoglu and Restrepo, 2020).

However, as with any reform proposal, UBI-type programs involve significant drawbacks that raise skepticism about both the effectiveness and the feasibility of their implementation (Ravaillon, 2019; Kearney and Mogstad, 2019). Topping the list of concerns is the potential large cost due to such program's universality and how it would be financed. Questions have beem raised regarding possible taxation counterparts that could be similarly as distortionary as means-testing thresholds or whether a UBI program could crowd-out the budget of other programs directed at poverty alleviation. A second concern is its potential disincentive to work due to large income effects, especially at the bottom of the income distribution, which would lean the balance toward the need for work requirements as in the EITC program. Lastly, there is the natural economic intuition of equating marginal utilities behind economic redistribution. Thus, it is often argued that the UBI is not intrinsically designed to generate equity, since it pays the same benefits to the rich and the poor.

This paper assesses the effects of substituting the current income security share of the US welfare system for a UBI. Despite the growing momentum of the debate and the many unanswered questions, the macroeconomic literature still lacks a detailed understanding of what would be the general equilibrium, distributional, and welfare effects of a large scale reform of the welfare system that implements a UBI. More specifically, what would be expected of the labor supply and what would happen to the accrual of disposable income for different strands of the distribution in such a reconstruction and what would be its overall effect on inequality. In order to tackle this task, I numerically solve a dynamic general equilibrium model that is able to provide micro-founded life-cycle and budgetary implications of such a broad welfare state reform as well as a normative assessment that relies on rich dynamics and heterogeneity, taking into account the overall impact on inequality. With respect to the literature, this work is in the tradition of evaluating reforms and transfer programs in heterogeneous agents models (Berriel and Zilberman, 2012; Lopez-Daneri, 2016; Pashchenko and Porapakkarm, 2017; Hannusch, 2019; Daruich and Fernandez, 2020; Wellschmied, 2021; Ortigueira and Siassi, 2021; Guner et al., 2020, 2021; Conesa et al., 2021; Ferreira et al., 2021; Mukbaniani, 2021) and is an addition on the quantitative macroeconomics side to a growing list of recent studies that focus on UBI policy (Jones and Marinescu, 2019; Hanna and Olken, 2018; Banerjee et al., 2019; Ghatak and Maniquet, 2019; Hoynes and Rothstein, 2019).

I develop a large-scale overlapping generations model with retirement and heterogeneity across households that incorporates both intensive and extensive margins of the labor supply, human capital accumulation through labor market experience, and childbearing costs. Households are also heterogeneous with respect to their permanent ability and estimated idiosyncratic productivity shocks. The model has a welfare system composed of social security and income security systems (henceforth SS and IS systems) that mimics the US structure, accounting for means-testing requirements and its taxation counterparts. The IS system is composed of the Earned Income Tax Credit (EITC) and means-tested transfers such as the Supplemental Nutrition Assistance Program (SNAP), the Temporary Assistance for Needy Families (TANF), and the Supplemental Security Income (SSI), the latter only available through retirement. The SS system is budget-balanced and pays retirement benefits to all households in the economy. I calibrate the model to the US economy, and with this macroeconomic toolkit, I conduct counterfactual analyses of implementing reforms in the welfare system toward a UBI and evaluate the welfare implications of means-tested versus unconditional transfers.

In order to bring this model to the data, I estimate a wage process taking into account the target population of cash transfer recipients using the 2008 panels of the Survey of Income and Program Participation (SIPP) in a similar fashion to Heathcote et al. (2010) and calibrate parameters to match data moments. The model approximates both the non-targeted earnings and the wealth distribution of the US due to a combination of the steepness of the earnings profile of high-productivity households via human capital accumulation and the means-testing transfer schedule. In a further step, I conduct a counterfactual exercise in the model environment designed to approximate the effects of the Alaska Permanent Fund dividend. As empirically shown in Jones and Marinescu (2019), this program has macroeconomic outcomes, and the model is able to, in an off-sample fashion, generate aggregate responses that are in the same sign on an order of magnitude of the ones estimated.

The first counterfactual I implement is an expenditure-neutral reform that keeps constant the total amount of budget outlays in transfers and let the tax rate on consumption endogenously adjust to balance the government's budget. The aggregate response encompasses an increase of 4 percent in physical capital, with an accompanying decrease in the equilibrium interest rate. The result is driven by agents that, early in their life-cycle, are at the bottom of the wealth distribution in the benchmark scenario and now save more due to the absence of means-testing and the average level of transfers in the counterfactual economy. Pushed by an increase in aggregate capital, output increases by 3 percent. The income effect generated by the transfers affects the aggregate labor market by inducing a small increase in total hours, reflecting the rise in the intensive margin of releasing households from the incentive to work less in order to fall inside the means-testing brackets. At the same time, the extensive margin reacts in the opposite direction with a decrease in labor force participation of half a percentage point. This reform does not affect much the tax effort toward revenues as the endogenous tax rate on consumption increases from 7.3 percent to 8 percent.

In my second counterfactual exercise, I implement a UBI reform similar to the one proposed by Andrew Yang, Democratic presidential candidate in the US 2020 election. I let the level of aggregate transfers be the equivalent of 20 percent of output in the benchmark economy. This yields a transfer of approximately US$12,000 annually to each household in the economy. In this scenario - and not surprisingly - the tax rate on consumption needs to increase 18 percentage points in order to balance the government's budget. The aggregate response of the economy is a contraction of both capital and output, stemming simultaneously from the drop in hours, the decline in labor force participation, and the decrease in the precautionary savings motive at the bottom generated by the high level of the consumption floor. In terms of the impact on inequality, the second UBI reform increases the Gini coefficient for pre-tax earnings and wealth, mostly due to the selection mechanism arising from the high-productivity agents who remain in the labor force and who can buffer consumption through a higher level of savings. However, the inequality in disposable income at the very bottom of the distribution decreases in both cases, driven by a reduction in the means accrued by the very top quintile. In the large UBI economy, this result is followed by the redistribution of more consumption toward the bottom, which is again reshuffled from the top.

I also conduct a normative analysis of the reforms by evaluating the model's responses to welfare. Under a utilitarian social welfare function, the consumption equivalent variation required for the UBI alternative to attain the same level of welfare as in the current system at the beginning of the life-cycle is -0.12 percent. Alternatively, the generous UBI transfer improves welfare by 0.29 percent. The transitional dynamics amplify the welfare responses of the steady state in the same direction mostly due to the sharper movements in aggregate labor in comparison to the slow adjustment in capital. The decomposition of welfare at the age dimension shows that the welfare losses in the first counterfactual scenario are more pronounced during earlier ages, as households that have children receive lower transfers when compared to the ones in the means-tested system, which includes the different brackets per the number of children of the EITC. The second reform has average gains across all generations alive at the period of the reform. Moreover, the first counterfactual affects high-ability households less, while the second counterfactual is preferred by the ones with low ability.

This paper is organized as follows. In the next section, I present a review of the related literature. In Section 3, I construct the setting of my quantitative model, provide intuition about the underlying theory, and define the recursive competitive equilibrium. In the subsequent Section 4, I describe the calibration used to map the model to the data. Section 5 presents the results for the benchmark economy and the properties of the initial steady state. Section 6 lays out the quantitative exercises explored and the results for two counterfactual UBI reforms. In Section 7, I explore the results for the transitional dynamics between the initial steady state and the final steady state of the reforms. Section 8 conducts the normative evaluation of the reforms by exploring different measures of welfare. The last section states my conclusions.

2 Related Literature

I begin by briefly discussing the empirical evidence on the labor market effect of unconditional transfers. In a comprehensive summary, Marinescu (2017) documents the empirical findings of related experiments such as the negative income tax, casino dividend recipients, and lottery winners. She observes that overall, in such programs, there is either no effect on labor market supply or a slight but not statistically significant reduction in work and earnings. For the case of the Permanent Fund, one of the few clear examples of windfall transfers in a wide geographic region, Jones and Marinescu (2019) use a synthetic control method and find that the dividend cash transfer had no effect on the employment to population ratio and increased part-time work by 1.8 percentage points, suggesting a close to zero income effect for the extensive margin. In Section 5.3, I will refer to these estimates and use them as a validation of the general equilibrium effects of my model. I include other measurements that, though not used explicitly in this paper, are also relevant for the underlying debate on the distinction between macro and micro labor supply responses to transfers.

A small response of the labor supply is also confirmed by a windfall cash transfer program held in Iran that substitutes energy subsidies and reaches more than 70 million citizens, yielding a take-up rate of about 95 percent. The evidence is in Salehi-Isfahani and Mostafazi-Dehzooei (2018), who analyze a rich panel of households and find no discernible negative labor supply effect on both hours and labor force participation, with positive outcomes for women and self-employed men. In the opposite direction, a study by Giupponi (2019) on welfare transfers based on a spouse's death uses Italian administrative data to estimate the income effect of losing the benefit. She estimates a marginal propensity to earn out of unearned income of approximately -1.0, indicating a larger response than previously observed in the literature. Lastly, recent evidence by Egger et al. (2019) estimates the behavioral and general equilibrium impacts of large cash transfers in rural villages in Kenya. The authors do not observe meaningful changes in the labor supply of treated households, with an increase in spending and a local fiscal multiplier of 2.5.

The long-term effect of transfers is estimated by Price and Song (2018) for participants in the Seattle-Denver Income Maintenance Experiment, a program inspired by the NIT proposal. Following adults for over four decades using Social Security data, the authors found that the treatment decreased earned income during the experiment, caused no significant effect immediately after it, and decreased earnings later in life. In their paper, the authors argue that the latter arises due to the interaction of a stronger preference for leisure in older ages and extra accumulated wealth. On the other hand, while further confirming the small labor supply evidence, but suggesting that it does not change at older ages, Cesarini et al. (2017) studied the wealth effect of lottery prizes in Sweden. The authors found that winners slightly reduce earnings, the effect being persistent and similar by age, education, and sex.

Turning to settings akin to my quantitative model, Fabre et al. (2014)'s paper is an early work wherein the authors compare the welfare effects of unemployment insurance (UI) against the UBI finding that the former is socially robust to the introduction of the latter. Despite drawbacks embedded in UI, such as moral hazard and government monitoring costs, the authors argue that it would take empirically implausible values for the parameters associated with these costs to make a UBI socially preferable. The main reason is that, in the mechanism proposed under incomplete markets, the UI insures agents in states of the world when they need it the most. Lopez-Daneri (2016) is a key reference for my proposed framework as it studies a revenue-neutral reform of the US income tax and welfare system in the form of an NIT. The author calibrates a life-cycle model to the US economy with welfare payments in a non-linear function of income and a lump-sum payment of retirement benefits. Focusing on an equilibrium with transitional dynamics for an open economy, the author finds that the optimal NIT imposes a 22 percent marginal tax rate and a transfer of 11 percent of the GDP of the benchmark economy with an ex-ante welfare gain of 2.1 percent.

Ortigueira and Siassi (2021) develop a structural dynamic model with a rich system of means-tested transfers where households make not only the standard decisions about consumption and savings but also decisions about family formation and program participation. The authors find in their model that lone mothers have large incentives to work, with low-productive ones receiving, on average, a participation subsidy amounting to 15 percent of their labor earnings. Also, asset testing and eligibility for programs such as SNAP or TANF introduce substantial distortions in low-productivity workers' savings decisions, a point discussed in detail in Wellschmied (2021). In the context of Medicaid, Pashchenko and Porapakkarm (2017) show that assets-testing can reduce labor supply distortions in an environment with unobserved productivity.

In a contemporaneous paper, Daruich and Fernandez (2020) provide a quantitative general equilibrium approach to a UBI reform with a novel and different focus on skill investments during early childhood and education decisions. The model incorporates explicit intergenerational linkages with altruistic care of parents toward their children and their decision outcomes. In the Daruich and Fernandez (2020) setting, college education choices are made based on financial prospects from work, transfers from parents, or borrowing and also includes a novel "out-of-work" shock. Another contemporaneous paper is Conesa et al. (2021), which analyzes the role of different types of funding and levels of generosity of a UBI in a model with two types of consumption goods, allowing the study of progressive consumption taxes. In a third contemporaneous paper, Guner et al. (2021)

further study the issue of welfare-state reform, comparing the welfare effects of a UBI and a NIT, also in their optimal levels. Guner et al. (2021) use a setting with intra-household heterogeneity with single and married, male and female agents. Ferreira et al. (2021) address the comparison of a UBI with conditional cash transfers (CCTs) in developing economies with the particular case of the Bolsa-Família program in Brazil. Mukbaniani (2021) studies the effects of a UBI in a setting with infinitely lived households.

My paper contributes to this literature and differentiates itself from the previously mentioned papers by explicitly framing a policy scenario of a reform toward a UBI as a departure from the status quo by a substitution of the IS system. In doing so, I follow Ortigueira and Siassi (2021) and Wellschmied (2021) and depart from the standard framework by modeling the IS system and the many brackets and kinks for the different means-testing requirements, with a careful treatment of the asset-testing component. Such constraints are directly modeled into the households' problem via the budget constraint and are calibrated in order to match the relevant equivalents in the data.[3] Another novel part consists of the interaction of the system with the operative extensive and intensive margins of the labor supply modeled as in Chang et al. (2019), which yields a mechanism that allows me to understand the trade-off of both margins under the different policies. While conducting the counterfactual exercises for the reform, in Section 6.1.2 I further explore the relevance of these distortions at the micro level by studying in detail how they become active in the mechanism. Finally, I validate the labor supply general equilibrium effects of my model by comparing them to the empirical estimate of Jones and Marinescu (2019).

Moreover, on top of that I account for human capital accumulation based on labor market experience and the effect of children, and combine all such ingredients in a general equilibrium framework, taking into account the transitional dynamics. The equilibrium component can be understood as complementary to the approach in dynamic structural models of the labor supply, such as Chan (2013), to the approach in public economics in Saez (2002), Brewer et al. (2010), and Rothstein (2010), and to other approaches reviewed

[3] See Appendix B.

by Chan and Moffitt (2018).

There is also a set of recent papers that study the UBI phenomenon through different perspectives. Hanna and Olken (2018) use data from Indonesia and Peru to analyze the trade-offs involved in proxy targeting versus a universal basic income. Banerjee et al. (2019) draw on the evidence from cash transfer programs in developing countries to anticipate the potential effects of a UBI as an incremental policy focused on mitigating poverty. Ghatak and Maniquet (2019) develop and study a theoretical framework to assess the normative justifications of a UBI system. Finally, and in close relation to the scope of this paper, Hoynes and Rothstein (2019) study the role of UBIs in advanced economies with a descriptive framework that encompasses different policy designs. They forecast that a UBI would direct larger transfers to childless and middle-income households rather than poor ones. The main contribution of this paper from the perspective of this literature is thus to add a macroeconomic framework that can serve as a quantitative laboratory to assess the impact of a nationwide reform of the welfare system and deliver precise predictions to many of the unanswered questions raised in the literature.

3 The Model

This section describes the dynamic general equilibrium model I use to analyze the macroeconomic effects of a reform of the welfare system in the US towards a universal basic income. The environment is a life-cycle, overlapping generations economy with incomplete markets and individual heterogeneity, endogenous labor supply, human capital accumulation, and a tax and transfer system similar to the one in the US.

Households are heterogeneous with respect to their age, $j \in \{1, \ldots, J\}$, permanent ability, $\theta \in \Theta$, idiosyncratic productivity shock, $z \in \mathcal{Z}$, human capital stock, $h \in \mathcal{H}$, and asset holdings $a \in \mathcal{A}$. I also model an extra degree of heterogeneity in the family structure by allowing households to differ in terms of child-bearing, as it is one of the key determinants of allocations within the US tax code, thus keeping track of whether households are child-bearers or not, $k \in \mathcal{K} = \{0, 1\}$. The state space of the economy is then the set $S = \mathcal{A} \times \mathcal{H} \times \mathcal{Z} \times \mathcal{K} \times \Theta \times \{1, \ldots, J\}$. In the following subsections, I discuss in detail every entry of the individual state space element $s = (a, h, z, k, \theta, j) \in S$.

As the environment is set with the underlying purpose of assessing a reform of the transfer system that will be analyzed both in steady states and along the transition, throughout the description of the model, I will selectively omit indices in order to avoid loading the notation. More specifically, I will denote all individual variables as defined over the individual state space s; hence they age-dependent and thus implicitly indexed by j. However, they should also be understood as implicitly indexed by time t. As the aggregate variables are more naturally understood to be time-dependent, I will explicitly index them by t.

3.1 Demographics

Each model period stands for one year. Time t is discrete with infinite horizon and the economy is populated by a continuum of mass one of households who live at most J years. There is uncertainty regarding the time of death in every age $j = 1, \ldots, J$ so that the household faces probability ψ_j of surviving to age j. Therefore, in every period, a fraction of the household population dies and leaves accidental bequests q. The age profile of the population $\{\mu_j\}_{j=1}^{J}$ is modeled by assuming that the fraction of households with age j in the population is given by the law of motion $\mu_j = \frac{\psi_j}{(1+g_n)} \mu_{j-1}$, that satisfies $\sum_{j=1}^{J} \mu_j = 1$, and where g_n is the population growth rate.

I assume that the household does not decide the number of children or when to have them in a similar fashion to Attanasio et al. (2008). At every period t, a fraction p_k of the households is defined to have children during their life-cycle, and are then flagged by $k = 1$. When they do so, they all simultaneously have the same number of children which solely depends exogenously on their age. Households have a number of kids $n_{k,j}$ at age j who are born at working ages $\underline{j}^i$, with $i \in I$, where I is finite. I also assume that children live in the household until they are 18 years old.[4] Given this structure, and by knowing age j and the different ages at which children are born $\underline{j}^i$, we can count the number of

[4] Here I follow the same interpretation of Attanasio et al. (2008) used in Fehr and Kindermann (2018).

children in the household $n_{k,j}$, as follows:

$$n_{k,j} = \sum_{i \in I} \mathbb{1}\left[\underline{j}^i \leq j \leq \underline{j}^i + 17\right]. \tag{1}$$

Households with children pay a child-care cost η whenever they are working and have young children in the household, defined as children between zero and two years old. At the aggregate level, I define the sum of such costs as CC_t.

3.2 Preferences

Households have a time-separable period utility function and maximize their discounted expected lifetime utility from nondurable goods consumption c and labor supply l. It is defined as follows

$$\mathbb{E}\left[\sum_{j=1}^{J} \beta^{j-1} \left(\prod_{i=1}^{j} \psi_i\right) u(c,l)\right], \tag{2}$$

where β is the discount factor and $\mathbb{E}$ is the expectation operator.

3.3 Technology

There is a single good produced in this economy with technology given by a Cobb-Douglas production function that exhibits constant returns to scale, $Y = F(K_t, L_t) = K_t^{\alpha} L_t^{1-\alpha}$, where $\alpha \in (0,1)$ is the output share of capital income and Y_t, K_t and L_t denote, respectively, aggregate output, physical capital, and labor. The final good can be consumed or invested in physical capital on a one-to-one basis.

The price of the consumption good is normalized to one and aggregate investment in physical capital, I_t, is defined by the following law of motion:

$$K_{t+1} = (1 - \delta_k)K_t + I_t, \tag{3}$$

where δ_k is the depreciation rate of physical capital.

This technology is used by a representative firm that behaves competitively maximizing profits at every period t by choosing labor and capital given factor prices. The profit maximization problem is:

$$\Pi_t = \max_{K_t, L_t} K_t^{\alpha} L_t^{1-\alpha} - w_t L_t - (r_t + \delta_k) K_t. \tag{4}$$

which yields the following first-order conditions:

$$r_t = \alpha \left(\frac{K_t}{L_t} \right)^{\alpha - 1} - \delta_k \tag{5}$$

$$w_t = (1 - \alpha) \left(\frac{K_t}{L_t} \right)^{\alpha} \tag{6}$$

3.4 Endowments and Labor Income

Agents are born with zero assets, endowed with one unit of time, and are forced to retire at age J_R. While agents are working, the individual wage depends on the competitive wage w_t, a permanent ability shock $\theta \sim N(0, \sigma_\theta^2)$, human capital level h_j, and an idiosyncratic persistent shock z_j.

I assume that households can only choose their hours within the set $[0, 1]$ and are subject to a non-convexity associated with the set-up costs for work, such as commuting time, as in Chang et al. (2019). I then define $\ell(l)$ to be the effective hours of work and use the following functional form to account for this effect:

$$\ell(l) = \max \left\{ 0, l - \bar{l} \right\}, \; l \in [0, 1], \tag{7}$$

where l is the individual labor supply and $0 < \bar{l} < 1$.

The function in (7) above imposes a wedge in the mapping between chosen hours and labor earnings and it gives rise to adjustments along the extensive and intensive margins as in Prescott et al. (2009). It can also be understood in the same fashion as the non-linearity of such mapping in Erosa et al. (2016).

Moreover, this formulation is particularly suited to the nature of this paper's question, which calls for precise predictions about the behavior of the labor supply and allows sharp distinctions between participation and movements through part-time and full-time work.[5] This characterization is useful later in the validation of the model in Section 5.3.

Households pre-tax labor income is then defined by:

$$y(l, h_j, z_j) = \quad w \cdot \exp(\theta) \cdot \exp(z_j) \cdot h_j \cdot \ell(l) \tag{8}$$

I follow the approach used in Attanasio et al. (2008) and Guner et al. (2020, 2021) and assume that the human capital component evolves according to a law of motion that takes into account the increasing return on wage due to labor market experience:

$$h_{j+1} = H(h_j, l, j; \nu, \delta_h) = \exp\left[\ \ln h_j + (\nu_1 + \nu_2 \cdot j)\, \mathbb{1}_{[l_j>0]} - \delta_h \left(1 - \mathbb{1}_{[l_j>0]}\right)\right] \tag{9}$$

where ν_1 captures the positive effect of working, ν_2 is the diminishing marginal return of the incremental year in the labor force, and δ_h stands for the depreciation rate of the human capital stock when out of the labor force.[6] I define the aggregate level of human capital by HC_t. The idiosyncratic component z_j follows an AR(1) process defined by :

$$z_{j+1} = \rho z_j + \varepsilon_j,\ \varepsilon_j \sim N(0, \sigma_\varepsilon^2) \tag{10}$$

[5]As emphasized in Chang et al. (2019), in this setting, adjustments along the intensive margin generate larger increases in efficiency units than those along the extensive margin. Because of this, I report later in the text, among other relevant moments, the mean aggregate efficiency units of labor.

[6]Here, I also follow the interpretation used in Fehr and Kindermann (2018).

which is discretized in a Markov chain with transition matrix $\pi_{z,z'} = \Pr(z_{j+1} = z'|z_j = z)$ and stationary distribution $\Pi(z)$.

From age J_R onward the labor supply is forcefully zero and agents live off of potential transfers, retirement benefits, and accumulated wealth. I also assume that there is no altruistic bequest motive and there is the certainty of death at $J + 1$. Hence, agents alive at age J consume all resources, implying $a_{J+1} = 0$.

3.5 Government

The government runs a welfare system designed to mimic the one in the US economy, has pure public spending G_t, has payments of its debt stock B_t, and collects taxes from households to finance its budget. I assume that both spending and public debt are defined by exogenous and constant shares of Y_t given by b_G and b_B, respectively.

The revenue to finance welfare and spending is levied by an exogenous tax rate on capital income, τ_r, a non-linear, exogenous, and progressive tax schedule on labor income, $T_l(y)$, and an endogenous tax rate on consumption $\tau_{c,t}$ that adjusts to balance the government budget. Finally, an endogenous payroll tax rate $\tau_{SS,t}$ separately balances the budget of the Social Security system.

The labor income tax function is given by $T_l(y) = y_j - \tau_0 y^{(1-\tau_1)}$, where τ_0 is the scale parameter that defines the level of the average tax rate and τ_1 is the parameter that governs the degree of progressivity implied by the curvature of the function. This formulation, initially used in Benabou (2002), has recently become the benchmark in the literature measuring the impact of top-income taxation on government revenue in general equilibrium economies with heterogeneous agents (Guner et al., 2016; Heathcote et al., 2017; Holter et al., 2019). I denote by TL_t the aggregate level of labor income tax collected.

The income security system (IS) is composed of the Earned Income Tax Credit (EITC), other means-tested cash transfers such as the Suplemental Nutrition Assistance Program (SNAP) or the Temporary Assistance for Needy Families (TANF), and the Supplemental Security Income (SSI), available only when agents retire. I model the brackets and testing details of the EITC exactly as defined by the Internal Revenue Services (IRS) by following the formulations in Ortigueira and Siassi (2021), and I use a simplified way to model the SNAP and TANF programs for tractability purposes in a similar fashion to Wellschmied (2021). The SSI is modeled as defined by the US Social Security Administration (SSA).

First, it is helpful to lay out key definitions used in the characterization of the transfer programs. Total labor income $y(l, h_j, z_j)$ will henceforth stand for *gross income* and $d = ra$ for *investment income*. I also need to define *gross adjusted income* as $y_a \equiv y(l, h_j, z_j) + d$. The EITC is a refundable credit for which eligibility is determined by two criteria: first, investment income cannot exceed a level $\bar{d}_{TC}$, and second, gross adjusted income cannot be higher than an upper bound $\bar{y}^k_{TC}$ which depends on the number of children $n_{k,j}$ present in the household. Since it is defined as a percentage of positive labor income y, it is, in essence, a work subsidy. The payment structure is composed of three parts: a phase-in region, a so-called plateau region, and a subsequent phase-out region.

The individual level of transfers for the EITC is defined as T_{TC} and the overall structure is summarized as follows:

$$T_{TC}[y, d, j] = \begin{cases} \kappa^k_1 y, & \text{if } 0 \leq y < \underline{y}^k \\ \kappa^k_1 \underline{y}^k, & \text{if } \underline{y}^k \leq y < \bar{y}^k \\ \max\{\kappa^k_1 \underline{y}^k - \kappa^k_2 (y - \bar{y}^k), 0\}, & y > \bar{y}^k \\ 0, & \text{if } d > \bar{d}_{TC} \text{ or } y_a > \bar{y}^k_{TC} \text{ or } j \geq J_R \end{cases} \tag{11}$$

where κ^k_1 and κ^k_2 are the phase-in and phase-out rates, respectively, and $\underline{y}^k$ and $\bar{y}^k$ are the income thresholds for the plateau. Note that all brackets are indexed by k, which stands for the dependence on the number of children $n_{k,j}$. The investment eligibility requirement, on the other hand, is invariant to such number. I define the total aggregate level of transfers paid via the EITC by TTC_t, standing for total tax credit.

I model the other means-tested cash transfer programs in a similar fashion, with the difference that now thresholds are on households' asset holdings and adjusted income, as defined in the tax code for both SNAP and TANF. The SSI, given the absence of labor income during retirement, is only tested for households' asset level. I denote thie maximum level of assets for both TANF and SNAP as $\bar{d}_{CT}$, and the maximum level of adjusted income for the SNAP as $\bar{y}_{CT}$. I abstract from all other qualitative requirements for eligibility regarding family size or co-habitation of parents for households with children as well as the tapering in their phase-out brackets.

The payment schedule for the individual level of transfers T_{CT} for such programs is thus defined :

$$T_{CT}[y_a, a, j] = \begin{cases} t_{SNAP}, & \text{if } a \leq \bar{d}_{CT} \text{ and } y_a \leq \bar{y}_{CT} \text{ and } j < J_R \\ t_{SSI}, & \text{if } a \leq \bar{d}_{SSI} \text{ and } j \geq J_R \\ 0, & \text{otherwise} \end{cases} \tag{12}$$

where t_{SNAP} and t_{SSI} are the transfer values. I denote the total aggregate level of cash transfers by TCT_t, standing for total cash transfers. The total expenditure of the government on means-tested cash transfers is then defined as the sum $TR_t = TTC_t + TCT_t$.

The SS system is operated on a pay-as-you-go schedule. It is balanced by a payroll tax rate $\tau_{SS,t}$ and pays retirement benefits independent of individuals' history defined by $b(x_t) = b_{SS}x_t$, where b_{SS} is the replacement rate and x_t is the average level of labor earnings of period $t-1$, normalized by the measure of working households.

Last, I also assume that the government is responsible for collecting all accidental bequests q_j, denoted by Q_t when at the aggregate level. Hence, at any time t, the budget of the tax system is balanced if, and only if,

$$G_t + (1 + r_t)B_t + TR_t = \tau_{c,t}C_t + TL_t + \tau_r r_t A_t + Q_t + (1 + g_n)B_{t+1}. \tag{13}$$

Here we have that, in the aggregate, the transition path is characterized by several time-dependent endogenous objects, including the government's debt. This formulation follows the one in Kindermann and Krueger (Forthcoming) and, by assumption, the government does not run fiscal deficits to ensure satisfaction of its budget constraint.

3.6 Recursive Household Problem

Let $v(s)$ denote the value function of a j-year-old agent. As defined previously, $s = (a, h, z, k, \theta, j) \in S$ is the individual state space. Also, let $v^R(s)$ for $j = J_R, \dots, J$ denote the value function of an individual aged j who is retired and receives Social Security benefits. I normalize the value function of the terminal age J to zero, $v^R(s_{-j}, J+1) = 0$, where henceforth s_{-j} stands for the individual state space without the age dimension.

The problem of an agent at age $j = 1, \dots, J_R - 1$ that lies inside the fraction p_k of the population that bears children in their life-cycle is represented in the recursive form in the Bellman equation (14). For the agents inside the fraction $(1 - p_k)$, the definition is identical to $k = 0$, $\forall j$.

$$v(a, h, z; k = 1, \theta, j) = \max_{c, a', l} u(c, l) + \beta \psi_{j+1} \mathbb{E}_z \left[v(a', h', z'; k = 1, \theta, j + 1) \right]$$

s.t.

$$(1 + \tau_c)c + a' + \eta \mathbb{1}_{[l > \bar{l},\, (j - \underline{j}^i) \leq 2]} = a(1 + r(1 - \tau_r)) + (1 - \tau_{SS}) y(l, h, z) - T_l[y(l, h, z)] + T_{TC}[y(l, h, z), d, j] + T_{CT}[y_a, a, j] \tag{14}$$

$$y(l, h, z) = w \exp(z + \theta) h \ell(l), \quad h' = H(h, l, j; \nu, \delta_h)$$

$$n_{k, j+1} = \sum_{i \in I} \mathbb{1} \left[\underline{j}^i \leq j + 1 \leq \underline{j}^i + 17 \right]$$

$$c > 0, \qquad a' \geq 0, \qquad 0 \leq l \leq 1$$

For individuals at ages $j = J_R, \dots, J$ the problem is:

$$v^R(a,j) = \max_{c,a'} u(c,0) + \beta\psi_{j+1} v^R(a', j+1)$$

s.t.

$$(1+\tau_c)c + a' = a(1 + r(1-\tau_r)) + b(x) + T_{CT}[0, a, j] \tag{15}$$

$$c > 0, \quad a' \geq 0$$

The solution of the dynamic programs (14) and (15) provides us with the decision rules for the asset holdings $a : S \to \mathbb{R}_+$, consumption $c : S \to \mathbb{R}_{++}$, labor supply $l : S \to [0,1]$, and human capital allocation $h : S \to \mathbb{R}_+$.

3.7 Equilibrium

Agents are heterogeneous at each point in time in the state $s \in S$. The agents' distribution among the states s is described by a measure of probability Φ_t defined on subsets of the state space S. Let $(S, \mathcal{B}(S), \Phi_t)$ be a space of probability, where $\mathcal{B}(S)$ is the Borel σ-algebra on S. For each $\omega \subset \mathcal{B}(S)$, $\Phi_t(\omega)$ denotes the fraction of agents who are in probability state ω. There is a transition function $M_t(s, \omega)$ that governs the movement over the state space from time t to time $t+1$ and that depends on the invariant probability distribution of the idiosyncratic shock $\Pi(z)$ and on the decision rules obtained from the household problem.

The definition (**??**) stands for the recursive competitive equilibrium. The definition for the stationary equilibrium can be found in Section C of the Appendix.

Definition 1 (Recursive Competitive Equilibrium). *A recursive competitive equilibrium with population growth for this economy is an allocation of value functions* $\{v_t(s), v_t^R(s)\}_{t=0}^{\infty}$, *policy functions* $\{c_t(s), a_t'(s), l_t(s), h_t(s)\}_{t=0}^{\infty}$, *prices* $\{w_t, r_t\}_{t=0}^{\infty}$, *production plans for the firm* $\{K_t, L_t\}_{t=0}^{\infty}$, *consumption taxes* $\{\tau_{c,t}\}_{t=0}^{\infty}$, *social security taxes and benefits* $\{\tau_{SS,t}, b(x_t)\}_{t=0}^{\infty}$, *aggregate trans-*

fers $\{TR_t\}_{t=0}^{\infty}$*, government expenditures and debt* $\{G_t, B_t\}_{t=0}^{\infty}$*, accidental bequests* $\{Q_t\}_{t=0}^{\infty}$*, and an age-dependent measure of agents* $\{\Phi_t\}_{t=0}^{\infty}$*, such that,* $\forall t$*:*

1. *Given factor prices, taxes and transfers, and initial conditions, the value functions* $\{v_t(s), v_t^R(s)\}$ *and policy functions* $\{a_t'(s), c_t(s), l_t(s), h_t(s)\}$ *solve the households' optimization problems (14) and (15);*

2. *The individual and aggregate behaviors are consistent:*

$$G_t = g_y Y_t, \;\; B_t = g_b Y_t$$

$$(1+g_n)K_{t+1} = \int_S a_t'(s) d\Phi_t(s) - (1+g_n)B_{t+1}$$

$$C_t = \int_S c_t(s) d\Phi_t(s)$$

$$L_t = \int_S \exp(\theta + z_j) h_t(s) \ell(l_t(s)) d\Phi_t\left(s_{-j}, \{1, \ldots, J_R - 1\}\right)$$

3. $\{r_t, w_t\}$ *are such that they satisfy the firm's first-order conditions (5) and (6);*

4. *The final good market clears:*

$$C_t + K_{t+1} + G_t + CC_t = AK_t^{\alpha} L_t^{1-\alpha} + (1-\delta_k)K_t$$

5. *The government balances its budget:*

$$G_t + \int_S \left[T_{TC,t}(s) + T_{CT,t}(s)\right] d\Phi_t(s) + (1+r_t)B_t = Q_t +$$
$$\int_S \left[\tau_r r_t a_t(s) + \tau_{c,t} c_t(s) + \left(y_t(s) - \tau_0 y_t(s)^{(1-\tau_1)}\right)\right] d\Phi_t(s) + (1+g_n)B_{t+1}$$

6. *Social Security's budget balances:*

$$\tau_{SS,t} w_t L_t = \int_S b(x_t) d\Phi_t\left(s_{-j}, \{J_R, \ldots, J\}\right)$$

7. *Accidental bequests equal the savings left from deceased households:*

$$Q_t = \int_S (1 - \psi_{j+1}) a'_t(s)\, d\Phi_t(s)$$

8. *Given the decision rules, Φ_t satisfies:*

$$\Phi_{t+1}(\omega) = \int_S M_t(s, \omega) d\Phi_t(s),\ \forall \omega \subset \mathcal{B}(S),$$

where $M_t : (S, \mathcal{B}(S)) \to (S, \mathcal{B}(S))$, can be written as folllows: $\forall j \in \{2, \ldots, J\}$,

$$M_t(s, \omega) = \begin{cases} \pi_{z,z'} \cdot \psi_{j+1}\,, \ \ \textit{if} \ \ a'_t(s) \in \mathcal{A},\ h'_t(s) \in \mathcal{H},\ k \in \mathcal{K},\ \theta \in \Theta,\ j+1 \in \{2, \ldots, J\} \\ 0\ ,\ \textit{otherwise.} \end{cases}$$

and for $j \in \{1\}$,

$$\Phi_{t+1}(S_{-J}, 1) = (1 + g_n)^t \begin{cases} \sum_{k \in \mathcal{K}, \theta \in \Theta} p_k \cdot p_\theta\,, \ \ \textit{if} \ \ 0 \in \mathcal{A},\ h_0 \in \mathcal{H},\ \bar{z} \in \mathcal{Z} \\ 0\ ,\ \textit{otherwise,} \end{cases}$$

where p_k and p_θ are, respectively, the probabilities of being a household with children and of drawing θ out of its discretized distribution. The initial conditions are $a_0 = 0$, $h_0 = 1$, and $\bar{z}$, the average level of productivity.

4 Calibration

4.1 Demographics

In the model, agents are born at $j = 1$, which stands for age 20 in real life; start their retirement at age $J_R = 45$, standing for 65 in real life; and die with probability one at age $J = 80$, equivalent to 100 years old. The age-dependent survival probabilities $\{\psi_j\}_{j=1}^{J}$ are the ones estimated by Fehr and Kindermann (2018) for the US population in 2010. Population growth is set to be $g_n = 1.1$ percent, the average long run value for the US. I set the fraction of households that will have children during their life span to $p_k = 30\%$. They will have three children born at ages $\underline{j}^i = \{27, 30, 33\}$, being $I = \{1, 2, 3\}$ in equation (1) that defines the number of children at age j, $n_{k,j}$ (Fehr and Kindermann, 2018). The number of children is set to a maximum of 3 due to the design of the EITC as defined by the IRS. All details are discussed in Appendix B.

4.2 Preferences

The period utility is

$$u(c, l) = \log(c) - \varphi \frac{l^{1+\frac{1}{\gamma}}}{1 + \frac{1}{\gamma}} \tag{16}$$

where φ controls the intensity of labor vs. consumption and γ governs the Frisch elasticity. Preferences are in King-Plosser-Rebelo form and are consistent with a balanced growth path.

I set $\gamma = 1$ as in Lopez-Daneri (2016). I jointly and endogenously calibrate φ and $\bar{l}$, so that the aggregate average hours dedicated to work are a third of the household's unit endowment of time $H = 33$ percent and the labor force participation (LFP) rate is 75.6 percent. The first number is standard in the literature and the second one is calculated using from the Bureau of Labor Statistics (BLS) taken from the Current Population Survey (CPS) for males older than 20. In order to smooth the effect of recent changes in the secular trend of this statistic, I calculate separately the LFP for this range in their reported values for 2008 (75.6 percent)[7]. Finally, I endogenously calibrate the time discount factor β to match a capital-output ratio of $K/Y = 2.9$, as in Kindermann and Krueger (Forthcoming).

4.3 Technology

I set the capital share of the economy to be $\alpha = 35$ percent as in Lopez-Daneri (2016), which is the average in the US between 1960-2007. I calibrate the depreciation rate of capital δ_k so that the benchmark steady-state real interest rate is $r = 4$ percent.

4.4 Labor Income

As mentioned above, I calibrate the parameter $\bar{l}$ governing the wedge between hours and earnings jointly with φ to match average hours and the LFP rates. The variance for the permanent ability shock is calibrated to be $\sigma_\theta^2 = 0.693$ in order to target the Gini index of the earnings distribution. The bend points $\{\nu_1, \nu_2\}$ for the returns to experience in the human capital law of motion are taken from the coefficients estimated in the Mincerian regression given by equation (20) shown in Appendix A.2. As the third coefficient of the cubic polynomial is of a small order of magnitude and has a less straightforward economic interpretation, I consider only the first two. The depreciation of human capital is taken from the value estimated in Guvenen et al. (2014) and thus set to $\delta_h = 1.5$ percent.

If households have kids with age $j^i \in \{0, 1, 2\}$ in the household, they pay childcare cost $\eta = 0.082$ whenever they have positive labor supply. This value is calibrated to target childcare costs standing for 11 percent of the average household income. The number is taken from the 2018 report "The US and the High Cost of Child Care" released by Child Care Aware of America[8] and stands for the average level of the share of earnings paid by married couples based on a different methodology of calculations that take into account the main stages of childhood. Finally, the persistence ρ and the error variance σ_ε^2 are the ones obtained from the estimation of the income process from the SIPP 2008. I use the

[7] The table can be found at this link.
[8] The report can be found in this link.

point estimates obtained with the identity matrix as the GMM weighting matrix. The methodology is described in Appendix A.2 and depicted in Table 18.

4.5 Government

I follow Holter et al. (2019) and choose the fractions $b_G = 7.25$ percent and $b_B = 61.85$ percent such that the value of pure public consumption, G, is equal to two times the military spending and that the outstanding government debt, B, in the model is equal to the US debt-to-GDP ratio.

On the taxation side, I calibrate the capital income tax rate as $\tau_r = 7.4$ percent as in Lopez-Daneri (2016). I set the parameters governing the progressive income tax function as in Holter et al. (2019), where they use OECD tax data to find the values for married couples in the US. That yields a scale parameter $\tau_0 = 0.9420$ and curvature $\tau_1 = 0.1577$. Finally, the payroll contribution rate of the Social Security system, τ_{SS}, is calibrated endogenously to target a replacement rate $b_{SS} = 36$ percent. This is the median rate calculated by the CBO based on either the highest 35 years of earnings or the last 5 years of substantial earnings. It is the number calculated for both sexes and includes all quintiles of the earnings distribution.[9] As mentioned previously, the tax on consumption τ_c is the endogenous equilibrium outcome that balances the government budget.

Finally, the whole IS system ran by the government and embedded in the model amounts to 29 parameters. As there are several values and references to document, I explain it all in detail in Appendix B.

4.6 Summary of Calibration

I summarize the information associated with the calibrated parameters in a sequence of tables. In Table 1, one can find the exogenously calibrated parameters and their sources. Table 2 shows the endogenously calibrated parameters, the targeted moments associated with each of them, and the source of such moments for their data counterparts. Finally,

[9]More details can be found in the report via this link.

in another set of tables in Appendix B, I display all the parameters and values used in the model economy's income security system. Tables 19 and 20 collect the EITC parameters. In Tables 21 and 22 one can find the parameters for the remaining IS programs.

Table 1: Exogenously Calibrated Parameters.

	Parameter	Value	Target / Source
Demographics			
Model's terminal and retirement ages	JJ, J_R	80, 45	Ages 100 and 65
Population growth	n_p	1.1%	Historical data
Survival probabilities	$\{\psi_j\}_{j=1}^{J}$	-	Fehr and Kindermann (2018)
Ages children are born	$\{n_i\}_{i=1}^{3}$	27, 30, 33	Exogenous
Fraction of pop. with children	p_k	30%	Bureau of Labor Statistics
Preferences			
Frisch elasticity	γ	1.00	Lopez-Daneri (2016)
Technology			
Capital share	α	0.35	Historical data
Labor Income			
Persistence and variance of AR(1)	$\{\rho, \sigma_\epsilon^2\}$	0.9766, 0.0243	SIPP 2008
Human capital returns	$\{\nu_1, \nu_2\}$	0.04550, -0.0010	SIPP 2008
Depreciation rate of human capital	δ_h	1.5%	Guvenen et al. (2014)
Government			
Public consumption goods, national debt	$\{b_G, b_B\}$	7.25%, 61.85%	Holter et al. (2019)
Investment income tax rate	τ_r	7.4%	Lopez-Daneri (2016)
Scale and curvature of income taxes	$\{\tau_0, \tau_1\}$	0.9420, 0.1577	Holter et al. (2019)

Notes: The table shows model parameters, their numerical values, targeted moments in the model economy, and their data sources.

Table 2: Endogenously Calibrated Parameters.

	Parameter	Value	Target	Source
Preferences				
Discount factor	β	0.980	$K/Y = 2.9$	Kindermann and Krueger (Forthcoming)
Disutility of labor	φ	11.605	H = 33%	Standard
Commuting costs	$\bar{l}$	0.149	LFP = 75.6%	Bureau of Labor Statistics
Labor Income				
Childcare cost	η	0.082	11% of $\bar{y}$	Child Care Aware of America
Variance of permanent shocks	σ_θ^2	0.693	Earn. Gini = 0.60	SIPP 2008
Technology				
K depreciation rate	δ_k	7.8%	r^* = 4%	Standard
Government				
SS Payroll tax	τ_{SS}	10.61%	b_{SS} = 36%	Congressional Budget Office

Notes: The table shows model parameters, their numerical values, targeted moments in the model economy, and their data sources.

5 The Benchmark Economy

5.1 Aggregates

I begin the assessment of the benchmark economy by reporting the equilibrium quantities of the main aggregate variables of the model and comparing them to their counterpart targeted and non-targeted levels in the data. Table 3 summarizes the moments of the benchmark model with the baseline welfare system composed of the means-tested transfers. The model closely matches several of the aggregate levels of interest. As expected, the capital-to-ouput ratio, K/Y, the aggregate level of average hours worked, H, the equilibrium interest rate, r, and the labor force participation (LFP) rate are all at their targeted levels. The investment-to-GDP ratio, I/Y, and the consumption-to-GDP ratio, C/Y, were not targeted but are both at levels consistent with US data.

The size of the IS system, captured by the share of the total amount of transfers by GDP, TR/Y, is almost four times the size of the one calculated by the CBO. Even though the parameters of this system are calibrated to reflect the relative share of their values in our model economy, the risky nature of the environment under incomplete markets endogenously selects households into regions where they can obtain insurance. Since there is no other source of direct insurance during the working age besides savings, it is natural that the endogenous outcome would lean toward a reliance on the IS system for this purpose.

As I target the replacement rate of the SS system, b_{SS}, the payroll tax used to close the system's budget endogenously achieves the rate of 10.61 percent, which is thus non-targeted and close to the 12.4 percent rate set by the IRS. A similar pattern applies to the endogenous tax on consumption, τ_c, with the difference that the US does not have such a tax at the federal level. Nonetheless, the value obtained of 7.4 percent is on the same order of magnitude of the one estimated by Trabandt and Uhlig (2011), and this rate provides an approximation of the tax burden of the benchmark income security system to provide the aggregate level of transfers TR, which is key in the counterfactual comparisons.

Table 3: Aggregate Variables in the Benchmark Economy.

Variable	Benchmark	Target / Data	Source
Targeted			
K/Y	290.3%	290%	Standard
H	33.0%	33%	Standard
LFP	76.5%	75.6%	BLS
r	0.042	0.040	Standard
Untargeted			
C/Y	62.6%	68%	FRED (St. Louis Fed)
I/Y	25.5%	17%	FRED (St. Louis Fed)
TR/Y	4.0%	1.3%	CBO
τ_c	7.4%	5%	Trabandt and Uhlig (2011)
τ_{SS}	10.6%	12.4%	IRS

Notes: The table shows targeted and untargeted moments in the model economy, their counterparts in the data, and their data sources. The counterparts shown are taken from several sources. The BLS source for the LFP data target is the same as that described in the text. I use the last available period of FRED data for the share of personal consumption expenditures over GDP (Obs.: Q4 2019), and gross private domestic investment over GDP (Obs.: Q4 2019). They can be found, respectively, in the following links: here and here. The CBO data stand for the breakdown of mandatory spending in 2018 and can be found here. The SS withtholding rate is defined by the IRS and can be found here.

5.2 Earnings and Wealth Distributions

The evaluation of the model fit also depends on the comparison of the inequality on labor earnings and wealth in the benchmark economy with the one observed in the data. Table 4 shows such distributional outcomes of the model in comparison with the SIPP 2008 estimates, all of them untargeted moments, except, as mentioned previously, for the Gini coefficient of the labor earnings distribution.

The model is able to approximate the earnings distribution, with some understatement in the third and fourth quintiles and an overstatement in the fifth quintile. Given that we have estimated the wage process directly from our sample of the SIPP data and exogenously fed this source of earnings risk into the model, such a positive result is expected. However, the fit in terms of magnitude in the quintiles is reassuring that the labor income side of the baseline economy is able to exhibit behavior similar to the data. There is an understatement of the earnings accrued by the middle quintile and some excess of earnings at the very top. This effect stems mostly from the human capital structure of the model, which tends to drive the returns to labor toward the more productive households, which have a smaller opportunity cost of participation.

A second and more rigorous assessment of the fit can be done by observing the wealth distribution outcomes. As the savings decision is one of the critical endogenous choices of the agents in the model, their behavior in terms of these choices gives us a more accurate understanding of whether the environment of the benchmark economy captures correctly the mechanism behind such a decision in the data. The overall level of wealth inequality as captured by the Gini coefficient is not very far from the one calculated in our sample of the SIPP data. The model understates the accrual of wealth by households of the third quintile, but is able to generate substantial wealth concentration at the top, overstating the top quintile, but with a realistic breakdown in the final cuts of the upper tail.

At the very bottom of the wealth distribution, since the model does not allow borrowing, the distribution stops at zero assets. It is not able then to capture the negative value standing for debt, as observed in the data for the first quintile. However, the model is overall able to capture a low level of savings for the first three quintiles, closely approximating the distribution computed in the data from other surveys such as the Survey of Consumer Finances (SCF) or the Panel Study of Income Dynamics (PSID) (Kuhn and Rios-Rull, 2016; Krueger et al., 2016a). As the SIPP data for assets are taken from a point in time provided in a topical module, it is reassuring that the model is at least consistent with other data sources.[10] This outcome is mainly possible due to a combination of two model ingredients: the steep profile in earnings generated by the human capital accumulation component and the different levels of asset and investment income testing that the IS system imposes on agents in the economy.

The intuition behind this outcome comes from the fact that households are born with

[10] In Appendix A, I add summary statistics alongside with more details and explanations of the SIPP 2008 panel.

zero assets and then climb up the savings ladder as they receive idiosyncratic shocks. The shocks are persistent and households that receive low-level shocks prefer to choose a smaller level of assets in order to frontload consumption when incentives to work are small. This consumption-savings trade-off is further enhanced by the presence of the asset thresholds of the means-tested transfers. This point is developed again later, when I highlight the distortions induced by the means-testing vis-a-vis the the UBI.[11]

Table 4: Earnings and Wealth Distributions (in %).

	Earnings		**Wealth**	
	Data	Model	Data	Model
Bottom				
0% - 1%	0.0	0.0	-0.8	0.0
1% - 5%	0.0	0.2	-0.9	0.0
5% - 10%	0.0	0.4	-0.3	0.0
Quintile				
0% - 20%	0.0	2.0	-0.2	0.1
20% - 40%	2.4	4.2	1.0	0.5
40% - 60%	12.7	8.6	7.2	1.4
60% - 80%	25.2	22.5	20.5	13.8
80% - 100%	59.6	62.5	73.2	84.1
Top				
90% - 100%	39.2	43.3	52.3	60.3
95% - 100%	25.3	28.3	38.7	39.3
99% - 100%	8.9	10.2	13.6	12.3
Gini	0.60	0.60	0.74	0.79

Notes: The table shows the different quantiles for the model's earnings and wealth distributions and compares them to their data counterparts. The data shown in the table are all taken from my own calculations from the SIPP 2008 panel. A more detailed description can be found in Section A of the Appendix.

[11] Such low wealth accumulation due to asset means-testing has a mechanism similar to the one pointed out in Hubbard et al. (1995) and re-emphasized in Wellschmied (2021).

5.3 The Alaska Permanent Fund Dividend

A final step taken toward evaluating the model fit consists of checking whether the predicted behavior of the model economy aggregates is in accordance with the empirical evidence of the effects of unconditional transfers on the labor supply side of the economy. In order to do so, I will compare the outcomes of the model to some of the estimates in Jones and Marinescu (2019) for the impact of the Alaska Permanent Fund dividend. As mentioned before, Alaska's experience is, by now, the closest we can get in terms of empirical evidence to an understanding of the macroeconomic and general equilibrium impact of unconditional transfers in the US.

The idea behind this validation is to operate the following thought experiment: we start with the economy in the initial steady state with the means-tested transfer system and then move to a counterfactual economy where all households receive the dividend. The structure of benefits is maintained intact, and thus the dividend is just an addition on top of the currently existing benefits. This extra expenditure in the government's budget constraint is funded by windfall revenues, and thus, there is no need for the adjustment of taxes to keep the government budget constraint balanced. The size of the transfer distributed to each of the households is the equivalent of US $1,115 in model units, which is the average dividend level from 1982 to 2018.[12] This yields a transfer of 1.9 percent of the GDP per capita in the model economy.

In the first row of Table 5, I show the relevant point estimates taken from Jones and Marinescu (2019). The first column shows the difference in the average employment rate between Alaska and Jones and Marinescu (2019)'s controlled sample. This is the evidence that highlights the adjustment of the extensive margin of labor and shows virtually zero effects with a point estimate of -0.001. In the second column, I move to one of their measures of adjustment at the intensive margin, which is the part-time rate (part-time employment as a share of the population). They estimate an aggregate increase of 1.8 percentage points between treatment and control averages. In the second row, I show the

[12] The table with the historical data on the dividend is provided by the Alaska Department of Revenue - Permanent Fund Dividend Division and can be found at this link.

differences in model averages between the benchmark and the counterfactual economy.

It is also worth noticing that the results for the part-time rate require a mapping of this definition in terms of the model economy. As in Jones and Marinescu (2019) the main data source is the CPS, and part-time employment is defined as less than 35 hours of work per week. As the labor supply in the model is defined in terms of the percentage of the households' unit endowment of time, part-time then represents approximately the use of 29 percent or less of their endowment when compared to a full-time work-week. Given that the model has the non-convex mapping between hours and earnings defined in equation (7), it exhibits a continuous intensive margin that allows for this notion to be well-defined in terms of the model labor supply allocations.

The results in Table 5 show that the model is able to closely replicate the changes in the average employment rate and the average part-time rate as given by the Alaska evidence. It approximates well the signs and the numerical order of magnitude for both statistics.

Table 5: Estimated Differences Between Treatment and Control for Alaska.

	Differences of Averages	
	Employment Rate	**Part-time Rate**
Data	-0.001	0.018
Model	-0.003	0.091

Notes: The table shows data and model differences of averages for the employment and the part-time rate. The rows for data show the estimates obtained in Jones and Marinescu (2019). The rows for the model show differences between model aggregates in the benchmark and counterfactual economies.

6 Quantitative Exercises

In this section I outline the results of the quantitative exercises conducted highlighting the impacts on aggregates and inequality. In Section 6.1, I discuss the thought experiment behind the expenditure-neutral UBI counterfactual, its results and the mechanism behind the economies with and without means-testing. In Section 6.2, I then move to a UBI reform with a level of US$12,000 annually. In Sections 6.3 and 6.4, I discuss, respectively, the impact of both reforms on inequality and the government budget constraint.

6.1 Expenditure-neutral UBI

The idea behind the counterfactual toward a UBI reform of the income security system is simple: substitute all transfers $T_{TC}[y, d, j]$ and $T_{CT}[y_a, a, j]$ defined in (11) and (12) with an unconditional payment TR_{UBI}. I hold constant the commitment on spending and debt level, $G = b_G Y$, $B = b_B Y$, and distribute to the households the same aggregate level of total transfers TR computed for the benchmark equilibrium in a per household base. The budget constraint of the household then becomes:

$$\text{if } j < J_r: \ (1+\tau_c)c + a' + \eta \mathbb{1}_{[l > \bar{l}]} = a(1 + r(1-\tau_r))$$

$$+ (1-\tau_{SS})y(l,h,z) - T_l[y(l,h,z)] + TR_{UBI} \tag{17}$$

$$\text{if } j \geq J_r: \quad (1+\tau_c)c + a' = a(1 + r(1-\tau_r)) + b(x) + TR_{UBI} \tag{18}$$

The government budget balance is still financed with consumption taxes - i.e., with τ_c endogenously changing - and equation (13) holds in the same way with the substitution of TR by TR_{UBI}. These transfers have the same numerical value in this expenditure-neutral exercise.

6.1.1 Aggregates

In Table 6, I summarize the aggregate changes generated by the counterfactual exercise in comparison with the benchmark scenario. First, one can observe that the capital-output ratio is larger in the UBI economy, mainly driven by the increase in savings that aggregate up to a higher level of the capital stock, K. I explore the mechanism behind this movement in Section 6.1.2. One can also observe the impact of the reform on the budget captured by τ_c, which is now slightly higher than the benchmark level due to the decrease in both C/Y and L/Y. I develop this point further and in light of the distributional outcomes in the breakdown of the government constraint in Section 6.4.

With respect to the labor supply response, the impact on aggregate hours is moderate, with the overall level climbing to about 1.4 percentage points higher than the one in the benchmark. This happens because, in the counterfactual economy, households no longer need to adjust their intensive margin downward to fall inside the means-testing brackets. The UBI also operates via the extensive margin, shown by the movement at the extensive margin that decreases the labor force participation rate by less than half of a percentage point. The overall increase in L is relatively smaller than the increase in K, the latter then being the force behind the increase in output, Y.

The aggregate stock of human capital in relation to output, HC/Y, decreases by about 7 percentage points due to the decrease in the number of participants in the labor force, without the participation of high-productivity households. There is an overall reduction in labor earnings inequality as shown by the decrease in the Gini coefficient. This mostly stems from the smaller accrual at the top quintile, which is redistributed to quintiles below. A similar pattern happens with wealth inequality with an increase in wealth accrued by all those at the bottom, especially the third quintile, and the reduction at the very top. This movement happens due to the release of the investment and asset-testing constraints that provided an extra incentive for smaller savings in the benchmark scenario. Together with that, there is a decrease in the accumulation of capital by agents who receive high and persistent labor income shocks. The combination of such movements aggregates up and is the force behind the capital stock increase.

Table 6: Comparison of Aggregates for the First Counterfactual.

Variable	Means-Tested	UBI
Y	100	102.4
K	100	104.0
L	100	101.7
C	100	102.7
HC	100	99.7
H	33.0%	34.4%
LFP	76.5%	76.2%
K/Y	290.3%	294.5%
C/Y	62.6%	62.1%
L/Y	56.3%	55.9%
HC/Y	232.8%	226.0%
TR/Y	4.0%	3.9%
w	1.154	1.163
r	0.042	0.040
τ_c	7.3%	8.0%
Earnings Gini	0.60	0.57
Wealth Gini	0.79	0.74

Notes: The table shows model-generated aggregate statistics. The column "Means-Tested" shows the results of the benchmark model and the column "UBI" shows the results for the counterfactual exercise.

6.1.2 The Mechanism

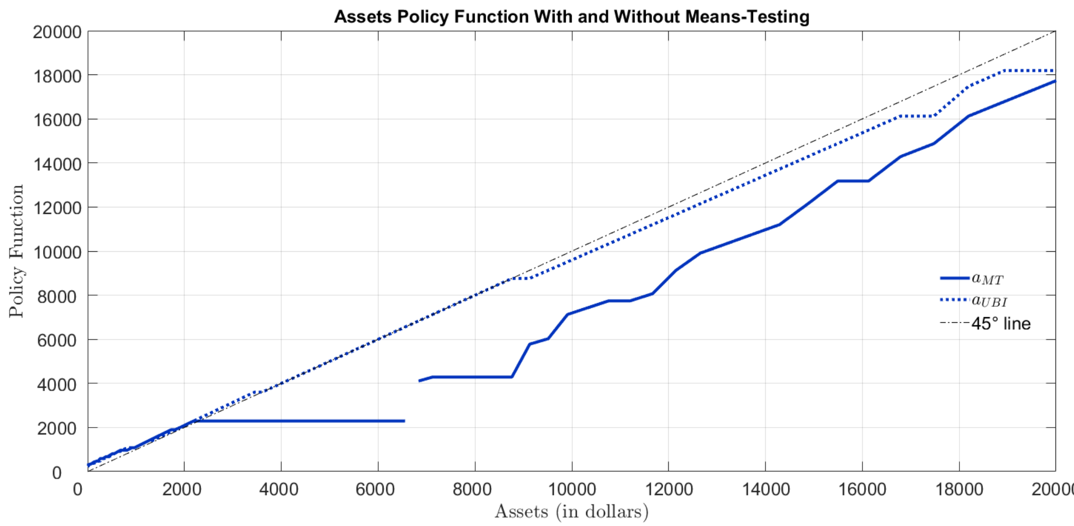
In order to understand one of the mechanisms behind the movements shown in the aggregate effects, I explore one of the sources of distortions arising from the different types of means-testing in the model. I do so for a selected part of the assets state space chosen to highlight where such testing is more salient and directly affects the allocations via the kinks in the budget constraint of the household's maximization problem.

In Figure 1, I show the assets' policy function for a 40 year old who received an average shock and with the low level of ability.[13] At this age, such a household is subject to the asset means-testing stemming from both the EITC and the SNAP transfer programs. In the graph's solid line, one can observe precisely how the policy function of the agent becomes flat once it hits one of the asset-testing constraints. This happens when the households' asset level is $2,500, which is the calibrated level for d_{CT}. It then remains to choose the same level of this threshold in order to remain qualified for the program until it hits around $7,200, the point at which the allocation is not optimal anymore, jumping to a new savings level around $4,500.

The intuition behind this is that at a certain level of assets, the household prefers to stay exactly at the constraint in order to receive the benefit paid by the program. It has strong incentives to do so, since by choosing to save a smaller amount than it would otherwise for that level of asset, it can increase its current period consumption not only by dissaving, but also by having access to an income increment via transfers. This trade-off is made clearer, as I plot with a dashed line the policy function of the same household but in the UBI economy, where such distortions are not present. Different from the previous case, the policy function for the assets' state space surrounding the value of the d_{CT} constraint has a regular monotonically increasing pattern and lies much closer to the 45-degree line. This allows the household to achieve higher savings values, an expected result of releasing a constraint in the dynamic programming problem. This then works as the micro-level mechanism behind the increased aggregate capital stock K shown in Table 6.

[13]The Markov process for the idiosyncratic productivity shock is discretized in 7 points using the standard Rouwenhorst method. In order to make it simpler and avoid talking about normalized level magnitudes that do not add much intuition, in a small abuse of notation, I use in this section interchangeably the index and level of the shock, being, for instance, $z = 4$, the average shock that lies in the fourth or middle position of the discretized array. More details of the computation can be found in Appendix E.2.

Figure 1: Distortions in the Assets' Policy Function Stemming from Means-Testing.



Notes: The figure shows the assets' policy function along the assets state space for both the benchmark and the counterfactual economies. The solid line shows the function for the means-tested economy and the dashed line shows the one for the expenditure-neutral UBI. The household represented is a 40-year-old with an average productivity shock and with the low level of ability. The dotted line is the 45 degree line.

6.2 Andrew Yang's UBI

The second counterfactual conducted is a non-neutral increase in the the total amount of transfers, TR, in the economy to a level equivalent to $TR/Y = 20$ percent in the initial steady-state. This exercise is inspired by the policy proposal advocated by Andrew Yang, a candidate in the the Democratic Party primaries for the 2020 US presidential election.[14] The thought experiment is to give every agent in the economy a UBI that would amount to US$12,000 per year, or US$1,000 monthly. We proceed in a fashion otherwise identical to the previous counterfactual exercise.

Table 7 shows the results for the aggregate quantities. As expected, the budget cost to raise the level of transfers to the desired level is high, and hence, the taxation on consumption has to climb up to 29.6 percent to balance the government's budget. Such high

[14] Andrew Yang's Freedom Dividend policy proposal can be found at this link.

taxation combined with the high level of transfers ends up driving agents to react sharply in terms of their labor supply. The intensive margin captured by the aggregate hours decreases substantially, reducing by about 7 percentage points. The same sharp drop is seen in the LFP rate, which decreases by 13 percentage points. These movements on the labor side of the economy are to a great extent driven by the non-convex structure of the labor supply. With commuting costs, the aggregate response of labor is amplified due to the larger macro Frisch elasticity that this formulation yields. As the environment is in general equilibrium, there is an accompanying adjustment of the wage rate, which increases by almost 2 percent.

The overall result is that the economy contracts significantly and becomes much more unequal in terms of pre-tax labor earnings. However, both the capital-to-ouput and the consumption-to-output ratios increase because the output decreases relatively more than K and C. The total stock of human capital in the economy, HC, exhibits a substantial decrease when compared to the former steady states, but a higher value in terms of GDP when compared with the former counterfactual. This result stems from a selection effect operating behind the extensive margin: low-productivity agents sort themselves into zero labor supply due to the generous consumption floor created by the UBI, while high-productivity agents remain attached to the labor force throughout their life-cycle, with virtually no depreciation of their individual human capital. The rearrangement toward inequality shown by the Gini is then a byproduct of such a process and happens directly through the accrual of less earnings at the bottom, a result of the drop in the labor supply of low-productivity households.

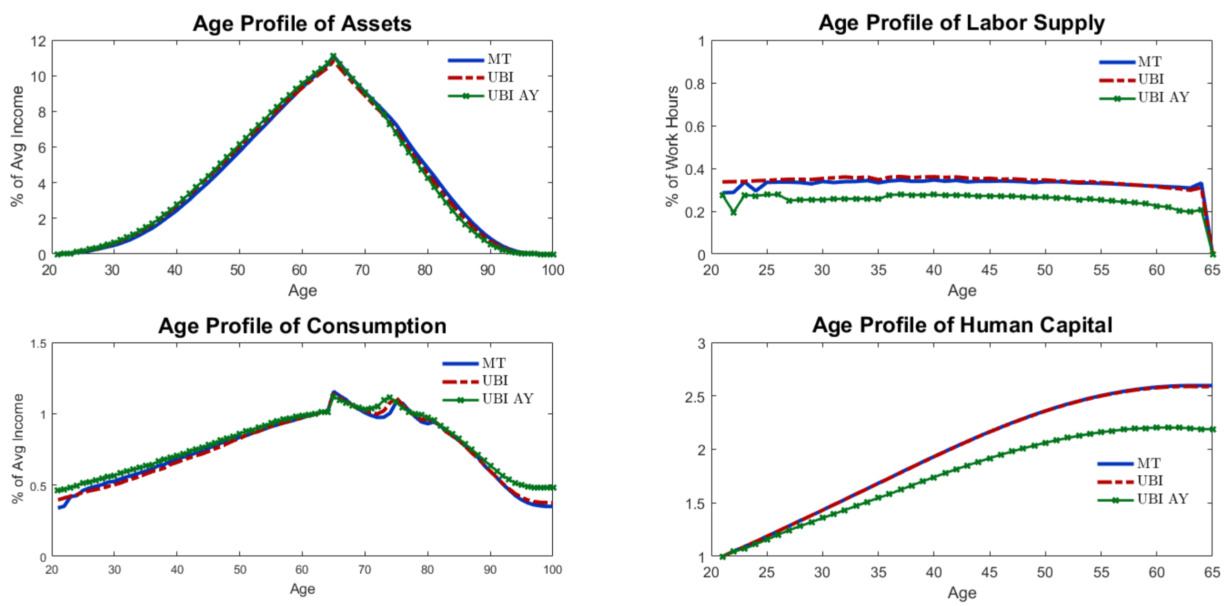
Table 7: Comparison of Aggregates for the Second Counterfactual.

Variable	**Means-Tested**	**UBI**	**UBI AY**
Y	100	102.4	89.2
K	100	104.0	92.2
L	100	101.7	87.7
C	100	102.7	93.2
HC	100	99.7	88.2
H	33.0%	34.4%	25.7%
LFP	76.5%	76.2%	63.5%
K/Y	290.3%	294.5%	299.8%
C/Y	62.6%	62.1%	65.3%
L/Y	56.3%	55.9%	55.3%
HC/Y	232.8%	226.0%	229.4%
TR/Y	4.0%	3.9%	22.4%
w	1.154	1.163	1.174
r	0.042	0.040	0.038
τ_c	7.3%	8.0%	29.6%
Earnings Gini	0.60	0.57	0.64
Wealth Gini	0.79	0.74	0.75

Notes: The table shows model-generated aggregate statistics. The column "Means-Tested" shows the results of the benchmark model, the column "UBI" shows the results for the expenditure-neutral counterfactual, and the column "UBI AY" shows the results for the exercise inspired by Andrew Yang's proposal.

This result is further seen in Table 8 in our detailing of the inequality effects but also in the average life-cycle profile for hours worked and human capital accumulation shown in Figure 2. One can observe that the second UBI counterfactual profile lies below the averages of the other two in both allocations. Another important effect is the increase in consumption relative to GDP, C/Y, which can also be evidenced by the fact that through their entire life-cycle, households in the larger UBI consume more relative to average income in the steady-state. Regarding wealth inequality, an effect similar to the previous counterfactual happens with a reduction in the overall level. This time, however, it happens with slightly a smaller intensity as households work less overall and thus have smaller resources to turn into savings.

Figure 2: Average Life-Cycle Profiles.



Notes: The figure shows the average life-cycle profiles for assets, labor suply, consumption, and human capital for the three economies studied. The solid line shows the profiles for the means-tested economy, the dashed line shows the ones for the expenditure-neutral UBI, and the crossed line shows the ones for Andrew Yang's proposal. The age range is from 20 to 100 years old and assets and consumption are shown as a percentage of households' average income, the labor supply as a percentage of work hours, and human capital in its own level units.

6.3 Impact on Inequality

Table 8 shows the distributional outcomes of disposable income and consumption for the benchmark means-tested model and the two scenarios under the UBI counterfactual. We can observe that the expenditure-neutral UBI is slightly more redistributive after tax and transfers than the benchmark model. More specifically, the bottom quintile exhibits a small growth in accrued income under the UBI, which arises as a result of the reshuffling of income from the second quintile. The small UBI is not uniformly progressive as the second highest quintile also obtains more post-tax income, mostly through an increase in savings. The second UBI counterfactual exhibits a different pattern but with more disposable income at the very bottom, with the redistribution dropping from the highest quintile. This happens due to the suppression of earnings caused by the large drop in the labor supply, which keeps only the highly productive working. It is noteworthy that pre-tax inequality decreases in the first counterfactual but not in the second, as shown in Table 7 but post-tax inequality decreases in both with a redistribution toward the bottom stemming from the very top.

Regarding consumption inequality, the first UBI economy is virtually equal, which shows that the stronger movements happen in the savings decision as evidenced by the aforementioned decrease in wealth inequality. The second UBI economy, nonetheless, exhibits much more consumption equality than the benchmark and the first counterfactual economy exhibits a cascading effect from the top quintile toward the lower quintiles.

Table 8: Comparison of Quantiles Between Benchmark and Counterfactuals.

	Disposable Income			**Consumption**		
	MT	UBI	UBI AY	MT	UBI	UBI AY
Quantile						
Bottom 20%	1.3%	1.4%	3.0%	5.9%	5.0%	6.4%
20% - 40%	5.9%	5.7%	5.3%	9.2%	9.2%	10.9%
40% - 60%	10.6%	11.2%	10.5%	13.9%	15.2%	15.9%
60% - 80%	21.3%	22.9%	22.2%	22.5%	23.0%	22.7%
80% - 100%	60.9%	58.8%	59.0%	48.4%	47.6%	44.1%
Gini	0.58	0.56	0.55	0.42	0.42	0.37

Notes: The table shows model-generated distributional statistics by quintile for consumption and disposable income. The column "MT" shows the results of the benchmark model, the column "UBI" shows the results for the expenditure-neutral counterfactual, and the column "UBI AY" shows the results for the exercise inspired by Andrew Yang's proposal.

6.4 The Government Budget Constraint

In light of all the movements shown previously, it is worth taking a deeper look at how the transmission of inequality affects aggregate outcomes. More specifically, one importantly affected equilibrium object is the government budget constraint. In Table 9, I show the breakdown of the budget by each of its sources and for each of the three steady states analyzed so far.

As can be seen in Table 6, the tax rate on consumption, τ_c, increases moderately in the first counterfactual. This result is intuitive as most of the aggregate inputs that experience the incidence of taxation decrease in comparison with the benchmark economy. In the breakdown, the revenue stemming from the progressive taxation on labor is slightly smaller, in terms of GDP, than in the benchmark, and the revenue accruing from savings is basically unchanged. Hence, since the overall level of spending did not increase much, the difference is obtained from the consumption tax revenue.

For the second counterfactual, the substantial increase in consumption tax revenue can be understood together with the movements shown in Table 7. Naturally, as a significantly higher level of TR/Y now needs to be financed, τ_c increases sharply. However, as low-productivity households drop out of the labor force while the high-productivity ones keep working, the relative labor input L/Y does not fall as much when compared to the first counterfactual; however, aggregate human capital HC/Y per GDP exhibits a strong increase. This is consonant with the higher degree of inequality shown in the pre-tax earnings Gini. With this new distribution, the endogenous outcomes allow for total revenue stemming from progressive taxation TL/Y to be at a higher level in the breakdown of the budget than in previous steady states, which attenuates the increase in consumption revenue needed to fund the large UBI.

Table 9: Comparison of Sources of Revenue Between Benchmark and Counterfactuals.

Variable	Means-Tested	UBI	UBI AY
Revenues			
$\tau_c C/Y$	4.6%	5.0%	19.4%
$\tau_r rA/Y$	1.1%	1.1%	1.0%
TL/Y	3.2%	2.8%	6.9%
Q/Y	4.3%	4.1%	4.0%
Revenue$/Y$	13.2%	13.0%	31.3%
Expenditures			
TR/Y	4.0%	3.9%	22.4%
G/Y	7.2%	7.2%	7.2%
$(r - g_n)B/Y$	2.0%	1.9%	1.7%
Expenditure$/Y$	13.2%	12.9%	31.3%

Notes: The table shows model-generated aggregate shares of output for different accounts of the governmnet budget constraint. The column "Means-Tested" shows the results of the benchmark model, the column "UBI" shows the results for the expenditure-neutral counterfactual, and the column "UBI AY" shows the results for the exercise inspired by Andrew Yang's proposal.

7 Transitional Dynamics

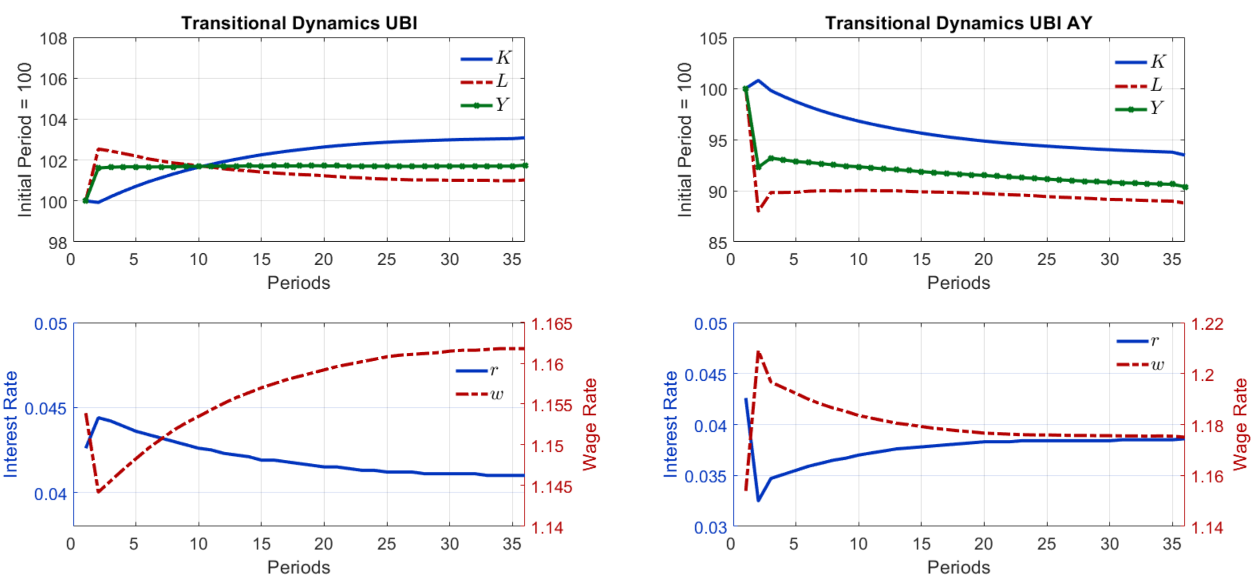
The exercise conducted in the transitional dynamics consists of starting at the initial steady state at period $t = 0$ and, at period $t = 1$, enacting the counterfactual reform. The policy is permanent and unexpected by the agents. The generations $j = 1, \ldots, J$ that were alive in period $t = 0$ will reoptimize to adapt themselves to the new scenario and prices in the capital and labor markets adjust along the transition path, clearing all markets in the economy.[15]

[15]The adjustment to the new steady state is close to being achieved in 35 periods, which I use as the maximum for computational purposes.

7.1 Aggregates

Figure 3 depicts the transitional dynamics of the main aggregate variables and of prices after each of the UBI counterfactual reforms is enacted. The left-hand side shows the expenditure-neutral UBI, while the right-hand side shows the generous UBI.

Figure 3: Transitional Dynamics of Aggregate Variables.



Notes: The figure shows the transitional dynamics for aggregate capital, labor input, and output as well as the wage and interest rates for the three economies studied. In the top panels, the solid line shows the time path for aggregate capital, the dashed line for labor input, and the crossed line for aggregate output. In the bottom panels the solid line shows the time path for the interest rate and the dashed line shows the time path for the wage rate. The initial period represents the original steady-state quantities, which are normalized to 100. The duration of the transition is 35 years.

When the first reform is enacted, agents immediately and largely adjust their labor supply decisions due to the loss of the generous means-tested transfers to a low level of UBI. This reaction can be observed by the spike in aggregate labor, L, which achieves a level 3 percent higher than the one in the initial steady state. Moreover, there is also the trade-off between consumption and savings, which can be seen in the decrease in aggregate capital, K. The drop in capital in the initial period is nonetheless smaller relative to the jump in labor, only starting to increase to the higher levels of the new steady state 3 years after the reform. In the final periods, one can observe that the equilibrium trades off the initial movement in the labor supply for the increase in savings, then reaches the level of the aggregates in the new steady state, all higher than their initial levels. The adjustment in prices simply follows the behavior expected from the decreasing marginal returns of the neoclassical production function.

There is a symmetric initial response of the aggregate variables and prices between counterfactuals. The second reform, the one at Andrew Yang's level of UBI, yields precisely the opposite signs of change in the aggregates. With the new and unexpected large transfer, agents drop out of the labor force and work significantly less, thus reducing L by more than 10 percent. The extra income combined with the exclusion of asset-testing, causes a small increase in the level of K, which later converges to the smaller level in the new steady state due to the decrease in precautionary savings and hours worked allowed by the UBI's consumption floor. Eventually, both factors and output reach their lower steady-state levels, while price adjustments mirror the behavior in the previous counterfactual, but keeping the monotonically decreasing level of interest rates and the higher level of the wage rate as we increase the generosity of the UBI.

7.2 Inequality at the Transition

In Table 10, I show the distributions of disposable income and consumption in the first period of the transition. The inequality when the reform is enacted highlights the differences between the short and the long run that drive the welfare results explained in the next section. When the results are compared to those in Table 8, one immediately notices that for the second counterfactual, the generous UBI, there are notable differences in the results for all of the quintiles of the displayed distributions. The most important movement is the redistribution in consumption when compared to the benchmark steady state. There is an increase in all three bottom quintiles at the expense of a decrease in the top quintile.

For the first exercise, however, there is an increase of inequality in consumption. Similar to the long run, there is less consumption being accrued at the bottom and significantly more at the top. The intuition behind this lies in the fact that for the low strand of the distribution, the amount of transfers received is smaller than before, while for the top earners, their return to work is high enough for their labor behavior to be positively affected, allowing for more consumption together with the UBI top-off. The Gini index of the consumption distribution is higher than the benchmark and its equivalent in the steady-state, reflecting the shift of accrual toward the top.

Table 10: Comparison of Quantiles Between Benchmark and Counterfactuals at the Transition.

	Disposable Income			**Consumption**		
	MT	UBI	UBI AY	MT	UBI	UBI AY
Quantile						
Bottom 20%	1.3%	1.5%	3.0%	5.9%	4.8%	6.5%
20% - 40%	5.9%	5.7%	5.2%	9.2%	9.0%	11.2%
40% - 60%	10.6%	11.3%	10.3%	13.9%	15.0%	16.0%
60% - 80%	21.3%	22.8%	22.4%	22.5%	22.7%	22.8%
80% - 100%	60.9%	58.6%	59.0%	48.4%	48.3%	43.2%
Gini	0.58	0.53	0.51	0.42	0.44	0.36

Notes: The table shows model-generated distributional statistics by quintile for consumption and disposable income in the first period of the transition. The column "MT" shows the results of the benchmark model, the column "UBI" shows the results for the expenditure-neutral counterfactual, and the column "UBI AY" shows the results for the exercise inspired by Andrew Yang's proposal.

8 Welfare

In this section I conduct an evaluation of both reforms through an analysis of the welfare responses in the short and long run. The context for the welfare analysis is an inquiry on whether or not to means-test the income security net of the government based on the computation of a chosen measure of social welfare. Given the initial conditions, I follow

Conesa et al. (2008) and define the utilitarian social welfare function (SWF) for a newborn agent as follows:

$$W(\{\tau\}, \zeta, TR) = \int_S v^*(a = 0, h = 1, z = \bar{z}, k, \theta, j = 1 \mid \{\tau\}, \zeta, TR)\, d\Phi^* \tag{19}$$

where $\{\tau\}$ are all the taxation parameters, ζ is the collection of means-testing parameters, $\zeta = \{\bar{y}^k_{TC}, \bar{d}_{TC}, \ldots\}$, TR is the aggregate level of total transfers, and $\{v^*, \Phi^*\}$ are the equilibrium value functions and distributions.

In Table 11, I show the results for the welfare evaluation through the comparison with the three steady states studied so far as well as the transition between the benchmark and each of the counterfactuals. I report the aggregate steady-state welfare for households with age $j = 1$, i.e., the discounted expected value of being born into each economy through the consumption equivalent ariation (CEV). This measure defines the increment in consumption that we would need to give households in each state of the world so that they would be indifferent between their level of consumption in the alternative economies, hence under the veil of ignorance.[16]

Table 11: Comparison of Consumption Equivalent Variation.

	UBI	**UBI AY**
CEV Steady-state	-0.12%	0.29%
CEV Transition	-0.13%	0.34%

Notes: The column "UBI" shows the results for the expenditure-neutral counterfactual, and the column "UBI AY" shows the results for the exercise inspired by Andrew Yang's proposal.

The CEV required is of -0.12 percent, making the expenditure-neutral UBI a policy that reduces welfare under a utilitarian SWF. The opposite is true for the US$1,000 UBI,

[16] I present the algebra and details on how to obtain the CEV for the model in Appendix D.

with an increase of 0.29 percent in welfare. If we take into account the welfare cost at the transition i.e., the cost to the generations that were alive in the period when the reform was enacted and whose choice needs to be reoptimized - we observe that the effects of both reforms are amplified in the same direction of their steady-state signs. The intuition behind this movement lies in the distributional consequences seen before. We have seen in Table 10 that inequality in consumption is higher than in the steady state, with the disutility of work affecting the top more, and the dampening of consumption at the bottom. The following section unpacks the forces behind these welfare variations.

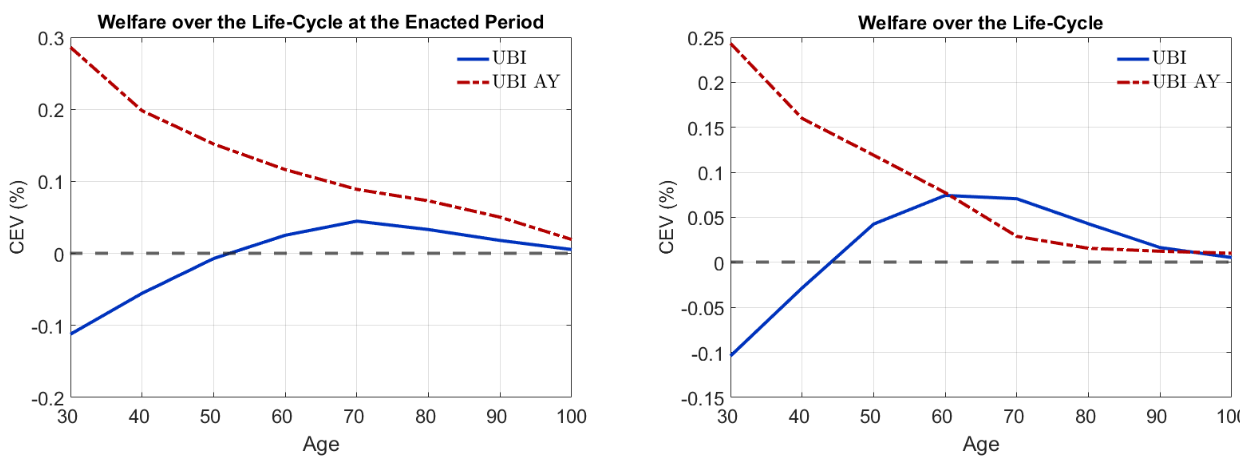
8.1 Decomposing the Welfare Effects

In order to understand better who are the winners and losers of both reforms, it is useful to decompose the welfare changes in different cuts of the state space. To get a better sense of the role of the age dimension, I plot in Figure 4 the cross-sectional average of the value function over the life-cycle, which can be equivalently defined as an age-dependent SWF in terms of the CEV. I do so by showing the average between decades of households' lives. Figure 4 shows the comparison between the two counterfactuals both in their steady states and in the first period of the reform.

We can observe in the plot on the left-hand side that the expenditure-neutral system exhibits more negative levels of welfare than the benchmark scenario throughout the life-cycle, with lower levels at the beginning. As households have children at early ages and the targeted transfers' generosity is biased toward families with children, it is natural that a transfer with an average level lower than before leaves agents worse off in that period of their lives. However, as soon as households start seizing the increasing path of their earnings profile, the savings they accumulate under the new UBI regime decreases the dominance of negative welfare. In effect, households in the benchmark economy during those periods are trapped into working less effective hours and saving less to remain inside the constraints that guarantee reception of the benefits. Eventually, at later ages, after the dissaving process is exhausted in each economy, the welfare of both converges to similar levels. During the transition, the losses are larger and for a larger number of years in households' lives.

Regarding the second counterfactual, in the long run, welfare is slightly negative for the very first ages: almost zero for a long part of the working years, almost all the way through retirement. Without the breakdown through the life-cycle, this effect is masked by the comparison only of newborn households. An important part of the positive welfare changes only happens closer to retirement, mostly due to the absence of the assets means-testing of the SSI, a fact common in all profiles in all comparisons. In the first period of the transition, on the other hand, the gains are uniformly positive across all ages of the cross-section. This once again emphasizes the benefits of simultaneously working less while seizing a high consumption floor in an economy that starts with a large amount of capital that slowly decreases.

Figure 4: Consumption Equivalent Variation Over the Life-Cycle.



Notes: The figure shows the CEV over the life-cycle for the two counterfactual economies studied. The CEVs shown are for 10-year averages and hence start at the average for cohorts between 20 and 30 years old, yielding 8 averages until the last decade ending at 100 years old. The left panel shows the averaged cohort CEVs under the veil of ignorance in the first period of the transition and the right panel shows the same quantities at their steady states.

Another important dimension of the decomposition is the permanent ability level of the households. The value θ is the only source of labor income heterogeneity of households' initial conditions and directly tracks the overall level of earnings inequality captured by the Gini index. In Table 12, one can observe the breakdown for the two points iat which I discretize this shock. Given the way that the wage risk was estimated, this point can be roughly interpreted as a comparison of college and non-college levels of initial ability. The results for the steady states show that there is an inverse pattern between the two counterfactuals. In the small UBI economy, low-ability households carry the heavier burden and are worse off due to the expected lack of generosity of the income security system at the first ages of their lives. High-ability households, on the other hand, will most probably be attached to the labor force with high efficiency units and thus have a small positive welfare change stemming from the change to unconditional transfers. In the second counterfactual, the breakdown works in a converse manner: since high-ability agents will most likely be the ones suffering the hike in taxation needed to sustain the reform, they benefit less from the new policy. Low-ability households, on the other hand, anticipate the abundance of leisure and consumption in relative terms and accrue a substantial part of the gains.

Table 12: Decomposition of Consumption Equivalent Variation.

CEV	**UBI**	**UBI AY**
Steady State	-0.129%	0.293%
Initial Heterogeneity		
Low ability	-0.156%	0.265%
High ability	0.027%	0.028%

Notes: The table shows the decomposition of the CEV into the two levels of permanent ability of the model economy. The column "UBI" shows the results for the expenditure-neutral counterfactual, and the column "UBI AY" shows the results for the exercise inspired by Andrew Yang's proposal.

9 Conclusion

In this paper, I addressed the question of what would be the impact of a nationwide reform of the US welfare system to a universal basic income proposal. I have developed an overlapping generations model with idiosyncratic income risk that incorporates both intensive and extensive margins of the labor supply, human capital accumulation through labor market experience, and child-bearing costs. The model has a welfare system with an income security net that matches the US design and accounts for means-testing requirements in income and wealth and its taxation counterparts. My analysis focuses on the changes in aggregates, inequality, government budget, and welfare.

I calibrated the model to the US and conducted two counterfactual exercises implementing UBI reforms. In the first reform, an expenditure-neutral level of unconditional transfers generates an income effect that leads households in the UBI economy to work more hours and decrease their participation in the labor force. Due to the absence of restrictions on the maximum level of assets, households save more and aggregate capital increases, followed by an increase in output of 2.4 percent. I have not found a large impact on revenue requirements, as the endogenous tax rate on consumption increases by less than a percentage point to sustain such a reform.

In my second counterfactual exercise, I implement Andrew Yang's proposal for a UBI. I set the level of transfers to be US$12,000 annually to each agent in the economy. In this scenario the tax rate on consumption needs to increase 22.3 percentage points in order to balance the government's budget. The aggregate response of the economy is a contraction of both capital and output. The second UBI reform increases the Gini coefficient for pre-tax earnings mostly due to the selection mechanism arising from the high-productivity agents who remain in the labor force and are able to buffer consumption through a higher level of savings. There is redistribution in both counterfactuals toward the bottom, driven by a reduction in the means accrued by the top. At the transition the small UBI transfer increases consumption inequality, whereas the large-scale program significantly redistributes consumption accrual from the top to the three bottom quintiles.

The welfare system under the expenditure-neutral UBI yields a welfare loss of -0.12 percent in consumption equivalent variation relative to the initial means-tested welfare system. The UBI economy achieves a lower welfare than the current IS system at early ages when households have children but then exhibits a higher welfare in later ages and a lower variance of consumption during the retirement years. Alternatively, the generous UBI transfer improves welfare in 0.29 percent, exhibiting gains for all decade averages of households alive during the transition.

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Appendix

A Data - Survey of Income and Program Participation (SIPP)

In this section I outline the empirical estimates obtained from the 2008 panel of the Survey of Income and Program Participation (SIPP). The SIPP is a representative sample of the civilian United States population and provides information on earnings, transfers from different US income security programs, a fine breakdown of households' balance sheets and detailed demographics that are used in the calibration of the model for the US economy. The SIPP is the natural candidate for household survey data for this paper's question as it has detailed questions about many of the programs designed to target this stratum of the population.

The 2008 panel consists of 16 waves for which interviews are conducted every 4 months. The sample selection used spans through May of 2008 to December 2013, and is observed monthly. I deflate all values with the CPI for the last month in my sample. In the SIPP, I use the classification of reference person in my selection within observation units. The data for assets are taken from the Assets and Liabilities Topical Modules of the 2008 panel.

A.1 Summary Statistics

I conduct the empirical documentation following a methodology similar to the one used in Kaplan et al. (2014) and Kuhn and Rios-Rull (2016), in which the authors characterize several measures of inequality in different household survey data sets. All quantities are the ones reported in the data at the household level. I restrict the sample to households in which the reference person has age equal to or above 20 years old and drop all households with non-negative earnings. This is done in order to be consistent with the model demographics and earnings definition.

Table 13 displays the summary statistics for my sample.

Table 13: Summary Statistics.

Variable	Mean	Std. Dev.	Min	Max
Earnings	4,191.66	5,577.00	0.00	137,092.23
Income	5,390.19	5,466.13	-5,122.40	138,741.75
Net Worth	230,946.89	809,158.29	-1,623,320.00	10,9060,488.00
Cash Transfers	57.70	252.42	0.00	6,698.90

Tables 14 and 15 characterize the percentiles' partitions.

Table 14: Distribution for the SIPP 2008 Panel.

Percentiles	1	5	10	25	50
Earnings	0.00	0.00	0.00	0.00	1,252.843
Income	-23.67	277.60	820.04	1482.90	2,922.38
Net worth	-186,678.5	-54,410.21	-13,507.89	227.26	32,303.46

Table 15: Distribution for the SIPP 2008 Panel (continued).

Percentiles	75	90	95	99	Gini
Earnings	4,201.95	7,878.44	11,685.46	17, 221.73	0.60
Income	5,323.50	8,763.49	12,519.49	18,241.98	0.46
Net worth	168,110.1	431,124.9	773,315.3	1,269,938	0.74

Table 16 displays the correlations between the statistics calculated. In order for such correlations to be contemporaneous, solely for this table I restrict the observations to those that are present in the 10th Topical Module of the 2008 panel. This yields monthly observations from September to December of 2011.

Table 16: Joint Distribution for the SIPP 2008 Panel.

	Earnings	**Income**	**Net Worth**	**Transfers**
Earnings	1.00			
Income	0.9410	1.00		
Net Worth	0.2979	0.4177	1.00	
Transfers	-0.1154	-0.0794	-0.0848	1.00

A.2 Estimation of the Wage Process

I use the data from the SIPP 2008 panel to estimate the idiosyncratic income risk present in the model. I select households in which the reference person is between 20 and 65 years old and drop observations with non-positive earnings ending with a sample of 1.2 million observations grouped in 34,620 households. I run the regression on log wages shown in equation (20) and obtain the wage residuals w_{ijt}, which will then be used in the process estimation.

$$\log W_{ijt} = c + \mathbf{D}_t + \mathbf{E}_{ijt} + \nu' \mathbf{A}_{ijt} + w_{ijt} \tag{20}$$

where i stands for reference person, W_{ijt} are wages obtained dividing total household monthly earnings by hours worked, c is a regression constant, $\mathbf{D}_t$ are time dummies for the years of observation 2003-2013, $\mathbf{E}_{ijt}$ are dummies that control for two levels of schooling - less than or equal to a high school diploma or some college or a college degree - and $\mathbf{A}_{ijt}$ stands for a cubic polynomial on years of potential labor market experience, which are tied to age.

Following the literature, my specification is the first-stage regression. As shown in Table 1, the point estimates for $\{\nu_1, \nu_2\}$ are used in the calibration of the human capital law of motion in equation (9). Given its numerically small size, I do not use the point estimate for the third coefficient. Table 17 shows the result for the different specifications of the Mincerian regression.

Table 17: Regression Results for Equation (20).

Dependent Variables	$\log W_{ijt}$
D_{2009}	0.0119
	(0.0025)
D_{2010}	-0.0179
	(0 .0025)
D_{2011}	-0.0454
	(0 .0026)
D_{2012}	-0.0561
	(0.0026)
D_{2013}	-0.0738
	(0 .0030)
E_2	0.4852
	(0.0014)
ν_1	0.0455
	(0.0007)
ν_2	-0.0010
	(0.0000)
ν_3	5.68e-06
	(5.26e-07)
Constant	2.7422
	(0.0048)
Observations	1,184,840
Number of Households	34,620

Standard errors in parentheses

As in Heathcote et al. (2010), I assume stationarity and postulate that the log residuals follow a process with persistent and transitory shocks, z and η, respectively:

$$w_{i,j} = \eta_{i,j} + z_{i,j}, \;\; \eta_{i,j} \sim N(0, \sigma_\eta^2), \;\; z_{i0} \sim N(0, \sigma_{z_0}^2) \tag{21}$$

$$z_{i,j+1} = \rho z_{i,j} + \varepsilon_{i,j}, \;\; \varepsilon_{i,j} \sim N(0, \sigma_\varepsilon^2) \tag{22}$$

The parameters from this process can be identified in levels by the theoretical moments. More precisely, ρ is identified by the slope of the autocovariance of z at lags greater than 0; σ_ε^2 and σ_η^2 are both identified by the difference between variance and autocovariance of z, and $\sigma_{z_0}^2$ can be obtained residually from $var(z_{i,0})$.

I obtain the empirical moments used in the estimation by computing an age covariance matrix with entries that have been calculated with a minimum of 100 observations for each age pair. This yields a total of 256 moments for four parameters, which renders the model to be largely overidentified. Again, as is standard in the literature, I use a minimum-distance estimator of the GMM family and conduct the estimation using two types of weighting matrices Ω, an identity and a diagonal of the optimal weighting matrix.[17] In the model economy, I use the estimates obtained with the former and treat the transitory shock as a measurement error, thus setting $\hat{\sigma}_\eta^2 = 0$. Table 18 shows the estimates obtained.

Table 18: Estimation of the Income Process.

Ω	$\hat{\rho}$	$\hat{\sigma}_\varepsilon^2$	$\hat{\sigma}_\eta^2$	$\hat{\sigma}_{z_0}^2$
Identity	0.9766	0.0243	0.2917	0.2129
	(0.0020)	(0.0012)	(0.0002)	(0.0218)
Diag Optimal	0.9546	0.0446	0.2302	0.1528
	(0.0007)	(0.0004)	(0.0001)	(0.0217)

B Calibration of Means-Tested Programs

The model uses three different types of means-tested transfers with parameters that require mapping to the data: the EITC, the SNAP/TANF, and the SSI. I explain here in detail how I proceed for each parameter of each program.

The requirements for the EITC are defined by the IRS. First, there are the earned Ilimits that allow households to be eligible for the program. In the model they are defined by

[17] The suggestion can be found in Guvenen (2009).

the variable $\bar{y}^k_{TC}$, which depends on the number of children present in the household $n_{k,j}$. I define these quantities in terms of model units as shares of GDP per household. As households have unit mass, this simply means shares of the final good Y. For example, the total earned income limit in 2019 for a taxpayer filing as a head of household with one child is US$ 41,094. Assuming GDP per capita in the US of $60,000, this yields 25.95 percent of GDP. In the model then, I define $\bar{y}^{n_{k,j}=2}_{TC} = 0.26 * Y$. As in the simulated economy there is no notion of marriage and the data used in the SIPP are based on a sample in which the observation unit is characterized by the reference person, I use the data for taxpayers filing as head of household in the case of the EITC. An analogous procedure is then used for the subsequent thresholds depending on the number of children.

The limit on investment income, $\bar{d}_{TC}$, as of 2019, is US$3,600 and independent of the number of children in the household. For this parameter, my preferred choice of mapping is in relation to average assets per capita, A. As I will use a similar calculation for the asset-testing of the other programs, I will map them to the mean Equity in 401k and Thrift savings accounts calculated for my sample of the SIPP data. The limit is then 11.0 percent of this value. Table 19 collects all of the aforementioned parameters.

Table 19: EITC Parameters.

# Children	$\bar{d}_{TC}$	Target	$\bar{y}_{TC}$	Target
$n_{k,j} = 0$	0.35	$\approx$ 11% of A	0.23	$\approx$ 26% of Y
$n_{k,j} = 1$	0.35		0.61	$\approx$ 69% of Y
$n_{k,j} = 2$	0.35		0.76	$\approx$ 87% of Y
$n_{k,j} = 3$	0.35		0.82	$\approx$ 93% of Y

The phase-in and phase-out rates κ_1 and κ_2 are independent of model units and are thus exactly the ones defined by the IRS for 2019. The phase-in level $\underline{y}$ multiplied by the phase-in rate yields the maximum credit amount at each child level. For example, for a taxpayer filing as a household with no children, the maximum credit is US$529 per year and $\underline{y}^{n_{k,j}=0}$ is US$6,920, which is approximately 11 percent of GDP per capita. Both the phase-in and phase-out levels are similarly defined in terms of percentages of Y.[18] Table 20 collects all remaining details of the parameterization of the EITC.

Table 20: EITC Parameters (continued).

# Children	κ_1	κ_2	Target	$\underline{y}$	Target	$\bar{y}$	Target
$n_{k,j} = 0$	0.0765	0.0765	IRS	0.9	$\approx$ 11% of Y	0.12	$\approx$ 14% of Y
$n_{k,j} = 1$	0.3400	0.1590		0.14	$\approx$ 16% of Y	0.26	$\approx$ 30% of Y
$n_{k,j} = 2$	0.4000	0.2100		0.21	$\approx$ 24% of Y	0.28	$\approx$ 32% of Y
$n_{k,j} = 3$	0.4510	0.2100		0.21	$\approx$ 24% of Y	0.28	$\approx$ 32% of Y

The cash transfer parameters are defined in a similar fashion. First, it is important to notice that recently there has been a change in the requirements of asset limits for SNAP and TANF. By 2018, 37 had states abolished the test for food stamps and 8 for the TANF (Wellschmied, 2021). As I am bundling both programs together, I keep the asset means-testing with the constraint $\bar{d}_{CT}$. In the tax code this test is based on households' resources, which vary by program. I will keep the mapping with the 401k accounts used before for the EITC. Currently, for SNAP, the US Department of Agriculture (USDA) defines a maximum of US$2,250 in countable resources or US$3,500 if at least one member of the household is age 60 or older. A recent study by the PEW Charitable Trusts finds that more than half of the states in the US use a threshold between US$1,000 and US$2,500. I choose US$2,500, which is 7.6 percent of the average equity in the SIPP sample and proceed in the same way as for the EITC to map it to 7.6% of A in the benchmark economy.[19]

For the income limit $\bar{y}_{CT}$, I use the value defined by the USDA for maximum gross income for a household of size 2. This maps in the model to about 40 percent of Y. I proceed in the same way for the annual benefit t_{SNAP}. The USDA defines a monthly

[18] All details regarding the numbers and limits used here can be found at this IRS link and at this link from the Center on Budget and Policy Priorities.

[19] The USDA website that defines all criteria for SNAP from 2019 to 2020 can be found at the following link. The website with the PEW study about limits on family assets in the context of the TANF can be found at this link.

benefit of US$355, which compounds annually to approximately 7 percent of the GDP per capita. Table 21 summarizes the information for the SNAP/TANF transfers.

Table 21: Cash Transfers Parameters.

Test	$\bar{d}_{CT}$	Target	$\bar{y}_{CT}$	Target	t_{SNAP}	Target
Value	0.23	$\approx 7.6\%$ of A	0.35	$\approx 40\%$ of Y	0.05	$\approx 7\%$ of Y

Finally, the only remaining program is the SSI, which in the model environment is only attainable during retirement. The SSI is tested only on resources, which in this case do not include households' houses or vehicles. The maximum defined by the Social Security is US$2,000 for an individual and US$3,000 for a couple. I map that as approximately 6 percent of A. The monthly benefit rate defined by the Social Security is US$771 for an individual and US$1,157 for a couple. However, deductions will be taken from the SSI benefit if the household receives Social Security pensions. In the model all retired households receive a benefit $b(x_t)$ equal to 36 percent of the average income of the simulated economy, which amounts to the equivalent of US$2,160 monthly. If I were to directly follow the deduction schedule, households would not receive any SSI benefits. As a compromise, I set t_{SSI} to 1.3 percent of Y, yielding a monthly transfer of US$65.[20] Table 22 shows all values used for the SSI.

Table 22: SSI Parameters.

Test	$\bar{d}_{SSI}$	Target	t_{SSI}	Target
Value	0.19	$\approx 6\%$ of A	0.011	$\approx 1\%$ of Y

[20] The Social Security wesbite for the resources criteria for the SSI can be found at this link. For the rules regarding the benefit rates, one can go to this link.

C Stationary Recursive Competitive Equilibrium

Definition 2 (Stationary Recursive Competitive Equilibrium). *A stationary recursive competitive equilibrium with population growth for this economy is an allocation of value functions $\{v(s), v^R(s)\}$, policy functions $\{a'(s), c(s), l(s), h(s)\}$, prices $\{w, r\}$, an age-dependent but time-invariant measure of agents Φ, transfers, and taxes such that:*

1. *The value functions $\{v(s), v^R(s)\}$ and policy functions $\{a'(s), c(s), l(s), h(s)\}$ solve the households' optimization problems (14) and (15), given the factor prices and initial conditions;*

2. *The individual and aggregate behaviors are consistent:*

$$G = g_y Y, \;\; B = g_b Y$$

$$(1+g_n)K = \int_S a'(s) d\Phi - (1+g_n)B$$

$$C = \int_S c(s) d\Phi$$

$$L = \int_S \exp(\theta + z_j) h(s) \ell(l(s)) d\Phi \left(s_{-j}, \{1, \ldots, J_R - 1\}\right)$$

3. *$\{r, w\}$ are such that they satisfy the firm's first-order conditions (5) and (6);*

4. *The final good market clears:*

$$C + (g_n + \delta_k)K + G + CC = AK^\alpha L^{1-\alpha}$$

5. *The government balances its budget:*

$$G + \int_S \left[T_{TC}(s) + T_{CT}(s)\right] d\Phi + (r - g_n)B = \\ \int_S \left[\tau_r r a(s) + \tau_c c(s) + \left(y(s) - \tau_0 y(s)^{(1-\tau_1)}\right)\right] d\Phi + Q$$

6. *Social Security's budget balances:*

$$\tau_{SS} w L = b(x) \int_S d\Phi \left(s_{-j}, \{J_R, \ldots, J\} \right)$$

7. *Accidental bequests equal the savings left from deceased households:*

$$Q = \int_S (1 - \psi_{j+1}) a' (s) \, d\Phi (s)$$

8. *Given the decision rules, Φ satisfies:*

$$\Phi(\omega) = \int_S M(s, \omega) d\Phi, \; \forall \omega \subset \mathcal{B}(S)$$

where $M : (S, \mathcal{B}(S)) \to (S, \mathcal{B}(S))$, can be written as folllows: $\forall j \in \{2, \ldots, J\}$,

$$M(s, \omega) = \begin{cases} \pi_{z,z'} \cdot \psi_{j+1} \, , \;\; \textit{if} \;\; a'(s) \in \mathcal{A}, \; h'(s) \in \mathcal{H}, \; k \in \mathcal{K}, \; \theta \in \Theta, \; j+1 \in \{2, \ldots, J\} \\ 0 \, , \textit{otherwise.} \end{cases}$$

and for $j \in \{1\}$,

$$\Phi \left(S_{-J}, 1 \right) = (1 + g_n) \begin{cases} \sum\limits_{k \in \mathcal{K}, \theta \in \Theta} p_k \cdot p_\theta \, , \;\; \textit{if} \;\; 0 \in \mathcal{A}, \; h_0 \in \mathcal{H}, \; \bar{z} \in \mathcal{Z} \\ 0 \, , \textit{otherwise,} \end{cases}$$

where p_k and p_θ are, respectively, the probabilities of being a household with children and of drawing θ out of its discretized distribution. The initial conditions are $a_0 = 0$, $h_0 = 1$, and $\bar{z}$, the average level of productivity.

D Welfare Calculation

In this section I describe in detail how to derive the consumption equivalent variation that quantifies the welfare costs of the UBI reforms. I follow steps analogous to the ones in Krueger et al. (2016b).

The procedure consists basically of computing lifetime utility and how it changes if, at any point in time t, and for every state of the world, it is scaled by a factor of $1+g$. Denote the lifetime utility of an age $j=1$ household with individual state space s_{-j} by $v(s_{-j}, j=1)$ and the lifetime utility of the scaled-up consumption sequence by s_{-j} by $v(s_{-j}, j=1; g)$ [21].

First, we find the lifetime utility using the functional form for the utility function described in the calibration:

$$v(s_{-j}, j=1) = \mathbb{E}\left[\sum_{j=1}^{J} \beta^{j-1} \left(\prod_{i=1}^{j} \psi_i\right) u(c_j, l_j)\right] \tag{23}$$

$$= \mathbb{E}\left[\sum_{j=1}^{J} \beta^{j-1} \left(\prod_{i=1}^{j} \psi_i\right) \left\{\log(c_j) - \varphi \frac{l_j^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}}\right\}\right] \tag{24}$$

Now applying the scaling factor we have that:

[21] Here I borrow the typical notation in game theory that, given a vector v with arbitrary entries $i \in I$, we denote the same vector but exclude specific entry i_0 by v_{-i_0}.

$$
\begin{aligned}
v(s_{-j}, j=1; g) &= \mathbb{E}\left[\sum_{j=1}^{J} \beta^{j-1}\left(\prod_{i=1}^{j}\psi_i\right)\left\{\log[(1+g)c_j] - \varphi\frac{l_j^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}}\right\}\right] \\
&= \mathbb{E}\left[\sum_{j=1}^{J} \beta^{j-1}\left(\prod_{i=1}^{j}\psi_i\right)\left\{\log(1+g) + \log(c_j) - \varphi\frac{l_j^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}}\right\}\right] \\
&= \sum_{j=1}^{J} \beta^{j-1}\left(\prod_{i=1}^{j}\psi_i\right)\log(1+g) \qquad (25) \\
&+ \underbrace{\mathbb{E}\left[\sum_{j=1}^{J} \beta^{j-1}\left(\prod_{i=1}^{j}\psi_i\right)\left\{\log(c_j) - \varphi\frac{l_j^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}}\right\}\right]}_{=v(s_{-j}, j=1)} \\
&= \sum_{j=1}^{J} \beta^{j-1}\left(\prod_{i=1}^{j}\psi_i\right)\log(1+g) + v(s_{-j}, j=1) \qquad (26)
\end{aligned}
$$

If we ask the question by what percentage g do we need to increase consumption in the initial stationary equilibrium for the households to be indifferent between living in the old equilibrium or the new one, we are simply finding the g that solves the following equality:

$$
v^{MT}(s_{-j}, j=1; g) = v^{UBI}(s_{-j}, j=1) \qquad (27)
$$

where v^{MT} denotes that the equilibrium value function is relative to the initial means-tested steady state and v^{UBI} denotes the one associated with the new steady state under one of the UBI counterfactuals. Using equations (26) and (27), we can characterize the factor g:

$$v^{UBI}(s_{-j}, j=1) = \sum_{j=1}^{J} \beta^{j-1} \left(\prod_{i=1}^{j} \psi_i \right) \log(1+g) + v^{MT}(s_{-j}, j=1) \tag{28}$$

$$\implies g(s_{-j}, j=1) = \exp \left\{ \frac{v^{UBI}(s_{-j}, j=1) - v^{MT}(s_{-j}, j=1)}{\sum_{j=1}^{J} \beta^{j-1} \left(\prod_{i=1}^{j} \psi_i \right)} \right\} - 1 \tag{29}$$

which is defined for a newborn household with characteristics s_{-j}. If we want to evaluate the consequences of the reform under the veil of ignorance, i.e., before any identity is revealed, we can integrate over the state space and redefine g as:

$$g^{SS} = \exp \left\{ \frac{\int_S v^{UBI}(s_{-j}, j=1) d\Phi(s) - \int_S v^{MT}(s_{-j}, j=1) d\Phi(s)}{\sum_{j=1}^{J} \beta^{j-1} \left(\prod_{i=1}^{j} \psi_i \right)} \right\} - 1 \tag{30}$$

Finally, in order to make the same evaluation but taking into account the transitional dynamics, we perform the same thought experiment but consider the comparison between a previous steady state and the first period of the reform. Denoting v_{∞}^{MT} the value function associated with the starionary equilibrium under means-testing and $v_{t=1}^{UBI}$ the value function under the new UBI regime but during the period in which the reform is first enacted, we can define the associated g:

$$g^{Trans} = \exp \left\{ \frac{\int_S v_{t=1}^{UBI}(s_{-j}, j=1) d\Phi_{t=1}(s) - \int_S v_{\infty}^{MT}(s_{-j}, j=1) d\Phi_{\infty}(s)}{\sum_{j=1}^{J} \beta^{j-1} \left(\prod_{i=1}^{j} \psi_i \right)} \right\} - 1 \tag{31}$$

E Computation of the Model

E.1 Recursive Competitive Equilibrium

I solve for the households' problem by backward induction. The algorithm is similar to the one in Kindermann and Krueger (Forthcoming). Households surviving to the last period J have an immediate solution as $v_t^R(s_{-j}, J+1) = 0$. Aggregate quantities and prices are found by taking the following steps:

1. Guess initial values for K_t, L_t, $\tau_{c,t}$, and $\tau_{SS,t}$;

2. Given such initial values, use the firm's first-order conditions to obtain r_t and w_t;

3. Given prices and policy parameters, set the value function after the last age to 0 and solve the value function for the last period of life for each point of the grid. This yields policy functions and value functions over retirement $v_t^R(s)$;

4. Also given prices and policy parameters, solve for the household's decision rules by backward induction and value function iteration, repeating it until the first period of life;

5. Use forward induction to compute the associated distribution of households using the policy functions, starting from the known distribution at the beginning of the life-cycle;

6. Use the equilibrium conditions to update the values of the guessed variables and to compute all other aggregate variables;

7. Use dampening to obtain the new values for K_t and L_t, and check the whether the associated markets clear;

8. Iterate until convergence.

E.2 Details of the Computation

I discretize all continuous dimensions of the state space: assets, human capital, productivity shocks, and permanent ability levels. I do so in 200, 25, 7 and 2 points, respectively. The children component is a binary index $k \in \{0, 1\}$, and the age list $j \in \{1, \ldots J\}$ has 80 points for a fully fledged life-cycle. The transition is assumed to converge in 35 periods, adding the associated number of points to the individual arrays. Due to several kinks in the budget constraint generated by the means-tested transfers, the value function iteration to find the choice of the next period's optimal assets is done by brute force grid search. I explore monotonicity to increase efficiency. Due to the non-convexity, I also discretize the labor choice in 50 points and use a brute force grid search in the intra-period decision on the household's labor supply. I include an extra loop for precision on the evaluation of the extensive margin. As there are values for the human capital allocation that lie outside of the state space defined by the grids, I use linear interpolation in order to find indices for the next period's value function and stationary distribution. All aggregate statistics are calculated using the discrete theoretical stationary distribution, while the distributional and inequality measures are computed via Monte-Carlo simulation. I sample $N = 50,000$ agents and let all primitive allocations $\{a'^n(s), c^n(s), l^n(s), h^n(s)\}_{n=1}^N$ lie outside of the grid.

The code for the computation of the quantitative model is written in *Fortran90* and compiled using the Intel® Fortran Compiler. The household problem is solved taking advantage of single-node parallelization with OpenMP. Following Kindermann and Krueger (Forthcoming), I use a non-linearly spaced grid with substantially more nodes at the lower end, which are crucial for solving my problem due to the presence of multiple constraints for asset-testing. I discipline the choice of the assets' grid $\{\hat{a}^1, \ldots, \hat{a}^i, \ldots \hat{a}^{200}\}$ by using the formula:

$$\hat{a} = \bar{a} \frac{(1 + g_a)^{i-1} - 1}{(1 + g_a)^{199} - 1} \tag{32}$$

where $\bar{a}$ is the upper bound of the discrete space and $g_a > 0$ is the growth of the distance between points. In my computation I choose an $\bar{a}$ substantially high so that it does not constrain the household's optimization in any of the quantitative exercises conducted. Lastly, I choose $g_a = 0.04$, which guarantees that there are at least 42 points in the lower tail of the asset grid before the lowest asset means-testing threshold, $\bar{d}_{SSI}$.[22]

[22]A similar approach to dealing with the same computational challenge for asset means-testing can be found in Wellschmied (2021)'s description of the computational details in the paper's technical appendix.