Universal Basic Income: A Dynamic Assessment

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Abstract

Universal basic income (UBI) is an increasingly popular policy proposal but there is no evidence regarding its longer-term consequences. We find that UBI generates large welfare losses in a general equilibrium model with imperfect capital markets, labor market shocks, and intergenerational linkages via skill formation and transfers. This conclusion is robust to various alternative ways of financing UBI. By using observationally-equivalent models that eliminate different sources of endogenous dynamic linkages (equilibrium capital market and parental investment in child skills) we show that the latter are largely responsible for the negative welfare consequences.

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1 Introduction

The idea of universal basic income (UBI) – a set income that is given to all without any conditions – is making an important comeback in many countries. This is most likely the result of the large increase in inequality over the last few decades and stagnant median wages as well as anxieties about automation and robotization and, more recently, the increase in unemployment in response to the coronavirus epidemic and uncertainty about future prospects.[1] What do we know about UBIs?[2] What problems would an UBI ameliorate and which would it aggravate?

There is no real experience in advanced economies with a UBI policy, although studies have made use of variation in income arising from changes in oil revenue or EITC generosity to study potential consequences.[3] Although much of the attention has been on the effects of programs on labor supply, it may very well be that the more important consequences of a UBI are long run. There have not been, however, long-run large-scale experiments that allow one to evaluate the longer-term consequences of these programs. As stated by Hoynes and Rothstein (2019) in their excellent review article on UBI in advanced economies, "we have a good deal of evidence from a range of settings that substitution effects on short-run labor supply are moderate and income effects are small. There is also clear evidence that additional family resources improve children's outcomes, including health and school achievement. *The major open questions about UBIs, in our view, relate to longer-run effects*, which are much harder to study using randomized and natural experiments."[4]

How may the longer run effects of UBI differ from those in the short run? What are the consequences (from changes in prices and taxes) of a large scale UBI? There are various dimensions in which the policy consequences of a long-run large-scale program may differ from those of a small scale or shorter-run policy. First, and more traditionally, studying shorter-term or more local experiments will not capture the longer-run general equilibrium consequences of such a policy on variables ranging from the capital stock to wages and tax rates. Second, it may very well be that the more important consequences of a UBI are intergenerational. For example, policies that increased maternal employment and family income were found to increase child achievement (Morris et al., 2009). Programs such as SNAP and the EITC have been shown to improve health at birth (e.g., Almond et al., 2011) and increased generosity in the EITC is also associated with higher children's achievement (Dahl and Lochner, 2012; Chetty et al., 2011) and educational attainment (Bastian and Michelmore, 2018; Manoli and Turner, 2018). The universality and presumably generous payments implied by UBI may mean very different longer-run intergenerational consequences, however.

[1] A UBI policy has been advocated by people ranging from Pope Francis, to Elon Musk, or to former US presidential candidate Andrew Yang as well as by senior officials in organizations such as the United Nations or the World Economic Forum. See Wignaraja (2020).

[2] See Gentilini et al. (2019) for a recent excellent review of UBI history and lessons from diverse country experiences.

[3] The Alaska Permanent Fund and the Eastern Cherokee Native American tribe are programs which provide demogrants to adults. The first makes payments which may vary from year to year, ranging from $1,000-2,000 per person per year and financed by Alaska's oil revenues. The second provides payments of around $4,000 per person per year financed out of tribal casino revenues. See Jones and Marinescu (2018) and Akee et al. (2010, 2018).

[4] Emphasis is ours.

This paper provides a very inexpensive evaluation of such a UBI policy by studying its consequences in a computational model laboratory. We develop a model that incorporates many of the most important channels that affect the costs and benefits associated with a UBI policy. The model features an economy with imperfect capital markets and overlapping generations. An individual's first decision is an education choice (college) based on their assets, skills, and their taste for education. Skills and initial assets are endogenous: the first is the result of investments made by parents during an individual's childhood and the second is a parental transfer. College can be financed with a combination of the parental transfer, working while in college, and borrowing. After education, an individual works, has children, invests in their skills, makes a monetary transfer to their child, and eventually retires and dies. These intergenerational linkages are embedded in a fairly standard general equilibrium life-cycle Aiyagari framework with wage uncertainty and with a tax function calibrated to the US economy. This framework allows aggregate education, skills, labor supply, and savings to affect prices and the endogeneity of these outcomes means that they are affected by the additional income provided by UBI and via the change in taxes required to finance this policy.

The steady state of the model is parameterized and estimated to match household-level data near the year 2000 (the base year for prices) using a variety of data sources such as the Panel Study of Income Dynamics (PSID), the Child Development Supplement (CDS) to the PSID, and the 1979 cohort of the National Longitudinal Survey of Youth (NLSY79). Importantly, given Heathcote and Tsujiyama (2021) finding that the space for further redistribution depends on how large government expenditures are with respect to national income, we calibrate the model to match the appropriate ratio for the US economy. We validate the model in a variety of ways that are economically significant for the question we are studying. In particular, we show that that the model does a good job of matching labor income and wealth inequality by quintile (all non-targeted moments) as well as measures of intergenerational mobility. It also matches various non-targeted measures of inequality of investment in children, both in their skills and in monetary transfers by their parents, as well as statistics regarding student loans. Given the importance of labor supply responses and the (less well-studied) response of parental investment in children's skills to income/wealth shocks, we conduct the appropriate partial equilibrium exercises in the model to compare its predictions with those of the effects of lottery winnings on labor earnings (Golosov et al., 2021), the effect of non-labor income on labor supply (Blundell and MaCurdy, 1999), and the impact of cash transfers on child development (Dahl and Lochner, 2012). We show that the model generates responses in line with the empirical literature.

We introduce the UBI policy as a lump-sum transfer that unconditionally gives all adults a yearly income equivalent of $8,000 as measured in year 2000 dollars.[5] What are the potential benefits of a UBI policy? In an economy in which individuals are subject to both wage and employment shocks and in which credit and insurance markets are imperfect, UBI allows for greater smoothing of consumption and the guarantee of a minimum standard of living. It can also allow agents to undertake relatively expensive investments – in our model, attend college – at a lower cost than via borrowing. Furthermore, it can

[5] This is equivalent to $1,000 per month in 2020 dollars, as proposed, for example, in Andrew Yang's 2020 presidential campaign. It is also the amount evaluated by Hoynes and Rothstein (2019) and Golosov et al. (2021) among others.

have beneficial intergenerational consequences by facilitating parental investment in their child's skill formation and transferring resources to them when they become adults.[6] Of course, any positive effects of UBI must be weighed against the cost of increased distortionary taxation and potentially negative general equilibrium effects in order to assess the net welfare impact.

Using a utilitarian welfare function, we find that a UBI policy, despite decreasing inequality, has large negative welfare consequences for cohorts that are adults when the policy is introduced (6% in consumption equivalence units) and significantly larger negative welfare implications for subsequent cohorts and in the new steady state (22%). Labor supplied falls immediately and the capital stock decreases dramatically over time. Intergenerationally, the higher labor tax reduces investment in children's skills, decreases parental transfers, and lowers the share of agents with college education. In aggregate terms, we find that the UBI policy is associated with a long-run GDP reduction of almost 20%, of which the fall in the capital stock explains half, with the decline in labor supply and in efficiency units of labor being responsible for the remainder.

An important contribution of our paper is its investigation of the main channels responsible for the negative welfare results. We conduct several exercises that illuminate the dynamic roles of capital and intergenerational linkages. Our first exercise shows that the negative effects of UBI are much greater when UBI is received by all rather than given to only one cohort, even in a partial equilibrium environment. In fact, general equilibrium effects lessen the negative consequences of the policy. Second, the OLG structure of the economy allows us to conduct a novel analysis in which we study adjacent cohorts that differ only in whether UBI was introduced before versus after their parents had invested in their skill formation and before versus after their monetary transfer. These comparisons allow us to show that the first cohort whose state variables are all determined under UBI already suffers 57% of the steady-state losses. Furthermore, comparing those cohorts that differ only in whether they received skill investment versus skills and parental transfers prior to UBI, we show that the decline in skills is associated with a larger proportion of the welfare loss. Third, assessing welfare in the new steady-state, we show that even if all value functions were kept at the same level as in the original steady state of the non-UBI benchmark-economy, the change in distribution over these states is responsible for 47% of the welfare loss. As the distribution over states are determined by parents via their investment in child skills and their monetary transfers, this illustrates the importance of these linkages which are absent in models in which each generation starts de novo.

Turning next to the main mechanisms, we show that if we replace endogenous skills with an exogenous (and, therefore, policy invariant) transition matrix from parental education and skill to child skills, the long-run welfare losses are halved but the welfare losses of adults when the policy is introduced are relatively unaffected. The steady-state welfare loss is even smaller, and adults actually gain, in a different experiment in which the aggregate capital stock and interest rate are kept constant although agents are still allowed to borrow and save (at the same steady-state interest rate). This modification of

[6] The literature on UBI has also pointed to other, mainly psychological and mental health benefits, which we do not assess here but are important to consider as well in a fuller evaluation of this policy. There are also important ethical and philosophical arguments made on its behalf (Van Parijs and Vanderborght, 2017). See also Ghatak and Maniquet (2019) for a theoretical assessment of the desirability of a UBI.

the model reduces the amount of labor taxation required to fund UBI as revenue from capital taxation remains unchanged, which in turn allows for a smaller reduction in labor supply. Thus, the endogenous accumulation of human and physical capital (with its equilibrium effects on tax revenues) are the key drivers of the negative welfare results.

The Mirrleesian public finance literature has shown the usefulness of examining small changes in the tax and transfer system and decomposing their effect into mechanical, behavioral, and general equilibrium components.[7] Conducting the same mechanism exploration exercises just described above but for a very small UBI, we find similar qualitative results: both adults and future generations lose from a small UBI (due to the individual behavioral responses particularly), but these losses become smaller once skills are exogenous and actually become gains for all generations once the capital stock and interest rate are exogenous. It would be incorrect to conclude from this analysis, however, that greater redistribution decreases welfare. Conducting an alternative experiment in which we increase the redistributiveness of the labor tax system slightly while keeping a balanced budget by adjusting the average labor tax, we show that this reform makes adults better off.

How UBI is financed is potentially important. The benchmark policy finances UBI by changing one of the labor tax parameters (which we think of as governing the average labor tax) to balance the budget period by period. We also examine a few important alternative financing schemes: UBI replaces current redistribution programs and UBI is financed with a higher consumption tax. While the first still leads to average welfare losses for all cohorts, the second actually leads to average (but not Pareto) welfare gains for all cohorts. We show, however, that the welfare gains associated with UBI financed using consumption taxes is a consequence of consumption taxation substituting for labor taxation rather than deriving from UBI per se. We also use the model to evaluate UBI in a case in which this policy generates savings in government administrative expenditures and find that the savings required to obtain welfare gains is implausibly large. The model is also able to provide insight on how a riskier economy might affect the desirability of UBI by increasing the variance of wage shocks and by increasing the frequency of the out-of-work shocks to magnitudes suggested by the automation literature. Welfare losses from UBI can be reduced in such riskier contexts but they are still sizeable. Lastly, we examine the robustness of our conclusions to key parameter values by recalibrating the benchmark model to a lower Frisch elasticity and smaller degree of altruism. Both still result in significant welfare losses but these are smaller with a lower Frisch elasticity.

Some Related Literature

Although notable economists such as Tony Atkinson used public finance tools to evaluate UBI polices several decades ago (see, e.g. Atkinson (1991)), there are few studies of actual UBI policies. This is undoubtedly a consequence of the absence of programs that fulfill the criteria of being universal and significant in size. In a developed country context, the Earned Income Tax Credit (EITC), the 1970s Income Maintenance Experiments, cash welfare programs, and programs such as the Alaska Permanent Fund and the Indian tribe payments can be used to study some of the potential behavioral responses to

[7] We thank the editor for suggesting that we follow this approach.

a UBI. For excellent reviews of the literature see Gentilini et al. (2019) overall, Hoynes and Rothstein (2019) for high-income countries and Banerjee et al. (2019) and Hanna and Olken (2018) for developing countries. Our paper is among the first to address the void created by the lack of direct empirical evidence by providing a dynamic, general equilibrium, quantitative framework to understand the potential welfare consequences of UBI and the mechanisms responsible for them.

Given that UBI reforms may be interpreted as a particular change to the tax and transfer system, our paper relates to the large public finance literature that, following Mirrlees (1971), seeks to characterize the optimal tax system. Much of the discussion in this area has focused on the shape of the optimal income tax schedule, with Mirrlees' seminal paper finding linear taxes to be close to optimal whereas Diamond (1998) and Saez (2001) find that marginal tax rates should be U-shaped, with the proceeds used to finance sizeable lump-sum transfers (i.e., essentially a form of UBI). This finding has been shown to be robust in separate contexts that incorporate dynamics. For example, in partial equilibrium settings, Golosov et al. (2016) shows that this feature is present in a model where agents can accumulate savings and Stantcheva (2017) finds a similar results in a context with human capital accumulation.[8] Although our paper does not provide an optimal tax analysis, we nonetheless show that increasing cash transfers (even by a very small amount) leads to welfare losses and that endogenous human and physical capital accumulation, together with the general equilibrium implications of our dynamic model, are key for this finding. In fact, an observationally-equivalent version of our model that abstracts from these features finds welfare gains from the same small increase in lump-sum transfers.

In addition to the Mirrleesian approach used to characterize the optimal tax schedule, several other papers (e.g., Benabou, 2002; Bovenberg and Jacobs, 2005; Conesa et al., 2009; Krueger and Ludwig, 2016; Heathcote et al., 2017; Wu and Krueger, 2021) explore the welfare effects of alternative tax systems within a restricted class of functional forms (usually referred to as the Ramsey approach when focusing on optimal changes). While this approach does not seek to characterize the unrestricted optimal tax system, it is typically able to study the dynamic consequences of alternative reforms in richer, more complex, general equilibrium environments and to examine the welfare implications of changing from the current system to the new one over the economy's entire transition path to the new steady state. Among these, those that focus on UBI-type of reforms are especially relevant. Conesa et al. (2020), Luduvice (2021) and Guner et al. (2021), three contemporaneous papers, also study the effects of a UBI policy in the US using a quantitative general-equilibrium model.[9] Our models share several features: an OLG structure with idiosyncratic labor income shocks and with outcomes determined in general equilibrium. They also differ in some important respects. Luduvice (2021) and Guner et al. (2021) have a slightly richer demographic structure (e.g., in fertility or marriage) and incorporate more explicit features of the income security system. Conesa et al. (2020), instead, incorporates a form of progressive taxes on consumption goods to finance UBI. In all three papers, however, parents do not care about

[8] Farhi and Werning (2013b) also study taxation in a partial-equilibrium life-cycle model and find that labor income taxes that increase with age (up to an average value of 40%) are optimal. See Golosov and Tsyvinski (2015) and Stantcheva (2020) for excellent reviews of this literature.

[9] Earlier work by Lopez-Daneri (2016) examined a negative income tax reform as suggested by Milton Friedman. Another related early paper is Fabre et al. (2014) which compares UBI to unemployment insurance.

their children and there are no skill or education outcomes.

Conesa et al. (2020) and Luduvice (2021) study UBI policies of similar magnitudes to ours. Their welfare results, however, differ markedly from ours as they find that welfare increases in the long run. Guner et al. (2021) find that although UBI does not have a positive welfare effect, eliminating the current means-tested transfer system and replacing it with a negative income tax for all (i.e., a UBI with a proportional income tax) does yield welfare gains in the steady state, albeit small ones (0.06%).[10] It is likely that the difference in results can be explained by two important differences. First, Conesa et al. (2009) and Luduvice (2021) use consumption taxes to finance UBI. As we show in Section 7, for a given budget, a greater reliance on consumption taxes tends to increase future generations' welfare but, at least in our framework, this positive welfare effect is smalled when in addition UBI is introduced.[11]

Second, intergenerational linkages are absent in all three papers. Thus, UBI is unable to affect skills/education or initial assets (i.e., parental transfers in our framework). In our model, on the other hand, parents and children are linked both because parental education and skills help determine those of their children, but also endogenously because parents are altruistic – they care about their descendants' welfare – and invest in their child's skill formation and transfer funds to them. We show that these intergenerational linkages are quantitatively significant in determining the welfare effects of UBI.[12] We also show that a model without such dynamics would predict substantially different welfare effects to the ones we obtain. Lastly, the analysis of Guner et al. (2021) is for steady-state comparisons that abstract from transitional dynamics and that furthermore keeps the rate of return to capital constant. Our analysis of mechanisms in Section 6.4 using an observationally-equivalent model as our benchmark but keeping the capital stock and interest rate fixed, suggests that this may be a crucial reason why they find gains (albeit small) from a negative income tax whereas we find large losses.

The paper is organized as follows. Section 2 introduces the model, Section 3 explains its estimation, and Section 4 conducts several validation exercises. Section 5 presents the model's results for the benchmark UBI policy (financed by higher labor income taxes) and Section 6 explores the main channels behind the main results. Finally, Section 7 evaluates alternative ways to finance UBI.

2 The Model

The life cycle Agents live 20 periods which belong to four main stages: childhood, college, work (and parenthood), and retirement. Figure 1 shows the life cycle of an agent, in which each period refers to four years. Let j denote the period of their life (e.g., $j = 1$ refers to ages 0–3, $j = 2$ to ages 4–7, etc.). From $j = 1$ through $j = 4$ (ages 0–15) the child lives with her parents and makes no decisions. In period $j = 5$, the child has finished high school with an (endogenous) level of skills and has received (at the beginning of that period) a non-negative transfer from their parent which becomes their initial assets,

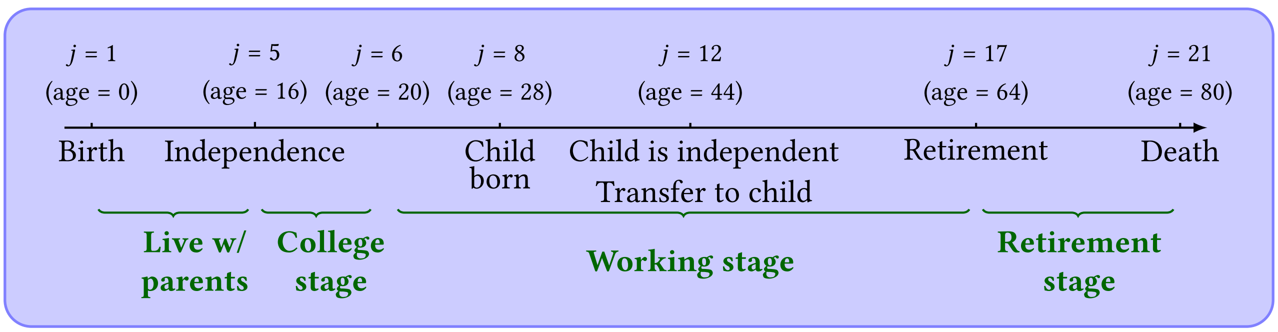
[10] In a (Ramsey) optimal tax design exercise, Ferriere et al. (2022) also find welfare gains from a large UBI transfer with an almost linear income tax, in a context of infinitely lived agents without endogenous human capital accumulation.

[11] An additional contributory factor may be the degree of distortion that these authors build into the benchmark economy. In Luduvice (2021) both capital and labor income tax schedules have significant kinks.

[12] Intergenerational linkages are also highlighted by Peruffo et al. (2021) when evaluating a UBI reform in Brazil.

a. The agent also learns their school taste (described in greater detail later) and is now considered an adult. The agent now makes their first decision: whether to attend college or to instead enter the work stage of life as a high-school graduate. If the agent attends college, they enter the work stage of life one period later, $j = 6$. In the work stage, agents decide in each period how much to work, save, and consume. They can borrow up to a limit, and save through a risk-free, non-state-contingent asset. While in their work stage, in period $j = 8$ (age 28), the individual becomes a parent (one child), whereupon new decisions – how much to invest in her child – must also be made. An individual retires in period $j = 17$ (age 64) and lives through period $j = 20$ (ages 76-79). Agents die right before the start of period $j = 21$. There is no population growth.

Figure 1: Life Cycle



The credit market We assume that agents can only trade risk-free bonds, but allow the interest rate to differ according to whether they are saving or borrowing. Loans used to pay for college have a lower interest rate.[13] Agents with positive savings receive an interest rate r, whereas those who borrow pay an interest rate $r^b = r + \iota$, where $\iota \geq 0$. The wedge between the two interest rates captures the cost of borrowing.[14] In addition, agents are subject to the "natural" borrowing limit.

Progressive taxation and Universal Basic Income To evaluate a UBI policy, it is important to understand how it modifies the existing tax and transfer system, which in the model is given by:

$$T(y, a, c) = y - \lambda y^{1-\tau_y} + \tau_a a r \mathbf{1}_{a \geq 0} + \tau_c c - \omega \tag{1}$$

where y is pre-tax labor income, ar is the interest income earned on (non-negative) assets a, c is consumption, and ω is a lump-sum transfer. We assume that consumption and capital income are subject to constant tax rates τ_c and τ_a, respectively. As indicated, the relationship between after-tax labor income $\tilde{y}$ and pre-tax labor income y is given by $\tilde{y} = \lambda y^{1-\tau_y} + \omega$. Note that this is the same non-linear tax function used by, e.g., Feldstein (1969), Benabou (2000), and Heathcote et al. (2017), but augmented to include lump-sum transfers ω. As shown in Heathcote et al. (2017), this function with $\omega = 0$, fits the relationship between after-tax and pre-tax income very well for all income quantiles except those at the bottom of the income distribution. Lump-sum transfers ω help match the after-tax income of the poorest individuals which is important for the welfare analysis. A UBI can be thought of as an increase

[13] Student loans are explained in detail below.

[14] As is standard practice (e.g., Abbott et al., Forthcoming), these costs are interpreted as the bank's cost of overseeing the loan per unit of consumption intermediated; these are "red tape" costs and are not payments to any model agent.

in ω. Note that τ_y helps determine the progressivity of the marginal tax rate whereas changes in λ affect after-tax (prior to transfers) labor income by the same proportion for all.[15] We will assume throughout that the government budget is balanced in each period, letting G denote (unmodeled) government expenditures which remain constant over time and across policies.

Wage process Individual wages depend on an individual's education e and on their (endogenous) endowment of efficiency units per unit of time worked, E, in the following fashion:

$$w_i(e, j) = w_e E_{ij}^{e} (\theta, \eta) \tag{2}$$

where w_e is the unit wage of education group e, $E_{e,j} (\theta, \eta)$ is the efficiency units, including the age profile for the education group, the return to skills θ, and the idiosyncratic labor productivity given by η, which is persistent and evolves stochastically following the education- and age-dependent process $\Gamma_{e,j} (\eta)$. We also allow for two extreme shocks – one that renders an agent's wage (and hence their labor income) equal to zero (which one can interpret as long-term unemployment arising from forces such as offshoring, technological change rendering certain skills obsolete, or disability) and a superstar shock that vastly increases their productivity.[16]

The production function We assume there is a representative firm with production technology:

$$Y = AK^{\alpha} H^{1-\alpha}, \quad H = \left[sH_0^{\Omega} + (1-s) H_1^{\Omega} \right]^{1/\Omega} \tag{3}$$

where A is TFP, K is aggregate physical capital and H is a CES aggregator of the labor supply of the two education groups where H_0 integrates over all the efficiency units per unit of time worked times hours of labor supplied by high-school workers of age j and then sums over all the working ages and H_1 performs the same calculation for college workers (See Appendix A for details). Firms are perfectly competitive and thus make zero profits and pay rental rates and unit wages equal to the marginal products:

$$r = A\alpha \left(\frac{H}{K} \right)^{1-\alpha} - \delta_k, \quad w_e = A(1-\alpha)s \left(\frac{K}{H} \right)^{\alpha} \left(\frac{H}{H_e} \right)^{1-\Omega} \tag{4}$$

where δ_k is the fixed rate of capital depreciation per period.

Preferences The agent is risk averse and her period utility over consumption c and labor h is

$$u(c, h) = \frac{c^{1-\gamma_c}}{1-\gamma_c} - \mu \frac{h^{1+\gamma_h}}{1+\gamma_h} \tag{5}$$

Furthermore, the future is discounted by β and the parent is altruistic as in Barro and Becker (1989), caring about the utility of the child (i.e, rather than obtaining a "warm glow") as detailed below.

2.1 The Agent's Maximization Problem and Equilibrium

The Education Stage At $j = 5$ (16 years old), the agent becomes an adult and makes their first decision: whether to attend college that period. The agent's state variables at the decision point are:

[15]We discuss the parametrization and calibration of the tax and transfer function in Section 3. We use the estimate of τ_y from Heathcote et al. (2017), which takes into account deductions and public cash transfers.

[16]These features are introduced to study the implications of UBI for riskier economies in Section 7 and to help match the upper tail of the income and wealth distributions.

initial assets consisting of the (non-negative) parental transfer (which would have been made at the start of that period), skills θ (a vector consisting of a cognitive and non-cognitive skill component), and shock ε (also revealed at the beginning of that period) to the taste for college κ. The latter, as is common in the literature (e.g., Heckman et al., 2006; Abbott et al., Forthcoming), affects the college value in the form of a psychic cost that enters in a linearly separable fashion.[17] After college, κ no longer affects outcomes. The education decision is irreversible and college entails a monetary cost p_e. The alternative to college ($e = 1$) is to enter the next phase of life as of that period as a high-school worker ($e = 0$).

Agents can finance their college education using a variety of methods: they can use their assets, take out loans, and work. College students can access subsidized loans at rate $r^s = r + \iota^s$ where $\iota^s < \iota$. These loans are subject to a borrowing limit $\underline{a}^s$.[18] Both the interest rate wedge and the borrowing limit are based on the rules for federal college loans, explained in detail in Section 3. To simplify computation, we follow Abbott et al. (Forthcoming) and assume that college student debt is refinanced into a single bond with fixed payments over for 5 periods (i.e., 20 years) following graduation and interest rate r^b, where $\tilde{a}^s(a')$ is the function performing this transformation (See Appendix B.2 for details).

While in college, students can work – providing high-school level labor – but their total available hours are reduced by a fixed amount of study time $\overline{h}$ (which also incurs disutility). Thus, the value function of an agent who decides to attend college and has assets a and skills θ is given by:

$$V_j^s\left(a,\theta,e=1\right) = \max_{c,a',h} u\left(c, h+\overline{h}\right) + \beta\mathbb{E}_{\eta'|e=1}V_{j+1}\left(\tilde{a}^s(a'),\theta,e=1,\eta'\right) \tag{6}$$
$$c + a' + p_e - y + T\left(y,a,c\right) = a\left(1+r\right)$$
$$y = hw_0E_{j=5,e=1}\left(\theta,\eta=0\right), \quad a' \geq \underline{a}^s, \quad 0 \leq h \leq 1-\overline{h}, \quad \eta' \sim \Gamma_{j=6,e=1}$$

As indicated in the maximization problem, the agent can borrow up to the limit $\underline{a}^s$ (repaying at interest rate $r^s > r$) or save at rate r. Note that we have assumed that the initial draw of η – the productivity shock – occurs after the college decision. The functional form assumption we make in Section 3 implies that we can evaluate E at the mean value of η (i.e., $\eta = 0$). We assume that work hours and college study hours incur the same disutility.

Once agents have finished their education (be it high school or college), we use $V_j\left(a,\theta,e,\eta\right)$ to denote the value of work for an agent of age j with assets a, skills θ, education e, and stochastic labor productivity shock η. It is defined by

$$V_j\left(a,\theta,e,\eta\right) = \max_{c,a',h} u\left(c,h\right) + \beta\mathbb{E}V_{j+1}\left(a',\theta,e,\eta'\right) \tag{7}$$
$$c + a' - y + T\left(y,a,c\right) = \begin{cases} a\left(1+r\right) & \text{if } a \geq 0 \\ a\left(1+r^b\right) & \text{if } a < 0 \end{cases}$$
$$y = hw_eE_{j,e}\left(\theta,\eta\right), \quad a' \geq \underline{a}_j, \quad 0 \leq h \leq 1, \quad \eta' \sim \Gamma_{j,e}(\eta)$$

[17] Including a taste for schooling is important to match the observed cross-sectional variation in education (e.g., its intergenerational persistence) as variation in income and in the returns to education can only partially account for it.

[18] This does not exceed the natural borrowing constraint as we assume that no one receives an out-of-work shock in the first period in which they work (nor the superstar shock introduced later in the paper.

As indicated, the agent can borrow up to $\underline{a}_j$, repaying at $r^b > r$, and the save at rate r.

To sum up, at the beginning of period $j = 5$, V_j^{sw} is the value of an agent who chooses between working (as a high-school graduate) versus a college education, i.e.,

$$V_j^{sw}(a,\theta,\varepsilon) = \max\left\{\mathbb{E}_{\eta|e}V_j(a,\theta,e=0,\eta), V_j^s(a,\theta,e=1) - \kappa(\varepsilon,\theta)\right\} \tag{8}$$

where the disutility from college is given by a scalar κ that depends both on a taste parameter ε (whose distribution depends potentially on parental education) and on the agent's own skills θ.

Working Stage and Children After education is complete and until retirement at the end of period 17, the agent works and their individual problem is equivalent to (7) except for those special periods in which the agent decides (i) investment in the child's skills and (ii) a monetary transfer to the child right before the child makes their college choice. We now describe the maximization problems associated with these decisions in detail.

Investment in child's skills: Agents are assumed to have one child in period $j = 8$ (age 28).[19] In that period and until the child leaves the household in period 5, the agent chooses in each period how much to invest m, in the development of the child's skills. The latter are assumed to have a cognitive and non-cognitive component, i.e., $\theta_k = \left\{\theta_{k,c}, \theta_{k,nc}\right\}$.[20] The child's initial draw of skills is stochastic and potentially a function of the parent's skill level (as detailed in Section 3). After that initial draw, skills evolve depending on parental investments I as follows:

$$\theta'_{k,q} = \left[\alpha_{1qj}\theta_{k,c}^{\varphi_{jq}} + \alpha_{2qj}\theta_{k,nc}^{\varphi_{jq}} + \alpha_{3qj}\theta_{c}^{\varphi_{jq}} + \alpha_{4qj}\theta_{nc}^{\varphi_{jq}} + \alpha_{5qj}I^{\varphi_{jq}}\right]^{1/\varphi_{jq}} \exp\left(\nu_q\right), \quad I = \bar{A}m \tag{9}$$

for $q \in \{c, nc\}$. The CES equation (9) is based on Cunha et al. (2010). The child's skill level next period, θ'_k, depends upon the child's current (cognitive and non-cognitive) skill level θ_k, parental (cognitive and non-cognitive) skills θ, and parental investments I, as well as an idiosyncratic shock ν. Note that the formulation above implies that parental investment cannot be targeted to a particular type of skill. To summarize, in addition to standard choices of consumption, savings, and labor supply, the agent also chooses how much to invest (m) in the child's skill development during each period j=8−11, as shown in the value function below:[21]

$$V_j(a,\theta,e,\eta,\theta_k) = \max_{c,a',h,\tau,m} u(c,h) - v(\tau) + \beta\mathbb{E}V_{j+1}\left(a',\theta,e,\eta',\theta'_k\right) \tag{10}$$

$$c + a' + m - y + T(y,a,c) = \begin{cases} a(1+r) & \text{if } a \geq 0 \\ a\left(1+r^b\right) & \text{if } a < 0 \end{cases}$$

$$y = hw_eE_{j,e}(\theta,\eta), \quad a' \geq \underline{a}_{j,e}, \quad 0 \leq h + \tau \leq 1, \quad \eta' \sim \Gamma_{j,e}(\eta)$$

$$\theta'_{k,q} = \left[\alpha_{1qj}\theta_{k,c}^{\varphi_{jq}} + \alpha_{2qj}\theta_{k,nc}^{\varphi_{jq}} + \alpha_{3qj}\theta_{c}^{\varphi_{jq}} + \alpha_{4qj}\theta_{nc}^{\varphi_{jq}} + \alpha_{5qj}I^{\varphi_{jq}}\right]^{1/\varphi_{jq}} \exp\left(\nu_q\right)$$

$$I = \bar{A}m, \quad m \in \{m_1, m_2, ...\}, \quad \nu_q \sim N(0, \sigma_{j,\nu_q}), \quad q \in \{c, nc\}$$

[19] The average age of first birth for married women in 2007 was 28.0 according to the National Center for Health Statistics.

[20] Although this is a potentially more complex view of skill formation than what would otherwise be optimal given our purposes, it has the advantage of allowing us to use the skill production function estimates of Cunha et al. (2010).

[21] The choice of m is made within a discrete set of possible alternatives (12) for computational reasons.

As of the beginning of period $j = 12$ ($j = 5$ from the child's perspective) the child's skills are assumed to be constant and the agent's maximization problem returns to that given in equation (7) but with an additional state variable θ_k.

Transfer to child: At the beginning of period $j = 12$ (period $j = 5$ for the child) but prior to knowing their child's κ realization (i.e., the draw of ε), the parent decides the size of the monetary transfer $\hat{a}$ to their child.[22] We denote the value function at in this sub-period by V_{transfer}. Importantly, the transfer is restricted to being non-negative – i.e., parents can neither bequeath debt to their child nor borrow against their child's future income. When making this choice, the parent is assumed to know their own income shock realization.

$$V_{\text{transfer}}\left(a, \theta, e, \eta, \theta_k\right) = \max_{\hat{a}} V_{j=12}\left(a - \hat{a}, \theta, e, \eta\right) + \delta \mathbb{E} V^{sw}_{j'=5}\left(\hat{a}, \theta_k, \varepsilon\right), \tag{11}$$
$$\hat{a} \geq 0, \quad \varepsilon \sim N(\bar{\varepsilon}_e \sigma_\varepsilon)$$

Unlike in equation (10), the value function in this stage now explicitly includes the child's continuation value $V^{sw}_{j'=5}$ where j' denotes the child's period-age. Note that δ measures the degree of parental altruism towards their child. This is the last period in which the parent's choices affects their child. After the agent's child becomes independent, the individual problem reverts to (7), so the child's state variables are no longer present. Lastly, note that the value function is written recursively, which implies that at every period in which parental choices affect her child's outcomes – i.e., all preceding periods – the utility of all her descendants have been taken into account. This formulation embeds the parental altruism motive.

The Retirement Stage At $j = 17$, the agent retires with two sources of income: savings and retirement benefits (π). To simplify the problem, we assume that retirement benefits depend only on the agent's education and skill level, a proxy for average lifetime income. Agents no longer work ($h = 0$). Formally, the problem at the age of retirement is

$$V_j\left(a, \theta, e\right) = \max_{c, a'} u\left(c, 0\right) + \beta V_{j+1}\left(a', \theta, e\right) \tag{12}$$
$$c + a' - \pi(\theta, e) + T\left(\pi(\theta, e), a, c\right) = \begin{cases} a\left(1 + r\right) & \text{if } a \geq 0 \\ a\left(1 + r^b\right) & \text{if } a < 0 \end{cases}, \quad a' \geq \underline{a}_j$$

Definition of Stationary Equilibrium The model has 20 overlapping generations alive at any time period and is solved numerically to characterize the stationary equilibrium allocation. Stationarity implies that we study an equilibrium in which the cross-sectional distribution for any given cohort of period-age j is invariant over time periods. Particularly important is that the distribution of initial states is determined by the choices of the older generations. In equilibrium, households choose education, consumption, labor supply, parental investment in child skills in the form of time and resources, and parental transfers such that they maximize their expected utility taken prices as given; firms maximize profits; and prices (wages of each education group and the interest rate) clear markets. The government

[22] The assumption that the child's taste is not perfectly known to the parent helps make the problem smoother which is useful for computational reasons.

budget is balanced in every period (including unmodeled expenditures G). Thus, G will be defined in the stationary equilibrium as a residual (see Appendix A for the expression).

3 Estimation

This section describes how we parameterize and estimate the model. The model is estimated using simulated method of moments to match standard moments as well as more novel ones for the US in the 2000s. Some of the parameters can be estimated "externally," while others must be estimated "internally" from the simulation of the model. For these, we numerically solve for the stationary distribution of the economy and calculate the moments of interest. Table 1 summarizes the parameters and moments used.

Mapping the model to the data We use three primary data sources: (i) the Panel Study of Income Dynamics (PSID), surveys between 1968 and 2016; (ii) the Child Development Supplement (CDS) to PSID, surveys of 1997, 2002 and 2007; and (iii) the 1979 cohort of the National Longitudinal Survey of Youth (NLSY79) surveys between 1979 and 2012. We map the individual model outcomes to the data using as a guiding principle that agents in the model represent a household.[23] In the data, wages are obtained by summing the labor income of the (one or two) adults' in the household and dividing by the total hours worked – also measured as the (sum of) hours worked by the adults in the household. Education and age, on the other hand, are the education level and age of the household head. Education is reduced to two categories: college (i.e., those with a four-year college degree or more) and high school (which corresponds to everyone else in the data).

Prices All prices are in 2000 dollars. These are normalized, using the TFP parameter A, such that the average annual income of a high school agent in period 13 (age 48) – \$28,312 in the data – is equal to one in the model. The yearly price of college is estimated using the Delta Cost Project to be \$6,588.[24]

Borrowing constraints Agents can borrow up to the natural borrowing limit. Thus, in period 20, $\underline{a}_{j=20} = 0$. In period $j = 19$, $\underline{a}_{j=19} \geq \omega(1+r^b)^{-1}$ Proceeding recursively, $\underline{a}_{j-1} \geq (\underline{a}_j + \omega)(1+r^b)^{-1}$. The (annualized) wedge for borrowing is set to 10%, which is the average among the values for credit card borrowing interest rates (net of r and average inflation) reported by Gross and Souleles (2002).

Taxes and Pension Benefits Given the tax function of equation (1), based on Trabandt and Uhlig (2011) we set $\tau_a = 0.36$ and $\tau_c = 0.05$. Parameter τ_y helps determine the progressivity of the marginal tax rate. We use the preferred estimation of $\tau_y = 0.18$ from Heathcote et al. (2017). A possible issue is that the authors include labor and capital income in y given that they do not have capital in their model, whereas we allow capital to be taxed at a different rate as suggested by the literature.[25] We checked

[23] This simplifies the model significantly by not modeling household formation decision (marriage, cohabitation, or divorce). See Fernández and Wong (2017).

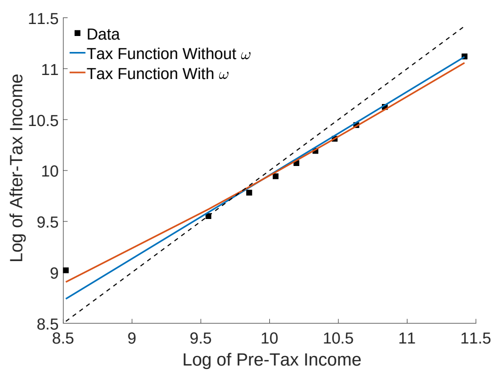
[24] The Delta Cost Project Database is a longitudinal database that studies colleges revenue and expenditures. Our estimate is based on 4-year private not-for-profit and public colleges, taking into account grants and scholarships, such that only privately borne tuition costs are considered.

[25] Although both capital and labor income are jointly taxed in the US tax code, we allow them to be taxed at different rates as is standard in the quantitative macro literature (e.g., Kaplan, 2012; Krueger and Ludwig, 2016; Luduvice, 2021; Abbott et al., Forthcoming). This allows for the fact that most households' assets (e.g., housing) do not generate income and, therefore, are not subject to capital income taxes. Instead, most of these assets are, if anything, subject to capital gains taxes. Although

whether we would obtain a significantly different estimate by using the NBER's TAXSIM (Feenberg and Coutts, 1993) to estimate after-tax income for households with different levels of (only) labor income, by US state in the year 2000. Using this data, we follow the steps of Heathcote et al. (2017) and estimate $\tau_y = 0.20$, consistent with their estimates. Lastly, λ is estimated using simulated method of moments to match a ratio of government expenses G to GDP of 19%.[26]

Figure 1 of Heathcote et al. (2017) graphs households' pre- versus post-tax income and shows that low-income households tend to have higher after-tax income than what the authors' estimates of the tax function without a lump-sum component suggests. Incorporating a lump-sum transfer ω and estimating the latter so as to match a measure of income redistribution – the ratio of the variance of pre-tax total (i.e., labor plus savings) income to after-tax total income – is one way to indirectly obtain its value. We do this using the PSID data constructed by Heathcote et al. (2010) and find ω equivalent to $1,632 per year.[27] Alternatively, we can calculate the difference between after-tax-and-transfers annual income and pre-tax annual income for low-income households with one child.[28] For those in the bottom 2%, we find that this difference is on average $1,843. As can be seen in Figure 2, incorporating this additional transfer provides a better fit with the data.

Figure 2: Tax Function Fit



Notes: The figure plots the log of pre-tax and after-tax income, by income deciles. The data is from the PSID dataset constructed by Heathcote et al. (2010). The blue line shows the fit of the tax function with $\tau_y = 0.18$ but $\omega = 0$. The red line shows the fit of the same function but with $\omega = \$1632$ (our estimated value). In both cases, λ is chosen to minimize the square distance between the data and the tax function.

The pension replacement rate is based on the Old Age, Survivors, and Disability Insurance federal program. We use education and skill level to estimate the average lifetime income on which the replacement benefit is based (See Appendix B.3 for details).

Intergenerational Skill Transmission The child skill production function is based on Cunha et al.. We use their parameter values which vary with the age of the child and were estimated using a rep-

a model with more than one asset can incorporate both capital income and capital gains taxes separately, our model has one asset and thus τ_a is set, following the literature, to capture the relevant mix of taxes on capital returns.

[26]This is the average over 2000-2006 and is the figure used by Heathcote et al. (2017) and Heathcote and Tsujiyama (2021).

[27]To get a sense of the shape of the tax function, the average marginal tax rate among those working is 32.5%. It is 22.3% among those in the bottom income quintile (also conditional on working) and 42.6% among those at the top quintile.

[28]As before, both after-tax-and-transfers annual income and pre-tax annual income are divided by the the number of adults in the household (either one or two).

resentative sample.[29] These values indicate that skills are more malleable when children are younger, i.e., the elasticity of substitution determined by φ_{jq} is larger the younger the child. Furthermore, in order to use these parameter values we follow the authors in assuming that skills are a vector with two components: cognitive skill and non-cognitive skill.[30] Thus, θ and θ_k are vectors with a separate entry for each skill (accordingly, α is also a vector). The initial draw of skills is assumed to depend on parent's skills as an AR(1) process, independent for cognitive and non-cognitive skills. For example, the draw of cognitive skills follows $\log\left(\theta_{k,c}\right) = \hat{\rho}_c \log\left(\theta_c\right) + \varepsilon_{\theta_{k,c}}$ where $\varepsilon_{\theta_{k,c}}$ is a shock, independent across skills. The persistence component $\hat{\rho}_c$ is, by definition, equal to $\frac{\text{Cov}\left(\log\left(\theta_{k,c}\right),\log(\theta_c)\right)}{\text{Var}(\log(\theta_c))}$. The functional form is equivalent for the initial draw of non-cognitive skills $\theta_{k,nc}$. We obtain $\text{Var}\left(\log\left(\theta_c\right)\right)$,$\text{Var}\left(\log\left(\theta_{nc}\right)\right)$, $\text{Var}\left(\log\left(\theta_{k,c}\right)\right)$, $\text{Var}\left(\log\left(\theta_{k,nc}\right)\right)$, and $\text{Cov}\left(\log\left(\theta_{k,c}\right), \log\left(\theta_c\right)\right)$ directly from Cunha et al. (2010). $\bar{A}$ is estimated such that the average level of log cognitive skills in the stationary equilibrium equals zero.[31]

Wage Process and Return to Skills We estimate the wage process and return to skills using NLSY and PSID data for households, assuming that the wage process of household i with education e at age j is given by $w^e E^e_{ij}$ with $E^e_{ij} = \epsilon^e_j \psi^e_{ij}$. As noted previously, ϵ^e_j is the age profile for the education group e and ψ^e_{ij} is the idiosyncratic labor productivity. As is well known, it is hard to match the high degree of wealth and income inequality in an incomplete markets economy without making additional assumptions. We follow Castaneda et al. (2003) and assume a "super-star" productivity state $\bar{\eta}$ that an agent enters with probability $\bar{\pi}$ and exits with probability $\underline{\pi}$.

During normal times, therefore, labor productivity evolves according to:

$$log\left(\psi^e_{ij}\right) = \lambda^e log\left(\theta_{ic}\right) + \eta^e_{ij}, \quad \eta^e_{ij} = \rho^e \eta^e_{ij-1} + z^e_{ij}, \quad z^e_{ij} \overset{iid}{\sim} N\left(0, \sigma^e_z\right) \tag{13}$$

where θ_{ic} is the agent's level of cognitive skills (one of the elements of θ) and η^e_{ij} is the idiosyncratic shock. An agent's initial productivity shock η^e_0 is drawn from a normal distribution with mean zero and variance $\sigma^e_{\eta_0}$. Allowing the impact of skills on wages to depend on education via λ^e is important for the education choice of agents with different skill levels. When the agent enters the superstar state, $\eta^e_{ij} = \bar{\eta}$. Upon exiting such state, they obtain a draw from the age and education dependent ergodic distribution associated with the AR(1) process. The three parameters of the superstar state are estimated to match the income share of the top 5 percent and the wealth shares of the top 1 and 0.1 percent. We obtain $\bar{\eta} = 6.11$, indicating that average productivity is augmented by 450 times its mean.

We define wages $w_{i,t}$ for household i in period t as the total labor income divided by the total number of hours worked.[32] Since the model period corresponds to four years in the data, we estimate the wage process by averaging observations over 4 years.[33] Using information on the highest degree completed

[29] Appendix Table B2 reports the parameter values and standard deviations.

[30] Cunha et al. highlight that abstracting from the two types of skills leads to estimates that suggest that investments on low-skilled children are much less productive (i.e., a more negative φ_{jq}).

[31] We use the same normalization as Cunha et al. (2010) to be consistent.

[32] Following standard practice, we drop observations in which hourly wages are less than half the minimum wage.

[33] An alternative, as in Krueger and Ludwig (2016), is to estimate the wage process using yearly data and then transform the estimates to 4-year periods. Appendix Table B6 shows that the estimates obtained this way are very similar. Both methods, however, essentially assume complete markets within a period and, by doing so, may not give sufficient weight to a UBI policy that would diminish the variance of consumption. To evaluate the importance of this limitation, in Appendix

by the head-of-household, we split households into those with a four-year college degree and higher and those with less education, corresponding to the college and high school categories of the model. For each education group, we use PSID data to obtain the age profile ϵ_j^e using a quadratic polynomial on the age of the head-of-household, controlling for year (defined as the initial year of the 4-year period) fixed effects and selection into work, $w_{i,t} = \beta_0 + \beta_1 \text{Age}_{i,t} + \beta_2 \text{Age}_{i,t}^2 + \beta_3 X_{i,t} + \gamma_t + \psi_{i,t}$, where $X_{i,t}$ is the control for selection into work based on a Heckman-selection estimator.[34] Appendix Table B3 shows the results. Armed with the age profile, we then use (13) to recover ψ_{ij}^e as a residual in the NLSY data.[35] Next, an estimate of λ^e is recovered by regressing the estimate of ψ_{ij}^e against the log of cognitive skills as measured by the AFQT score (i.e., we estimate equation 13). Lastly, the AR(1) process for the residual η (i.e., the shock to the efficiency units in equation 13), is estimated using the standard Minimum Distance Estimator developed by Rothenberg et al. (1971). Appendix Table B4 shows the estimates obtained by the process just described. As can be seen, the returns to skill are 1.5 times greater for college-educated workers than high-school ones. College agents draw their initial productivity from a distribution with a somewhat higher variance than high-school agents, but shocks received later are similar.

Out-of-Work Shock Agents can be hit by a shock that forces them to exit the labor force for an entire period. Using PSID data, we estimate the transition probabilities between the out-of-work and working states for different education-age groups using a Probit model and yearly household labor-income data (See Appendix B.6 for details). We conservatively assume that this out-of-work state corresponds to a household not earning labor income during an entire period (i.e., for 4 years in the data). Figure 3 shows that the implied probabilities of entering and remaining in the "out-of-work" state are monotonically increasing with age for both education groups, but both are higher for high-school than college households, particularly after age 40.

The out-of-work shock is included in η_{ij}^e with a value of $\eta_{ij}^e = -\inf$, which makes the hourly wage zero. The probability of entering this state next period depends on the age and education of individual (as shown by the left panel of Figure 3), but is otherwise assumed to be independent of the current value of $\eta_{ij}^e > -\inf$. The probability of exiting the out-of-work state is likewise given by the right panel of Figure 3, which also depends on age and education. Furthermore, we assume that individuals exit the out-of-work state with the lowest value of $\eta_{ij}^e > -\inf$ since the data shows that these individuals tend to have low earnings relative to their education/age groups upon re-employment.[36] Our estimates imply that the share of individuals in the out-of-work state is 0.04% when they are 36 years old and

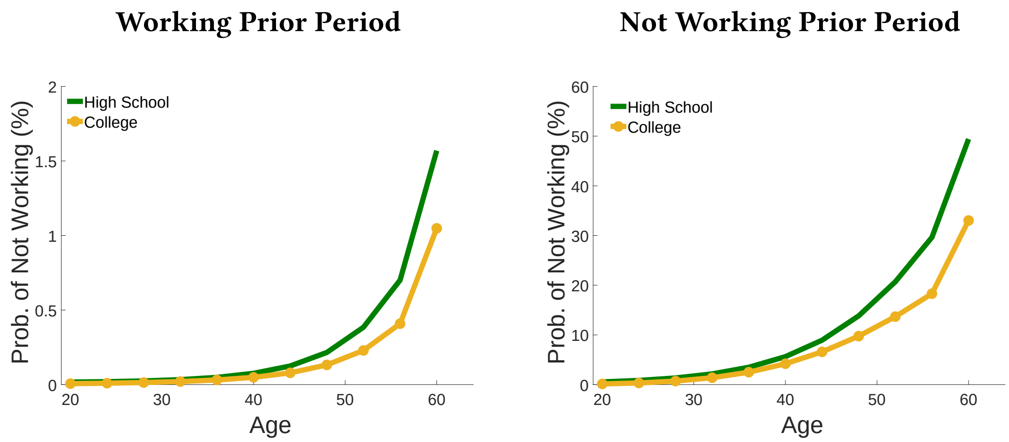
B.8 we double the variance of the wage shocks, σ_z^e, and examine how this affects the main results.

[34]To control for selection into work, we use a Heckman-selection estimator. In particular, we construct Inverse Mills ratios by estimating the participating equation separately for each education group using number of children interacted with a two-adult-household dummy as well as year-region fixed effects.

[35]We need to use NLSY for this step since the PSID in general does not have information that is pertinent for measures of skills such as an AFQT score. The PSID, instead, is preferred for estimating the age profiles since the age of the sample does not covary perfectly with the year of the survey (as is the case of NLSY).

[36]The lowest value of η_{ij}^e is age and education dependent. Moreover, these values depend on the discretization procedure. In our procedure (based on the Rouwenhorst method), these values imply that wages are approximately between 30 and 90% below the age-education group average. Using the PSID data, we estimate that the wages of households who are currently working but were not working the previous year to be, on average, approximately 60% lower than those of households who were working, controlling for age and education.

Figure 3: Model: Period (4-Year) Out-of-Work Transition Probabilities



Notes: The probability of not working next period by age, conditional upon working the prior period (left) and not working the prior period (right) as calculated using PSID data for college and non-college households.

increases to 1.7% by the time households are 60 years old. Although these are small numbers, it is useful to introduce this state in the benchmark model in order to later investigate how an increase in the probability of entering this state affects the attractiveness of UBI.

School Taste It is difficult to match the intergenerational persistence of education in this class of models without introducing something like school tastes/psychic costs of education, (e.g., Abbott et al., Forthcoming; Krueger and Ludwig, 2016). We assume that school (dis)taste in utility terms is given by

$$\kappa(\varepsilon, \theta) = \alpha + \alpha_{\theta_c} log(\theta_c) + \alpha_{\theta_{nc}} log(\theta_{nc}) + \varepsilon \tag{14}$$

This specification allows higher-skilled individuals to have (on average) lower levels of school distaste (for $\alpha_{\theta_c} > 0$ and/or $\alpha_{\theta_{nc}} > 0$). Parental education also affects school taste as ε is an idiosyncratic shock which is assumed to follow a normal distribution $N\left(\bar{\varepsilon}_{e_p}, \sigma_\varepsilon\right)$ whose mean depends on parental education. Without loss of generality, we assume that $\bar{\varepsilon}_{e_p}$ is zero for children of high-school parents. Although the parameters are simultaneously estimated, it is intuitive to think that α is estimated to match the college graduation share from NLSY; α_{θ_c} and $\alpha_{\theta_{nc}}$ are estimated to match the relation between college graduation and cognitive and non cognitive skills, respectively, as measured by regressing college graduation on the log of cognitive (AFQT score) and non cognitive (Rotter's locus of control score) skills; σ_ε is estimated to match the variance in college graduation after controlling for skills (i.e., the variance of the residual in the previously mentioned regression); and $\bar{\varepsilon}_{e_p}$ is estimated to match the intergenerational persistence of education (measured according to the determinant of the intergenerational education transition matrix from child-mother pairs in the PSID-CDS data).[37] We use mother's education instead of that of the household head since father's education is missing for approximately 29% of the children in our final

[37] AFQT and Rotter's locus of control are common measures of cognitive and non-cognitive skills, respectively. Given that we use Cunha et al. (2010) estimates for our skill development function, we highlight that they also use AFQT and Rotter's locus of control scores in the measurement equation of their estimation.

PSID-CDS sample.[38] See Table 1 for the values of these moments.

College loans College students have access to subsidized loans at rate $r^s = r + \iota^s$. According to the National Center for Education Statistics report "Student Financing of Undergraduate Education: 1999-2000," among the undergraduates who borrow, nearly all (97%) took out federal student loans, whereas only 13% took out non-federal loans. Moreover, the average loan value was similar for both federal and non-federal loans and hence we focus on federal loans. Among the latter loans, the Stafford loan program was the most common: 96% of undergraduates who borrowed took out Stafford loans. As there are various types of Stafford loans, we use the weighted average interest rate to set $\iota^s = 0.009$ (see Daruich and Kozlowski, 2020). The borrowing limit in college is set to match the cumulative borrowing limit on Stafford loans ($23,000).

Preferences We specify the period utility over consumption and labor as $u(c, h) = \frac{c^{1-\gamma_c}}{1-\gamma_c} - \mu \frac{h^{1+\gamma_h}}{1+\gamma_h}$. We follow the literature and assume that $\gamma_c = 1$ (i.e., $\frac{c^{1-\gamma_c}}{1-\gamma_c} = \log(c)$) and $\gamma_h = 2$ (i.e., the Frisch elasticity is 1/2).[39] μ is estimated to match the weekly average hours of labor from the PSID sample over the ages of 20-64. We assume that being in college requires 30 hours a week (giving us $\overline{h}$).[40] Finally, altruism factor δ is estimated to match intergenerational mobility, as measured by the regression coefficient of child rank in their cohort's income distribution on their parents' income rank from Chetty et al. (2014).[41]

Aggregate production function We set $\alpha = \frac{1}{3}$ in the aggregate Cobb-Douglas production function and the capital depreciation rate $\delta_k = 23.6\%$ (i.e., 6.5% annually). We use the CPS from 1962-2015 to estimate $\Omega = 0.43$ and $s = 0.53$ (in equation 3) following the standard procedure of regressing the variation of wage bills with the change in labor supply as suggested by the first order conditions of the representative firm (e.g., Katz and Murphy, 1992; Heckman et al., 1998).

3.1 Simulated Methods of Moments: Results

Appendix Table B1 provides a summary of the parameters that are externally calibrated. The remaining thirteen parameters of the model are estimated using simulated method of moments. We use a Sobol sequence to estimate the model in a thirteen-dimensional hypercube in which parameters are distributed

[38] Restricting the sample to those with education not missing for household head and using the latter's education level, we obtain a slightly more persistent dynamic with a determinant of 0.62 (and standard error of 0.035) instead of 0.69 (0.034).

[39] See Meghir and Phillips (2010) for a discussion of estimates of the Frisch elasticity.

[40] This reduces the proportion of students who would otherwise work full time in college, which would diminish the importance of parental transfers or of borrowing to finance education. 77% of students in our model work while in college, with an unconditional average amount of hours worked equal to 7 hours per week. According to the National Center for Education Statistics, between 50% and 82% of full-time and part-time college students, respectively, work while in college. Average hours worked are not reported, but based on the group shares (e.g., share of students who work between 10 and 19 hours) we infer that average (unconditional) weekly hours are approximately 10 for full-time students.

[41] The authors produce estimate that use child's income (0.28) and child's household income (0.34). We pick middle point between those two estimates. The authors measure household gross income (mainly) based on the 1040 tax return, thus including both labor and capital income. Consequently, to match this moment we also use agents' gross income which includes labor and asset (savings) income. They measure children's income when these are approximately 30 years old, which we replicate in our model using income in age-period $j = 8$. Whereas Chetty et al. (2014) proxy parental income during the time that children were growing up with measures of parents' income from later years, we average parental income over the periods that the child lives with their parents ($j = 8$ to 11).

uniformly and over a "large" support. This provides a global method to find potentially good combinations of parameters. Table 1 shows the estimated parameters and the corresponding moments.

Table 1: Estimation: parameters and moments

Parameter	Value	Description	Moment	Data	Model
Preferences					
μ	40.8	Mean labor disutility	Avg. weekly hours worked	31.0	30.7
δ	0.66	Altruism	Intergenerational persistence of income	0.31	0.31
School Taste: $\kappa(\varepsilon,\theta) = \alpha + \alpha_{\theta_c} log(\theta_c) + \alpha_{\theta_{nc}} log(\theta_{nc}) + \varepsilon$; $\varepsilon \sim N(\bar{\varepsilon}_{e_p}, \sigma_\varepsilon)$; $\bar{\varepsilon}_{e_p=0} = 0, \bar{\varepsilon}_{e_p=1} = \bar{\varepsilon}$					
α	60.6	Avg. taste for college	College share	0.32	0.32
α_{θ_c}	-76.3	College taste and cog. skills relation	College: cog skills slope	0.38	0.34
$\alpha_{\theta_{nc}}$	-19.5	College taste and noncog. skills relation	College: noncog skills slope	0.08	0.09
σ_ε	61.3	SD of college taste shock	College: residual variance	0.17	0.16
$\bar{\varepsilon}$	-43.5	Draw of school taste: mean by parent's education	Intergenerational persistence of education	0.69	0.69
Investment in Skill Formation: $I = \bar{A}m$					
$\bar{A}$	8.5	Productivity normalization	Average log-skills	0.0	0.0
Superstar Shock					
$\bar{\eta}$	6.11	Efficiency in superstar state	Income share top 5pct	0.33	0.32
$\bar{\pi}$ ($\times 10^4$)	2.23	Probability of entering state	Wealth share top 1pct	0.34	0.35
$\underline{\pi}$	0.34	Probability of exiting state	Wealth share top 0.1pct	0.17	0.18
Labor Income Tax: $y - \lambda y^{1-\tau} - \omega$					
λ	0.82	Tax function	Gov. Expenses/Output	0.19	0.20
ω ($\times 10^2$)	5.91	Lump-sum transfer	Income variance ratio: Disposable to pre-gov	0.63	0.63

Notes: See the text for definitions and data sources.

Recapitulating, δ relates to the degree of altruism, whereas μ is the disutility of labor. α, α_θ (vector of two parameters), $\bar{\varepsilon}$, and σ_ε relate to the distribution of school taste and its relation to skills and parental education. $\bar{A}$ is a normalization such that the average level of log cognitive skills equals zero. The parameters $\bar{\eta}$, $\bar{\pi}$, and $\underline{\pi}$ govern the productivity level in the superstar state, the probability of entering that state, and the probability of exiting the state, respectively. Finally, λ and ω relate to the government's average tax rate and redistribution of income, respectively.

As can be seen from the table, the model provides a good fit of the data. The education distribution and its correlation with skills and parental education are close to the data estimates as is the intergenerational persistence of income. Average time working is successfully matched as is the top income share and top wealth shares. Finally, the characteristics of the current tax system in the US are well matched: the share of government expenses G to GDP and the degree of income redistribution as measured by the ratio of the variances of log disposable-income and log pre-government-income match the data. The parameters imply that the cutoff level of labor income for which households receive a net transfer of zero (ignoring capital and consumption taxation) is \$14,242 or at 34% of average household income.

4 Validation

We study the validity of the estimated model in two ways. First, we contrast non-targeted model moments with data moments, choosing those that are informative of the fit of the model in important dimensions for the evaluation of a UBI policy. Second, we examine how wealth shocks and cash transfers affect labor supply and child skills in the model and compare them to results in the literature.

Table 2: Validation: Non-Targeted Moments

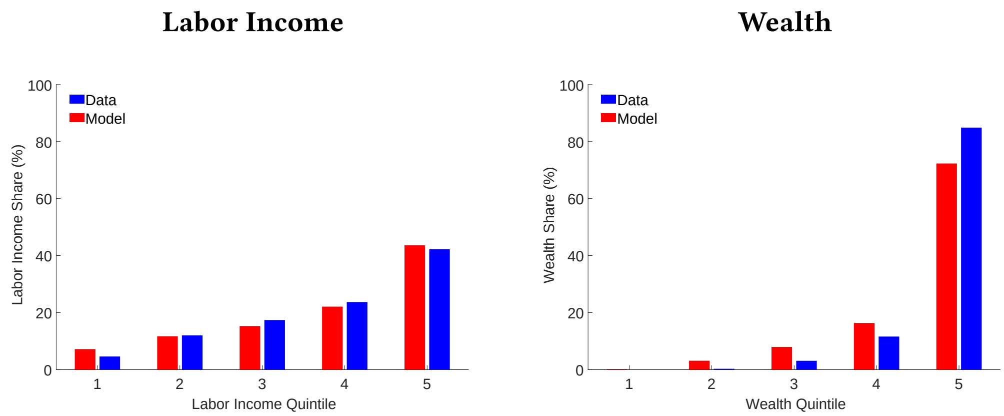
Moment	Data	Model
Investments in Children		
Avg. annual expenditures on children (Lee and Seshadri, 2019)	\$5,500–7,500	\$6,896
Expenditure ratio by parental income: middle to bottom (USDA)	1.38	1.35
Expenditure ratio by parental income: top to bottom (USDA)	2.01	1.76
Intergenerational Mobility (Chetty et al., 2014)		
Prob. of child born in bottom 20% exiting bottom 20%	66.3%	65.9%
College		
Income ratio by education: college vs high school (PSID)	1.73	1.80
Regression of child's college dummy to log-labor-income (PSID)	0.23	0.18
Avg. parental transfers as a share of avg. annual labor income (PSID)	1.44	1.55
Avg. parental transfers: ratio by child's education (PSID)	1.37	1.25
Share of college students with loans (NCES)	62–68%	68%
Share of college students with loans: high-school parent (NCES)	71–78%	82%
Share of college students with loans: college parent (NCES)	55–65%	56%
Income and Wealth Inequality (PSID and World Inequality Database)		See Figure 4
Savings		
Capital-output ratio (annualized) (Inklaar and Timmer, 2013)	≈ 3	2.9

Notes: Average expenditures on children's skills are from Figure 5 in Lee and Seshadri (2019). The ratios of these expenditures are from Lino (2008), table ES1. The bottom households earn less than \$48,500, middle is between \$48,500 and \$77,100, and top is greater than \$ 77,100 (all then converted to year 2000 dollars and halved to make them comparable to the model numbers). The probability that the child has exited the bottom quintile conditional on their parent's income belonging to that quintile is measured as in Chetty et al. (2014). The second entry in "College" is obtained by regressing an indicator for college on the log of parental labor income. The parental transfer calculations in the model exclude the top 1% of transfers. Share of students with college loans are obtained from the National Center for Education Statistics (NCES) for college graduates between the years 2000 and 2016. College loans by parental education are from 2008 and 2016 graduates (2000 graduates are not available), with ranges based on alternative education groups reported by NCES.

4.1 Non-Targeted Moments

Table 2 summarizes the first validation results, i.e., those from non-targeted moments. Average investments on children are obtained from Figure 5 in Lee and Seshadri (2019), who estimate expenditures related to children's cognitive skills, obtaining a range that varies by age. Our model-derived average

Figure 4: Validation: Income and Wealth Inequality



Notes: The labor income shares by quintile are from the cross-section of agents age 20-64. We use PSID data and compare with model estimates excluding those that obtained a superstar shock that period. Wealth shares are obtained from the World Inequality Database. In the model, we include all working-age adults.

estimate for the ages 4-16 lies within this range (see row 1 in Table 2.).

We can also examine a variety of inequality measures to see how well the model performs in this important dimension. Starting with investment in child skills, the ratio of total expenditures in these over the four periods of childhood for middle income households relative to bottom income households and the equivalent ration for top relative to bottom income households in the model can be compared with the data (from Lino (2008), table ES1). The bottom are households that earn less than $48,500, middle is between $48,500 and $77,100, and top is greater than $ 77,100 (all then converted to year 2000 dollars and halved to make them comparable to the model numbers). The model does a good job of replicating the inequality in these ratios, understating somewhat the skill investment ratio of high to low income parents. Turning to intergenerational mobility, using the same income measures for parents and children that we employed to construct the rank-rank measure of intergenerational mobility in Section 3, the probability of a child born to the bottom quintile of the income distribution of exiting this quintile matches the data very well (65.9% in the model relative to 66.3% in the data).

Next, as a measure of the skill premium we can examine the ratio of average labor income of college relative to high school workers: it is close to that found in the PSID data (1.80 vs 1.73).[42] Figure 4 also shows how the model performs in terms of labor income and wealth inequality. The model does a good job of replicating labor income shares by quintile, though the share of the bottom quintile is slightly higher than in the data.[43]

With regards to capital accumulation forces in the model, Table 2 shows that the capital-output ratio (annualized) is 2.9 in the model, which is in line with the typical estimate of 3 (e.g., Inklaar and Timmer, 2013). With regards to its distribution, Figure 4 shows that wealth is much more concentrated than

[42]This was calculated, in the data as in the model, by taking the ratio of college labor earnings to high school labor earnings at each age, and then averaging these ratios over the ages.

[43]One consideration to bear in mind, however, is that individuals may not report all their labor earnings in the PSID data, e.g., tips, self-employment income, etc. As before, we exclude those parents who receive a superstar shock in that period in the model calculations as these households are not well represented in the data.

labor income in the model, just like in the data. Although somewhat less concentrated than in the data, the model also predicts that the bottom two quintiles have almost no wealth.

We study monetary transfers by using the PSID to estimate the total transfer received on average by children between the ages of 17 and 30. This yields an estimate of $46,956 per child, equivalent to 144% of average annual labor income.[44] This estimate is similar to the one of $44,897 from Johnson (2013), based on NLSY data. Transfers from parents to child as a share of labor income is well matched in the model.[45] In addition, the degree of inequality in these transfers as measured by the ratio of transfers received by children who obtain a college education relative to those who do not is well matched. In the PSID data this is 1.37 whereas in the model it is 1.25. Lastly, we can also examine how parental income affects the probability that a child obtains a college education by regressing an indicator for college on the log of labor income of the parents, where the latter is the average annual labor income starting when the child is born until the child is 16 (using the PSID-CDS). The model and the data yield similar results: a 10% increase in income is associated with a 2.3% increase in the probability of college in the data vs 1.8 in the model.

With regards to college loans, we focus on federal loans as estimated by the National Center for Education Statistics – following the estimation of college loans described in Section 3. We find that the model is in line with the data on the share of college students with loans, the share of college students with loans given that their parents did not go to college and the equivalent proportion for those whose parents went to college.[46] All in all, this evidence suggests that the model captures well how college students finance their education.[47]

4.2 Wealth Shocks and Labor Supply

A traditionally important way in which non-labor income such as UBI can affect economic outcomes is via its effects on labor supply. As there is only limited evidence on labor supply from UBI-type policies, we rely on a broader literature to provide evidence on this elasticity. Two recent papers, both studying the behavior of lottery winners, provide valuable evidence on how a sizeable wealth shock affects labor outcomes. Cesarini et al. (2017) make use of of administrative data and studied lottery winnings in Sweden at both the individual and household level. Their administrative panel data allows them to study outcomes over a ten year horizon. They find that annual labor earnings decrease by around $1.31 dollars for every $100 dollars of post-tax lottery winnings and that this is more or less constant over time. In the context of the US, which is the most relevant for our paper, Golosov et al. (2021) also study the effect of winning the lottery on a series of economic variables using tax records with third-party reported lottery winnings. Restricting their sample to individuals between the ages of 21 and 64 and to winnings of a minimum of $30,000 (in year 2016 dollars), they employ an event study methodology that

[44] This includes small and large transfers (e.g., to buy houses or cars), in-kind transfers (i.e., college tuition), and estimates for housing costs if the child lives with the parents. See Daruich (2021) for details.

[45] We exclude the top 1% of transfers generated by the model since the data does not represent well higher incomes which presumably are associated with higher transfers.

[46] We report a range as their education measures have finer education categories than ours.

[47] As discussed previously, the model is also in line with the evidence of college students working while in college (see footnote 40).

exploits variation in the year in which lotteries were won, comparing early winners to later ones. They find immediate and large effects from winning: average annual labor earnings fall by $2.34 dollars for every $100 of post-tax lottery winnings, as measured on a per-adult (i.e., household level) – just like we calibrated our model – during the first 5 years after winning the prize.

Table 3: Validation: Labor income elasticity to wealth shocks

Change in Labor Income per $100 of Prize			
Model		**Findings: US**	**Findings: Sweden**
Average Prize	**Distribution of Prizes**	**Golosov et al. (2021)**	**Cesarini et al. (2017)**
-$1.92	-$2.20	-$2.34	-$1.31

Note: The effect of (post-tax) lottery prizes on pre-tax labor income is calculated for a representative sample of adults in the model (excluding those who wouldn't have worked even without winning lottery). Column 1 awards the average post-tax lottery prize; column 2 awards different prizes (the average of each of four ranges) with the distribution across ranges as reported by Golosov et al. (2021). The third and fourth columns report the estimates from US and Swedish data by Golosov et al. (2021) and Cesarini et al. (2017), respectively. Each row reports the average reduction in labor income per $100 of lottery prize. All taxes and prices are kept unchanged.

We can examine the effects of a lottery using our model by studying the labor market responses over one period (4 years) from awarding lottery prizes to a random sample of agents between the ages of 20 and 64.[48] We perform this exercise in a partial equilibrium setting as these prizes affect only a very small proportion of the population and hence do not change prices or taxes. As shown in Table 3 column 1, when adults win the average (post-tax) lottery prize of $131,689 (in 2000 dollars), they reduce their labor earnings on average by $1.92 for every $100 of post-tax lottery winnings. We also experimented with giving individuals a wider range of prizes using the distribution of winners into the four ranges reported in Golosov et al. (2021) and assigning each range the mean prize for that interval.[49] This exercise, reported in column 2, yields a larger response of $2.20 for every $100 of post-tax lottery winnings. As can be seen, these figures lie between those of the two papers (though closer to US estimates) and demonstrate a substantial response to a wealth shock. Thus, we conclude that our model generates labor supply responses that are in line with the findings of the lottery literature.

We can also use findings from Blundell and MaCurdy (1999), which summarize an older labor supply literature and report (see their Table 1) that the median income elasticity of labor supply to non-labor income (based on 22 alternative estimates for men) is -0.07, with the 10^{th} percentile and 90^{th} percentile of these estimates being -0.29 and -0.01. We estimate the (non-labor) income elasticity of labor supply by providing a cash transfer equivalent to $1,000 per year to all households, keeping prices and tax rates fixed at their steady-state values. Given that the empirical estimates in the literature are obtained from environments that vary in the duration of this additional non-labor income, we run the simulations for three alternative durations: one period (or 4 years), five periods (20 years), and for the remainder

[48] We do not give prizes to agents that would not work even without winning the lottery as Golosov et al. (2021) restrict the sample to agents who worked the two preceding years. That excludes agents who are retired, received an out-of-work shock, or were very wealthy.

[49] We thank the authors for sharing the distribution of post-tax lottery winnings (equivalent to their Table A.1 which reports pre-tax winnings).

of life. In all cases the introduction, but not the duration, of the non-labor income is unexpected by the agents. We then compute, for each agent, the labor supply elasticity as the ratio of the percentage change in hours worked to the percentage change in non-labor income in the first period in which the policy is introduced. Table 4 reports moments of the distribution of labor elasticities obtained from the simulations. The model produces labor elasticities between -0.15 and -0.01, all within Blundell and MaCurdy (1999) range. In conclusion, we find that the labor supply elasticities in the model to both wealth shocks and non-labor income are in line with the empirical evidence.

Table 4: Validation: Income Elasticity of Labor Supply in the Model

	Based on $1,000 per year for:		
	One period (4 years)	**Five periods (20 years)**	**Rest of life**
Mean	-0.014	-0.051	-0.063
Median	-0.012	-0.043	-0.054
10^{th} percentile	-0.026	-0.092	-0.109
90^{th} percentile	-0.005	-0.021	-0.028

Note: Labor supply elasticity from an extra $1,000 per year of non-labor income at constant prices and taxes. See text for details.

4.3 Cash Transfer Program and Child Skills

UBI may also have important dynamic effects by changing how much parents – particularly those who have low income and are more likely to be borrowing constrained – invest in children's skill formation. We use the findings of Dahl and Lochner (2012) who estimate the effect of income on children's skill development using changes to the Earned Income Tax Credit (EITC) as exogenous sources of income variation. The changes led low-income families to see an increase of up to $2,100 of disposable income per year. Using an instrumental variables strategy (which uses the change in EITC to predict income based on past income), they estimate the causal effect of income on children's math and reading achievement. Their baseline estimates imply that a $1,000 increase in income raises combined math and reading test scores of children by 4.11 percent (+/- 2.57) of a standard deviation in the short run.[50]

We introduce a similar policy in the steady-state of the model, by giving agents an extra $1,000 per year (i.e., an extra $4,000 per period) during the periods that children reside with their parents (i.e., adult periods 8 through 11 or child periods 1 through 4). Since the EITC only affected a relatively small group of families, we keep all prices unchanged, including tax rates, at their original steady-state levels. We assume that the policy is unexpected and that agents know that the policy is in effect for only one generation. We evaluate the policy on the children of the targeted generation.[51]

Table 5 reports the predicted effect on children's cognitive skills in the simulated model for families with different levels of annual income. The model predicts that the cognitive skills of children whose parents' annual income is less $30,000 would increase between 1.1-2.8 percent of a standard deviation, within the range estimated by Dahl and Lochner (2017). Effects are even larger for the out-of-work

[50]See Table 3 in Dahl and Lochner (2017) for the (corrected) results.

[51]This assumption, in addition to being reasonable, simplifies the evaluation since it implies that we do not need to solve a full transition exercise (since children's value functions for a given set of state variables are unchanged).

Table 5: Validation: Cash Transfers and Cognitive Skills

Dahl and Lochner (2012)	Model: Effect by Annual Total Income (in $1,000)						
	Out of work	<= 10	<= 20	<= 30	<= 40	<= 50	> 50
1.54–6.67%	8.1%	2.75%	2.00%	1.1%	0.82%	0.66%	0.00%

Note: This table reports the change in a child's cognitive skills (as a percentage of a standard deviation) from a transfer of $1000 per year ($4000 per period) to parents, as a function of a parent's total income. The numbers reported in the first column (Dahl and Lochner) are the corrected numbers presented in Table 3 of Dahl and Lochner (2017). The empirical estimate represents the 95% confidence interval given by the point estimate of 4.11% +/- 1.96 x std. dev. of 1.31%. See the text for details.

agents in our model, with an increase in children's skills of 8.1%. Note that their study could not estimate how the additional income affects families with higher incomes since the change in EITC mostly impacted households earning below $25,000 a year. It is easy, however, to study this with the model simulations. Reassuringly, as reported in the table, the effect of the additional income decreases with family income, becoming close to zero around $50,000. We conclude that the model generates results in keeping with Dahl and Lochner (2012), a fact that lends credibility to the model predictions regarding the consequences of a UBI policy.

5 UBI Benchmark Policy Evaluation

In this section we introduce the UBI policy as a lump-sum transfer made every period to all individuals once they become adults (i.e., an increase in ω above its initial level) and financed by changing the average labor tax parameter (λ) to keep the budget balanced every period.[52] The benchmark analysis considers a particular level of UBI that has been suggested by policy makers and is currently being tested in a short-run small-scale environment by the YC Research group in Oakland, California. We assume that every adult (ages 16-79, periods $j = 5$ to $j = 20$) receives the equivalent of an annual transfer of $8,000, equivalent to 18.0% of the pre-UBI steady-state GDP.[53] Section 7 considers a variety of alternative environments, including alternative sizes of UBI and ways to finance it.

We assume that the policy is introduced unexpectedly at the beginning of some period t (denoted by $t = 0$), after individuals have received their shocks for that period (e.g., their labor productivity shock, child's skill shock, and taste shock) and parents have made their transfer, but prior to individual decisions for that period. We examine the dynamic consequences of such a policy, analyzing how it affects inequality and the welfare of different cohorts by taking into account intergenerational dynamics as well as general equilibrium effects through prices and taxes.

[52]The government is assumed to have a constant amount of expenses G. Although we could allow the government to run a deficit, this opens up the question of whether welfare gains could not have been achieved simply by doing so independently of the UBI policy. As we are not conducting an optimal tax exercise, we think that ignoring this option is best.

[53]Recall that these are year 2000 dollars. This is equivalent to $1,000 per month in 2020 dollars and the number proposed, for example, by Andrew Yang in his 2020 presidential campaign. It is also the amount evaluated by Hoynes and Rothstein (2019) and by some structural macro papers such as Golosov et al. (2021) and Luduvice (2021). To obtain the cost of UBI as a share of GDP, we calculate $\frac{\$8,000 \times 0.8}{\$35,639} = 18.0\%$, where 0.8 is the share of individuals who receive UBI and $35,639 is the GDP per capita in the initial steady state (also equal to total GDP since the mass of individuals is normalized to one).

5.1 Aggregate and Distributional Effects

Figure 5 shows the effects of the UBI policy on a series of key variables and outcomes over the transition to the new steady state. As shown in (iv) of Figure 5, this requires an initial large increase in average marginal labor-income tax rate of 28.6 percentage points which, over time, increases by an additional 6.1 percentage points; the average labor tax rate (computed as the revenue from labor taxation divided by total labor income) increases by a similar amount.

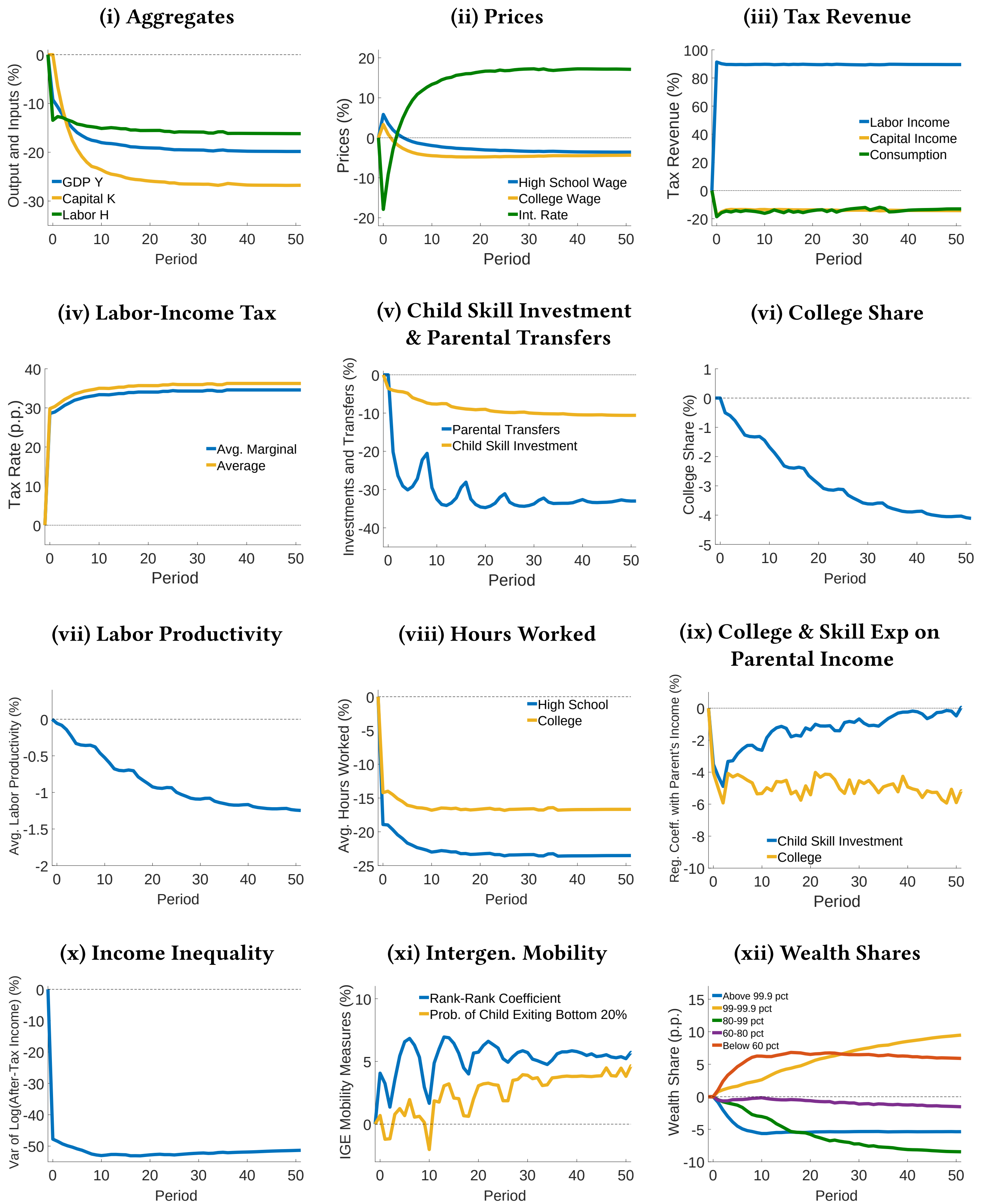
Starting with the aggregate variables depicted in (i), note that GDP declines over time due to the fall in both capital and aggregate efficiency units of labor time supplied (H). In the new steady state, GDP is 19.9% lower. Half of the decline is due to the fall in the capital stock (of 26.9%) and the remainder to the fall in H (which recall that includes skills, education and hours worked). As GDP falls, UBI expenses become a larger share of the latter, reaching 28.0% of GDP in the new steady state.

It is useful to distinguish between variables that change relatively quickly versus those that take more time to affect the economy. In the first category, hours worked both by college and high school workers (see viii) fall sharply and immediately before slowly converging to their new steady-state level where they are 16.7% and 23.4% lower, respectively. K also falls fairly rapidly, becoming significantly smaller in the new steady state. The counterpart of these changes can be seen in (ii): the interest rate first falls due to the large decrease in labor supply, but then increases as the K to H ratio declines due to the greater decrease in capital over time. They are also reflected in the large changes in the composition of tax revenue. As changes in the government budget are accommodated via changes in labor taxation (via λ), the fall in capital (and consumption), in addition to hours worked and productivity, require a very sharp increase in revenue from labor taxation. Note from (iii) that these revenue responses remain fairly constant throughout.

Turning next to more slowly moving variables, parental investment in child skills m is reduced by 5.9% for the generation born when the UBI policy is introduced, and these reductions become even larger (11.5%) in the new steady state (see v). The share of college agents in each new cohort (vi) falls by 0.2 percentage points for the cohort born when UBI is introduced and by 1.4 percentage points in the new steady state – a 4.3% decrease. Appendix Figure F1 shows that the return to college, measured using the net-present value of after-tax income differences per dollar invested in college, decreases dramatically after UBI is introduced because of the change in tax rates. Over time (as shown in vii) this reduces the average productivity of each new born cohort as measured by the cognitive skills component in an agent's efficiency units (i.e., by $\psi^e = e^{\lambda^e \log(\theta_c)}$ averaged over the indicated cohort).

UBI leaves almost unchanged the cutoff at which households receive positive net transfers from labor taxation (ignoring asset and consumption taxation), going from \$16,912 in the initial state (or 40% of average income in the initial steady state) to \$16,578 in the new steady state (or 49% of average income in the new steady state). The changed distribution of income, however, implies that whereas in the original steady state, 19.5% of the adult population received positive transfers, with UBI this is dramatically larger: 35.9% in the new steady state. The distributional consequences of UBI are more positive, as it reduces both cross-sectional and intergenerational inequality. As shown in (ix) of Figure

Figure 5: Benchmark UBI: Dynamic Response



Notes: The numbers in the y axes of all figures, except for (iv) and (xii), are in percentage changes from the initial steady state. The 0 in the x axes refers to the period in which the policy is introduced. See text for details.

5, a regression of total parental investment in child skill formation (m) on parental income decreases the coefficient on the latter by 5.0% in the short run, but then increases over the transition to be only 0.1% lower in the long run. As can be seen in (ii) of Figure 6, this is because the reduction in investments in child skills is concentrated in the middle of the parental income distribution, with smaller effects on the extremes. The equivalent regression exercise with college as dependent variable shows that the coefficient decreases by 5% in the short run and by 6.8% in the long run. Figure 6 (iii) shows that the fall in college share discussed previously is concentrated among children who receive parental transfers.[54] Children without such transfers are more likely to go to college, suggesting that UBI may help alleviate children's borrowing constraints.[55]

The total effect of these changes are reflected in the substantially reduced after-tax income inequality as measured by the cross-sectional variance of the latter (see x), which falls by 48% as soon as the policy is introduced and then slowly decreases to a final value of 50.5%. Figure 6 (i) shows that after-tax labor income is much more equally distributed after UBI is introduced, resulting especially from the reduction in income at the top of the distribution. The change in intergenerational mobility, on the other hand, is less dramatic.[56] The rank-rank coefficient on gross income (used by Chetty et al. (2014) and multiplied by -1 so that an increase signifies less dependence on parental income rank) for each cohort of children born after the policy increases by 1.4% at $t = 0$ and by 4.8% in the new steady state (xi).[57] Also shown in (xi) is the increased probability of a child born to parents in the bottom 20% exiting it. This increases from 66.1% to 69.1% in long run. Lastly, as shown in (xii), wealth inequality changes in non-monotonic ways: the top 0.1% decreases its share, the next 0.9% substantially increases its share as does the bottom 60%. This may be the result of the higher tax rate on super-star after-tax income which reduces it substantially and hence decreases the ability of those agents to accumulate large asset positions whereas agents in the lower half of the distribution accumulate more assets given the direct effect of UBI on their income and the more compressed income distribution.

5.2 Welfare

To summarize, UBI substantially decreases various measures of inequality but also skills, education, time worked, and capital accumulation. Ultimately, we are interested in understanding how the policy impacts welfare. We next turn to answering this question.

We can provide a summary measure of welfare under UBI by measuring consumption equivalence for various cohorts and aggregating these to obtain, by cohort, an average welfare measure of the latter

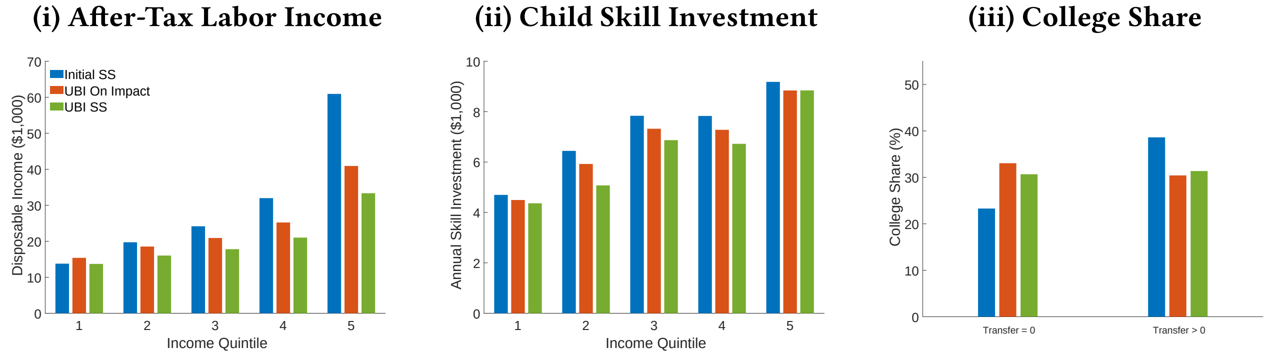
[54] 44% of agents receive zero transfers in the original steady state and this share increases to 63% under UBI (63%).

[55] Note that this effect takes place "on impact" as well, i.e., for the first cohort of children who receive UBI and need to make college decisions but whose parents have already made transfers to them before UBI was introduced. See Appendix Figure F2 for the effect of UBI on college outcomes across various potential college determinants and for additional conditional distributions for college determinants.

[56] All intergenerational mobility numbers are calculated using parental income averaged over the periods that the child lives with their parents ($j = 8$ to 11) and child's income measured at $j' = 8$.

[57] The graph of intergenerational mobility is especially jagged because this coefficient reflects the incomes of two generations. Take, for example, the cohort born when the policy is introduced (cohort 0). Their parents spent a large part of their lives in an economy without UBI whereas cohorts born further on in the future will have parents (and, eventually and indirectly, grandparents) who are also born in a world with UBI with its attendant effects on skills, education and prices.

Figure 6: Benchmark UBI: Distributional Effects



Notes: This figure reports the effect of UBI in the first period it is introduced ("On Impact"), in the new steady state and, for comparison, in the pre-UBI steady state . After-tax labor income is labor income after labor taxes and transfers. Child skill investment refers to the average annualized m and is by quintile of total parental income. College share is reported separately for those with zero transfer and those with strictly positive parental transfers.

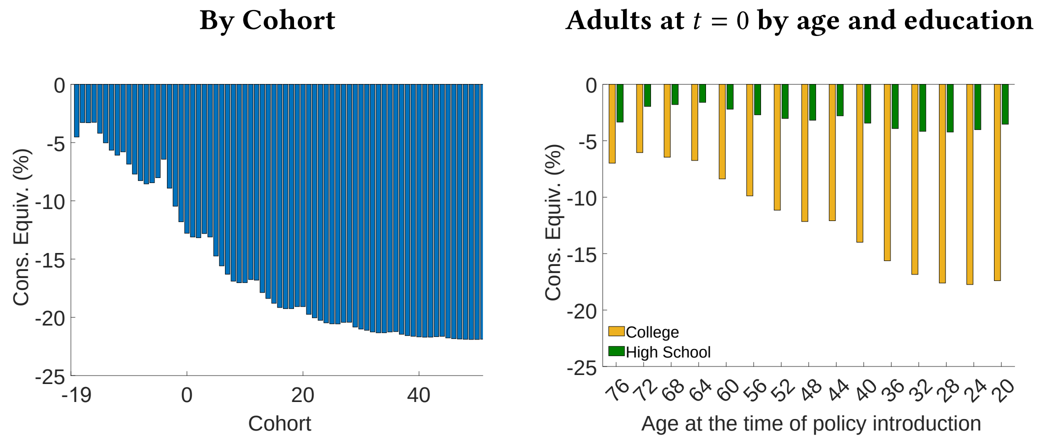
(See Appendix C for details). The left panel of Figure 7 shows the average welfare gain from the benchmark UBI policy for different cohorts where the y-axis measures the percent by which – in consumption equivalence units – the UBI policy is preferred to the original steady state. Cohort 0 is the first cohort born when the policy is introduced. Cohorts to the left of zero (that is, until negative 19) are the cohorts who were already alive when the policy was introduced; cohorts to the right of zero are those born after the policy is introduced. For adult cohorts (those strictly to the left of -3) we show average welfare gains by cohort. For all other cohorts, we calculate welfare gains under the veil of ignorance.[58]

As shown in Figure 7, UBI has negative welfare consequences for all cohorts, both those alive when the policy is introduced and those born later. Given the choice between being born in the steady state of an economy with or without UBI, an individual would be willing to sacrifice over 22% of consumption to remain in the non-UBI economy. Agents who are adults when the policy is introduced (i.e, those of period age $j = 5$ to 20) have an average welfare loss of 6.0% in consumption equivalent units. The right-hand panel of Figure 7 further explores the heterogeneity in welfare consequences by differentiating each age (cohort) by their education status. As can be seen in the figure, among agents who are adults when the UBI policy is introduced, both college and high school agents lose on average, with generally larger losses for younger cohorts across both education groups and for college workers in general. Only 26.5% of all adults (i.e., individuals from cohorts -4 to -19) would favor the introduction of UBI.

We can investigate further the heterogeneity in welfare from UBI for cohorts that are adult when the policy is introduced. For each age group, agents are placed into low (below 25th percentile), middle (25th to 75th), and high (above 75th) groups, according the their age-adjusted asset holdings. We can also perform the same division by skill level and by education (in the latter, distinguishing by high school vs. college). The consumption equivalent welfare changes from UBI are reported in Table 6. As shown, there are large losses from UBI for adult agents independently of their age-adjusted asset

[58]Note that cohorts -1 to -3 are alive when the policy is introduced. To reduce the computational burden, we calculate their welfare change under the veil of ignorance (i.e., under the assumption that the agent obtains a random draw from the equilibrium distribution of the state variables $(\theta, \hat{a}, \kappa)$, which varies by cohort).

Figure 7: Welfare Dynamics of UBI



Notes: Welfare gain (as measured by consumption equivalence) from the introduction of UBI for different cohorts. In the left-hand figure, cohort 0 is the one born the period in which the policy is introduced. A cohort with a negative number indicates that it was born that (absolute) number of periods prior to the introduction of the policy whereas a positive number indicates a cohort that will be born that number of periods after the policy is introduced. The right-hand figure depicts welfare changes for different cohorts (here indicated by their age at the beginning of period 0) and by education. See the text for details.

Table 6: Heterogeneity

	Low	**Middle**	**High**
By Wealth (within age)	-5.6%	-5.8%	-6.6%
By Skills (θ_c)	1.7%	-6.1%	-13.2%
By Education	-3.1%	–	-11.9%

Notes: Average welfare gains for adult agents at $t = 0$. For wealth and skills, low is below the 25th percentile, middle is between 25th-75th percentiles, high is above 75th percentile of variable. For education, the two categories refer to high school and college.

category, and there are significant losses across both education categories but especially for college agents. For the cognitive skill groups, those with lower cognitive skills gain from UBI but those with cognitive skills in the middle category and especially those in the upper quartile lose significantly.

We next turn to understanding the role of various factors in producing welfare losses.

6 Understanding the Welfare Effects of UBI

To understand the welfare consequences of UBI, we perform the following exercises. First, we study mostly steady-state welfare and examine partial and general equilibrium consequences of UBI. Second, we perform a novel comparison of adjacent cohorts who differ only as to which elements of their state variables were determined pior, as opposed to after, UBI is introduced. This allows us to better understand the reaction and importance of skill investments and parental transfers. Third, we perform a decomposition of the steady-state welfare losses, allowing us to calculate the contribution of endogenous intergenerational links. Lastly, we delve deeper into the heart of the dynamic mechanisms by modifying the model so that (i) endogenous parental skill investment is replaced by a fixed transition matrix and, (ii) the endogenous equilibrium capital market is replaced by an exogenous one.

6.1 Welfare Analysis: Incentives, Taxation, and General Equilibrium

How does UBI affect welfare? First, UBI provides a floor to how low income can fall, which is especially useful for poorer agents with high marginal utility of consumption. It does this directly via the transfer but also indirectly by increasing agents' ability to borrow against future income. UBI therefore allows agents to decrease their consumption variance and permits them to transfer more and invest more in their children, if they so wish. It also allows them to decrease their precautionary savings. A second effect on these variables comes from the higher taxes needed to finance UBI. Lastly, there is a third effect arising from general equilibrium consequences from these outcomes. Below we distinguish among these in order to understand how these channels affect welfare.

In order to quantify the importance of these channels, Table 7 reports the results from several exercises that shed light on their significance. The first two rows report the effects of UBI in what we call "the short run." In this exercise, only one cohort obtains the UBI benefit (which starts at age $j = 5$). This cohort understands that only they will be provided with the UBI benefit and thus that over time the economy will transition back to its original steady state. Throughout this exercise, prices are maintained at their original steady-state level. Furthermore, to distinguish between how incentives change simply as a result of having greater income via UBI and those introduced as a result of higher taxes, the first row keeps tax rates unchanged (hence the budget is not balanced) whereas the second row requires the cohort receiving UBI to pay for it via higher taxes (for only that cohort).[59] In this sense, the first exercise resembles the validation exercises conducted in section 4 that examined the effect of winning the lottery on labor supply and of a cash transfer on children's skills.

Table 7: UBI: From Short-Run PE to Long-Run GE

Alternative Exercises			**Change from Initial Steady State (%)**												
Budget Balanced	**Long Run**	**GE**	**Skill Inv.** m	**Parental Transfers**	**Labor Prod.**	**College**	**Capital**	**Hours Worked**	**Income Inequality**	**Wage** w_0	**Wage** w_1	**Rate** r	**Welf. Adults**	**Welf. SS or Children**
No	No	No	6.7	57.3	0.3	0.9	5.1	-9.6	-3.1	–	–	–	27.3	8.4
Yes	No	No	-3.2	-48.8	-0.1	-0.4	-26.3	-17.1	-4.1	–	–	–	-4.0	-5.7
Yes	Yes	No	-14.2	-65.9	-1.6	-5.3	-58.4	-20.4	-57.0	–	–	–	-7.4	-28.6
Yes	Yes	Yes	**-11.5**	**-32.2**	**-1.3**	**-4.3**	**-26.9**	**-21.3**	**-50.5**	**-3.5**	**-4.2**	**16.6**	**-6.0**	**-22.3**

Notes: The column "Long Run" indicates whether the variables, including welfare measured in consumption equivalence units, are from the stationary equilibrium obtained under the experiment conducted in the text. Budget balance indicates whether taxes are changed to keep the budget balanced and GE refers to general equilibrium price effects. See text for other definitions.

As seen in the table, when only one cohort receives UBI and there are no tax consequences, the cohort reacts by working less and by increasing children's skills investments and parental transfers in order to share their good fortune. UBI's effect on inequality in the children's cohort, as measured by their post-tax income, however, is relatively small (-3.1%), suggesting that the increase in parental investments is not the main driver of the reduction in inequality. As shown in the second row, however, once the cohort is burdened with the tax consequences of UBI, both that cohort and their children

[59] Note that this exercise overstates the tax burden of UBI as taxes (and their benefits) are normally borne by all in the economy which allows younger agents – who earn less in general – to pay a smaller share of taxes which will then be balanced by paying a larger share when they become older. This intertemporal tax-burden sharing is not feasible when only one cohort is paying, in each period, the cost of UBI.

are made worse off. Their capital stock (not the economy-wide one) falls by 26% whereas when they did not face taxes this increased by 5%.[60] Hours worked fall by twice the amount and now transfers are dramatically reduced by almost 50%. Investment in skills decline and results in a smaller share of children choosing college. Overall, both the cohort's and their children's welfare is negatively impacted.

The third row introduces the full dynamic effects of UBI but in a partial equilibrium environment. All cohorts receive UBI which must be funded, as in the full UBI model, via greater labor taxation to balance the budget by taxing all adults (rather than one cohort). In the new steady state capital falls almost 60%, decreasing capital tax revenue by the same percentage. This requires further large increases in labor taxation and, consequently, investments in and transfers to children fall substantially, resulting in a lower proportion of college workers and lower productivity. Welfare of adult cohorts and in steady state is much lower: adults would be willing to sacrifice 7.4% of consumption and agents born in the new steady state would sacrifice almost four times that amount. Inequality is dramatically reduced, showing the importance of higher taxes and income transfers in achieving this result.

Finally, the fourth row reports the full steady-state effects of the UBI policy by incorporating the general equilibrium price changes. The general equilibrium effects of a higher interest rate mitigate the negative effects of taxes on capital accumulation through greater asset income and by increasing the incentive to save. The fall in tax revenue from the decline in capital is consequently much smaller due to both the smaller drop in K and the accompanying rise in r, resulting in capital tax revenue declining by around 10 percent (instead of the 60% of the partial equilibrium exercise). Wages drop for both college and high school agents, but the fall in transfers and investment in children skills is less than before, leading to a smaller fall in labor productivity. Overall, welfare both for current adults and for agents born in the new steady state is higher than without the general equilibrium effects.

To summarize, longer-run dynamics almost double the welfare losses for current adults and more than quadruple them in steady state. As is often the case, general equilibrium effects dampen these welfare results, by about 20 percent in our case.

6.2 Intergenerational Linkages: Young Cohorts During the Transition

The welfare analysis clearly shows that the negative consequences of UBI grow over time. We can examine the role of intergenerational linkages in producing these outcomes by studying how adjacent cohorts fare with UBI. These cohorts differ by which state variables were determined prior versus after UBI was introduced. Cohort zero denotes the cohort born when the UBI policy is instituted. This is the first generation in which all the individual state variables are determined within the new UBI environment. Cohort -3 was born 3 periods before the UBI policy. Thus its skills (θ) were in large part determined prior to $t = 0$ as parents had already invested in forming their skills for three of the four skill-formation periods, but neither parental transfers nor college decisions have been made. Cohorts -4 and -5 were born 4 and 5 periods before $t = 0$ and thus have pre-determined state variables $(\theta, \hat{a})$ and $(\theta, \hat{a}, e)$, respectively, at $t = 0$. That is, cohort -4 has yet to decide on college whereas cohort -5 has already made its college decision and is the last cohort to have all its state variables determined prior

[60] We calculate the capital stock of the cohort as the average assets a over each period of their lives.

to the imposition of the UBI policy. How each cohort fares allows us to have an understanding, albeit imperfect, of the importance of intergenerational links in the transition to the new steady state.[61] The column on the far right denoted "steady state" indicates that all variables are for individuals born in the new steady state of the economy with UBI. Comparison with the values of the variables in that column give an idea of how much of the transition has happened in the first few periods after UBI is introduced.

Table 8 reports the change in key variables for various cohorts, all measured relative to the initial steady state and averaged for each cohort. As can be seen in the table, the first cohort that can be affected by UBI in the totality of its state variables – cohort 0 – suffers a decrease in investment in their skills and a large drop in parental transfers. The decrease in investment in child skills is more than 50% of the decrease in the new steady state and the fall in parental transfers is similar to that of cohorts born in the new steady state. This economy is still richer (in both capital and human capital) than in the steady state, hence taxes are lower. The fall in consumption-equivalent welfare is consequently smaller than its new steady-state value (about 57% of its final decrease). Next, comparing cohort 0 with cohort -3, we see that the having almost complete parental investment in child skills is important: that cohort's fall in labor productivity is smaller and its decline in welfare is about 30% smaller.

Table 8: UBI: Outcomes for Various Cohorts

	Cohort				
	-5 (Fixed $\theta, \hat{a}, e$)	**-4 (Fixed $\theta, \hat{a}$)**	**-3 (Almost Fixed θ)**	**0**	**Steady State**
Skill Investment (m) (%)	0.0	0.0	-0.8	-5.9	-11.5
Parental Transfers $\hat{a}$ (%)	0.0	0.0	-20.1	-30.1	-32.2
College (%)	0.0	-0.5	-0.6	-1.3	-4.3
Labor Productivity (%)	0.0	-0.1	-0.1	-0.3	-1.3
Consumption Equivalence (%)	-8.0	-6.4	-8.9	-12.8	-22.3

Notes: All the numbers reported are in percentage change relative to a cohort born in the initial steady state. Cohort 0 is the cohort born the period in which the UBI policy is introduced. A cohort with a negative number indicates that it was born that (absolute) number of periods prior to the introduction of the policy whereas "Steady State" refers to the cohort born in the new steady state after the policy is introduced. Labor productivity refers to the value of $e^{\lambda^e \log(\theta_c)}$.

Turning next to cohort -4, note that this cohort has its childhood skills fixed and has received both its taste shock and parental transfer prior to the imposition of UBI and right before making its college decision. It is interesting to note, however, comparing cohorts -3 and -4 (who almost do not differ in their skills but receive very different parental transfers), that the reduction in the college share and productivity is very similar. This may be due in part to the direct and indirect (looser borrowing constraints) effects of UBI which allow the younger cohort to have a similar college profile despite the lower average parental transfers. Cohort -4 has almost 30% smaller welfare losses than cohort -3 as it does not suffer the 20% drop in parental transfers.

[61]Imperfect because each cohort lives a different fraction of its life in the new environment which is also changing as the economy transitions to the new steady state. In this sense, studying adjacent cohorts is similar to performing an "event" study in the empirical labor/macro literature in which one compares a cohort too old to be affected by a policy change to one that is affected (e.g., mandatory high-school education).

Lastly, turning next to cohort -5, it is interesting to note that welfare losses are not monotonic over the cohorts. In particular, although cohort -5 has higher skills and parental transfers on average than cohort -3, it suffers almost as large a welfare loss as does that the younger cohort and a substantially larger welfare loss than cohort -4. This is due to the fact that its college education decision was taken prior to UBI and the higher taxes make college less valuable than before whereas higher interest rates increase the return to asset accumulation and make debt more expensive. Thus, it is primarily the lower return to college (higher taxes and interest rates) and the greater opportunity cost of its price (forgone savings) that is responsible for the welfare differential.

The differences in welfare losses across cohorts -4, -3 and 0 highlight the importance of intergenerational linkages. For cohort -4, parents cannot reoptimize and change their skill investment and transfer when faced with UBI. This benefits that cohort: its welfare losses are substantially smaller – by 6.4 percentage points – than those of cohort 0 (the first cohort for which parents are able to fully readjust skill investment and transfers). For the intermediate cohort that has almost fixed skills but for which parental transfers can be reoptimized (i.e., cohort -3), welfare losses are 3.9 percentage points smaller than those suffered by cohort 0, i.e., a bit under two thirds of the 6.4 percentage points difference. Thus, roughly a bit under two thirds of the welfare losses stemming from intergenerational linkages are due to parental investment in skills with the remaining part driven by parental transfers.

6.3 UBI Welfare Changes: A Steady-State Decomposition

To understand further the sources of steady-state welfare losses from UBI the following decomposition is instructive. Changes in welfare arise, necessarily, from two sources: (i) changes in the value of an agent at each state $V_{j=5}(a, \theta, \varepsilon)$, and (ii) changes in the distribution over those states $\mu_{j=5}(a, \theta, \varepsilon)$.[62] The changed distribution of $\mu_{j=5}$ is the result of endogenous parental decisions of skill investment and monetary transfers $\hat{a}$. Thus, one way to gauge the quantitative importance of these is to recalculate welfare gains by keeping $V_{j=5}$ constant at their original steady-state values (i.e., from the economy without UBI) but changing the distribution $\mu_{j=5}$ to the one in the new steady-state with UBI, $\mu'_{j=5}$. Performing this calculation yields a welfare loss of -10.6%, i.e., 47% of the total losses of 22.3 percent.

Alternatively, we can keep constant the original distribution $\mu_{j=5}$ and change the original steady-state $V_{j=5}$ to those of the steady state economy with UBI: $V'_{j=5}$. This yields welfare losses of -12.4%, i.e., 56% of the total losses, pointing to the importance of the welfare losses coming from the lower capital stock, higher taxation, and the accompanying GE effects.

6.4 Understanding the Mechanisms

The preceding exercises make clear that dynamic mechanisms play an important role in producing the welfare outcomes. When UBI is introduced, the economy needs to increase tax revenue by 59% in order to fund the related expenditures. As noted previously, labor supply, capital and, more slowly, investment in children skills fall in response to declining post-tax income and higher labor taxes, requiring further increases in labor income taxation to respond to the resulting shortfall. We now investigate in greater

[62]The $j = 5$ in the value function serves as a reminder that this is the period-age when agents become adults.

depth the role played by the reductions in skills and in the aggregate capital stock.

The first row of Table 9 reproduces the changes in the main variables from the steady state of the benchmark economy to the steady state of the UBI economy as well as the (utilitarian) welfare change of $t = 0$ adult cohorts. In the subsequent model experiments, the changes are reported with respect to the steady state of the modified model without UBI (which always keep all other parameter values unchanged from the benchmark model).

Table 9: UBI: The Roles of Endogenous Skills and Capital

	Change from Initial Steady State (%)											
	Skill Inv. m	**Parental Transfers**	**Labor Prod.**	**College**	**Capital**	**Hours Worked**	**Income Inequality**	**Wage** w_0	**Wage** w_2	**Rate** r	**Welf. Adults**	**Welf. Steady State**
Benchmark Model	-11.5	-32.2	-1.3	-4.3	-26.9	-21.3	-50.5	-3.5	-4.2	16.6	-6.0	-22.3
Fixed Skills	–	-34.6	-0.0	-0.4	-25.7	-21.9	-51.3	-2.5	-5.3	16.4	-5.9	-12.6
Fixed Capital	-4.3	-52.7	-0.4	-1.2	–	-15.2	-46.7	5.1	3.8	–	2.4	-4.2
Fixed Skills & Capital	–	-51.7	-0.0	-0.0	–	-16.0	-47.4	5.6	3.4	–	2.7	-0.8

Notes: The first row reports the steady-state effect of UBI in the benchmark model as shown in Section 5. The second and third rows report the steady-state effects of UBI in models when skills and capital, respectively, are exogenously determined. The last row keeps both skills and capital exogenously determined. See text for details.

We continue the exploration of intergenerational links by modifying the baseline model to eliminate the dependency of child skills on parental investments. We introduce an exogenous transition matrix that gives each child a draw from the original steady-state distribution of skills corresponding to their parents' education and skill level.[63] As can be seen in row 2 of Table 9, the welfare consequences for adults remain similar, but the long-run welfare consequences are dramatically different: the welfare losses are 56 percent smaller than with endogenous skill formation. Interestingly, the share of college workers barely changes from its original steady-state level and given the constant overall distribution of skills, labor productivity remain basically unchanged. We conclude that the endogeneity of skill formation plays an important role in the welfare consequences for future generations but the fact that change takes place slowly over cohorts reduces the importance of this factor for current adults.

The capital stock adjusts more rapidly than workers' productivity as the latter is modified by only one generation per period and thus changes slowly in aggregate terms. To explore the importance of capital dynamics, we modify the baseline model such that the aggregate capital stock and interest rate are kept exogenously constant at the steady state of the pre-UBI benchmark model, thus keeping capital tax revenue unchanged as well.[64] Agents are still able to borrow and save (at the original steady state interest rates), but these decisions do not affect the aggregate capital market outcomes (i.e., as if borrowing/saving from external capital markets). As can be seen in the welfare results of row 3 of Table 9, a fixed capital stock and interest rate radically changes the implications of UBI. Adults now gain on average from UBI and the welfare losses in the new steady state are less than a fifth of what they were previously. The constant capital tax revenue requires a smaller increase in labor taxation in response to UBI and the constant capital in production permits wages to increase, thereby reducing significantly the prior decline in hours worked, parental investment in child skills, and the share of college workers.

[63] Although the model is not reestimated, Appendix Table F1 shows that it provides almost as good a fit of the moments used in the estimation of the benchmark model. Note that college remains a choice variable in the modified model.

[64] This model is, by design, exactly observationally equivalent to the steady state of the pre-UBI benchmark model.

Lastly, we can introduce both model modifications simultaneously.[65] As shown in row 4 of Table 9, relative to keeping only the capital stock and interest rate fixed, these modifications increase the welfare of adults by only a bit (0.3%) relative to the exogenous capital only model, but the two together have a relatively large impact on steady-state welfare, reducing the decline in welfare by another 80% to 0.8% instead of 4.2% in the preceding exercise.

The above analysis allows us to conclude that the endogeneity of both capital and child skills are quantitatively important in determining the welfare consequences of UBI both for the adults at the time the policy is introduced and for the long run. Any analysis that abstracts from these mechanisms will be missing important channels through which UBI and other tax and transfer policies impact welfare.

6.5 A Mirrleesian-Style Decomposition

An important question to address is whether the welfare results obtained from the benchmark model with UBI are at odds with the public finance literature (e.g., Saez, 2001; Golosov et al., 2016; Heathcote and Tsujiyama, 2021) that concludes that there is too little redistribution in the US. Although our paper is not designed to be an optimal taxation contribution, we can use some of the methods of that literature to explore this question further. Table 10 below reports the results of making a small change in the tax and transfer system and quantitatively decomposing these changes into a mechanical effect, a behavioral effect in partial equilibrium, and a total effect in general equilibrium. In particular, we approximate a small change in the lump-sum transfer (equivalently, introduce a small UBI) by permanently increasing ω by \$100 (annually) for all adults. This is financed (balanced budget) by changing the labor tax rate parameter λ in each period, as in the benchmark UBI policy.

Table 10: Small Increase in Lump Sum Transfers: A Mirrleesian-Style Decomposition

	Welf. Adults	Welf. S. State	Taxes λ	Hours Worked	Skill Inv. m	Parental Transfers	College	Labor Prod.	Labor Income	Capital K	Wage w_0	Wage w_1	Int. Rate r
a) Benchmark Model													
Mechanichal	0.0483	0.0625	-0.4245	–	–	–	–	–	–	–	–	–	–
Short-run PE	0.0053	0	-0.5688	-0.1515	0.0254	0.0459	0.0033	0.0012	-0.1090	–	–	–	–
Long-run PE	-0.0103	-0.1560	-0.5500	-0.1586	0.0073	-0.7840	-0.0146	-0.0047	-0.1118	-0.5614	–	–	–
Long-run GE	-0.0179	-0.3237	-0.6332	-0.1263	-0.0259	-1.6052	-0.0291	-0.0096	-0.0346	-1.2431	0.0654	0.0576	-0.2529
b) Long-run GE Model with Fixed:													
Skills	-0.0082	-0.0197	-0.5054	-0.2037	–	0.1290	0.0000	0.0000	-0.1501	-0.1666	-0.1038	0.0708	0.1012
Capital	0.3284	0.3887	-0.3448	-0.1560	0.0804	-0.4673	0.0303	0.0103	0.1581	–	0.2746	0.2378	–
Skills & Capital	0.2312	0.2160	-0.3894	-0.1819	–	-0.1774	-0.0038	-0.0007	0.0843	–	0.1815	0.2194	–

Notes: This table evaluates the effects of increasing lump-sum transfers ω by the equivalent of \$100 annually, financed by adjusting λ. Panel (a) decomposes the total effects into: a mechanical component (i.e., without any behavioral adjustments); a short-run PE exercise that incorporates behavioral changes but only provides the tax and transfer change to one cohort; a long-run PE exercise that permanently implements the policy change; and finally the incorporation of GE effects. Panel (b) evaluates the same long-run GE intervention but for the the models with fixed skills and fixed capital. See text for details.

The first row of Table 10 shows the mechanical effect of such a policy, i.e., it reports outcomes under

[65] Although this model is not re-estimated, Appendix Table F2 shows that using the original calibration in this model provides almost as good of a fit of the moments used in the estimation of our benchmark model.

the assumption that individual choices are unchanged and that the higher ω and the accompanying change in λ are accommodated solely via changes in consumption. This increase in redistribution increases the average welfare of current adults and future cohorts by 0.074% and 0.087% (steady state), respectively. λ falls by 0.43% to finance the increase in expenditure. Thus, increased redistribution, absent behavioral changes, is welfare improving.

The next three exercises include the behavioral responses but, as in the analysis of Section 6.1, in order to more clearly distinguish between shorter-run behavioral consequences from longer-run ones, we start by giving $100 only to one cohort (starting at age 16 and ending in the last period of their lives) and requiring that same cohort (and only that cohort) to finance the additional revenue required, all in partial equilibrium (i.e., keeping prices, but not taxes, constant).[66] Once the behavioral response is included (row 2), λ_t over the remaining periods of the policy changes on average by an additional 34% (expressed relative to its fall in the mechanical exercise) as average hours worked by that cohort over its lifetime decrease significantly (by .15%).[67] The cohort shares the benefits of greater redistribution with their children by investing more in their skill formation and increasing transfers, so a greater proportion of these children become college educated. Note that the welfare gains are positive, but smaller than in the prior mechanical exercise as the decrease in labor supply requires a larger increase in taxes.

A relevant question is whether the labor supply response is primarily a consequence of greater labor taxes or of the $100 received. One way to answer this is to keep the new sequence of taxes faced by the cohort in the one-cohort exercise but without increasing transfers by the $100. This exercise generates an average decrease of labor supply of only 0.0033%, i.e., almost 98% of the decrease in hours worked is coming from the increase in lump-sum transfers and not from the increase in taxes. This accords well with our validation exercise in section 4.2 on the effect of lottery winnings on labor supply.[68]

Next, we examine the full partial-equilibrium consequences of the increased transfer policy by giving all cohorts the additional $100. The policy is no longer at the cohort level – taxes are paid by the entire population each period. Although the change required in λ (as measured in the new steady state) is a bit smaller than before, for the first time there is a welfare loss, both for current adults and in the new steady state.[69] Although parents are investing a bit more in their child's skills on average, parental transfers drop, agents are less likely to choose college, and labor productivity falls overall. Labor income drops, requiring greater taxation of the latter, but the fall in capital is quantitatively more important, decreasing by a full half percent and reducing tax revenue by that amount.

Lastly, we turn to the full effect of the policy by allowing for general equilibrium changes. In the new steady state, labor supply decreases by less as wages increase for both types of workers. The interest

[66] Note that this "one cohort only" policy reduces any intergenerational consequences from such a policy but does not eliminate them entirely as the descendants of this cohort will have a changed distribution of skills and hence face different tax rates until the economy goes back to its original steady state.

[67] The tax number reported in row 2 is the average percentage change in λ over the remaining periods of life of this cohort only. Although taxes continue to change because of the dynamic effects of this policy (on investment in child skills and transfers), all such effects are minimal and essentially become zero after 7 periods.

[68] We can also simply increase ω by $100 without changing taxes (i.e., introduce "manna from heaven") which reduces hours worked by 0.14% – a finding very much in keeping with the preceding conclusion.

[69] To get a sense of the importance of a decrease in λ of 0.55%, the average marginal tax rate increases by 1.08% (or 0.35pp).

rate falls, however, which further reduces agents' incentives to save, resulting in a 1.2% reduction in the capital stock. This implies a decrease in capital tax revenue of almost 1.5%, requiring labor taxes to increase even more than in partial equilibrium. Thus, welfare losses are even larger than in partial equilibrium due to the higher labor taxation required and its effects on parental investment in skills, parental transfers, and share of college workers. Unlike the benchmark UBI policy, general equilibrium does not help mitigate the adverse effects obtained in partial equilibrium. All in all, the model suggests that welfare gains from increasing lump-sum transfers are only possible when dynamic behavioral responses and aggregate effects (e.g., the decline in the capital stock) are absent.

To summarize, short-run behavioral effects (i.e., those that arise from a cash transfer that is given to and financed only by one cohort) reduce the gains significantly, but the net welfare effects remain positive, in line with the static public finance literature (e.g., Diamond, 1998; Saez, 2001) and partial-equilibrium models with limited intergenerational dynamic effects (e.g., Farhi and Werning, 2013b; Golosov et al., 2016; Stantcheva, 2017). It is only after taking into account the aggregate consequences on the capital stock and longer-run dynamics through parental skill investment that the true welfare losses become apparent.

Panel B of Table 10 revisits the analysis of Section 6.4 and evaluates the importance of dynamic effects in the model by eliminating endogenous skill formation and capital accumulation. As before, the table reports the change brought about by the $100 UBI relative to the steady state of the economy with the exogenous feature, and only for the full general-equilibrium results.

As can be seen in the first line of panel B, replacing endogenous skills with the transition matrix results in significantly smaller welfare losses both for adults and especially in the new steady state. The steady state distribution of skills remains essentially unchanged as does the share of college workers, resulting in unchanged labor productivity, allowing labor taxes to respond less and dampening the decrease in capital significantly. Whereas in the benchmark model capital tax revenue fell by 1.5%, here the fall is .065%, leading to much smaller welfare losses. This shows clearly the important interaction between skills and capital. When the former are kept virtually constant, labor income (and therefore tax revenue) declines less and the return to capital stays relatively high, both of which dampen the fall in capital accumulation. This in turn allows the reduction in tax revenue to be smaller, mitigating the need for large increases in labor income taxation.

The second line of panel B replaces endogenous capital accumulation with an exogenous capital stock and interest rate as in Section 6.4. This modification leads, for the first time, to welfare gains for both adults and in the new steady state, surprisingly with larger gains to the latter group. Although the reduction in hours worked is similar to that in the benchmark model, wages increase for both education groups and parents invest more in their child's skills, increasing the share of college workers and resulting in higher labor productivity despite the fall in parental transfers. Lastly, line 3 of panel B shuts down both sources of endogenous dynamics. Once again, this leads to welfare gains for both adults and in the new steady state, although somewhat smaller than before. This, perhaps surprising, result stems from the fact that parents can no longer react to higher wages by increasing their investment in child skills, which then does not allow labor income to increase as much as before and thus keeps labor taxes relatively higher.

The exercises above allow us to conclude that the size of our benchmark UBI intervention is not the reason we find welfare losses from increasing lump-sum transfers since losses are present also with a small increase in such transfers. Instead, increased redistribution via greater lump-sum transfer leads to lower welfare only once dynamic elements such as capital accumulation and parental investment in children's skills are considered. One should not conclude, however, that this implies that greater distribution is welfare decreasing for adults. To make this point, Table 11 conducts the same series of decomposition exercises as panel A of Table 10, but for a small policy change in the mix of labor taxes. We consider an increase in τ_y of 0.01, i.e., from 0.18 to 0.19, and change λ to keep the budget balanced at its original level. Note that an increase in τ has non-monotonic effects on agents labor income: it increases after-tax labor income for those that earn less than 1 and increases it for those above 1 (recall that earnings are earnings are normalized, as explained in Section 3).

Table 11: Small Increase in Tax Progressivity τ: A Mirrleesian Style Decomposition

	Welf. Adults	Welf. S. State	Taxes λ	Hours Worked	Skill Inv. m	Parental Transfers	College	Labor Prod.	Labor Income	Capital K	Wage w_0	Wage w_1	Int. Rate r
Mech.	0.4647	0.5241	0.4749	–	–	–	–	–	–	–	–	–	–
SR PE	0.0678	0	-0.1429	-0.3712	0.0796	-1.8694	0.0086	0.0033	-0.3861	–	–	–	–
LR PE	0.0667	-0.6174	-0.1637	-0.3478	-0.1005	-3.6934	-0.0643	-0.0201	-0.3719	-3.2497	–	–	–
LR GE	0.1061	-0.2443	0.0187	-0.4217	-0.0396	-1.8190	-0.0318	-0.0095	-0.5417	-1.7254	-0.1508	-0.1164	0.5547

Notes: This table evaluates the effects of increasing tax progressivity parameter τ_y by 0.01, financed by adjusting λ. Panel (a) decomposes the total effects into: a mechanical component (i.e., without any behavioral adjustments); a short-run PE exercise that now incorporates behavioral changes but only provides the tax and transfer change to one cohort; a long-run PE exercise that permanently implements the policy change; and finally the incorporation of GE effects. See text for details.

As shown in the first line of Table 11, which only considers the mechanical effect of the change in tax mix, this policy increases (utilitarian) welfare significantly. It allows λ to increase by .475% (permitting agents to keep a greater proportion of their after-tax income, ceteris paribus) and it increases the labor income cutoff at which agents pre-tax labor income is equal to after-tax labor income from \$16,913 to \$17,485.[70] The next line shows that introducing behavioral effects but allowing only one cohort to face the new tax policy delivers smaller welfare gains. Hours worked fall as does labor income, requiring labor taxes to increase. Next, when all cohorts face this same partial equilibrium policy, the effect on the welfare of adults has counterbalancing effects. Greater redistribution is welfare enhancing but parental investments and transfers fall, decreasing the proportion of college workers and lowering labor productivity. Furthermore, the large fall in capital of over 3% decreases tax revenue, requiring further adjustments in λ and overall decreasing the welfare of future generations. The combined changes in τ and λ imply that the average marginal labor tax rate increases by 2.64% (0.85pp) in the new (partial equilibrium) steady state. Once general equilibrium effects are introduced, the prior large fall in the steady state capital stock is mitigated by the increase in the interest rate, allowing the new steady-state λ to actually be higher than in the original steady state (i.e., agents keep a greater proportion of their

[70] This benefits agents with lower labor income, e.g., those with an annual pre-tax labor income of \$10,000 now have an extra \$151 in after-tax income under the new tax system.

labor income, ceteris paribus). The decrease in wages, however, leads parents to invest less in child skills and to a lower proportion of college workers. Hours worked fall and welfare in the new steady state is lower but the decline is 60% smaller than that obtained absent the general equilibrium effects.

Note that the results of both exercises are in line with those obtained in the literature in the sense that redistribution yields welfare gains when only one cohort is considered. The losses from greater redistribution only show up once the dynamic consequences of this policy kick in, both in partial and general equilibrium settings. Thus, endogenous accumulation of human and physical capital (with its equilibrium effects on tax revenues and the interest rate), which are typically lacking in static models (e.g. Diamond, 1998; Saez, 2001) and are dampened in dynamic models without human capital accumulation (e.g., Farhi and Werning, 2013b; Golosov et al., 2016; Boar and Midrigan, 2020; Guner et al., 2021; Ferriere et al., 2022) or without general equilibrium forces (e.g., Farhi and Werning, 2013b; Golosov et al., 2016; Stantcheva, 2017) or without capital taxation revenue (e.g., Stantcheva, 2017), are the key features behind our results.

7 Alternative Environments

This section considers various alternative ways of financing UBI including reducing administrative costs of running means-tested programs, evaluates the desirability of UBI in a riskier environment where agents face a greater likelihood of being hit by an out-of-work shock, and examines the robustness of the main conclusions to less altruism and a lower Frisch elasticity. A sensitivity analysis to small perturbations in each internally estimated parameter value can be found in the Appendix Section F.3.

UBI replaces current redistribution programs The benchmark model features UBI as an additional source of income redistribution beyond that already provided by the current tax and transfer system (as measured by τ_y and ω in our model). Given that UBI would ensure that households did not fall below the poverty level, a reasonable conjecture is that some of the current redistributive programs would be cut back or even eliminated. Although the degree to which these programs would be reduced is unclear, we explore this question by evaluating the extreme case in which UBI replaces the current level of ω and/or is implemented together with a transformation of the labor income tax into a linear one (i.e., $\omega = 0$ and/or $\tau = 0$). While these alternative implementations reduce the negative long-run welfare consequences, Appendix D shows that both adult cohorts and future generations still lose from UBI.

UBI reduces administrative costs Proponents of UBI suggest that an important benefit of the policy is that it would reduce the administrative costs of targeted programs. Given its universal character, UBI would not require the degree of monitoring and red tape as do means-tested programs (e.g., TANF, SNAP, SSDI). How much existing costs would be reduced is unclear, however, so we instead show in Appendix Figure D1 that the cost reductions would need to be immense for there to be steady-state welfare gains. Even eliminating the expenses associated with all federal employees or all administrative costs of current transfer programs would fall substantially short of what would be required. Only by eliminating a quarter of the cost of all public employees would the savings be large enough for UBI to lead to welfare gains among current adults. Savings would be need to be twice as large to generate long-run welfare gains.

UBI financed by consumption taxation The US stands out among OECD countries for its low reliance on consumption taxation.[71] An alternative to increasing the taxation of labor income to finance UBI would be to instead increase the taxation of consumption. Appendix Figure D2 shows that the welfare consequences of this UBI policy differ radically from those of studied previously, in that all cohorts gain on average. However, we show that this is a consequence of making the tax system less reliant on labor income taxation rather than from the transfers associated with UBI.[72]

A riskier economy Appendix B.8 studies the effect of doubling the wage shock variance, which also increases the share of low-income individuals, and finds large (but lower) welfare losses from UBI in the recalibrated model. In Appendix E, we study how the effects of UBI might change if the degree of risk in the economy changed as a result of greater job obsolescence. A major concern regarding greater robotization/automation is that it will considerably reduce the number of jobs available by making certain occupations obsolete. From this perspective, it is argued by some that a UBI policy would help provide the basic needs of individuals who were negatively impacted. Although the present model is not designed to understand automation, it is able to reflect this important concern in a simple fashion by viewing the consequences of accelerated technological change as an increase in the proportion of workers who receive an out-of-work shock. A riskier economy has similar implications for current adults vs. future cohorts in that all cohorts lose from the introduction of UBI. Comparing across economy's with greater versus lower out-of-work shocks, UBI becomes less welfare reducing, however, for adult cohorts whereas generations born in the new steady state suffer even greater losses. This asymmetry reflects the reduced ability of adults to reoptimize their past decisions both as parents – e.g., via skill investment – and at later stages – e.g., via asset accumulation – to a riskier environment.

Robustness: Altruism The benchmark analysis used an altruism parameter δ equal to 0.66, estimated to match the intergenerational persistence of income. To evaluate the role of this parameter, we re-estimate the model to match the same set of moments but impose a lower value of altruism, $\delta = 0.5$. The second row of Table 12 reports the changes in outcomes from UBI relative to the steady-state of the lower-altruism economy without the policy. As can be seen by comparing rows 1 and 3, welfare losses from UBI for adults are the same in both the lower and higher altruism economies. The long-run losses, however, are much larger. This is a result of parents, when faced with the higher taxes implied by UBI, making greater reductions in their investment in child skill and in their transfers, leading to lower labor productivity and a lower share of college workers. Altogether long-run losses are almost 50% larger, but lower altruism implies that current adults put less weight on these future losses.[73]

[71] In 2018, taxes on goods and services accounted for 17.6% of tax revenue whereas it accounts for 32.1% on average among other OECD countries (Enache, 2020).

[72] Luduvice (2021) also finds that a UBI policy (of a similar magnitude to the one here) financed by consumption taxes leads to long-run welfare gains. Our evaluation of UBI financed with labor income taxes vs. consumption taxes suggests that this is likely due to the larger role played by consumption taxation rather than to UBI itself.

[73] Farhi and Werning (2007) and Farhi and Werning (2013a) find that intergenerational linkages across generations should be dampened (e.g., by having a ban on negative bequests and higher progressive estate taxation) when the welfare function puts additional weight on future generations. Given our results, it would be interesting to revisit these findings in a framework with endogenous human and physical capital accumulation.

Robustness: Frisch elasticity The benchmark analysis uses a Frisch elasticity estimate of 0.5 (i.e., $\gamma_h = 2$), as is common in the public finance literature (e.g., Heathcote and Tsujiyama, 2021). The heterogenous-agents macro literature tends to use lower levels of Frisch elasticity, based on the literature summarized by Meghir and Phillips (2010). Thus, we re-estimate our model using a lower estimate of 1/3 ($\gamma_h = 3$) and reevaluate UBI using the reestimated model. The third row of Table 12 shows that, as expected, welfare losses are smaller when labor supply is less elastic. Although all cohorts lose, the welfare consequences of UBI become far less negative: steady-state welfare losses are half as large and adults losses are cut by two thirds. This is clearly driven by a much smaller reduction in labor supply, which makes the efficiency cost of taxation smaller, (relatively) increases income and hence the capital stock, and thus allows UBI to become more affordable.

Table 12: UBI: Sensitivity to Frisch Elasticity and Altruism

	Change from Initial Steady State (%)											
	Money m	**Parental Transfers**	**Labor Prod.**	**College**	**Capital**	**Hours Worked**	**Income Inequality**	**Wage** w_0	**Wage** w_1	**Rate** r	**Welf. Adults**	**Welf. Steady State**
Benchmark	-11.5	-32.2	-1.3	-4.3	-26.9	-21.3	-50.5	-3.5	-4.2	16.6	-6.0	-22.3
Lower Altruism	-21.5	-47.4	-2.6	-8.0	-29.7	-24.4	-59.6	-4.7	-4.1	18.9	-6.0	-32.2
Lower Frisch Elast.	-5.5	-29.8	-0.7	-2.8	-20.3	-13.2	-45.7	-3.2	-3.8	15.0	-2.1	-11.7

Notes: The first row reports the effect of UBI in our main model, as shown in Section 5. The second row reflects the case in which the model is re-estimated but it is forced to have a lower level of parental altruism, $\delta = 0.5$ (instead of 0.66). The third row reports the effects of UBI in a model re-estimated using a lower labor supply elasticity, with $\gamma_h = 3$ (instead of 2).

8 Conclusion

This paper studies a UBI policy in a framework well-suited to evaluate its potential costs and benefits. We develop an overlapping generations, general equilibrium, life-cycle model with imperfect capital markets and endogenous choices of labor supply, saving, education, and parental investment in child skills. Agents are subject to various sources of uncertainty including income and “out-of-work” shocks. We show that the estimated model, which includes a tax function that is parameterized to be a good fit for the US economy, is in line with empirical evidence on the effect of cash transfers and lottery winnings on labor supply and child development as well as with a series of important inequality measures.

We introduce a UBI policy that provides each adult with $8,000 per year, financed by additional labor taxes in the benchmark exercise. This policy, despite significantly decreasing inequality, has negative welfare consequences for cohorts that were adults when the policy was introduced and significantly larger negative welfare implications for subsequent cohorts and in the new steady state. Labor supplied falls immediately and the capital stock decreases dramatically over time. Intergenerationally, the higher labor tax reduces investment in children’s skills, decreases parental transfers, and lowers the share of agents with college education.

An important contribution of our paper is its investigation of the main channels responsible for the negative welfare results. We conduct several exercises that illuminate the dynamic roles of capital and intergenerational linkages. We show that replacing endogenous skills with an exogenous (and, therefore, policy invariant) transition matrix from parental education and skill to child skills, halves the long-run welfare losses but leaves the losses of cohorts who were adults when the policy was introduced relatively unaffected. The steady-state welfare loss is even smaller, and adult cohorts actually gain, in a different experiment in which the aggregate capital stock and interest rate are kept constant although agents are still allowed to borrow and save (at the same steady-state interest rate). This modification of the model reduces the amount of labor taxation required to fund UBI as revenue from capital taxation remains unchanged, which in turn allows for a smaller reduction in labor supply.

We also conduct a Mirrleesian-style decomposition exercise for a small lump-sum transfer and show that short-run behavioral effects (as captured by a cash transfer that is given to and financed by only one cohort) reduce the gains associated with the mechanical redistribution of resources toward lower-income households, but the welfare effects remain positive. It is only after taking into account longer-run dynamics that welfare losses from a small UBI become apparent. Similar to the full-scale UBI policy, these losses become smaller once skills are exogenous and actually become gains for all generations once the capital stock and interest rate are exogenous. It would be incorrect to conclude from our results, however, that greater redistribution decreases welfare. Conducting an alternative experiment in which we increase the redistributiveness of the labor tax system slightly while keeping a balanced budget by adjusting the average labor tax, we show that this reform makes adults better off.

Our analysis provides lessons beyond those regarding the evaluation of UBI. First, they point to potential problems with evaluating large policy changes solely from evidence derived from short-run experimental settings for small groups (i.e., not in general equilibrium). The negative effects of UBI need the dynamic and aggregate components to become apparent. Second, they may serve as a caution to the tax literature that evaluates reforms in models without physical and human capital accumulation or that abstracts from equilibrium feedback from these channels.

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Online Appendix

This material is for a separate, online appendix.

A Stationary Equilibrium

We introduce some notation to define the equilibrium more easily. Let $s_j \in S_j$ be the age-specific state vector of an individual of age j, as defined by the recursive representation of the individual's problems in Section 2. Let the Borel sigma-algebras defined over those state spaces be $\mu = \{\mu_j\}$. Then, a stationary recursive competitive equilibrium for this economy is a collection of: (i) decision rules for education $\{d^e(s_{j=5})\}$, consumption, labor supply, and assets holdings $\{c_j(s_j), h_j(s_j), a'_j(s_j)\}$, parental investments $\{m_j(s_j)\}$, and parental transfers $\{\hat{a}(s_j)\}$; value functions $\{V_j(s_j), V_j^s(s_j), V^{sw}(s_j)\}$; (iii) aggregate capital and labor inputs $\{K, H_0, H_1\}$; (iv) prices $\{r, w_0, w_1\}$; (v) tax policy $\{\tau_c, \lambda_y, \tau_y, \tau_a, \omega\}$; and (vi) a vector of measures μ such that:

1. Given prices, decision rules solve the respective household problems and $\{V_j(s_j), V_j^s(s_j), V^{sw}(s_j)\}$ are the associated value functions.

2. Given prices, aggregate capital and labor inputs solve the representative firm's problem, i.e., it equates marginal products to prices.

3. Labor market for each education level clears.
   For high-school level:
$$H_0 = \sum_{j=5}^{16} \int_{S_j} E_{j,0}(\theta, \eta)\, h_j(s_j|e=0)\, d\mu_j + \sum_{j=5}^{5} \int_{S_j} E_{j,1}(\theta)\, h_j(s_j|e=1)\, d\mu_j$$
   where the first summation is the supply of high-school graduates while the second is the labor supply of college students (their labor is equivalent to that of high-school agents in period 5).
   For college level:
$$H_1 = \sum_{j=6}^{16} \int_{S_j} E_{j,1}(\theta, \eta)\, h_j(s_j|e=1)\, d\mu_j.$$

4. Asset market clears
$$K = \sum_{j=5}^{20} \int_{S_j} a_j(s_j)\, d\mu_j.$$
   Note that the asset positions $a_j(s_j)$ include the parental transfers $\hat{a}$ since they are measured after such transfers take place.

5. Good market clears:
$$\sum_{j=5}^{20} \int_{S_j} c_j(s_j)\, d\mu_j + \delta K + G + \sum_{j=5}^{5} \int_{S_j} p_e 1\{d_j^e(s_j) = 1\}\, d\mu_{j=5} + \sum_{j=8}^{11} \int_{S_j} m_j(s_j)\, d\mu_j = F(K, H)$$

where the last two term on the left hand side represent the expenditures on college and childhood skill formation, respectively.

6. Government budget holds with equality

$$\sum_{j=17}^{20}\int_{S_j}\pi\left(\theta,e\right)d\mu_j+G=\sum_{j=5}^{20}\int_{S_j}T\left(y\left(s_j\right),k\left(s_j\right),c\left(s_j\right)\right)d\mu_j.$$

   Government expenditures on retirement benefits and G equal net revenues from taxes—which include the lump-sum transfer ω.

7. Individual and aggregate behaviors are consistent: measures μ is a fixed point of $\mu\left(S\right)=Q\left(S,\mu\right)$ where $Q\left(S,\cdot\right)$ is transition function generated by decision rules and exogenous laws of motion, and S is the generic subset of the Borel-sigma algebra defined over the state space.

B Estimation

B.1 Externally calibrated parameters

See Table B1.

B.2 College Loans Transformation

We transform college loans into regular bonds using the following formula:

$$\tilde{a}^s(a')=a'\times\frac{r^s}{1-\left(1+r^s\right)^{-5}}\times\frac{1-\left(1+r^b\right)^{-5}}{r^b}$$

Stafford college loans, the ones on which our estimation is based, have various repayment plans during which the borrower pays a fixed amount each month. Even though repayment plans typically last 10 years, they can be extended to up to 25 years. As in Abbott et al. (Forthcoming), we choose 20 years for our fixed payment plan.

B.3 Replacement benefits: US Social Security System

The pension replacement rate is obtained from the Old Age Insurance of the US Social Security System. We use education as well as the skill level to estimate a proxy for average lifetime income, on which the replacement benefit is based. Average income at age j is estimated as $\widehat{y}_j\left(\theta_c,e\right)=w_eE_{j,e}\left(\theta_c,\overline{\eta}\right)\times\overline{h}$ where $\overline{\eta}$ is the average shock (i.e., zero) and $\bar{h}$ are the average hours worked (in the initial steady state – and calibrated to match the data). Averaging over j allows average lifetime income $\widehat{y}(\theta_c,e)$ to be calculated and used in (15) to obtain the replacement benefits.

Table B1: Estimation: Externally calibrated parameters

Parameter	Value	Description	Source
Taxes			
τ_a	0.36	Tax rate on capital returns	Trabandt and Uhlig (2011)
τ_c	0.05	Tax rate on consumption	Trabandt and Uhlig (2011)
τ_y	0.18	Progressivity of labor income tax	Heathcote et al. (2017)
Borrowing Limit & Rates			
$\underline{a}^s$	0.09	College loan: \$23,000	Stafford Loans
ι	0.10	Wedge of 10% (relative to r)	Gross and Souleles (2002)
ι^s	0.01	Wedge of 1% (relative to r)	Daruich and Kozlowski (2020)
Preferences			
β	0.92	Annual discount rate of 0.98	Standard
γ_c	1	Intertemporal elasticity of substitution of 1	Standard
γ_h	2	Frisch elasticity of 1/2	Standard
$\overline{h}$	0.27	Being in college requires 30 hours per week	NCES
Intergenerational Persistence of Initial Skills			
$\hat{\rho}_c$	0.03	Cognitive skills	Cunha et al. (2010)
$\hat{\rho}_{nc}$	0.39	Noncognitive skills	Cunha et al. (2010)
Aggregate Production Function			
A	4.35	Average annual income of high-school household, age 48	Normalization
α	1/3	Labor income share of 1/3	Standard
δ_k	0.24	Annual depreciation rate of 6.5%	Standard
Ω	0.43	Substitutability in aggregate labor H	CPS (1962–2015)
s	0.53	High-school weight in aggregate labor H	CPS (1962–2015)

Notes: For the parameters relevant to pension benefits, see Appendix B.3; for intergenerational skill transmission, see Appendix B.4; for wage process, out-of-work shock, and return to skills, see Appendix Table B4, Appendix Figure B1, and Figure 3.

The pension formula is given by

$$\pi(\theta_c, e) = \begin{cases} 0.9\widehat{y}(\theta_c, e) & \text{if } \widehat{y}(\theta_c, e) \leq 0.3\bar{y} \\ 0.9(0.3\bar{y}) + 0.32(\widehat{y}(\theta_c, e) - 0.3\bar{y}) & \text{if } 0.3\bar{y} \leq \widehat{y}(\theta_c, e) \leq 2\bar{y} \\ 0.9(0.3\bar{y}) + 0.32(2-0.3)\bar{y} + 0.15(\widehat{y}(\theta_c, e) - 2\bar{y}) & \text{if } 2\bar{y} \leq \widehat{y}(\theta_c, e) \leq 4.1\bar{y} \\ 0.9(0.3\bar{y}) + 0.32(2-0.3)\bar{y} + 0.15(4.1-2)\bar{y} & \text{if } 4.1\bar{y} \leq \widehat{y}(\theta_c es, e) \end{cases} \tag{15}$$

where $\bar{y}$ is the average income (calculated as the wage times the average hours worked in the initial steady state – and calibrated to match the data) of approximately \$288,000 (\$72,000 annually).

B.4 Child Skill Production Function

We use Cunha et al. (2010) estimates of the multistage production functions for children's cognitive and noncognitive skills:

$$\theta'_{k,q} = \left[\alpha_{1qj}\theta_{k,c}^{\varphi_{jq}} + \alpha_{2qj}\theta_{k,nc}^{\varphi_{jq}} + \alpha_{3qj}\theta_{c}^{\varphi_{jq}} + \alpha_{4qj}\theta_{nc}^{\varphi_{jq}} + \alpha_{5qj}I^{\varphi_{jq}}\right]^{1/\varphi_{jq}} \exp(\nu_q), \qquad \nu_q \sim N(0, \sigma_{j,\nu_q})$$

for $q \in \{c, nc\}$, i.e., cognitive and noncognitive skills. Using a nonlinear factor model with endogenous inputs, their main estimates, which are based on 2-year periods, are reported in Table B2. We interpret their 1st stage estimates as referring to the period in which the child is born in our model, i.e., the parent's period-age is $j = 8$ (child's period-age is $j' = 1$, or 0–3 years old). The 2nd stage is assumed to refer to the period before the child makes their college decision, i.e., the parent's period-age is $j = 11$ (child's period-age is $j' = 4$, or 12–15 years old). We use linear interpolation to obtain the estimates for $j = 9$ and $j = 10$.

Table B2: Child Skill Production Function: estimates from Cunha et al. (2010)

	Cognitive Skills		**Non-Cognitive Skills**	
	1st Stage $(j = 8, j' = 1)$	**2nd Stage** $(j = 11, j' = 4)$	**1st Stage** $(j = 8, j' = 1)$	**2nd Stage** $(j = 11, j' = 4)$
Current Cognitive Skills $(\hat{\alpha}_{1qj})$	0.479	0.831	0.000	0.000
	(0.026)	(0.011)	(0.026)	(0.010)
Current Non-Cognitive Skills $(\hat{\alpha}_{2qj})$	0.070	0.001	0.585	0.816
	(0.024)	(0.005)	(0.032)	(0.013)
Parent's Cognitive Skills $(\hat{\alpha}_{3qj})$	0.031	0.073	0.017	0.000
	(0.013)	(0.008)	(0.013)	(0.008)
Parent's Non-Cognitive Skills $(\hat{\alpha}_{4qj})$	0.258	0.051	0.333	0.133
	(0.029)	(0.014)	(0.034)	(0.017)
Investments $(\hat{\alpha}_{5qj})$	0.161	0.044	0.065	0.051
	(0.015)	(0.006)	(0.021)	(0.006)
Complementarity parameter $(\hat{\varphi}_{jq})$	0.313	-1.243	-0.610	-0.551
	(0.134)	(0.125)	(0.215)	(0.169)
Variance of Shocks $\left(\hat{\sigma}_{j,\nu_q}\right)$	0.176	0.087	0.222	0.101
	(0.007)	(0.003)	(0.013)	(0.004)

Notes: Standard errors in parentheses. The 1st stage refers to the period in which the child is born, i.e., the parent's period-age is $j = 8$ (child's period-age is $j' = 1$, or 0–3 years old). The 2nd stage refers to the period before the child becomes independent, i.e., the parent's period-age is $j = 11$ (child's period-age is $j' = 4$, or 12–15 years old).

To go from 2-year periods to 4-year periods needed in our model, we follow similar steps as in Daruich (2021). Using $\hat{\alpha}$ to denote the estimates in Cunha et al. (2010) and α for the values in our model, the two main steps/assumptions for the transformation are: (i) we iterate in the production function under the assumption that the shock ν only takes place in the last iteration, i.e., replace $\theta_{k,q}$ by $\left[\alpha_{1qj}\theta_{k,c}^{\varphi_{jq}} + \alpha_{2qj}\theta_{k,nc}^{\varphi_{jq}} + \alpha_{3qj}\theta_{c}^{\varphi_{jq}} + \alpha_{4qj}\theta_{nc}^{\varphi_{jq}} + \alpha_{5qj}I^{\varphi_{jq}}\right]^{1/\varphi_{jq}}$;[74] and (ii) we assume that the cross-effect of skills (i.e., of cognitive on non-cognitive and of non-cognitive on cognitive) is only updated every two periods.[75] Under these assumptions, the persistence parameter needs to be squared (i.e., $\alpha_{1cj} = \hat{\alpha}_{1cj}^2$ and $\alpha_{2ncj} = \hat{\alpha}_{2ncj}^2$), while other parameters inside the CES function need to be multiplied by 1 plus the persistence parameter (e.g., $\alpha_{2cj} = \left(1 + \hat{\alpha}_{1cj}\right)\hat{\alpha}_{2cj}$).

[74] We assume that the variance of the shock in the 4-year model is twice the one in the 2-year model (i.e., $\sigma j, {\nu_q}^2 = \hat{\sigma} j, {\nu_q}^2$).

[75] Removing this assumption does not change results significantly since the weights corresponding to these elements are very small or even zero in the estimation (in Table B2, see row 2 under columns 1 and 2, as well as row 1 under columns 3 and 4), but it eliminates the CES functional form if $\varphi_{jc} \neq \varphi_{jnc}$.

B.5 Wage Process and Age Profiles

Table B3: Wage Age Profiles by Education Group

	(1) High School	(2) College
Age	0.0234***	0.0552***
	(0.00315)	(0.00469)
Age^2	-0.000199***	-0.000513***
	(3.76e-05)	(5.63e-05)
Inv. Mills Ratio	-0.843***	-1.630***
	(0.0267)	(0.0859)
Constant	2.247***	1.953***
	(0.0634)	(0.0954)
Observations	14,580	8,546
R-squared	0.086	0.124
# of households	2256	1165

Source: PSID (1968–2016). A period is 4 years long. Standard errors in parentheses. *** *p<0.01,* ** *p<0.05,* * *p<0.1. The regressions include year fixed effects. To control for selection into work we use a Heckman-selection estimator. The inverse Mills ratios is constructed by estimating the labor force participation equation separately for each education group, using the number of children as well as year-region (as defined by the Census) fixed effects. Standard errors in parentheses.*

Table B4: Returns to skill and wage process by education group

	(1) High School	(2) College
λ^e	0.654	0.976
	(0.0250)	(0.0559)
ρ^e	0.921	0.978
	(0.0005)	(0.0006)
σ_z^e	0.040	0.045
	(0.0001)	(0.0002)
$\sigma_{\eta_0}^e$	0.046	0.055
	(0.0002)	(0.0003)

Source: PSID (1968–2016) and NLSY (1979–2012). A period is 4 years long. Cognitive skills (from NLSY) are measured using log(AFQT), i.e., the natural logarithm of the AFQT raw score. The regressions include year fixed effects. Robust standard errors are reported in parentheses for λ^e. Bootstrap standard errors are reported in parentheses for ρ^e, σ_z^e, and $\sigma_{\eta_0}^e$ (i.e., the parameters estimated using the minimum distance estimator).

B.6 Out of Work Estimation

Using PSID data, we estimate the Probit model $\Pr\left(\text{Working}_{i,t}\right) = \Phi\big(\alpha + \beta_1 \text{Working}_{i,t-1} \times \text{Age}_{i,t} + \beta_2 \text{Working}_{i,t-1} \times \text{Age}^2_{i,t} + \beta_3 \text{Working}_{i,t-1} + \beta_4 \text{Age}_{i,t} + \beta_5 \text{Age}^2_{i,t} + \gamma_t + \text{Female}_i + \varepsilon_{i,t}\big)$, where $\text{Age}_{i,t}$ is the age of the household head and Female_i is a dummy variable that takes the value of one if the household head is female and γ_t is a year fixed effect.[76] We also include fixed effects for number of children, a two-adult-household dummy, and region. A household is coded as not working if (all) its adult members are not working that year.[77] We then use these to calculate the transition probabilities for the model periods (e.g., the probability of being out of work in period j corresponding to ages 44-47 given that the household worked in period $j-1$ is calculated as $Pr(NW_{t=44}|W_{t=43}) \prod_{t=45}^{t=47}(NW_t|NW_{t-1})$, where t indicates age).

Table B5: Yearly Probability of Working

	(1) Non-College	(2) College
Working_{t-1}	0.653	-0.489
	(0.538)	(1.250)
$\text{Working}_{t-1} \times \text{Age}$	0.0795***	0.134**
	(0.0267)	(0.0654)
$\text{Working}_{t-1} \times \text{Age}^2$		-0.000746**
-0.00133*		
	(0.000311)	(0.000802)
Age	-0.0331	-0.0834
	(0.0243)	(0.0610)
Age^2	1.48e-05	0.000536
	(0.000282)	(0.000751)
Female	0.0617	0.265***
	(0.0468)	(0.101)
Constant	1.227**	2.382**
	(0.501)	(1.173)
Observations	39,868	19,583

*Source: PSID (1968–1996). Regressions include fixed effects for the interaction between number of children, a two-adult-household dummy, and region. Robust standard errors in parentheses. *, **, *** denote statistical significance at the 10, 5, and 1 percent level, respectively. Methodology is explained in the main text.*

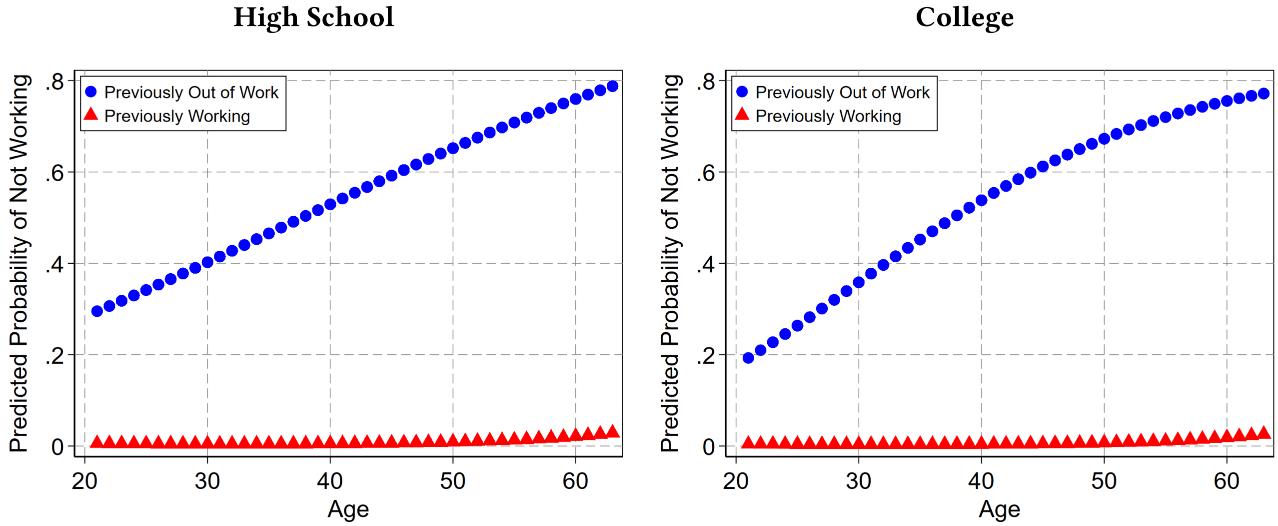
B.7 Wage Process Using Yearly Data

In the baseline estimation of the wage process we use wage data averaged over 4 years, following the definition of the model periods. An alternative, as in Krueger and Ludwig (2016), is to estimate the wage process using yearly data and then transform the estimates to 4-year periods. Denoting with

[76] We do not use PSID years after 1996 since the surveys are biennial after that year.

[77] Retirees, students, and those denoted as "housewives" by the PSID are not included in the "out-of-work" calculations.

Figure B1: Data: Yearly Out-of-Work Transition Probabilities



Notes: College refers to those with at least a four-year college degree. High school refers to those with less than a four-year college degree. Source: PSID, 1968-1996.

$\hat{\rho}^e$ and $\hat{\sigma}_z^e$ the yearly variables, the corresponding 4-year period variables are $\rho^e = (\hat{\rho}^e)^4$ and $\sigma_z^e = \left[1 + (\hat{\rho}^e)^2 + (\hat{\rho}^e)^4 + (\hat{\rho}^e)^6\right] \hat{\sigma}_z^e$. Table B6 shows the results from the estimation, transformed to the 4-year period equivalent. The results are very similar to the baseline estimation reported in Appendix Table B4.

Table B6: Returns to skill and wage process by education group using yearly data

	(1) High School	(2) College
λ^e	0.568	0.950
ρ^e	0.893	0.962
σ_z^e	0.045	0.050
$\sigma_{\eta_0}^e$	0.026	0.030

Source: PSID (1968–2016) and NLSY (1979–2012). Estimation using yearly data and then transformed to 4-year periods.

B.8 UBI with increased wage shocks variance

The baseline model essentially assumes complete markets within a 4-year-long period and, by doing so, may diminish the welfare consequences of a UBI policy. To evaluate the importance of this assumption, we double the variance of the wage shocks, σ_z^e, and examine how this affects the welfare gains from UBI.

The first column of Table B7 reproduces the results from introducing UBI keeping τ_y unchanged. The second column shows the results of doubling the variance of the wage shocks (leaving all other parameter values unchanged). Welfare reacts in a similar pattern as before, but with smaller losses both in the short and long run.

Table B7: UBI: Robustness to Large Wage Shocks

	Baseline	**Double** σ_z^e
Adults at $t = 0$		
Welfare gains	-6.0%	-3.6%
Share in favor	26.5%	33.7%
Steady State		
Welfare gains	-22.3%	-18.2%
Output Y	-19.9%	-18.7%
Capital K	-26.9%	-26.1%
Hours worked	-21.3%	-20.8%
Avg. marginal tax rate	106.7%	103.4%
Labor productivity	-1.3%	-1.0%
College share	-4.3%	-3.3%
Parental investment m	-11.5%	-9.3%
Reg: m to income	-2.7%	-10.4%
Parental transfers $\hat{a}$	-32.2%	-33.3%
Reg: College to income	-9.5%	-8.4%
Income inequality	-50.5%	-53.6%
Wealth share: Above 99.9 pct	-5.4pp	-4.4pp
Wealth share: 99-99.9 pct	10.7pp	9.4pp
Wealth share: 80-99 pct	-8.6pp	-8.0pp
Wealth share: 60-80 pct	-2.1pp	-1.8pp
Wealth share: Below 60 pct	5.3pp	4.8pp
Intergenerational mobility	4.8%	3.4%
Upward mobility	4.6%	1.1%

Notes: $t = 0$ refers to the period in which the policy is introduced. Welfare gains are in percentage change in consumption equivalent units. Income inequality is measured as the variance of log(after-tax income) in the cross-section of agents.

C Welfare Definition: Consumption Equivalence

Let $P = \{0, 1, 2, ...\}$ denote the policy introduced, with $P = 0$ being the initial economy in steady state. We refer to consumption equivalence as the percentage change in consumption (Δ) in the initial economy that makes agents indifferent between the initial economy ($P = 0$) and the one with the policy P in place.

For agents about to become adults (having received the transfer from their parent but not the realization of the school taste shock), in particular, let $\tilde{V}^P_{j=5}(a, \theta, \varepsilon, \Delta)$ be the expected welfare of agents with initial states (a, θ, ε) in the economy P if their consumption (and that of their descendants) were multiplied by $(1+\Delta)$:

$$\tilde{V}^P_{j=5}(a,\theta,\varepsilon,\Delta) = E^P\left\{\sum_{j=5}^{j=20}\beta^{(j-5)}u\left(c^P_j(1+\Delta), h^P_j\right) + \beta^{(12-5)}\delta\tilde{V}^P_{j'=5}(\hat{a},\theta_k,\varepsilon',\Delta)\right\}$$

where, to simplify notation, we do not include time subscripts (needed for the transition analysis), the school taste parameter, nor show that the policy functions depend on the state. Note that these policy functions are assumed to be unchanged when Δ is introduced (e.g., c^P refers to the consumption chosen by an individual in economy P and is unchanged by Δ). For agents of other ages $j \neq 5$, we define a similar element as $\tilde{V}^P_j(z,\Delta)$ where z is a vector of state variables corresponding to period j.

For any agent we define the consumption equivalence $\Delta^P_j(z)$ as the Δ that makes individuals indifferent between being in the initial economy ($P=0$) and the one with policy P in place,

$$\tilde{V}^0_j\left(z,\Delta^P_j(z)\right) = \tilde{V}^P_j(z,0)$$

And we can obtain a measure of average welfare (equivalent to welfare under the veil of ignorance) as

$$\bar{V}^P(\Delta) = \int_z \tilde{V}^P_j(z,\Delta)\,\mu^P_j(z)$$

where μ^P_j refers to the distribution over states z in the economy P. Then, we define the consumption equivalence $\bar{\Delta}^P_j$ to be the one that makes a cohort indifferent between the initial steady-state economy and having policy P in place, i.e.,

$$\bar{V}^0_j\left(\bar{\Delta}^P_j\right) = \bar{V}^P_j(0)$$

D Alternative Implementations of UBI

In this Appendix we examine in greater depth alternative ways to implement UBI. We first consider the case in which the UBI reform results in the current progressive tax rate on labor income being replaced with a linear schedule. This is a way to study a reasonable alternative scenario in which UBI replaces some current spending on lower-income individuals. Next, similar in spirit to the exercise with linear taxation, we study the case in which UBI eliminates the current social programs captured by ω. Relatedly, we examine how the welfare results are modified when UBI allows administrative costs to fall. Lastly, we study the case of UBI financed by consumption taxes. With the exception of linear taxation, these alternatives result in UBI becoming more popular with agents who are adults when the policy is introduced. Table D1 summarizes the results for each alternative discussed below.

UBI and Linear Labor Income Taxation

In the main analysis, UBI is modeled as an additional source of income redistribution beyond that already provided by the current tax and transfer system. This system includes social programs and benefits primarily targeted to poorer households as well as redistribution (e.g., Medicaid, food stamps, AFDC, and EITC). Given that the UBI policy would ensure that households did not fall below the poverty level, a reasonable conjecture is that some of these programs would be cut back or even eliminated. Reducing the importance of these social programs could be interpreted, through the lens of the tax function, as a reduction of the tax progressivity parameter τ_y since it would reduce the tax benefits of low-income households.[78] Although the degree to which these programs would be reduced is unclear, one way to explore this question is by evaluating the extreme case of a linear labor income tax. Thus, in this section we model UBI as an increase in ω as before but simultaneously set $\tau_y = 0$. The level of non-modeled government expenditures G remains unchanged, hence the labor tax parameter λ must adjust to balance the budget.

Table D1: UBI: Alternative Implementations

	Benchmark	**UBI Substitutes Current Progressivity**			**Cons.**
		(i) $\tau_y = 0$	**(ii) Replaces ω**	**(i) + (ii)**	**Taxation**
Adults at $t = 0$					
Welfare gains	-6.0%	-6.1%	-3.0%	-5.2%	1.5%
Share in favor	26.5%	14.7%	32.6%	7.5%	59.8%
Steady State					
Welfare gains	-22.3%	-15.9%	-12.3%	-11.5%	7.0%
Output Y	-19.9%	-8.8%	-13.1%	-2.6%	-7.3%
Capital K	-26.9%	-10.9%	-18.2%	-1.5%	-8.4%
Hours worked	-21.3%	-13.0%	-14.1%	-6.8%	-10.1%
Avg. marginal tax rate	106.7%	80.1%	75.0%	52.4%	-3.8%
Consumption tax rate	0.0%	0.0%	0.0%	0.0%	757.2%
Labor productivity	-1.3%	-0.8%	-0.7%	-0.6%	0.7%
College share	-4.3%	-2.5%	-2.4%	-1.8%	2.2%
Parental investment m	-11.5%	-7.8%	-6.4%	-5.3%	7.4%
Reg: m to income	-0.1%	-1.1%	-4.0%	6.0%	-24.6%
Parental transfers $\hat{a}$	-32.2%	-29.9%	-22.3%	-22.2%	-23.3%
Reg: College to income	-6.8%	-9.3%	-5.6%	1.1%	-6.4%
Income inequality	-50.5%	-24.7%	-38.2%	-8.8%	-33.8%
Wealth share: Above 99.9 pct	-5.4pp	16.1pp	-4.0pp	20.2pp	1.8pp
Wealth share: 99-99.9 pct	10.7pp	4.1pp	7.4pp	-0.1pp	1.4pp
Wealth share: 80-99 pct	-8.6pp	-11.3pp	-5.6pp	-9.7pp	-1.7pp
Wealth share: 60-80 pct	-2.1pp	-6.2pp	-1.4pp	-6.3pp	-1.4pp
Wealth share: Below 60 pct	5.3pp	-2.8pp	3.5pp	-4.1pp	-0.1pp
Intergenerational mobility	4.8%	9.8%	3.3%	10.0%	15.3%
Upward mobility	4.6%	4.9%	1.1%	5.3%	4.8%

Notes: All entries other than wealth shares are expressed in percentage change relative to the steady-state without UBI. Wealth shares are in percentage points. $t = 0$ refers to the period in which the policy is introduced. Welfare gains are in percentage change in consumption equivalent units. Income inequality is measured as the variance of log(after-tax income) in the cross-section of agents. See the notes of Table 2 and of Figure 5 for remaining definitions.

Given that the policy experiment essentially consists of two parts (i) a change in the marginal tax system to a linear tax (i.e., τ_y is set to zero) and then (ii) an increase in ω by the amount of the UBI transfer, it is useful to first ask how much each contributes to the change that is required in λ. If the change were restricted to setting $\tau_y = 0$, λ would decrease from its original value of .82 to .73 in the first period, eventually increasing to .74 in the new steady state. In terms of the average marginal labor-

[78]Note that the calibrated tax function of the economy without UBI implies that individuals below a certain level of labor earnings receive net transfers from the government (in addition to ω).

income tax rate, this would decrease by 17.1% (5.6pp) in the first period and by 20.9% (6.8) in the new steady state. The cutoff level under which individuals receive a net transfer (ignoring consumption and asset taxation) decreases to \$6,513 as opposed to \$16,912 under the initial steady state demonstrating the importance of the progressive labor tax in the first place.

Next, we ask the new tax system to fund the increase in ω required by UBI via changes in λ (as in the benchmark UBI implementation). This policy requires a slightly smaller increase in the average marginal labor-income tax rate (which is now the same for all labor income, i.e., it is $(1-\lambda)$ given that $\tau_y = 0$) than when τ_y was left unchanged. When the policy is introduced, the average labor-income tax rate requires an immediate 75% increase, in contrast with the 88% required in the benchmark case. Parental investments in child skills (m) are reduced by 7.8% in the new steady state, less than the 11.5% for the benchmark UBI policy. The share of agents with a college education falls by 0.8 percentage points (or 2.5%) in the new steady state, a bit larger than the decrease under the benchmark UBI policy.

The decreased progressivity of the tax system reduces the effect of UBI on inequality. The variance of the log of post tax income falls by significantly less than before and the wealth share of the top 0.1 percentile increases by 16 percentage points instead of falling substantially as in the benchmark policy.

Lastly, the welfare consequences of this policy are slightly more negative for current adults. The consumption equivalent welfare loss for them is 6.1%, even though the steady-state welfare losses are one-quarter smaller than for the benchmark UBI. Part of the long-run differences stem from the fact that capital is not reduced as harshly, given that more wealth is now accumulated at the top.

UBI eliminates initial ω

The previous section studied a UBI policy in which the current degree of progressivity of the taxation of labor income was replaced by a linear tax, i.e., $\tau_y = 0$. An alternative way to model the idea that UBI could replace other forms of transfers to lower-income households is to instead have it eliminate the original level of transfers, i.e., ω. We study this alternative by assuming that the net increase in UBI per person per year is \$6,368, i.e., the \$8,000 (benchmark UBI value) minus \$1,632 (the estimated value of ω in the non-UBI steady state). The third column of Table D1 shows that the welfare losses are half as large as those obtained under the original UBI policy, reflecting the reduced tax burden and the positive consequences from what is essentially a lower level of UBI.[79]

UBI reduces administrative costs

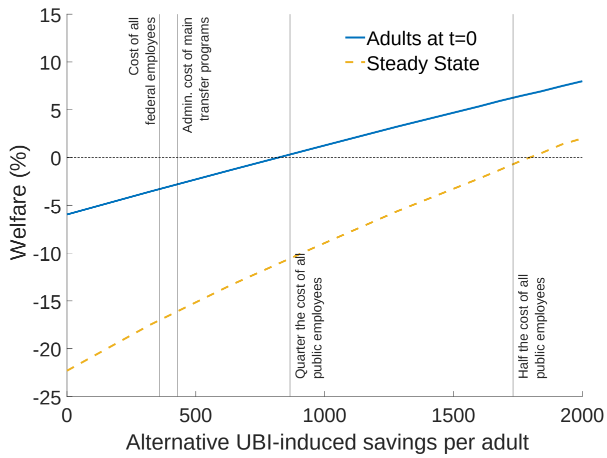
Proponents of UBI suggest that an important benefit of the policy is that it would reduce the administrative costs of targeted programs. Given its universal character, UBI would not require as high a degree of monitoring and red tape as these other programs (e.g., TANF, SNAP, SSDI). How much existing costs would be reduced is unclear. Rather than take a stand on which programs would be eliminated, we instead calculate an upper bound to these potential gains of eliminating the costs associated with these programs without reducing their associated benefits. Thus, we evaluate alternative scenarios in which UBI reduces government expenditures G by different amounts, allowing the labor tax rate parameter λ

[79] Column 4 of Table D1 shows that allowing UBI to replace current tax progressivity through both τ_y and ω also reduces long-run losses, but only slightly more than in the case when only ω is reduced.

to adjust so as to keep the budget balanced as usual.

Figure D1 shows the welfare gains/losses both for adults at $t = 0$ and for cohorts born in the new steady state, under alternative reductions of G per adult. The benchmark UBI policy assumes no reduction in G, so it is represented by the zero on the x axis. As expected, both adults at $t = 0$ and future cohorts gain as the UBI-induced savings increase. To aid with the interpretation of the saving magnitudes, the vertical lines show the estimated cost per adult of (i) all (civilian) federal employees; (ii) the administrative costs of the largest current transfer programs (as studied in Hoynes and Rothstein (2019)); (iii) 50% of the cost of all public employees at the local, state, and federal levels.[80] As shown in the figure, the cost reductions would need to be immense for there to be steady-state welfare gains. Eliminating the expenses associated with all federal employees or all administrative costs of current transfer programs would fall substantially short of what would be required. Only by eliminating a quarter and half of the cost of all public employees would the savings be large enough for UBI to lead to welfare gains among current adults and in the long run, respectively.

Figure D1: UBI: Reducing Administrative Costs



Notes: $t = 0$ refers to the period in which the policy is introduced. Welfare gains are in percentage change in consumption equivalent units. The vertical lines show the estimated cost per adult of (i) all (civilian) federal employees; (ii) the administrative costs of the largest current transfer programs; (iii) 50% of the cost of all public employees at the local, state, and federal levels. See text for details. Sources: CBO, Center on Budget and Policy Priorities, Brock (2001), and Hoynes and Rothstein (2019).

UBI and Consumption Taxation

An alternative to increased taxation of labor income would be to increase the taxation of consumption to finance UBI.

A consumption tax funded UBI policy requires an increase in the consumption tax of 36 percentage

[80]The Congressional Budget Office estimates that federal civilian employees represent 1.5% of the US workforce. Brock (2001) estimates that public employees (at local, state and federal levels) amount to 14.5% of the workforce. We estimate the costs of these workers by multiplying these shares by the total labor income generated by the steady-state of the model (equivalent to assuming the same average wage for public workers as in the general economy). For the administrative costs, Hoynes and Rothstein (2019) estimate that current transfer programs (excluding retirement benefits) cost 1,541 billion dollars (in 2017 dollars). The Center on Budget and Policy Priorities estimates that administrative costs of such programs are between 1 and 10%. We use 10% in order to estimate an upper bound on potential savings.

points right away. Over time, a further increase is needed, bringing the steady-state increase to 38 percentage points. The welfare consequences of this UBI policy differ radically from those of studied previously. As can be seen in Figure D2, all cohorts gain on average. For agents who are adult when the policy is introduced, the average welfare gain is of 1.5%. Steady-state welfare gains under the veil of ignorance are 7.0%.[81] As shown in Table D1, output, capital, and time worked fall less than in the benchmark UBI policy. Furthermore, parental investment in child skills, the share of college workers, and labor productivity increase even relative to the no-UBI steady state. Parental transfers decrease less but the reduction in various measures of inequality are smaller than with with UBI financed via labor taxation, perhaps because the wealth distribution changes less. An exception to this is the rank-rank measure of intergenerational mobility (and to a smaller extent the mobility of the bottom quintile) which increases substantially relative to benchmark financing. This policy would have the support of close to 60% of the adult population, more than double the share that would favor UBI financed via greater reliance on labor income taxation.

To gain a better understanding of the welfare results, it is useful to perform an alternative exercise. Suppose that *prior* to any UBI policy, we increase the consumption tax by the full 38pp that would be required under the consumption-tax-financed UBI policy, allowing the labor income tax λ to adjust so that the budget remains balanced. That is, we are simply changing the tax instrument mix without introducing UBI, so as to keep the government budget balanced. The consequences of this change are welfare gains among those who are adults when this change is introduced (2.8% in consumption equivalence units) and large steady-state gains of 14.4%, basically twice as large as the ones of UBI combined with consumption taxation, echoing the findings in favor of consumption taxation in the literature (e.g., Coleman, 2000; Correia, 2010). This indicates that the gains from a consumption-tax-financed UBI are due to the change in tax system – to a greater reliance on consumption as opposed to labor taxation – rather than to the insurance or credit-constraint changing properties of the UBI payment.[82,83]

E A Riskier Economy and UBI

This section examines how the effects of UBI depend on the degree of risk in the economy. A major concern regarding greater robotization/automation is that it will considerably reduce the number of jobs available by making certain occupations obsolete. From this perspective, it is argued by some that a UBI policy would help provide the basic needs of individuals who were negatively impacted.[84] Although the present model is not designed to understand automation, it is able to reflect an important concern

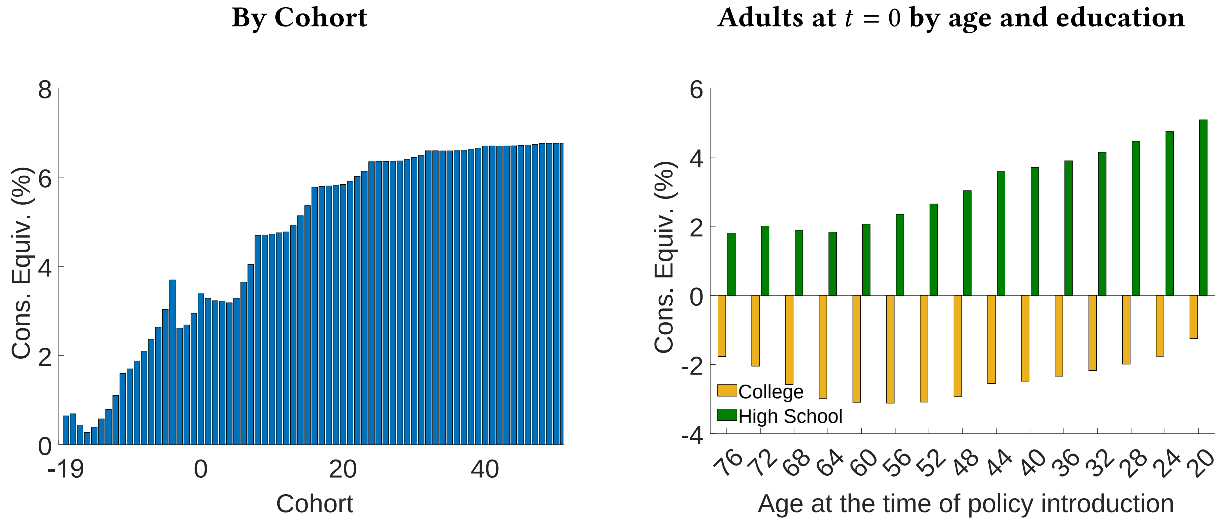
[81]Luduvice (2021) also finds that a UBI policy (of a similar magnitude to the one here) financed by consumption taxes leads to long-run welfare gains. Our evaluation of UBI financed with labor income taxes vs. consumption taxes suggests that this is likely due to the larger role played by consumption taxation rather than to UBI itself.

[82]Indeed, eliminating labor taxes altogether and relying instead on consumption taxation without UBI (i.e., setting $\lambda = 1$, $\tau_y = 0$, and increasing τ_c to balance the budget), yields welfare gains among the current adults (of 1.7%) and large steady-state welfare gains (of 8.3%).

[83]Note that, of course, this does not imply that consumption taxes without UBI are Pareto preferred to consumption taxes with UBI. The (utilitarian) welfare gains in the former, however, are larger.

[84]This has been suggested, among others, by Elon Musk, Richard Branson, and Mark Zuckerberg (see, e.g., Clifford, 2018).

Figure D2: Welfare Dynamics of UBI: Financed with Consumption Tax



Notes: See notes of Figure 7.

in a simple fashion by viewing the consequences of this accelerated technological change as an increase in the proportion of workers who receive an out-of-work shock.[85]

Higher Frequency of "Out of Work" Shocks

The initial steady state of the model implies that, conditional upon working in the current period, individuals between age $j = 5$ to $j = 10$ inclusive experience an out-of-work shock with probability 0.5% over the next 6 periods (i.e., 0.5% of the individuals between 16 and 40 years old and working will get hit by an out-of-work shock over the next 24 years as they age and turn 44 to 64 years old). McKinsey (2017) and OECD (2019) predict the share of current jobs lost as a result of automation could be between 5% and 15% but numbers even closer to 25 or 30% have been suggested (Frey and Osborne, 2017). Most of the empirical evidence also suggests that the occupations of less-educated individuals are more likely to be affected. We introduce the higher rate of occupational obsolescence by increasing each age-dependent probability of entering the out-of-work state (as shown by the left panel of Appendix Figure B1) by a common education-specific factor in such a way as to match estimates on the share of jobs that would be lost over 6 periods (24 years). Following the estimates of McKinsey (2017), we assume that the probability that a college graduate loses their job is 58% lower than the one for a high-school graduate.[86] We leave unchanged the probability of a worker transitioning from out-of-work to employment as how automation affects job creation is unclear.

Note that, ceteris paribus, a higher frequency of out-of-work shocks for high-school educated workers implies a lower college premium: high-school workers essentially become scarcer (see equation 4). As this is simply a consequence of using a model in which unemployed workers do not compete for jobs and, furthermore, contradicts most predictions regarding the returns to less-skilled labor, we adjust the

[85] Acemoglu and Restrepo (2020) show that commuting zones most exposed to industrial robots saw decreases in employment and wages.

[86] Hence, the probability of being out of work in period j if an individual with education e was working in period $j-1$ goes from x_j^e to $x_j^e(1+q^e)$ for all working periods, $e \in \{0,1\}$.

weight s of college vs. high-school work in the aggregate production function (3) such that, keeping the aggregate capital stock fixed at its initial steady-state value and allowing the aggregate labor supply (H_0 and H_1) to adjust only due to the exogenous increase in the probability of being out-of-work (i.e., no endogenous changes in skills, education or labor supply), the unit wage of high-school educated workers, w_0, is unchanged.[87] Lastly, as there is no reason to believe that technological change would reduce GDP (which would otherwise fall, ceteris paribus, simply as a result of greater out-of-work shocks), we increase total factor productivity in (3) such that, after adjusting s, GDP remains constant at the original capital stock and aggregate labor (with the latter adjusted mechanically for the higher probability of being out of work).[88]

More rigorously, let H_0^*, H_1^*, and K^* be the initial steady-state values of high-school labor, college labor, and capital, respectively. Let $\hat{H}_0$ and $\hat{H}_1$ be the corresponding values if the only adjustment were in the (exogenous) increase in the probability of being out-of-work (i.e., keeping unchanged skills, education, and labor supplied conditional on working). To keep the return to an efficiency unit of high-school workers unchanged, we find $\hat{s}$ such that $w_0\left(\hat{H}_0, \hat{H}_1, K^*|\hat{s}\right) = w_0\left(H_0^*, H_1^*, K^*|s\right)$, as defined by equation (4). Let $\hat{H}(\hat{s})$ be the resulting aggregate labor supply using $\hat{s}$. To keep output unchanged, we then increase total factor productivity, (previously normalized to equal 1), to $\hat{A}$ such that $\hat{A}\left(K^*\right)^{\alpha}\left(\hat{H}(\hat{s})\right)^{1-\alpha} = A\left(K^*\right)^{\alpha}\left(H^*\right)^{1-\alpha}$.

Appendix Table E1 reports some key aggregate variable values for the new steady state reached under different occupation/job destruction rates, ranging from 5% to 15%, assuming throughout that the change in the destruction rate was unforeseen at $t = 0$. These are all indicated in percentage change relative to the initial steady state. GDP decreases monotonically, driven mainly by labor reduction. Although time worked decreases with the percentage of jobs destroyed, the capital stock increases when the percentage of jobs destroyed becomes larger, as agents save more to better protect themselves against the increased income risk. The share of college-educated workers moves non-monotonically, despite the increased general risk, because the greater capital stock at the higher job destruction rates increases the return to college workers and they face a lower job destruction risk relative to high-school workers. Agents also work more conditional upon not being hit by the out-of-work shock (as can be seen by the row that excludes the out-of-work agents) and the unit wage of college and high-school workers increases. TFP increases (exogenously) as a result of the procedure described previously.

UBI In A Riskier Economy

We next ask how the introduction of UBI affects welfare in these riskier environments. We assume that the policy is introduced at the same time that the economy becomes riskier – in period $t = 0$ – and thus that adults already have their skills set, parental transfer, and, except for those adults of period-age j=5 (i.e., 16–19 year olds), their college decisions are already made.

The first row of Table E2 reports, in consumption equivalence units, the average percentage of con-

[87] This strategy implies that college workers have a more sizable role in the economy which is in line with the prediction that the new jobs created by automation will require more skills (e.g., McKinsey, 2017; Frey and Osborne, 2017; OECD, 2019).

[88] A full model of automation would endogenize the latter and specify who gets the returns associated with technological change.

Table E1: Greater Job Destruction: Long-Run Aggregate Effects

Jobs Destroyed	5%	10%	15%
	Change from Initial Steady State (%)		
GDP	-1.09%	-2.18%	-3.04%
Capital	-0.12%	0.21%	1.10%
Labor (Efficiency Units H)	-2.67%	-5.74%	-8.70%
College Share	-0.07%	-0.14%	-0.09%
Average Labor Productivity: Non-College	-0.05%	-0.09%	-0.15%
Average Labor Productivity: College	-0.00%	-0.01%	0.00%
Average Hours Worked: Non-College	-2.24%	-4.86%	-7.46%
Average Hours Worked: College	-1.06%	-2.40%	-3.79%
Average Hours Worked: All, Excl. Out of Work	0.24%	0.42%	0.54%
Total Factor Productivity $\hat{A}$	0.76%	1.70%	2.69%
Aggregate Production Function $\hat{s}$	-0.52%	-1.16%	-1.81%
Interest Rate r	-3.46%	-6.61%	-8.94%
Non-College Wage w_0	0.98%	1.92%	2.68%
College Wage w_1	1.45%	3.00%	4.41%
Average Marginal Labor-Income Tax Rate	0.54pp	1.08pp	1.54pp
Welfare in Steady State	-2.00%	-3.79%	-5.19%
Welfare for Adults at $t = 0$	-0.97%	-2.08%	-3.10%

Notes: Efficiency units of labor H is defined in Appendix A. Labor productivity refers to the value of $e^{\lambda^e \log(\theta_c)}$. Adults at $t = 0$ refers to agents who are adults when the policy is introduced; steady state refers to agents born in the new steady state with welfare evaluated behind the veil of ignorance.

sumption adults would be willing to sacrifice in order to have the benchmark UBI policy introduced. Note that the comparison therefore is between an economy with or without UBI and not with the original steady state without the increased risk of job destruction. The second row performs a similar consumption equivalence exercise, but this time for cohorts born in the new steady state of the economy with the UBI policy (under the veil of ignorance) relative to the steady state of the riskier economy without UBI.

Both adult cohorts and future generations lose as a result of introducing UBI into a riskier economy. The response to greater risk, however is different: the welfare losses become a bit smaller for adult cohorts as risk increases but become quite a bit larger in the steady state. This asymmetry is due to the fact that adults are less able to optimize their decisions to adjust to a riskier environment (as their state variables and asset accumulation decisions have been determined in a less risky economy) and UBI provides a cushion against these shocks. Future cohorts are also more likely to be out of work, but the losses from UBI are larger since the capital stock, investment in child skills, parental transfers, and the share of college educated agents have all fallen. The average marginal labor-income tax rate required to fund UBI is therefore increasing in the share of jobs destroyed, further increasing the welfare losses to the cohorts born in the new steady state.

Table E2: Greater Job Destruction + UBI

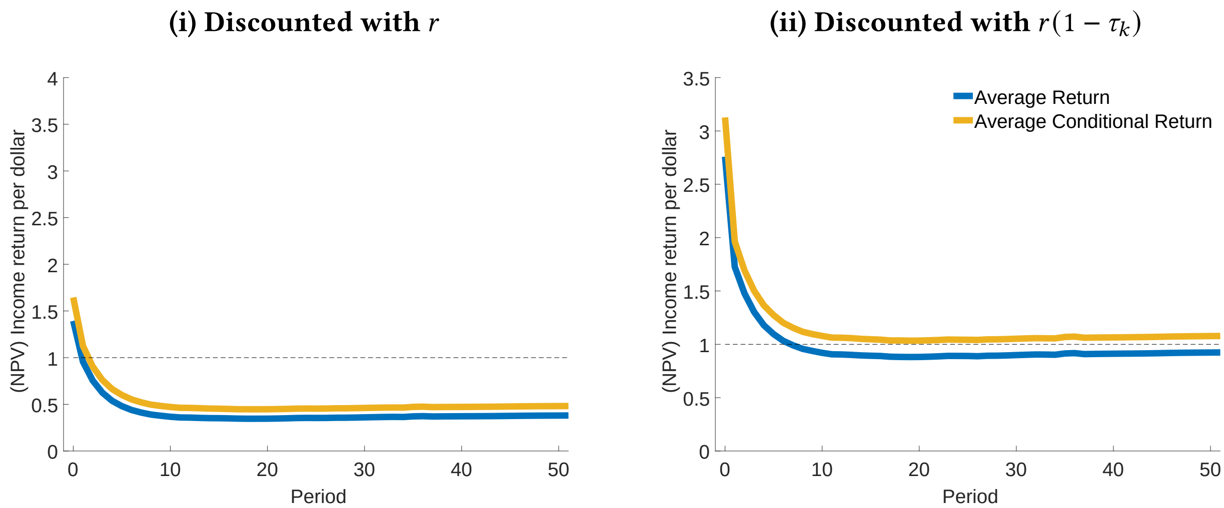
Jobs Destroyed	Benchmark (0.5%)	5%	10%	15%
Adults at $t = 0$				
Welfare gains	-6.0%	-5.9%	-5.8%	-5.7%
Steady State				
Welfare gains	-22.3%	-23.7%	-26.9%	-30.7%
Output Y	-19.9%	-21.7%	-24.5%	-27.1%
Capital K	-26.9%	-28.0%	-31.1%	-33.3%
Hours worked	-21.3%	-23.9%	-27.1%	-30.5%
Avg. marginal tax rate	34.7pp	36.3pp	38.7pp	41.3pp
Labor productivity	-1.3%	-1.5%	-1.8%	-2.1%
College share	-4.3%	-4.9%	-5.8%	-6.9%
Parental investment m	-11.5%	-12.8%	-14.9%	-17.1%
Reg: m to income	-2.7%	-2.8%	-1.8%	-1.4%
Parental transfers $\hat{a}$	-32.2%	-30.0%	-31.1%	-31.8%
Reg: College to income	-9.5%	-9.8%	-10.3%	-11.2%
Income inequality	-50.5%	-49.7%	-50.3%	-51.7%
Wealth share: Above 99.9 pct	-5.4pp	-5.3pp	-4.9pp	-4.7pp
Wealth share: 99-99.9 pct	10.7pp	11.8pp	13.0pp	14.0pp
Wealth share: 80-99 pct	-8.6pp	-8.3pp	-8.6pp	-9.1pp
Wealth share: 60-80 pct	-2.1pp	-2.3pp	-2.7pp	-3.1pp
Wealth share: Below 60 pct	5.3pp	4.1pp	3.3pp	2.9pp
Intergenerational mobility	4.8%	5.1%	5.8%	6.3%
Upward mobility	4.6%	-10.5%	-13.6%	-16.1%

Notes: Efficiency units of labor H is defined in Appendix A. Labor productivity refers to the value of $e^{\lambda^e \log(\theta_c)}$. Adults at $t = 0$ refers to agents who are adults when the policy is introduced; steady state refers to agents born in the new steady state with welfare evaluated behind the veil of ignorance. See the notes of Table 2 and of Figure 5 for remaining definitions.

F Additional Tables and Figures

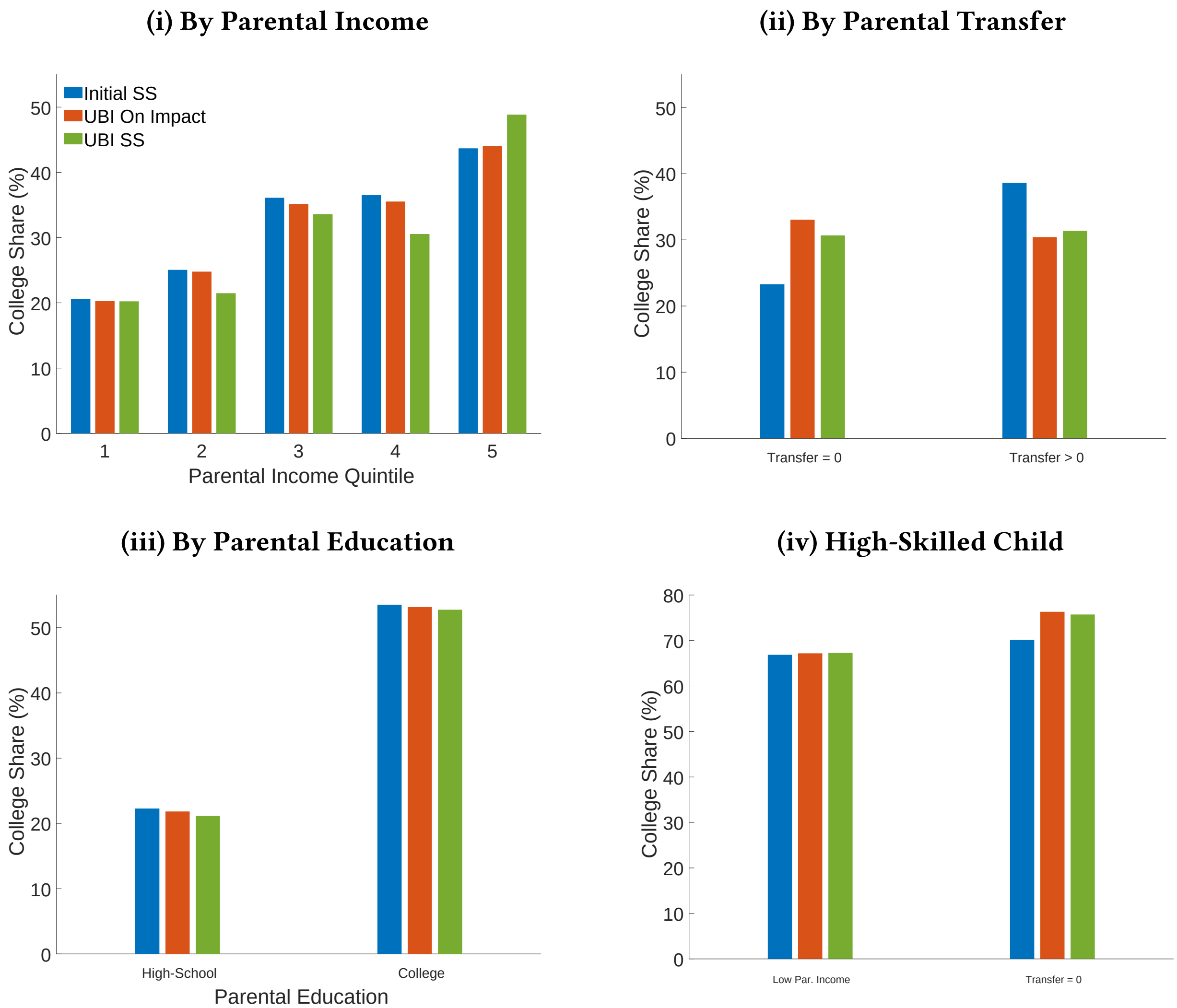
F.1 Return to college and other college determinants

Figure F1: Income Return to College Investment



Notes: This figure shows the labor income return (in net present value and net of taxes) expressed per dollar of college price, all relative to high school and assuming that hours worked are equal across education groups. Income is discounted by either the gross rate of return (r) or its value net of taxes ($r(1-\tau_k)$). The average return across individuals is reported, both unconditionally as well as conditional on individuals choosing to go to college.

Figure F2: College Share



Notes: This figure reports the effect of UBI the share of college graduates by certain characteristics, in the first the period UBI is introduced ("On Impact") and in the new steady state. For comparison, it also reports the values in the initial steady state (i.e., the one without UBI). Low parental income refers to parents with total income in the lowest decile. High-skilled children are defined as those with skills in the top quartile.

F.2 Models with Fixed Skills and Fixed Capital Stock

Table F1: Fixed Skills Model: Estimation Moments

Parameter	Value	Description	Moment	Data	Model
Preferences					
μ	40.8	Mean labor disutility	Avg. weekly hours worked	31.0	29.8
δ	0.66	Altruism	Intergenerational persistence of income	0.31	0.28
School Taste: $\kappa\left(\varepsilon,\theta\right)=\alpha+\alpha_{\theta_c}log\left(\theta_c\right)+\alpha_{\theta_{nc}}log\left(\theta_{nc}\right)+\varepsilon;\ \varepsilon\sim N(\bar{\varepsilon}_{e_p},\sigma_{\varepsilon});\ \bar{\varepsilon}_{e_p=0}=0,\bar{\varepsilon}_{e_p=1}=\bar{\varepsilon}$					
α	60.6	Avg. taste for college	College share	0.32	0.32
α_{θ_c}	-76.3	College taste and cog. skills relation	College: cog skills slope	0.38	0.35
$\alpha_{\theta_{nc}}$	-19.5	College taste and noncog. skills relation	College: noncog skills slope	0.08	0.09
σ_{ε}	61.3	SD of college taste shock	College: residual variance	0.17	0.15
$\bar{\varepsilon}$	-43.5	Draw of school taste: mean by parent's education	Intergenerational persistence of education	0.69	0.69
Investment in Skill Formation: $I=\bar{A}m$					
$\bar{A}$	8.5	Productivity normalization	Average log-skills	0.0	0.0
Superstar Shock					
$\bar{\eta}$	6.11	Efficiency in superstar state	Income share top 5pct	0.33	0.32
$\bar{\pi}$ ($\times 10^4$)	2.23	Probability of entering state	Wealth share top 1pct	0.34	0.36
$\underline{\pi}$	0.34	Probability of exiting state	Wealth share top 0.1pct	0.17	0.18
Labor Income Tax: $y-\lambda y^{1-\tau}-\omega$					
λ	0.82	Tax function	Gov. Expenses/Output	0.19	0.19
ω ($\times 10^2$)	5.91	Lump-sum transfer	Income variance ratio: Disposable to pre-gov	0.63	0.63

Notes: See the text for definitions and data sources. The model is not re-estimated, thus this table is simply to see how well the fixed skills model fits the moments estimated by the benchmark model.

Table F2: Fixed Skills and Fixed Capital Model: Estimation Moments

Parameter	Value	Description	Moment	Data	Model
Preferences					
μ	40.8	Mean labor disutility	Avg. weekly hours worked	31.0	29.8
δ	0.66	Altruism	Intergenerational persistence of income	0.31	0.28
School Taste: $\kappa(\varepsilon,\theta) = \alpha + \alpha_{\theta_c} log(\theta_c) + \alpha_{\theta_{nc}} log(\theta_{nc}) + \varepsilon$; $\varepsilon \sim N(\bar{\varepsilon}_{e_p}, \sigma_\varepsilon)$; $\bar{\varepsilon}_{e_p=0} = 0, \bar{\varepsilon}_{e_p=1} = \bar{\varepsilon}$					
α	60.6	Avg. taste for college	College share	0.32	0.32
α_{θ_c}	-76.3	College taste and cog. skills relation	College: cog skills slope	0.38	0.35
$\alpha_{\theta_{nc}}$	-19.5	College taste and noncog. skills relation	College: noncog skills slope	0.08	0.09
σ_ε	61.3	SD of college taste shock	College: residual variance	0.17	0.15
$\bar{\varepsilon}$	-43.5	Draw of school taste: mean by parent's education	Intergenerational persistence of education	0.69	0.69
Investment in Skill Formation: $I = \bar{A}m$					
$\bar{A}$	8.5	Productivity normalization	Average log-skills	0.0	0.0
Superstar Shock					
$\bar{\eta}$	6.11	Efficiency in superstar state	Income share top 5pct	0.33	0.32
$\bar{\pi}$ $(\times 10^4)$	2.23	Probability of entering state	Wealth share top 1pct	0.34	0.35
$\underline{\pi}$	0.34	Probability of exiting state	Wealth share top 0.1pct	0.17	0.18
Labor Income Tax: $y - \lambda y^{1-\tau} - \omega$					
λ	0.82	Tax function	Gov. Expenses/Output	0.19	0.19
ω $(\times 10^2)$	5.91	Lump-sum transfer	Income variance ratio: Disposable to pre-gov	0.63	0.63

Notes: See the text for definitions and data sources. NThe model is not re-estimated, thus this table is simply to see how well the fixed skills model fits the moments estimated by the benchmark model.

F.3 Parameter Sensitivity

Table F3: Change in Welfare From UBI Given 1% Greater Parameter Value

Parameter Increased by 1%	**Change in Welfare**	
	Adult	**Long-Run**
μ	0.03%	-0.16%
δ	-0.05%	0.14%
α	0.03%	-0.14%
α_{θ_c}	0.01%	-0.22%
$\alpha_{\theta_{nc}}$	0.01%	0.02%
σ_{ε}	-0.00%	0.49%
$\bar{\varepsilon}$	-0.00%	-0.24%
$\bar{A}$	-0.00%	0.27%
$\bar{\eta}$	0.10%	0.12%
$\bar{\pi}$	0.02%	0.04%
$\underline{\pi}$	-0.00%	0.00%
λ	0.52%	1.69%
ω	0.01%	0.03%
Baseline	**-5.96%**	**-22.31%**

Notes: This table reports the welfare change from UBI given a 1% increase in the parameter indicated, where the welfare change reported for the economy with the new parameter value vis a vis the benchmark model with UBI.