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DISCUSSION PAPER SERIES

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ABSTRACT

Universal Basic Income: Inspecting the Mechanisms*

We consider the aggregate and distributional impact of Universal Basic Income (UBI). We develop a model to study a wide range of UBI programs and financing schemes and to highlight the key mechanisms behind their impact. The most crucial channel is the rise in distortionary taxation (required to fund UBI) on labor force participation. Second in importance is the decline in self-insurance due to the insurance UBI provides, resulting in lower aggregate capital. Third, UBI creates a positive income effect lowering labor force participation. Alternative tax-transfer schemes mitigate the impact on labor force participation and the cost of UBI.

JEL Classification: E2, E6, J08

Keywords: universal basic income, labor force participation, inequality

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1. Introduction

Discussions about universal basic income (UBI) have become prevalent in recent years within policy circles and across popular media outlets. While UBI provides support to low income individuals, it is also notoriously costly and hence requires potentially dramatic changes in taxation.[1]

To date, no UBI program has ever been implemented on the aggregate level with a long-term commitment. This lack highlights the need for a quantitative macroeconomic analysis. Yet, the literature evaluating UBI's macroeconomic impact is still at its infancy. In this paper we are interested in analyzing the long-term allocation impact of UBI after the economy has converged to its long-run steady state. We develop a modeling environment that enables us to study a wide range of UBI programs and financing schemes. As we argue below, this richness allows us to underscore the key mechanisms driving the impact of UBI on the economy.

To begin, in section 2 we develop a quantitative, production-based general equilibrium model. It is characterized by incomplete markets, individual productivity shocks, and endogenous unemployment and labor force participation. In the model, individuals, as is common in the incomplete markets literature (in the spirit of Aiyagari (1994)), are subject to a borrowing constraint, and they self insure by accumulating capital. Moreover, they make optimal decisions about whether to participate in the labor market and, conditional upon doing so, face a labor-matching friction as in Diamond (1982), Mortensen (1982) and Pissarides (1985) (DMP hereafter). On the government side, we model in detail existing public insurance programs funded by labor and capital distortionary taxation.

We discuss the calibration of this model in section 3. Importantly, our calibration targets micro moments crucial to disciplining the realistic elasticities of labor force participation. Furthermore, our rich setting for idiosyncratic uncertainty, including productivity and unemployment shocks generates a realistic wealth distribution; this is important for capturing UBI insurance benefits in an empirically relevant way. Finally, we also show that the model matches the empirical evidence regarding the impact of UBI in a partial equilibrium experiment as in the Alaska setting discussed in Jones and Marinescu (2018).

We then employ our framework as a "laboratory" to evaluate the impact of introducing UBI programs (section 4). To a first order, we find that the introduction of UBI leads to a large decline in various macroeconomic variables such as output, aggregate capital, and labor force participation. Though UBI programs can reduce inequality and increase consumption for various segments of the population, we find that they have a negative effect on welfare.

[1] Hoynes and Rothstein (2019) provide an excellent review of the subject.

UBI depresses economic activity through three main channels. First, financing UBI by increasing distortionary taxation induces a substitution effect, pushing workers out of the labor force. Due to the capital-labor production complementary in our model, aggregate capital falls as well. We show that the distortionary taxation channel accounts for most of the overall decline in output due to UBI. The remaining impact is split between an "insurance" and an "income effect" channel. The former refers to how UBI provides additional public insurance, reducing demand for self insurance through savings and leading to a fall in aggregate capital. The latter channel refers to the way UBI induces a positive income effect, inducing workers to leave the labor force.

Given the importance of increased distortionary taxation in explaining the drop in labor force participation, we then consider the role of different financing schemes in mitigating UBI's cost. Overall, for each level of UBI, we find that a more progressive income tax scheme mitigates the output costs, and does so by increasing the incentives to join the labor force.[2] Although the labor force channel dominates, the impact of progressive taxation on capital is non-monotonic over different UBI levels. This non-monotonicity is due to variation in the relative importance of the insurance channel and the capital-labor complementarity discussed above.

Finally, motivated again by the importance of the labor force participation channel, we consider programs that partially substitute social insurance programs directed at those outside the labor force with UBI. Indeed, a moderate amount of UBI can boost economic activity and welfare, via two channels. First, the direct effect of replacing programs that condition on *not* participating in the labor force with UBI, which is unconditional, incentivizes labor force participation. Second, given the partial substitution of existing programs in favor of UBI, the tax increase required to finance UBI is smaller.

Our paper relates to emerging macroeconomic literature evaluating the economic impact of UBI. Daruich and Fernández (2020) study how UBI affects intergenerational linkages and skill formation. Conesa, Li and Li (2021) and Luduvice (2019) offer a rich, production-based, overlapping-generations model with labor force participation. Finally, Lopez-Daneri (2016) studies the impact of different degrees of negative income tax (which combines a lump-um and a linear tax) in a small open economy (i.e., one with a fixed interest rate). These papers examine specific sets of reforms and include detailed analysis of the welfare impact of the transition dynamics the reforms bring about. Our focus on the long term impact of UBI enables us to examine a wide range of policies (UBI and taxes); we use our model to analyze and quantify the key mechanisms through which the introduction of UBI, and its funding through distortionary taxation, affects the steady state of the economy. Specifically, we assess the role of (i) the substitution channel that arises

[2]This is consistent with the findings in Holter, Krueger and Stepanchuk (2019).

from the increased distortionary taxation associated with UBI financing; (ii) the insurance channel whereby UBI substitutes for self insurance; and (iii) the income effect channel by which UBI depresses labor supply.

2. Model

We consider a heterogeneous-agent search-and-matching model with incomplete markets in the spirit of Krusell, Mukoyama and Şahin (2010) without aggregate risk, and adding an endogenous labor force margin. Workers are born (and die) with exogenous probability. Newborns have no assets, are out of the labor force, and draw a permanent cost to enter the labor force. While in the labor force, as in the Bewley-Huggett-Aiyagari incomplete-markets model and the DMP model of frictional unemployment, individuals are subject to both uninsurable productivity and unemployment risks.[3] To self-insure against such risk, they accumulate assets. The rate of return on these assets, the distribution of asset holdings, the wage, and the probability of finding a job are objects determined in general equilibrium. On the government side of the model, the government collects taxes from labor and capital income and uses the revenues to fund payments to workers out of the labor force, unemployment benefits, government expenditures, and UBI.

2.1. Matching and market tightness

Workers who participate in the labor force are either employed or unemployed who search for a job. Let u denote the unemployed and v the number of vacancies posted by firms. A constant returns to scale matching function determines the number of new matches in a period. We define market tightness $\theta \equiv v/u$, as the ratio of the number of vacancies to the number of unemployed workers. Thus, we denote the probability that a worker meets a vacant job by $\lambda^w(\theta)$, where λ^w is strictly increasing in θ. Similarly, let $\lambda^f(\theta)$ be the probability that a firm with a vacancy meets an unemployed worker, where λ^f is strictly decreasing in θ. Finally, the unemployment rate is simply the ratio of u to the number of workers who participate in the labor force.

Matches separate at a constant and exogenous probability s each period. Matches formed in the current period become productive in the next one.[4] Workers die with probability ϕ and are replaced by workers born out of the labor force who instantly make a decision whether to enter it. Firms treat the death of a worker as an exogenous separation.

[3] See also Setty and Yedid-Levi (2020).

[4] Our model includes idiosyncratic productivity shocks and so allows endogenous separations. However, in our calibration such separations are never optimal. We therefore describe the model only with exogenous separations.

2.2. Idiosyncratic productivity

A worker's log-productivity in the labor force, $\log(p)$, evolves according to an AR(1) process $\log(p_t) = \rho \log(p_{t-1}) + \varepsilon_{p,t}$, where ρ denotes the persistence and $\varepsilon_{p,t}$ is an i.i.d. shock with mean zero and standard deviation σ_{ε_p}. We assume that a new ε_p is drawn every employment period and when transitioning from unemployment to employment. A worker who transitions from employment to unemployment maintains the most recent p throughout the unemployment spell. New entrants to the labor force have the lowest level of p, denoted by $\underline{p}$.

2.3. Asset structure

Workers have access to two types of assets: capital (k) and claims on aggregate profits (equity, x). The pre-tax return on capital is the rental rate r net of depreciation δ. The pre-tax return on equity is $\frac{d+\pi}{\pi}$, where d denotes dividends and π denotes the price of equity. Workers cannot hold claims on individual jobs, hence they cannot directly insure against the idiosyncratic risk they face.

A standard no-arbitrage condition implies that the returns on holding capital and equity are equal. As a result, workers are indifferent with respect to the composition of the two assets in their portfolios. This allows us to track the pre-tax "total financial resources," $a \equiv (1+r-\delta)k + (\pi+d)x$, as a single-state variable for each worker. In addition, there exists an ad-hoc borrowing constraint $a \geq 0$.

2.4. Government transfers and taxes

The government collects labor and capital income taxes. The labor taxes are collected according to the tax function suggested by Benabou (2002) and more recently used by Heathcote, Storesletten and Violante (2017). Specifically, the tax rate function for labor is

$$t_l(y_l) = 1 - \lambda_l \left(\frac{y_l}{\bar{y}_l}\right)^{-\tau_l} \tag{1}$$

where y_l is the flow income consisting of wage or unemployment benefits; $\bar{y}_l$ is the average flow income in the economy; and $t_l(y_l)$ is the tax rate. In this formulation $1-\lambda_l$ is the tax rate levied on a person who earns the average labor income and τ_l governs the degree of progressivity. For instance, if $\tau_l = 0$ then the tax rate is flat at $1-\lambda_l$, and the system is progressive if $\tau_l > 0$. In addition, the government collects taxes on financial income flow at a flat rate t_a.

Proceeds from the labor and capital income tax are used to finance a fixed amount of government expenditures (G), the benefits to workers out of the labor force (b^{NLF}), unemployment benefits (UI), and UBI, which is a lump sum transfer.

The UI system consists of a replacement rate h and a ceiling on the benefits κ. As long as the cap does not bind, the UI benefit is a fraction h of the average wage $\overline{w}(p)$ earned by employed workers with productivity p.[5]

2.5. Workers' optimization

Workers' period utility is represented by an increasing and strictly concave function $u(c)$, and they discount future streams of utility by a discount factor $\beta \in (0,1)$.

We begin the discussion with the value functions when participating in the labor force. Specifically, let $W(a,p)$ denote the value function of an employed worker who owns a assets and has a current productivity p. Similarly, $U(a,p)$ denotes the value function of an unemployed worker who owns a assets, and had productivity p in her last job. We specify the employed worker's problem:

$$\begin{aligned} W(a,p) &= \max_{c,a'}\{u(c)+\beta(1-\phi)\left[sU\left(a',p\right)+(1-s)\mathbb{E}\left[W\left(a',p'\right)\right]\right]\} \\ \text{s.t.} &: \\ & c+qa' = w(a,p)\left(1-t_l\left(w(a,p)\right)\right)+a\left(1-t_a\times(1-q)\right)+UBI \\ & a' \geq 0 \end{aligned} \tag{2}$$

That is, an employed worker begins a period with some level of assets (a), earns the period wage (w), pays taxes, and receives the lump sum transfer. The worker's wage – determined by Nash bargaining as explained below – is a function of the worker's productivity and asset holdings. Therefore, the beginning of period asset holdings a is the endogenous state variable, and p is the exogenous state variable of the problem. We denote the inverse of the gross real interest by $q \equiv \frac{1-\phi}{1+r-\delta}$, assuming that the assets of the deceased are distributed to survivors according to their asset holding. Flow income, $(1-q)a$, is taxed at the flat tax t_a.

Similarly, an unemployed worker begins a period with some level of assets (a), receives unemployment benefits $b(p) = \min\{h\overline{w}(p),\kappa\}$, pays taxes, and gets the lump sum transfer. The unemployed worker's problem is:

$$\begin{aligned} U(a,p) &= \max_{c,a'}\{u(c)+\beta(1-\phi)\left[(1-\lambda^w)U(a',p)+\lambda^w\mathbb{E}\left[W(a',p')\right]\right]\} \\ \text{s.t.} &: \\ & c+qa' = b(p)\left(1-t_l\left(b(p)\right)\right)+a\left(1-t_a\times(1-q)\right)+UBI \\ & a' \geq 0 \end{aligned} \tag{3}$$

[5] We use the average wage to avoid the need to track workers' individual histories. Our model results in wage functions with little variation in wages *within* a given productivity level.

Turning to the labor force participation decision, recall that workers are born out of the labor force without assets.[6] Those who choose to stay out of the labor force receive a periodic transfer and do not accumulate assets. Staying out of the labor force yields the value $V^{NLF} = \frac{b^{NLF}+UBI}{1-\beta(1-\phi)}$. The workers who choose to enter the labor force pay a utility cost Γ drawn from a normal distribution $N(\mu_\Gamma, \sigma_\Gamma)$. A worker who enters the labor force is unemployed and has the lowest level of productivity.

Given these assumptions, the entry decision is characterized by $\max\{V^{NLF}, U(0,\underline{p}) - \Gamma\}$, resulting in a cutoff cost Γ^*, such that a worker with $\Gamma < \Gamma^*$ chooses to enter the labor force.

2.6. Firms and production

There is a large number of firms that can potentially post vacancies, which cost ξ per vacancy. The value of an open vacancy, V, is

$$V = -\xi + q\left[(1-\lambda^f)V + \lambda^f(1-\phi)\mathbb{E}\left[J(a',p')\right] + \lambda^f\phi V\right], \tag{4}$$

where $J(a,p)$ denotes the value of a filled job for a firm matched with a worker with current asset level a, and productivity p:

$$J(a,p) = \max_{k(p)}\{pf(k(p)) - rk(p) - w(a,p) + q(1-\phi)\left[sV + (1-s)\mathbb{E}\left[J(a',p')\right]\right] + q\phi V\}. \tag{5}$$

We note that firms discount future profits by q – the marginal rate of substitution of equity owners. In order to produce, a firm with a filled vacancy has to rent capital. Let $k(p)$ be the capital-labor ratio for matches that employ a worker with productivity p. We assume a standard production function $f(k)$ with $f' > 0, f'' < 0$, such that a match produces $pf(k(p))$ units of output. Finally, we assume there is a free entry into vacancy posting and, as such, in equilibrium, firms post new vacancies until $V = 0$.

2.7. Wage determination

As is common in the DMP literature, we assume that the wage is determined, period by period, by Nash bargaining. In our model wages also depend on asset holdings (a) because the workers' value function depends on a. The resulting wage function is a solution to the problem

$$\max_{w(a,p)} (W(a,p) - U(a,p))^{\gamma}(J(a,p) - V)^{1-\gamma} \tag{6}$$

where $\gamma \in (0,1)$ represents the bargaining power of workers.

[6] This assumption allows us to solve separately for the labor force participation and wealth accumulation, which greatly simplifies the solution.

2.8. Equilibrium

We consider a stationary equilibrium. We refer the reader to Appendix A.1 for a detailed formal definition of this equilibrium.

3. Calibration

In what follows we discuss the calibration of the model. We set a period in the model to equal a month.

Sample definition To obtain key labor market moments we use the Current Population Survey (CPS) and the Annual Social and Economic Supplement (ASEC) data 2000-2019. We restrict our sample to those aged 18 to 65 at the time of the interview and drop those in the armed forces. For our definition of the relevant population we exclude three groups not in the labor force that we do not model: students (defined as everyone out of the labor force under age 25), retirees below the age of 65, and married individuals not in the labor force and not receiving any social assistance. The latter group is excluded because we assume it consists mostly of household spouses.

Hence, our sample definition is such that it concentrates on individuals who are more likely to be attached to the labor market. We note that the high labor force participation implied by this sample choice mitigates the costs associated with the UBI since it implies a low dependency ratio. Overall our sample definition implies a labor force participation rate of 0.90.

Production function The production function is set with one worker who produces with capital according to $f(k) = k^{\alpha}$. We choose $\alpha = 0.3$ and $\delta = 0.007$ to generate a capital share of 0.3 and an investment–output ratio of 0.23.

Death rate We calibrate the death rate $\phi = 0.00029$ to match the weighted average of the death rate with regard to the number of people at each age of male and female separately in ages 18-65.[7]

Preferences We use log-utility from consumption. We set the two parameters that determine the distribution of the cost of joining the labor force such that we match the labor force participation rate and the micro elasticity of labor force non-participation with respect to social assistance. This latter moment can be calculated analytically in the model in our setting. We choose it to match an elasticity of 0.3, consistent

[7] Available at https://www.ssa.gov/OACT/NOTES/as116/as116_Tbl_6_2010.html#wp1085673.

with labor force elasticity presented in Gruber (2000). Overall, we estimate $\mu_\Gamma = -68.51$ and $\sigma_\Gamma = 171.51$. Finally, we set $\beta = 0.9965$. This value, together with the death rate and depreciation rate, results in an annual interest rate of 3.1%.

Matching We assume a Cobb-Douglas matching function $M(u,v) = \chi u^\eta v^{1-\eta}$, so that $\lambda^w = \theta\lambda^f = \chi\theta^{1-\eta}$. We apply the Shimer (2005) approach that utilizes short-term unemployment in CPS to calculate an average job-finding rate of 0.362 for our sample.[8] We set the vacancy cost ξ to 2.29 to normalize market tightness at 1, which identifies (χ) as the job-finding rate.

We set η to 0.6.[9] We set the exogenous separation rate $s = 0.022$ to match the unemployment rate of 5.8% given the job-finding rate of 0.362 and ϕ according to the formula:

$$u = \frac{s+\phi-s\phi}{s+\phi-s\phi+\lambda^w(1-\phi)}$$

Finally, we set the worker's bargaining power parameter γ to 0.6.[10]

Productivity process We use the process estimated by Krueger, Mitman and Perri (2017) and adopt it to our specification, which excludes the transitory component. The resulting parameters (at a monthly frequency) are $\rho = 0.9905$ and $\sigma_{\varepsilon_p} = 0.1095$. We approximate the AR(1) process for individual productivity using the method described by Rouwenhorst (1995) with five points.

Policy parameters The parameters of the labor income-tax function are set to $\lambda_l = 0.9$ and $\tau_l = 0.15$ in accordance with Holter, Krueger and Stepanchuk (2019), who use US labor income tax data. This parameterization allows for negative income tax rates for low income, mimicking features of the EITC program. Finally, we use $t_a = 0.36$ following the discussion in Trabandt and Uhlig (2011).

We set the level of social assistance in the model, b^{NLF}, exogenously, using the same ASEC sample defined above. Specifically, we match the ratio of average social assistance for those outside the labor force to average earnings of those in the labor force (including zeros for the unemployed), using ASEC weights. The ratio of the two is 0.17.[11]

[8] Following the discussion in Polivka and Miller (1998) and Elsby, Michaels and Solon (2009), we apply a 1/0.83 correction factor to finding rates to account for the CPS 1994 redesign.

[9] See Petrongolo and Pissarides (2001), and Brügemann (2008).

[10] We follow most of the literature that equates the bargaining power to the matching elasticity even though the (Hosios (1990)) condition does not necessarily hold due to the market incompleteness.

[11] For the social assistance calculation, we include: Social Security income, welfare (public assistance) income, Supplemental Security Income (SSI), income from workers' compensation, income from disability benefits, and the market value of food stamps. Earnings include income from labor, business, and farm.

In our benchmark calibration of the UI system we set the replacement rate to 40%, as is typically used to describe the replacement rate in the US economy. We also set the ceiling on unemployment benefits $\kappa = 1.83$, which amounts to a fraction of about 60% of the median wage in the model.[12]

Summary and model fit We highlight the model's fit with regard to two sets of untargeted moments, which are especially relevant when evaluating the macroeconomic response to UBI policies.

First, we evaluate the model-implied income elasticity of labor force participation in an empirically relevant UBI setting. Specifically, in a setting of cash windfall (not financed through taxation), similar to the Alaska experiment studied by Jones and Marinescu (2018), our model implies a small labor supply response consistent with the Jones and Marinescu (2018) findings in the data.[13]

Second, to characterize the insurance benefits from UBI in a meaningful way, it is important for the model to capture both idiosyncratic uncertainty and self insurance. As discussed above, and following Krueger, Mitman and Perri (2017) and Setty and Yedid-Levi (2020), the model includes death probability, a realistic productivity process, and unemployment risk, all of which are important for improving the fit of the wealth distribution. As we discuss in Appendix A.2 the model accounts reasonably well for key wealth-distribution moments, especially with respect to the lower two quintiles of the wealth distribution, who stand to benefit the most from a UBI.

4. Policy results

In this section we present our main results regarding the impact of UBI on the economy. We consider three different scenarios: first, the introduction of UBI in the economy without any other policy change; second, the introduction of a UBI program coupled with a change in the progressivity of income taxation; and third, a partial substitution of UBI for existing welfare programs. Since our interest is to study a wide range of UBI programs and financing schemes, we solve for the steady state equilibrium following each candidate policy.

4.1. The impact of UBI

We start by discussing the effect on allocations of different UBI programs. In each exercise, we solve for the new general equilibrium steady state. Importantly, we keep the government budget balanced by adjusting

[12] See Section 3.1 in Setty and Yedid-Levi (2020) for a discussion of this calibration.

[13] Using their estimates, and assuming that part time is 50% of full-time position, implies less than 1 p.p decline in full time equivalent. Running a similar exercise in our model, we get a response of about 0.5 of a p.p. for labor force participation.

the tax rate on the average person while maintaining constant progressivity.[14] As we discuss below, taxes play a crucial role in UBI's effect on the economy.

The solid blue lines in Figure 1 depict the results from these exercises. On the x-axis the different UBI experiments are expressed in percentage of the steady-state GDP per capita prior to UBI introduction. On the y-axis we present the impact on different macroeconomic variables, expressed in terms of deviations from the no-UBI economy.

Starting from the top left, we see that UBI has a large negative effect on GDP per capita. Consider a 10% UBI, equivalent to roughly $500 monthly per capita (using 2017 GDP per capita). Such a program results in a 18% decline in GDP per capita. The general pattern that emerges from this figure is of a major GDP per capita drop even when UBI interventions are small; for example, a 2% UBI induces a 3% decline and 5% leads to a 8% fall.

To understand this large decline in GDP, it is essential to understand the large dropoffs in capital and labor (middle and right plots of the first row in Figure 1). They are an artifact of different direct and equilibrium effects, which we discuss as follows.

First, naturally, UBI needs to be financed. In the model, the higher labor tax rate induces a substitution effect that pushes workers outside of the labor force. Second, introducing UBI provides public insurance, implying that (holding wages constant) the differences in marginal utility of consumption across different idiosyncratic states decline. This results in reduced demand for self insurance through savings and a further fall in aggregate capital. Third, for the marginal person who makes the labor force participation decision, UBI leads to a positive income effect, inducing her to leave the labor force.

Capital-labor complementarity amplifies many of these effects and contributes to the large decline in GDP. The decline in the labor force participation present in the first and the third channels implies a decline in aggregate capital. Given the Cobb-Douglas production function, the fall in labor force participation does not directly affect capital-per-worker, and hence does not affect wages. In contrast, the decline in the demand for savings, due to the insurance channel, leads to lower capital per worker, and hence to lower labor productivity. The reduced productivity per worker induces a lower match surplus and pre-tax wages (Figure 1, bottom left plot in Panel A), amplifying the substitution effect, further lowering labor force participation. Lower labor productivity further gets reflected in fewer vacancy postings and a higher unemployment rate.

The overall impact of these forces in equilibrium is manifested in the large increase in the tax rate. For example, for the 10% UBI program the tax rate on the person with average earnings in the economy goes up

[14] In doing that, we follow Holter, Krueger and Stepanchuk (2019), who show that for the tax function we use, this is akin to holding τ_l constant, and changing λ_l to keep the budget balanced.

by 26 percentage points. Furthermore, for the 10% UBI program, capital declines by 28% and labor force participation drops by 14%, or about 12 percentage points. While unemployment rate goes up by about 2%, this amounts to a negligible 0.13 percentage points increase. Therefore, the labor force participation margin is the key margin in the context of labor inputs.

4.1.1. The role of distortionary taxation

To isolate the role of distortionary taxation, we solve again the model assuming that the UBI expenses do *not* need to be financed. This is similar to a policy in which an external windfall of funds is available, much in the spirit of the Alaska fund. In what follows we refer to this as the "Alaska Experiment."

The dashed red line in Figure 1 depicts the results for this exercise. Notably, the decline in GDP is dramatically attenuated - for a 10% UBI, the decline in GDP is 5.6% - only about a third of the fall in the first experiment, with increased distortionary taxation. Similar ratios are observed for aggregate capital and labor force participation. Thus, this result emphasizes the first-order importance of distortionary taxation when considering UBI programs; we return to this point in section 4.2 below.

4.1.2. Insurance vs. complementarity

The decline in capital is driven by two channels: first, the reduction in demand for savings from the household side; second, the complementarity of capital with labor force participation, which by itself declines.

To evaluate the extent to which each channel contributes to decline in capital, recall that given the Cobb-Douglas production function, the labor force participation rate does not by itself affect the capital per worker ratio. As such, in the Alaska Experiment, where the distortionary taxation channel is not present, any changes to capital per worker must reflect changes in the demand for savings.[15] Appendix Figure A.1 details both the aggregate capital and the capital per worker in the Alaska Experiment for different UBI cases: for the 10% UBI case the change in aggregate capital amounts to about 10%, while the decline in capital per worker is only 7%. The implication is that demand for savings explains about two-thirds of the decline in capital, with the remaining third due to complementarity.

4.1.3. Welfare

What are the potential benefits of the UBI program? As discussed above, it acts as a provision of public insurance. In the model, given prices, all consumption inequality results from the decision to participate

[15] There is potentially a change in the employment rate within the labor force that could affect the ratio of capital per worker; however, as the results in Figure 1 suggest, the change in this rate is negligible.

in the labor force, as well as from idiosyncratic shocks and the saving decisions they imply. Therefore, insurance provisions will be directly reflected in reduced consumption inequality. The leftmost plot in Panel B in Figure 1 demonstrates the decline in consumption inequality as manifested in the Gini coefficient for consumption. For a 10% UBI, the Gini coefficient falls by about 17%.

How is the decline in inequality related to consumption gains and losses across the economy? Since UBI is added to welfare payments, then those outside the labor force increase their consumption. With respect to those within the labor force, the middle plot in Panel B shows consumption over the different UBI policies for five levels of productivity. It demonstrates that, even within the labor force, those at the bottom of the productivity distribution gain from UBI.

How do the costs and benefits manifest themselves in overall welfare? As depicted in the right plot of Panel B, the large costs of UBI imply welfare drops for almost all UBI experiments we consider. Only for small interventions of around 1% (about $50 a month) is there a small (0.23% in consumption equivalence) rise in welfare.

4.2. Financing UBI with progressive taxation

The results from the previous section, and specifically the Alaska experiment, highlight the importance of distortionary taxation and labor force participation. This motivates us to consider changes in the progressivity of the tax schedule while keeping the government budget balanced.

The effect of increased progressivity on the economy is qualitatively ambiguous. On the one hand, a more progressive tax schedule could raise incentives to participate in the labor force and thereby limit the negative distortionary effect of the UBI financing burden. On the other hand, because increased progressivity reduces incentives to self insure, it lowers the demand for capital in the economy. This latter channel could further depress the demand for capital already induced by the insurance effect of UBI.

In the spirit of Holter, Krueger and Stepanchuk (2019) for the tax function that we use, changing τ_l is akin to changing the progressivity of the tax function. Figure 2 depicts the results for the baseline $\tau_l = 0.15$, along with a more progressive tax scheme ($\tau_l = 0.25$) and a less progressive one ($\tau_l = 0.05$).[16]

As the upper left plot of Figure 2 shows, as in the baseline case, UBI reduces GDP for all progressivity levels. However, for a given amount of UBI, GDP increases with progressivity.

Moreover, consider the case of a rise in progressivity over the benchmark value (from $\tau_l = 0.15$ to 0.25).

[16]To keep the budget balanced, whenever we change τ_l, we adjust λ_l (the tax on average income). Note that increasing τ_l would mechanically increase the EITC level. To avoid very large EITC driving our results, we bound its value at the maximum level obtained in the baseline calibration with $\tau_l = 0.15$.

Figure 2 suggests that, in this case, the higher the UBI level is, the larger the impact of progressivity on output is. To understand these patterns, we need to consider separately the effect of progressivity on capital and labor.

4.2.1. The impact on labor force

As the second and third plots in the first row of Figure 2 suggest, the effect of progressivity on output is mostly through labor force participation and not through capital. To understand this recall that, in the model, entry into the labor market occurs at low-productivity jobs. Therefore, workers put extra weight on wages in these entry-level jobs when making the decision whether to take them.

The increase in progressivity boosts after-tax wages in entry jobs, an effect illustrated in the left plot in the second row of Figure 2. This panel shows large gains in after-tax wages at entry. Moreover, for most UBI levels, after-tax wages are higher even for the average-productivity person.

4.2.2. The impact on capital

The rise in labor force participation due to progressivity (conditional on UBI level) would suggest a similar increase occurring in capital due to complementarity. Yet, as seen in the figure, the relation between capital and progressivity conditional on UBI level is not monotonic, and overall, capital seems less sensitive to progressivity. This is explained by the presence of a counteracting force, where high progressivity reduces the demand for savings and, thus, capital due to the public insurance provided by this high progressivity.

Following our strategy from Section 4.1, we turn to look at the change in capital per worker to isolate this demand for savings channel. As appendix Figure A.2 shows, for low levels of UBI, progressivity depresses the demand for savings, reducing capital per worker. But as UBI increases, the marginal value for progressive taxation as an insurance mechanism falls, as reflected in the shrinking difference between capital per worker for low and high progressivity schemes. This decline in the importance of the insurance channel for higher UBI levels, along with the relatively constant effect of progressivity on labor force participation, explain the non-monotonic relation between aggregate capital and progressivity over different UBI levels.

4.2.3. Welfare

Finally, in terms of welfare, as is clear from Panel B of Figure 2, progressivity reduces consumption inequality (left plot) and increases welfare (middle plot) for each level of UBI. More interestingly, the optimal UBI level (the one that maximizes welfare) varies with progressivity. Intuitively, with less progressivity, UBI plays a more important role, by providing insurance. The rightmost plot of Panel B shows an index of consumption-equivalent welfare, with each line normalized to 1 for the case of zero UBI. As this plot makes clear, even in the presence of very low progressivity ($\tau_l = 0.05$), UBI is maximized at a relatively low 4.5%.

4.3. Substituting welfare programs with UBI

So far we have considered UBI as an additional social insurance program. In our final exercise we study UBI as a substitute for some existing welfare programs, reflected in our model as payments to those outside the labor force.[17] We implement this change vis-a-vis our baseline model with the benchmark level of progressive taxation ($\tau_l = 0.15$).

Formally, we assume a cap on UBI denoted by $\overline{UBI}$, such that, below this value, the income of those outside the labor force (the sum of transfers and UBI, which also equals their consumption) is constant at the baseline level of transfers. Above this cap, UBI exceeds the total benefits from the partially substituted programs and thus income to those outside the labor force begins to rise. Appendix Figure A.3 demonstrates how consumption outside the labor force changes for different magnitudes of the UBI program.

This specific implementation of UBI alters the incentives individuals face in this economy, both from an insurance and a labor supply perspective. From the former standpoint, UBI provides (as before) more insurance for those in the labor force. From the labor supply perspective, the substitution of welfare for UBI implies that, in the region where welfare is replaced with UBI dollar for dollar, the government transfer when one is outside the labor force does not change but does increase when one is in the labor force. This mechanism naturally incentivizes labor force participation (at least in a partial equilibrium sense, holding taxes and prices constant).

The dash-dot purple line in Figure 1 summarizes the results from this exercise. Compared to the baseline exercise (the solid blue line), GDP per capita reveals a different pattern; for UBI levels below $\overline{UBI}$, GDP per capita increases; for amounts above it, it declines.

As is clear from the middle and right plots on the first row, the increase in GDP per capita stems solely from the rise in labor force participation. The higher participation can be traced to the change in incentives discussed above. By contrast, aggregate capital is almost constant below $\overline{UBI}$, suggesting that the labor-capital complementarity is roughly counteracted by the decline in demand for savings.

What are the implications for the tax rate? The rise in the labor force raises the tax base and reduces the number of individuals eligible for transfers. Compared to the baseline exercise, the tax increase required

[17] Recall from the discussion regarding the policy parameters in section 3 that our welfare calibration sums up benefits from multiple programs. We assume that UBI is a relevant substitute for Supplemental Security Income, welfare income, and the market value of food stamps. These amount to roughly one-third of the overall benefits discussed in footnote 10.

for financing UBI is smaller (second row, middle plot). By itself, this mitigates the negative effect of the financing cost of UBI on labor force participation.

What are the welfare implications of such a program? As the leftmost plot in Figure 1 Panel B reveals, introducing UBI while phasing out social assistance decreases inequality faster up to the cap. As shown in the middle plot of this panel, within the labor force, and compared to the benchmark policy, there is a larger increase in consumption at higher productivity levels, consistent with the smaller increase in the tax burden. As the right plot of Figure 1 Panel B reveals, overall welfare increases with UBI until reaching the cap ($\overline{UBI}$). This is consistent with the rise in overall resources in the economy (GDP per capita goes up) as well as in insurance (left two plots of Panel B).

Hence, to conclude, the specific design of UBI suggested above, is one that can increase in the long run both resources and welfare. This is because its design increases the incentives to participate in the labor force.

5. Conclusions

We consider the aggregate and distributional impact of UBI programs. The nature of the model enables us to evaluate in a meaningful way the key mechanisms driving the impact of UBI on the economy.

We find that the most important channel to consider involves distortionary taxation. The higher taxes required to fund UBI induce a substitution effect that reduces incentives to participate in the labor force. Introducing UBI also provides additional public insurance reducing the demand for self insurance. The result is a fall in aggregate capital, which is the other important way UBI negatively affects economic output. Finally, the third, and quantitatively least important, channel is the positive income effect that a UBI program induces on labor force participation.

Given the presence of these channels and their relative importance, we go on to show that making income taxation more progressive mitigates the negative UBI impact because greater tax code progressivity attenuates the negative effect of the substitution channel discussed above.

Finally, we show that there is a UBI program which can increase output and labor force participation in the economy. It is one in which UBI replaces some existing welfare programs. As we show, this mechanism incentivizes labor force participation as well as output.

In sum, we view our framework as useful for identifying the key channels through which UBI programs affect the economy and as sufficiently flexible to enable many different implementations of UBI policies to be considered.

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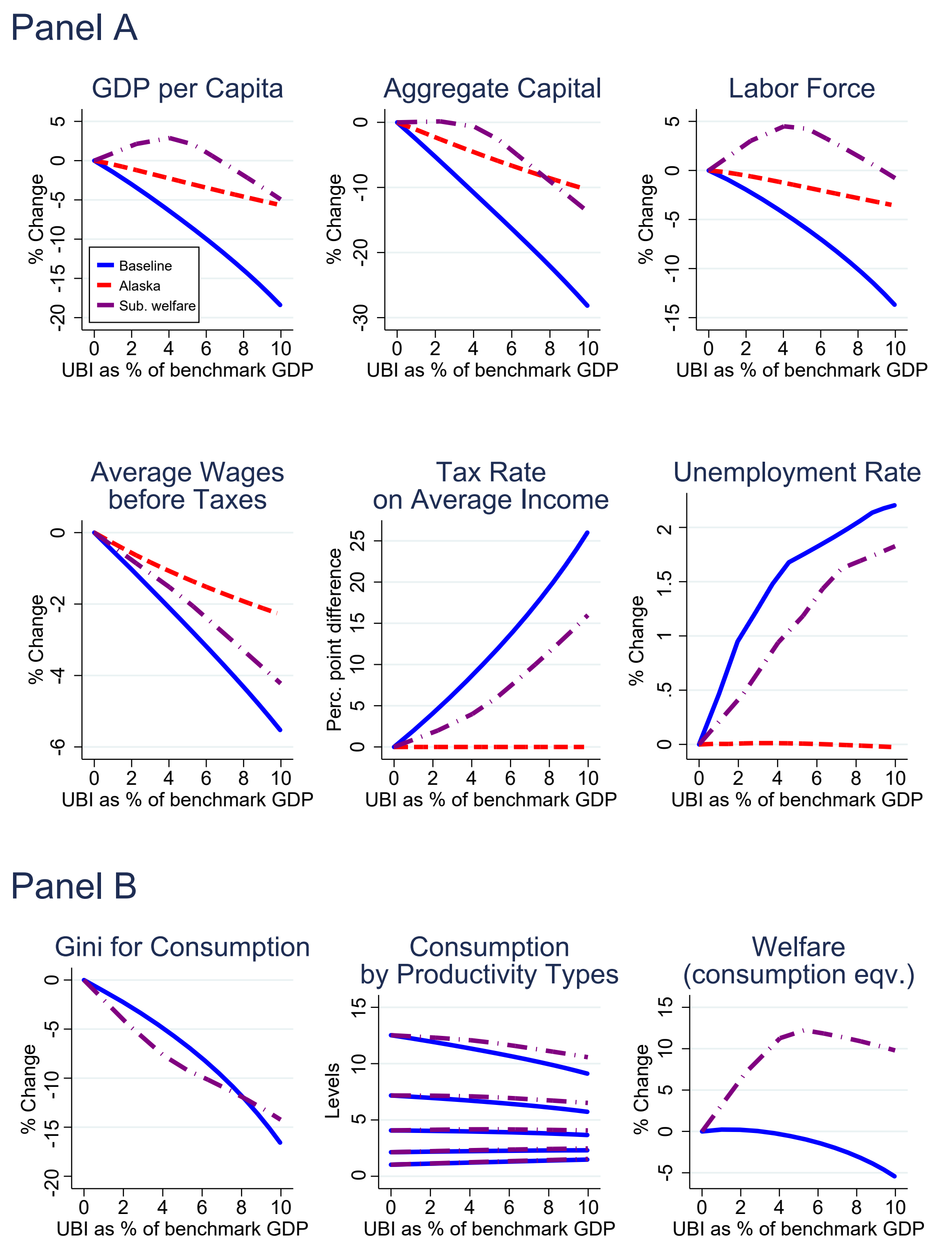
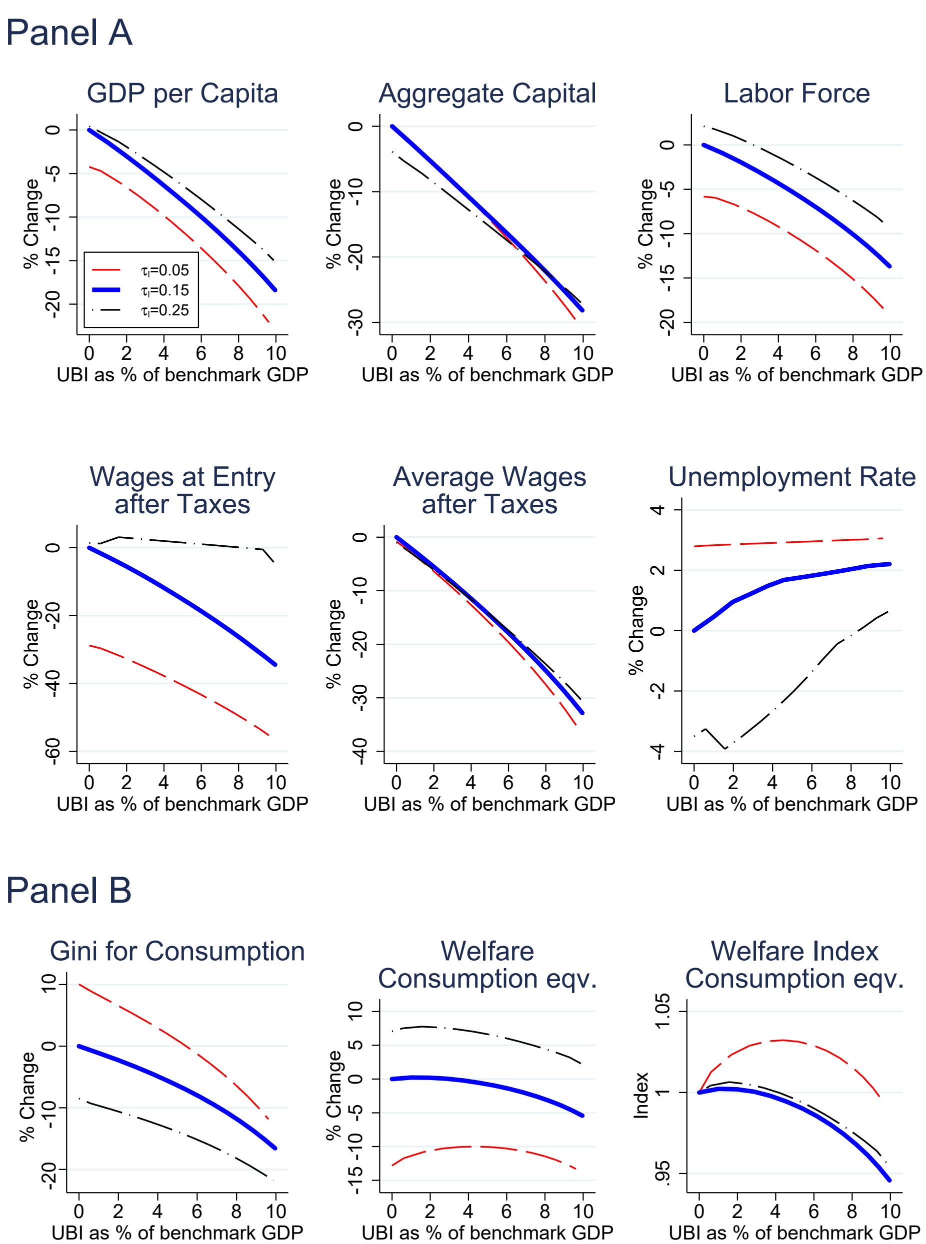
Figure 1: The impact of UBI on allocations and welfare



Notes: Steady state responses of macro aggregates to changes in UBI. UBI expressed as % of benchmark GDP. All measures are expressed in % from their benchmark steady state level other than Tax Rate on Average Income (p.p difference) and Consumption by Productivity Types (in levels). Blue solid line represents responses in the baseline model; The Alaska model (section 4.1.1) is represented by red dashed lines, and the model substituting welfare with UBI (section 4.3) represented by purple dash-dot lines.

Figure 2: Tax progressivity and the impact of UBI



Notes: Steady state responses of macro aggregates to changes in UBI. UBI expressed as % of benchmark GDP. All measures are expressed in % from their benchmark steady state level other than Welfare Index Consumption equivalent (Indexed to 1 for the no UBI case for each level of progressivity). Blue solid line represents responses in the baseline model (medium progressivity); High (low) progressivity is represented by the dash-dot black (dashed red) lines.

A. Online Appendix

A.1. Equilibrium and Solution Algorithm

In this appendix we describe the stationary equilibrium of the economy. For ease of notation and consistency with the computational method we describe a discrete state space. We use the notations $Pr(p'|p)$ as the transition probability of individual productivity, and $Pr(p)$ as the unconditional probability for individual productivity draws. A stationary equilibrium consists of:

1. A set of value functions $\{W(a,p), U(a,p), J(a,p), V^{NLF}, V\}$
2. Consumption $c^e(a,p)$ and $c^u(a,p)$ for employed and unemployed workers, respectively, as well as asset accumulation policy functions $g^e(a,p)$ and $g^u(a,p)$
3. A disutility cutoff Γ^*
4. Prices $\{r, w(a,p), \pi\}$
5. Vacancy level v and demand for capital per worker $k(p)$
6. Tightness ratio θ and implied probabilities λ^w and λ^f
7. A government policy consists of: tax on labor income $t_l(y_l)$ and a flat tax on financial income t_a; transfers b^{NLF} for individuals out of the labor force; lump sum transfers UBI; A government expenditure G; a UI policy of replacement rate h and a ceiling on benefits κ
8. Dividends d
9. Distributions over employment status (either e or u), assets a and individual productivity p, denoted by $\mu^e(a,p)$ and $\mu^u(a,p)$, as well as a measure of individuals outside the labor market μ^{NLF}

such that:

1. Given the job finding probability λ^w, the wage function, and prices $\{r,\pi\}$, the worker's choices of c and a' solve the optimization problem for each individual. This results in the value functions $W(a,p)$, and $U(a,p)$.
2. Given the value of staying outside of the labor force, and the value of entering the labor force U(0,$\underline{p}$), Γ^* is the threshold utility cost of joining the labor force.

3. Given the wage functions, prices, the distribution $\mu^e(a,p)$, and the workers asset accumulation decisions, each firm solves the optimal choice of $k(p)$. This results in $J(a,p)$.

4. Given the wage functions, prices, the distribution $\mu^u(a,p)$, the unemployed workers asset accumulation decisions, and the job filling probability λ^f, firms compute the value V. With free entry, $V=0$.

5. The asset market clears, and the aggregate demand for capital equals supply.

6. The wage functions $w(a,p)$ are determined by Nash bargaining.

7. The government has a balanced budget.

$$\begin{aligned}&\sum_a\sum_p\left[\mu^e(a,p)\left(w(a,p)t_l\left(w(a,p)\right)+at_a(1-q)\right)+\mu^u(a,p)\left(b(p)t_l\left(b(p)\right)+at_a(1-q)\right)\right]\\&=\sum_a\sum_p\left[\mu^u(a,p)b(p)\right]+G+\mu^{NLF}b^{NLF}+UBI\end{aligned}\tag{7}$$

8. The dividend paid to equity owners every period is the sum of flow profits from all matches, net of the expenditure on vacancies.[18]

$$d=\sum_a\sum_p\left[\left(pf(k(p))-rk(p)-w(a,p)\right)\mu^e(a,p)\right]-\xi v\tag{8}$$

9. The distributions $\mu^e(a,p)$ and $\mu^u(a,p)$ are invariant and generated by $\{\lambda^w,s,\phi\}$, the law of motion for individual productivity and the asset accumulation policy functions as follows:

$$\begin{aligned}\mu^e(a',p') &= (1-\phi)\{(1-s)\sum_a\sum_p\mu^e(a,p)\times Pr(p'|p)\times 1\{g^e(a,p)=a'\}\\&\quad+\lambda^w\sum_a\sum_p\mu^u(a,p)\times Pr(p'|p)\times 1\{g^u(a,p)=a'\}\}\\\mu^u(a',p') &= (1-\phi)\{s\sum_a\mu^e(a,p')\times 1\{g^e(a,p')=a'\}\\&\quad+(1-\lambda^w)\sum_a\mu^u(a,p')\times 1\{g^u(a,p')=a'\}\}+\phi\times Pr(p)\times 1\{a'=0\}\\1 &= \sum_a\sum_p\left(\mu^e(a,p)+\mu^u(a,p)\right)+\mu^{NLF}\end{aligned}$$

[18]As flow profits depend on asset holdings of individual workers, this distribution is taken into account.

A.2. Wealth moments

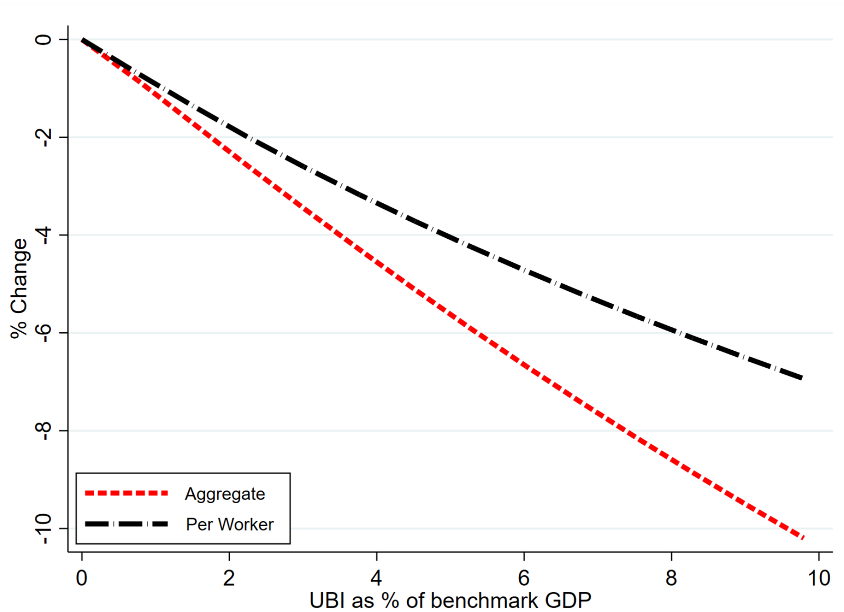
The table below presents the share of aggregate wealth owned by quintiles of the wealth distribution both for the data (data source: Table 1 of Krueger, Mitman and Perri (2017)) and our model economy. Further more, it reports the Gini coefficient of the wealth distribution.

Table A1: Wealth moments

	Data	Model
% share owned by		
Q1	-0.2	<0.05
Q2	1.2	1.5
Q3	4.6	7.4
Q4	11.9	21.5
Q5	82.5	69.5
Gini	0.78	0.68

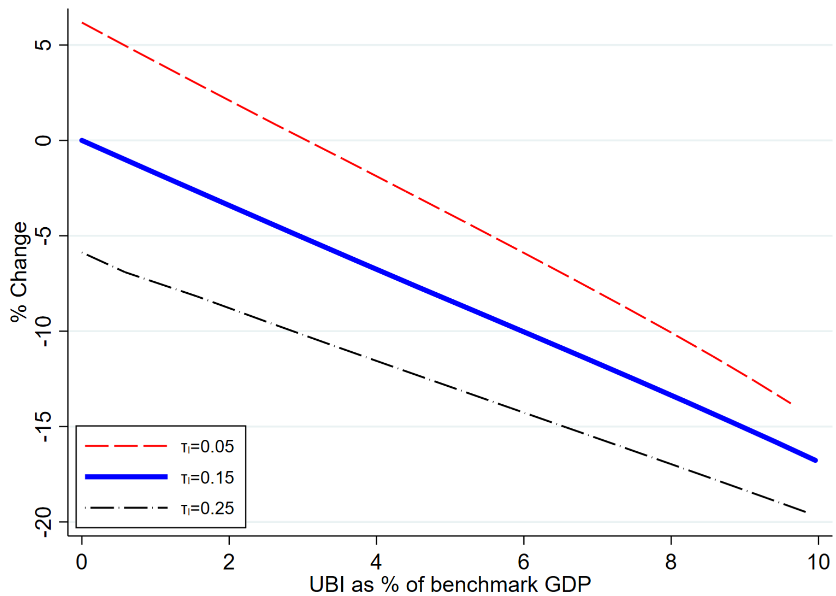
A.3. Appendix Figures

Figure A1: Aggregate Capital vs Capital per Worker - the Demand for Savings Channel



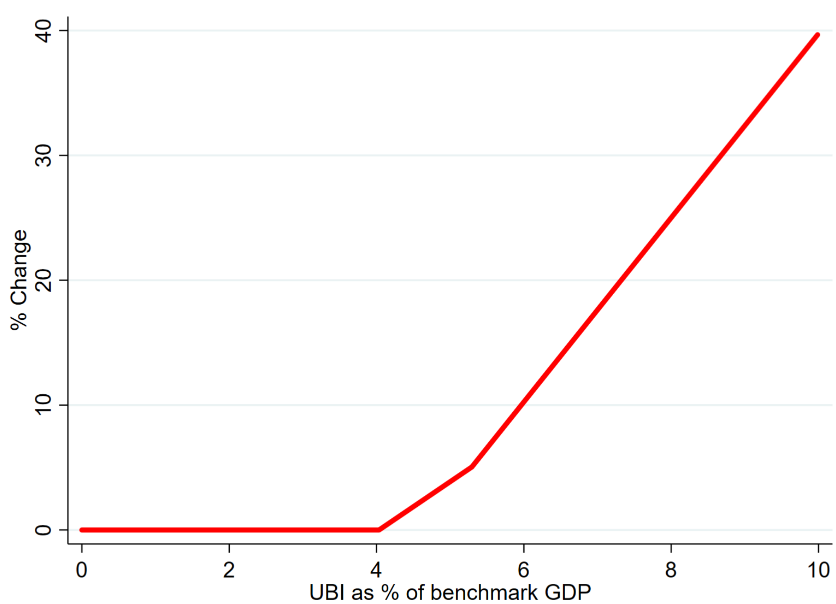
Notes: Steady state responses of aggregate capital (dashed red) and of capital per-worker (dash-dot black) to changes in UBI in the Alaska experiment. UBI and the capital measures are expressed as % of benchmark GDP.

Figure A2: Capital per Worker - different levels of progressivity



Notes: Steady state responses of capital per-worker to changes in UBI in the baseline model (blue), high (dash-dot black), and low (dash red) progressivity. UBI and the capital measures are expressed as % of benchmark GDP.

Figure A3: UBI substitutes for welfare: Consumption outside the labor force



Notes: Consumption outside the labor force implied by the policy whereby UBI substitutes for welfare payments up to a cap.