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# Welfare implications of switching to consumption taxation[☆]

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ABSTRACT

We evaluate a reform of the US tax system switching to consumption taxation instead of income taxation. We do so in an environment that allows for progressivity of consumption taxes through differential tax rates between basic and non-basic consumption goods. The consumption tax system that maximizes aggregate welfare involves a 4% subsidy on basic consumption goods and a 68% tax on non-basic goods. Such a tax scheme generates 10% higher output in the long run, with a small increase in inequality. Nonetheless, the benchmark with progressive income taxes and mild consumption taxes provides higher welfare on aggregate in the steady state, and even more so if we consider the transition.



## 1. Introduction

The standard argument in favor of a move towards increasing the reliance on indirect taxation is made on the grounds of efficiency considerations. The argument is that flat consumption taxes that are constant over time are less distortionary than the currently existing income tax code. While this is widely acknowledged among academic economists, it is usually perceived as a policy that increases inequality and reduces the progressivity of the tax system as a whole. We contribute to that literature by quantifying the impact of such reforms in an environment that accounts for differences in expenditure shares depending on earnings as observed in the data. While it is true that inequality would increase in the long run, the magnitudes are not that large. Nevertheless, such reforms only generate welfare gains in the partial equilibrium case.

We evaluate the welfare and macroeconomic implications of switching from income taxation to a system that exclusively relies on consumption taxation. In order to perform this policy exercise we propose a general equilibrium model with idiosyncratic uninsurable productivity risk in the spirit of Huggett (1996) and Aiyagari (1994). There are two crucial departures

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**Table 1**
Composition of consumption between basic goods ($C_1$) an the rest ($C_2$) depending on earnings, in %.

| | Bottom % | | | Quintile | | | | | Top % | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | [1,5] | [6,10] | Q1 | Q2 | Q3 | Q4 | Q5 | [91,95] | [96,99] | [99,100] |
| $C_1$ | 46.2 | 56.2 | 37.1 | 41.0 | 36.0 | 28.6 | 22.3 | 16.6 | 16.9 | 14.4 | 13.4 |
| $C_2$ | 53.8 | 43.8 | 62.9 | 59.0 | 64.0 | 71.4 | 77.8 | 83.4 | 83.1 | 85.6 | 86.6 |

of our model: first, we distinguish between basic consumption goods, that are subject to a consumption floor, and the rest of consumption goods. Second, we introduce a stochastic discount factor, in the spirit of Krusell and Smith (1998), allowing the model to generate a distribution of wealth more in line with the data.

In order to discipline our distinction between different types consumption goods, we look at the expenditure shares relative to labor earnings. We follow the criterion of defining basic goods as those for which their expenditure share is decreasing in labor earnings. Based on this criterion we label as basic goods food at home, rent, utilities, prescription medicine, television and books. All other expenditure categories are labeled as non-basic consumption goods.

Table 1 reports expenditure shares as a function of earnings quintiles from the Consumer Expenditure Survey (CEX) 2015 (see Section 2 for details). We observe that the share of expenditure in basic goods (labeled as $C_1$ in Table 1) is around 37–57% at the bottom of the earnings distribution, while it falls to less than 15% at the top. We carefully calibrate our economy to be consistent with both the observed distribution of earnings and the relationship between earnings and consumption shares across the two types of goods.

In an international comparison we observe that consumption taxes in the US are relatively low, especially when compared to most European economies. The Value Added Tax (VAT) in most European economies is above 20% and accounts for a substantial fraction of fiscal revenues, often close to the revenue generated by personal income taxes. In contrast, in the US sales taxes depend on the states and are subject to substantial differences in tax rates.

It is however a common feature to levy different tax rates on different types of consumption goods. Most notably, in the US grocery foods are exempted in 31 states of 46 states that have a state sales tax. Medical services and medicine are universally exempted. In contrast, clothing is exempted in only eight states, and the exemption does not apply to sport goods. A similar pattern emerges in Europe, where many goods are considered basic and therefore are subject to reduced rates. Our category of basic goods overlaps to a large extent with the categories that are exempt or subject to reduced rates in most tax systems around the world.

Our results suggest a strong rational for the widespread practice of taxing different goods at different rates. In fact, our quantitative results suggest that basic goods should be subsidized (a tax of −4%), with a corresponding tax rate for non-basic goods of 68%. In contrast, if we were to impose equal rates across consumption goods, we would obtain a tax of 44%.

Such a reform implies that only the most productive households with limited wealth experience welfare gains. In contrast, the rest of the population experience welfare losses (that are increasing in wealth holdings). Along the transition, only 7.5% of the population in the benchmark economy are better off with the reform. Our results are consistent with Nishiyama and Smetters (2007), who argue that switching to consumption taxation would not be efficient because of decreased consumption risk-sharing. In our case we find welfare losses are the norm even though we allow for means-tested transfers and progressive consumption taxes, that could potentially ameliorate the distributive consequences of reforms.

Interestingly, when we perform the same policy exercise in a partial equilibrium setup, we find generalized welfare gains for all consumers. The key difference is that hours worked fall by 4% in the partial equilibrium case, while they increase and become more unequally distributed in the general equilibrium case.

There is a long tradition advocating for expenditure taxation instead of income taxation that goes back to at least Kaldor (1955). In the recent literature, quantitative macroeconomic models similar to ours have been used to quantify the impact of different types of reforms. Besides Nishiyama and Smetters (2007) mentioned above, exercises quantifying the macroeconomic impact and inequality implications of consumption taxation, flat-tax reforms in the spirit of Hall and Rabushka (1995), or other similar reforms such as negative income taxes, can be found in Krusell et al. (1996), Ventura (1999), Altig et al. (2001), Correia (2010) and Lopez-Daneri (2016) among others.

Except for Li (2020) who considers durable and nondurable consumption, none of the other standard papers in that literature distinguish between different types of consumption goods. Lopez-Daneri (2016) also incorporates into the analysis the distribution of transfers as a function of income, but the policy exercises are different. The importance of transfers is highlighted also by the analysis in Correia (2010). For us this is a key ingredient of the analysis, since transfers at the lower end of the income distribution play a key role in allowing individuals to meet the subsistence levels of basic consumption goods. Finally, in a follow up paper, Conesa et al. (2020), we use a life-cycle version of the model to think about the welfare implications and the alternatives to finance different scenarios of Universal Basic Income.

The rest of the paper is structured as follows. Section 2 describes the empirical facts regarding the existing consumption tax systems and consumption patterns in the US. Section 3 describes the benchmark model and the calibration strategy. The numerical experiments are carried out in Section 4. We present the steady state results, the transition dynamics, and then evaluate the impact of general equilibrium effects. Section 5 summarizes and concludes.

## 2. Empirical facts on consumption taxation and the composition of consumption

### 2.1. The structure of consumption taxation

In the US, Pennsylvania was the first state to introduce a sales tax in 1921. Around half of the states introduced their own sales taxes during the 1920s and 1930s, others in the late 1940s and the 1960s. The states that still have not introduced sales taxes as of today are Alaska, Delaware, Montana, New Hampshire, and Oregon.

Most of the states apply reduced tax rates and exemptions on different categories. Grocery food is exempted in 31 out of 46 states that have sales taxes, and it is subject to reduced rates in the other states. Medical prescriptions are exempted in 42 states, and there are usually exemptions on newspapers and periodicals, and several services including transportation. Average tax ranges from 4% in Alabama to 7.5% in California.

In contrast to the US, many countries use a Value Added Tax (VAT) system. VAT is a broad-based tax on consumption by households, that taxes the sale to the final consumer through a staged payment process along the supply chain. Firms collect VAT (and pay it to the tax authority) on their sale revenues net of the VAT on the cost of their purchases of inputs and intermediate goods.

The VAT was first introduced in 1954 and is currently in place in 160 out of 193 countries in the world. All of the European Union members and the rest of OECD countries except the US implement a VAT. Moreover, it has become an increasingly larger component of GDP and government revenues. For example, in the OECD countries VAT as a percentage of GDP increased from an average 0.6% in 1965 to 6.8% in 2014. Moreover, VAT was only 2.2% of the OECD total tax revenue in 1965, and in 2014 20.1% of the tax revenue is collected through VAT. For the European Union members, VAT collects 7% of GDP (17% of the total tax revenue) in 2014.

Similar to sales taxes in US states, the VAT consists of a standard tax rate, together with several categories of reduced rates and exemptions. The standard VAT rates vary across countries. Worldwide, the standard tax rate ranges from 4.5% in Andorra to as high as 27% in Hungary. Within the OECD the average rate was 19.2% in 2014. EU member states are bound by common rules that set the minimum level of the standard rate at 15%. The average VAT rate of EU member states is 21.7%. Moreover, the standard VAT rates are also evolving over time.

More than half of the OECD countries apply reduced tax rates or exemption on categories like food at home, pharmaceutical products, medical and dental care, transportation, hotel accommodation, books newspapers and periodicals, admission to cultural events, supply of water and social services.

### 2.2. Consumption patterns in the CEX

In order to determine the distinction between basic goods and non-basic goods we look at the composition of consumption in relation to income in the CEX 2015. The consumer unit is one household, the expenditure profile is constructed according to labor earnings. We restrict our sample to households whose household head is between 21 and 65 years old and belongs to labor force. We calculate the share of consumption expenditure according to earning distributions for the 14 categories and 55 sub-categories of consumption from CEX 2015.[1] Then consumption categories classified into two groups: we consider basic goods those categories for which the share in total consumption decreases with earnings; all other categories are characterize as non-basic consumption. See Fig. 1 for the relationship between expenditure shares and earnings for the largest categories of consumption in the CEX.

The group with a declining consumption share as earnings increase takes up 46.2% of total consumption for the bottom 1% earners and only consists of 13.4% of total consumption of the top 1% earners. The specific categories included are food at home, rent payments, utilities, prescription medicine, television programs and books. Those are the categories we consider in our definition of basic goods, as in Table 1. Notice there is a substantial overlap between those categories and the goods that are usually subject to either reduced rates or exemptions.

Within the group of basic consumption, the shares of food at home and utilities decline the most with earnings: from 16.9% and 13.8% for the bottom 1% earners, to 5.6% and 4.0% for the top 1%, respectively. Rent payments also decrease rapidly with earnings, but with the highest share in the bottom 5%. On the other hand, expenses on food away from home and education, two large categories that belong to non-basic consumption, exhibit increasing patterns with earnings.

In this characterization we have not distinguished between consumption and spending. This is consistent with our model, where both goods are produced with the same technology and therefore the relative price is always one in the absence of taxes. See Aguiar and Hurst (2005) for a thorough examination of the distinction between consumption and spending patterns.

[1] See online Appendix D for more details.

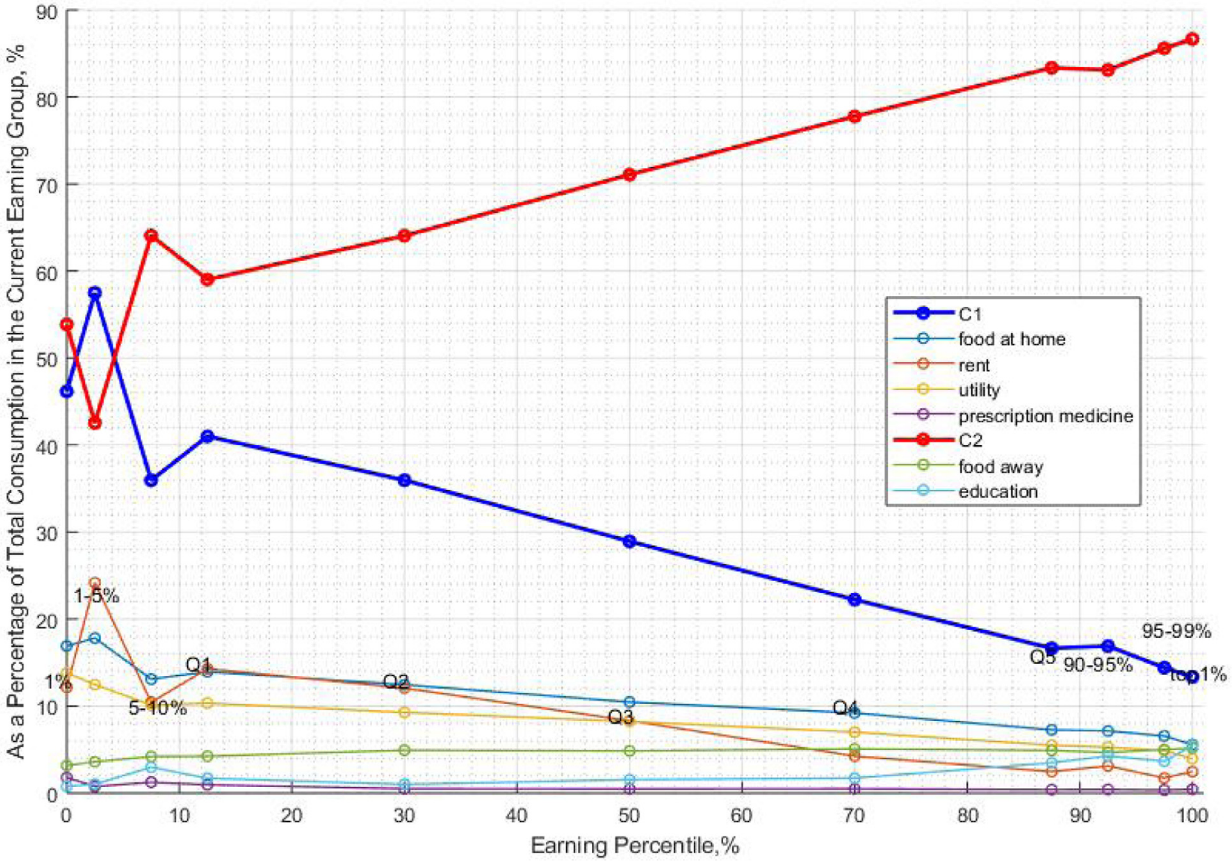



**Fig. 1.** Examples of $C_1$ and $C_2$.

## 3. The benchmark economy

### 3.1. Description of the model

The model builds on the Huggett (1993) and Aiyagari (1994) tradition, with endogenous labor supply and a government sector. The government sector uses taxes to finance a given level of government consumption, and provide households with transfers conditional on their income. The government budget balances period by period.

The economy is populated with a continuum (with measure 1) of infinitely lived households, who differ in asset holdings $a$, and their stochastic labor efficiency $\epsilon$. Each period, besides their labor and capital income, households also receive government transfers $tr$, which is conditional on earnings and assets. Households divide their income between basic consumption $c_1$, non-basic consumption $c_2$, and the amount of assets to be carried over to the next period. We assume that $c_1$ is subject to a minimum consumption level, denoted by $\underline{c}$. Households discount future with a stochastic factor $\beta$. The cumulative distribution function is denoted by $\mu$, over the domain of $A \times E \times D$, where $A$, $E$ and $D$ are the state spaces for financial assets $a$, labor efficiency $\epsilon$ and discount factor $\beta$.

Given prices and policies, households solve the following maximization problem:

$$V(a, \epsilon, \beta) = \max_{c_1, c_2, l, a'} \{u(c_1, c_2, l) + \beta \mathbb{E}[V(a', \epsilon', \beta')|\epsilon, \beta]\} \tag{1}$$

subject to

$$(1 + \tau_{c1})c_1 + (1 + \tau_{c2})c_2 + a' = \big(1 + (1 - \tau_a)r\big)a + w\epsilon l + tr(w\epsilon l, a) - T_w(w\epsilon l) \tag{2}$$

$$c_1 \geq \underline{c} \tag{3}$$

$$c_2 \geq 0 \tag{4}$$

$$a' \geq 0 \tag{5}$$

$$0 \leq l \leq 1 \tag{6}$$

$$\epsilon' = Q(\epsilon) \tag{7}$$

$$\beta' = \Pi(\beta) \tag{8}$$

where $\tau_{c1}$, $\tau_{c2}$ and $\tau_a$ denote the tax rates on basic consumption, non-basic consumption and asset returns, respectively. $T_w(\cdot)$ and $tr(\cdot)$ are labor income tax function and welfare transfer function.

The labor efficiency $\epsilon$ is assumed to follow a first order Markov process, denoted by $Q(\cdot)$. The discount factor $\beta$ follows a Markov process, denoted by $\Pi(\cdot)$.

The representative firm uses capital $K$ and efficiency units of labor $L$, and takes equilibrium prices as given. Capital depreciates at rate $\delta$. The firm's maximization problem yields

$$r = F_1(K, L) - \delta,$$
$$w = F_2(K, L).$$

We assume total fiscal revenue equals to total government outlays, which consists of a constant government consumption $G$ and aggregate welfare transfers $Tr$. $Tax_{c1}$, $Tax_{c2}$, $Tax_a$ and $Tax_w$ represent total consumption tax, total capital income tax and total labor income tax. The government budget constraint is then:

$$Tax_{c1} + Tax_{c2} + Tax_a + Tax_w = G + Tr$$

*Stationary equilibrium:* Given fiscal policy $\tau_{c1}$, $\tau_{c2}$, $\tau_a$, $T_w(\cdot)$, a transfer function $tr(\cdot, \cdot)$, and a constant level of government outlays $G + Tr$, a stationary equilibrium is defined as a pair of prices $\{r, w\}$, household value function $V(a, \epsilon, \beta)$ and policy functions $\{c_1(a, \epsilon, \beta), c_2(a, \epsilon, \beta), l(a, \epsilon, \beta), a'(a, \epsilon, \beta)\}$, aggregate variables $\{C_1, C_2, K, L, Tax_{c1}, Tax_{c2}, Tax_a, Tax_w, G, Tr\}$, and a cumulative distribution function $\mu(a, \epsilon, \beta)$ such that:

1. Given the prices and fiscal functions, $\{c_1(a, \epsilon, \beta), c_2(a, \epsilon, \beta), l(a, \epsilon, \beta), a'(a, \epsilon, \beta)\}$ solve the households maximization problem (1), subject to constraints (2) to (8).
2. Firms behave optimally:
$$r = F_1(K, L) - \delta$$
$$w = F_2(K, L);$$
3. The goods market clears:
$$C_1 + C_2 + \delta K + G = F(K, L)$$
$$C_1 = \int_{A\times E\times D} c_1(a, \epsilon, \beta)\ d\mu(a, \epsilon, \beta)$$
$$C_2 = \int_{A\times E\times D} c_2(a, \epsilon, \beta)\ d\mu(a, \epsilon, \beta)$$
$$K = \int_{A\times E\times D} a(a, \epsilon, \beta)\ d\mu(a, \epsilon, \beta);$$
4. The labor market clears:
$$L = \int_{A\times E\times D} \epsilon l(a, \epsilon, \beta)\ d\mu(a, \epsilon, \beta)$$
5. The government budget constraint is satisfied:
$$Tax_a + Tax_{c1} + Tax_{c2} + Tax_w = Tr + G$$
$$Tax_a = \int_{A\times E\times D} \tau_a r a(a, \epsilon, \beta)\ d\mu(a, \epsilon, \beta)$$
$$Tax_{c1} = \int_{A\times E\times D} \tau_{c1} c_1(a, \epsilon, \beta)\ d\mu(a, \epsilon, \beta)$$
$$Tax_{c2} = \int_{A\times E\times D} \tau_{c2} c_2(a, \epsilon, \beta)\ d\mu(a, \epsilon, \beta)$$
$$Tax_w = \int_{A\times E\times D} T_w(w\epsilon l(a, \epsilon, \beta))\ d\mu(a, \epsilon, \beta)$$
$$Tr = \int_{A\times E\times D} tr(w\epsilon l(a, \epsilon, \beta), a)\ d\mu(a, \epsilon, \beta)$$

6. The stationary distribution is consistent with the Markov transition rule and households' decision rules:

$$\mu(a', \epsilon', \beta') = \mu(a, \epsilon, \beta)\Pi(\beta, \beta')Q(\epsilon, \epsilon')\mathbf{1}(a' = a'(a, \epsilon, \beta))$$

where $Q(\epsilon, \epsilon')$ and $\Pi(\beta, \beta')$ are the Markov transition matrices and $\mathbf{1}(a' = a'(a, \epsilon, \beta))$ is an indicator function that takes value 1 if the expression inside is true and 0 otherwise.

### 3.2. Calibration

This section describes the calibration strategy. Some of the parameters are determined outside of the model, while others are jointly determined in equilibrium. The elasticity of intertemporal substitution and the Frisch labor supply elasticity are fixed from the literature. Technology parameters are directly measured from national accounts data. Finally, tax, government consumption and transfer policy are directly obtained from data. See Table 2 for parameters that are chosen outside the model. All other parameters are jointly determined in equilibrium to target selected data moments, and are shown in Table 3.

#### 3.2.1. Stochastic discount factor

We assume that the discount factor follows a Markov process with two states, $\beta_1 < \beta_2$. The transition matrix is $\Pi = \begin{pmatrix} \pi_1 & 1-\pi_1 \\ 1-\pi_2 & \pi_2 \end{pmatrix}$. The invariant distribution is assumed to be $(\pi_1^*, \pi_2^*) = (0.8, 0.2)$, following Krusell and Smith (1998). This implies that $\pi_1$ and $\pi_2$ satisfy $4\pi_1 - \pi_2 = 3$ and $\pi_1 > 0.75$. We arbitrarily choose a value for $\pi_1 = 0.98$, and then calibrate $\beta_1$ and $\beta_2$ to match the capital to output ratio and and the Gini index of wealth, respectively. We find the following values, as shown in Table 4:

**Table 2**
Parameters calibrated outside the model.

| Parameter | Description | Value |
|---|---|---|
| $\alpha$ | Capital share of output | 0.33 |
| $\delta$ | Capital depreciation rate | 0.059 |
| $\sigma$ | Curvature in utility of cons | 1.00 |
| $\chi$ | Frisch labor supply elasticity | 0.75 |
| $\pi_1$ | Transition matrix of discount factor | 0.98 |
| $\pi_1^*$ | Invariant distribution of discount factor | 0.8 |
| $\tau_a$ | Capital income tax | 0.40 |
| $\kappa_0$ | Marginal tax rate | 0.41 |
| $\kappa_1$ | Progressivity | 0.89 |
| $\tau_{c_2}$ | Consumption tax | 0.076 |
| $\mu_1$ | Welfare transfers | 1.38 |
| $\mu_2$ | Welfare transfers | 1.87 |
| $\mu_3$ | Welfare transfers | 1.50 |
| $\mu_4$ | Welfare transfers | 1.72 |
| $\mu_5$ | Welfare transfers | 1.33 |
| $\mu_6$ | Welfare transfers | 0.84 |
| $\mu_7$ | Welfare transfers | 0.79 |

**Table 3**
Parameters calibrated in equilibrium.

| Parameter | Description | Target | Value |
|---|---|---|---|
| $\beta_1$ | Low discount factor | $K/Y = 3.3$ | 0.86 |
| $\beta_2$ | High discount factor | Wealth gini = 0.78 | 1.07 |
| $\underline{c}$ | Minimum consumption | $\frac{C_1(Q_1)/C_2(Q_1)}{C_1(Q_5)/C_2(Q_5)} = 2.0$ | 0.14 |
| $\gamma$ | Necessity share in total $C$ | $(C_1 - \underline{c})/C_2 = 0.2$ | 0.15 |
| $B$ | | Average hour=1/3 | 11.74 |
| $\bar{a}$ | Asset threshold | 20.42 | |
| $\sigma_s$ | Variance | Earning Gini = 0.65 | 8.99 |
| $\sigma_{s1}$ | Variance | $C_1/C$ as a function of earning percentile | 3.90 |
| $\epsilon_{top}$ | Productivity at the top | Earning share at top 1% = 15.32% | 25.26 |
| $\pi_{top}$ | Probability at the top | Earning share at top 10% = 40.99% | 0.005 |
| $\rho_{norm}$ | Persistence at the bottom | 2-year earning persistence at bottom 80% = 0.94 | 0.90 |
| $\rho_{top}$ | Persistence at the top | 2-year earning persistence at top 1% = 0.58 | 0.78 |
| $\kappa_2$ | Labor tax | $Tr)/Y = 27.30\%$ | 1.53 |
| $\mu_8$ | | $Tr/G = 17.38\%$ | 0.41 |

**Table 4**
Markov $\beta$.

| | | |
|---|---|---|
| $\beta$ | 0.86 | 1.07 |
| $\Pi$ | 0.98 | 0.02 |
| | 0.08 | 0.92 |
| $(\pi_1^*, \pi_2^*)$ | 0.80 | 0.20 |

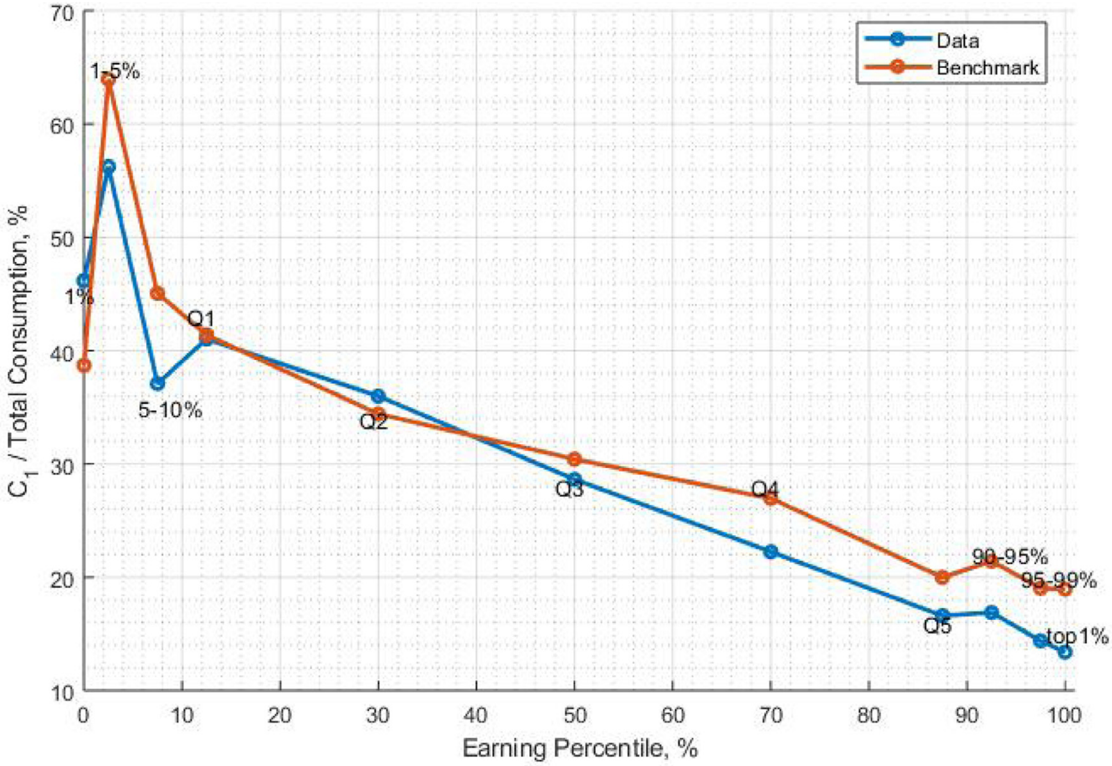



**Fig. 2.** $C_1$ as percentage of total consumption.

Note that we have $\beta_2$ exceeding 1. This is plausible as long as there are sufficient periods of being patient, which is true in our case.[2] A smaller value of $\pi_1$ results in a calibrated value of $\beta_2$ that is way too high, resulting in computational problems.

*3.2.2. Preferences*

The utility function takes the following functional form:

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

We set $\sigma$ equal to 1. Following Chetty et al. (2012), we set the Frisch elasticity of aggregate hours to $\chi = 0.75$. The rest of preference parameters are jointly determined in equilibrium.

The minimum consumption $\underline{c}$ is determined to capture the decreasing share of basic consumption in total consumption. Specifically, we choose $\underline{c}$ to target the $\frac{c_1(Q_1)/c_2(Q_1)}{c_1(Q_5)/c_2(Q_5)}$, where $c_j(Q_i)$ means the consumption of good $c_j$ by the $i$th earnings quintile. The share of basic consumption $\gamma$ is calibrated to match the average shares of the distribution of consumption. Fig. 2 shows the fit of the model to the data. The model generates a pattern of the ratio between $C_1$ and total $C$ as a function of earnings that is roughly consistent with the data.

Finally, $B$ is calibrated such that average hours worked are one third of available time.

[2] Toda (2019) proves that some realizations of stochastic discount factor can be greater than 1.

**Table 5**
Shock $\epsilon$ and transition matrix Q.

| Shock $\epsilon$ | | | | | | |
|---|---|---|---|---|---|---|
| $\epsilon$: | $\frac{1}{\sigma_s}$ | $\frac{1}{\sigma_{s1}}$ | 1 | $\sigma_{s1}$ | $\sigma_s$ | $\epsilon_{top}$ |
| Transition matrix Q | | | | | | |
| | $\rho_{norm}$ | $1-\rho_{norm}-\pi_{top}$ | 0 | 0 | 0 | $\pi_{top}$ |
| | $\frac{1-\rho_{norm}-\pi_{top}}{2}$ | $\rho_{norm}$ | $\frac{1-\rho_{norm}-\pi_{top}}{2}$ | 0 | 0 | $\pi_{top}$ |
| Q: | 0 | $\frac{1-\rho_{norm}-\pi_{top}}{2}$ | $\rho_{norm}$ | $\frac{1-\rho_{norm}-\pi_{top}}{2}$ | 0 | $\pi_{top}$ |
| | 0 | 0 | $\frac{1-\rho_{norm}-\pi_{top}}{2}$ | $\rho_{norm}$ | $\frac{1-\rho_{norm}-\pi_{top}}{2}$ | $\pi_{top}$ |
| | 0 | 0 | 0 | $1-\rho_{norm}-\pi_{top}$ | $\rho_{norm}$ | $\pi_{top}$ |
| | 0 | 0 | 0 | 0 | $1-\rho_{top}$ | $\rho_{top}$ |

### *3.2.3. Productivity process*

We use the same strategy to calibrate the productivity process as in Kindermann and Krueger (2014) or Conesa et al. (2018). This strategy proposes a "normal" productivity process (with 5 states) that follows the typical dynamics of a Markov process consistent with variance and persistence observed in PSID data, enriched with a "super-star" productivity state that is calibrated to be very large relative to the normal process, is infrequent, and has very little persistence. This type of productivity processes can potentially generate the high concentration at the top of the earnings distribution observed in the data, which is something difficult to achieve with only the "normal" process. Specifically, the shock states and the transition matrix take the following form (see Table 5):

The normal states of the labor productivity shock (the first five states) are symmetric in logarithm with $\sigma_s > \sigma_{s1}$. The parameter $\sigma_{s1}$ is calibrated to capture the trend of $C_1/(C_1+C_2)$ against the earnings distribution, and $\sigma_s$ is calibrated to match the earnings Gini index, 0.65 in the data. The superstar productivity is given by $\epsilon_{top}$, which is calibrated to target an earnings share of the top 1% of 15.32%.

The transition matrix of normal states (the left-top $5 \times 5$ block matrix) is roughly symmetric, going up or going down the efficiency ladder takes the same probabilities as long as one is not at the first or the fifth shock state. Following Conesa et al. (2018), we calibrate $\rho_{norm}$ to match the 2-year earnings persistence at the bottom 80% of 0.94. Besides moving around the current state, households also have a small probability $\pi_{top}$ to become a superstar. Parameter $\pi_{top}$ is calibrated to match the earnings share at the top 10% of 41.0%. Once a superstar, with the probability of $\rho_{top}$ you stay there or otherwise the worker moves down one ladder to become a normal type, we use $\rho_{top}$ to target the 2-year earnings persistence at the top 1% of 0.58.

### *3.2.4. Technology*

The production function is assumed to be Cobb–Douglas, with a capital income share of 0.33. The capital depreciation rate is set to be 5.9%, to match investment ratios in the steady state of the benchmark economy to averages in the data.

### *3.2.5. Fiscal policy*

Given the discussion in Section 2, we assume that in the benchmark there is only a consumption tax on non-basic consumption goods, and that basic consumption goods are tax exempt, meaning $\tau_{c1} = 0$. We calibrate $\tau_{c2} = 7.6\%$ to match the total consumption tax revenue to GDP ratio, which is 3.35% over the past ten years.[3]

We assume that the capital income tax is proportional to net earnings from wealth, with a marginal tax rate of $\tau_a = 0.40$ (see Domeij and Heathcote, 2004). The labor income tax follows Gouveia and Strauss (1994) and takes the form:

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

where $y = w\epsilon l$ is labor earnings, $\kappa_0$ controls the average tax rate, and $\kappa_1$ governs the degree of progressivity (how fast the marginal tax rate increases from 0 to $\kappa_0$).

Following Anagnostopoulos et al. (2012) we set $\kappa_0 = 0.41$ and $\kappa_1 = 0.89$. $\kappa_2$ is calibrated to generate total government outlays of 27.3% of GDP. This ratio is constructed from NIPA Tables 1.1.5, 3.2, 3.20 and 3.21. Basically, we exclude social security contributions from the current receipts of federal, state and local governments. We do that since we use an infinite horizon model and by construction we are abstracting from intergenerational transfers. Social security contributions amount to roughly 6.65% of GDP on average between 2000 and 2018.

The government provides a variety of means-tested welfare programs to help families with low income and protect them against hardship. The Congressional Research Service (CRS) identifies 83 overlapping welfare programs, classified into ten categories: cash assistance, medical, food, housing, energy and utilities, education, training, services, child care and child development, and community development.

From all available sources, we calculate the spending of the largest welfare programs, their proportions in total government outlays, constructed from the White House Office of Management and Budget Historical tables.[4]

[3] The data of tax revenue can be found at the Office of Management and Budget of the US Government.

[4] See online Appendix D for details.

Averaging over 1997 to 2016,[5] the largest welfare programs are 1. Medicaid (7.3% in the total outlays); 2. UI (1.8%); 3. SNAP (1.6%); 4. Housing Assistance (1.5%); 5. Earned Income Tax Credit (1.5%); 6. SSI (1.4%); 7. TANF (0.8%); 8. Children's Nutrition Program (0.5%); 9. Child Tax Credit (0.5%); 10. WIC (0.2%); 11. Children's Health Insurance Program (CHIP)(0.2%); 12. Low Income Home Energy Assistance (LIHEA) (0.1%).

Summing up, the total share of these welfare programs in total outlays is 17.4% on average over the period 1997 to 2016. Hence we fix transfers to total government outlays ratio at this number. For the distribution of the welfare transfer, we use PSID as the main data source and CEX and MEPS as supplements.

PSID is a thorough survey on households' income sources. Moreover, PSID also keeps records on welfare transfers, like food stamps (TANF), SSI, energy assistance and unemployment compensation, etc. However, PSID does not include tax credits and Medicaid, so we obtain information about EITC and child tax credit from the CEX, and Medicaid from MEPS. As we did for the CEX, we only include households from PSID and MEPS whose head of household is between 21 and 65 years old and works more than 260 hours a year.

Because of the differences in data samples, survey frequency and survey questions, there are several inconsistencies in the outcomes. For example, the average earnings in MEPS is roughly 80% of the average earnings in the PSID and CEX; PSID reports earnings at the top 1% group that are almost twice as those in MEPS. We adhere to PSID earnings data for its thoroughness, and interpolate EITC and child tax credits in CEX and Medicaid in MEPS to PSID earning level.[6]

The transfer function parameters are shown in Table 2. We choose a piece-wise linear function to describe the welfare transfers as a function of earnings and assets. That is:

$$\begin{aligned} tr = \Big( & (\mu_1 \mathbf{1}_{y \in bottom1} + \mu_2 \mathbf{1}_{y \in bottom1-5} + \mu_3 \mathbf{1}_{y \in bottom5-10} \\ & + \mu_4 \mathbf{1}_{y \in Q1} + \mu_5 \mathbf{1}_{y \in Q2} + \mu_6 \mathbf{1}_{y \in Q3} + \mu_7 \mathbf{1}_{y \in Q4} + \mu_8 \mathbf{1}_{y \in Q5})\Big) \mathbf{1}_{a \leq \bar{a}} \times Tr \end{aligned}$$

where $y$ denotes labor earnings, and $Tr$ is the total amount of welfare transfers, $\mathbf{1}$ is an indicator that takes value 1 if the criterion is satisfied, $y \in Q_1$ means that earnings fall into the first quintile of earnings distribution, $\bar{a}$ is the asset threshold for asset test.

For the welfare programs we consider, Medicaid, SNAP (in most states), SSI and TANF are subject to an asset test, whereas the rest of the programs are not. Usually when a welfare program is subject to an asset test, assets are split into two categories: uncountable and countable assets. Uncountable assets refer to the ones that do not account for the eligibility of a specific program and are considered as "exempted".

For example, in Medicaid, the assets that are exempted include 1. the first \$2000 of bank accounts and cash; 2. funeral and burial funds; 3. insurance policies below \$1500 (this amount varies); 3. primary home below \$595, 000 in most states and up to \$893, 000 in other states; 5. vehicles. Other asset test programs share similar criterion.

Because we do not distinguish between financial and real assets in our model, we set the asset limit for the overall welfare transfer programs to be \$600, 000, roughly ten times the GDP per capita. That results in $\bar{a} = 20.42$ for our benchmark economy. Finally, we take $\{\mu_i\}_{i=1}^{7}$ from the data and adjust $\mu_8$ such that the total welfare transfer takes up 17.38% of government spending.

### 3.3. Model validation

We compare the distributions in our benchmark economy to those in the data in Table 6 and Table 7. The model generates a distribution of earnings that matches the data fairly well. That is hardly surprising given that the Gini and the productivity process are calibrated to match selected moments of that distribution. The model matches the wealth Gini and the wealth distribution in most percentiles quite well but fails to generate as much concentration at the top 1% as seen in the data. In order to match the top 1% the model would require a very large value for $\beta_2$, resulting in convergence issues. The model also does a good job in matching the consumption distribution, owing to the fact that we specifically match the share of both consumption goods in total consumption using three different parameter: $\underline{c}$, $\gamma$ and $\sigma_{s1}$. The welfare transfers match the data almost perfectly, thanks to the piece-wise linear function we assume for the transfer function.

Finally, the tax burden in the benchmark model is also close to its data counterpart.

Overall, we believe the model does reasonably well in capturing the degree of inequality of the US economy along the relevant dimensions. We now turn to the main policy experiments.

## 4. Numerical experiments

In this section, we perform a series of experiments that replace income taxes (both capital and labor income taxes) with consumption taxes. The post reform budget constraint for households becomes:

$$(1 + \tau_{c1})c_1 + (1 + \tau_{c2})c_2 + a' = (1 + r)a + w\epsilon l + tr(w\epsilon l, a)$$

The way we proceed is as follows. We first present the general equilibrium results for both the steady state and the transition, and later we discuss the results in partial equilibrium.

[5] The reason we begin with 1997 is that TANF was implemented in Jan. 1st, 1997.

[6] The original data and the interpolation algorithm are shown in online Appendix E.

**Table 6**
Distribution of earnings, wealth, consumption and welfare transfer, in %.

| | Gini | Bottom% | | | Quintile | | | | | Top% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | [1,5] | [6,10] | Q1 | Q2 | Q3 | Q4 | Q5 | [91,95] | [96,99] | [99,100] |
| | | | | | | Earnings | | | | | | |
| Data | 0.65 | −0.1 | 0.0 | 0.0 | −0.1 | 2.8 | 11.1 | 21.7 | 64.5 | 13.3 | 17.7 | 15.3 |
| Model | 0.65 | 0.0 | 0.0 | 0.1 | 0.3 | 1.6 | 10.2 | 22.2 | 65.6 | 15.1 | 20.7 | 12.1 |
| | | | | | | Wealth | | | | | | |
| Data | 0.78 | −0.2 | 0.0 | 0.0 | −0.2 | 1.3 | 5.3 | 13.5 | 80.2 | 14.1 | 25.7 | 25.8 |
| Model | 0.78 | 0.0 | 0.2 | 0.0 | 0.8 | 1.9 | 1.7 | 11.0 | 84.6 | 21.6 | 30.4 | 12.8 |
| | | | | | | Basic consumption $C_1$ | | | | | | |
| Data | 0.27 | 0.7 | 2.7 | 4.3 | 16.1 | 18.6 | 20.1 | 21.2 | 24.1 | 6.4 | 5.4 | 1.5 |
| Model | 0.29 | 1.2 | 1.7 | 4.0 | 11.2 | 12.7 | 23.5 | 22.9 | 29.8 | 9.1 | 6.1 | 2.3 |
| | | | | | | Non-basic consumption $C_2$ | | | | | | |
| Data | 0.44 | 0.3 | 0.7 | 2.0 | 6.8 | 10.4 | 15.7 | 23.5 | 43.6 | 11.5 | 11.5 | 4.1 |
| Model | 0.55 | 1.5 | 1.2 | 1.3 | 6.4 | 7.1 | 22.3 | 25.5 | 38.9 | 11.6 | 8.1 | 3.4 |
| | | | | | | Welfare transfer, according to earning quintile | | | | | | |
| data | | 1.8 | 9.5 | 9.8 | 41.0 | 28.5 | 13.3 | 10.4 | 6.6 | 1.3 | 0.7 | 0.1 |
| Model | | 1.1 | 4.7 | 15.9 | 33.7 | 30.0 | 22.0 | 8.6 | 5.7 | 1.9 | 0.6 | 0.3 |

**Table 7**
Distribution of tax burden, in %.

| | Gini | Bottom % | | | Quintile | | | | | Top % | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | [1,5] | [6,10] | Q1 | Q2 | Q3 | Q4 | Q5 | [91,95] | [96,99] | [99,100] |
| Data | 0.74 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 5.9 | 18.0 | 75.8 | 16.9 | 25.0 | 15.3 |
| Model | 0.66 | 0.6 | 0.5 | 0.3 | 2.1 | 2.6 | 10.6 | 20.9 | 63.8 | 14.0 | 21.6 | 12.0 |
| | | | | | | By income distribution | | | | | | |
| Data | | 0.0 | 0.2 | 0.0 | 0.5 | 2.7 | 8.8 | 19.0 | 69.1 | 16.4 | 22.6 | 12.1 |
| Model | | 0.1 | 1.3 | 1.2 | 5.1 | 8.0 | 17.9 | 28.2 | 40.8 | 11.3 | 7.6 | 3.1 |

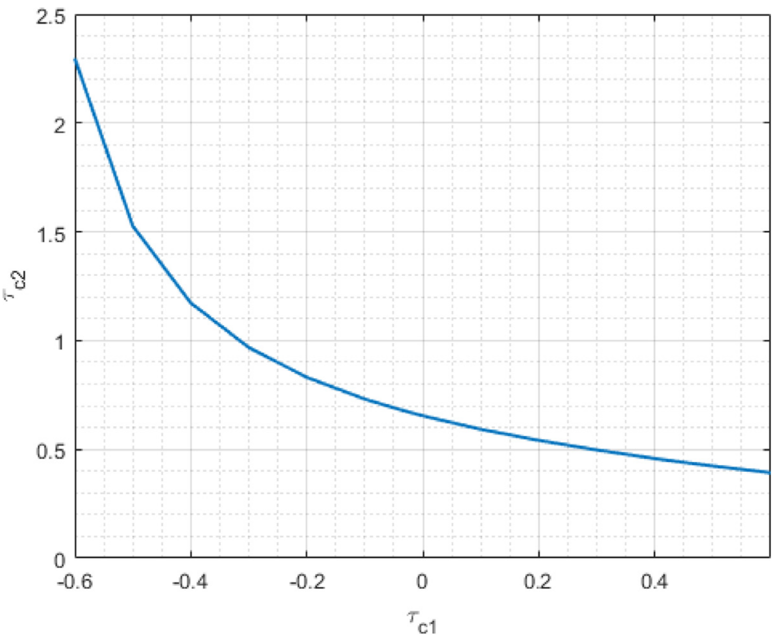



**Fig. 3.** Consumption taxes, $\tau_{c1}$ v.s. $\tau_{c2}$.

## *4.1. Steady state analysis*

For the steady state results, we fix the tax rate on basic goods $\tau_{c1}$ on a given grid of points, and then we let the tax rate on the non-basic consumption $\tau_{c2}$ adjust to balance the government budget. We obtain a different steady state equilibrium for each value on the grid of basic goods taxation. Fig. 3 plots the value of taxation of non-basic consumption goods that corresponds to each tax rate of basic goods in the stationary equilibrium.

**Table 8**
Aggregates results.

| Variable | Benchmark | | | | Optimal | | Flat | | Optimal PE[a] |
|---|---|---|---|---|---|---|---|---|---|
| $\tau_{c1}$ | 0.00 | −0.60 | −0.40 | −0.20 | −0.04 | 0.20 | 0.44 | 0.60 | −0.04 |
| $\tau_{c2}$ | 0.08 | 2.30 | 1.17 | 0.83 | 0.68 | 0.54 | 0.44 | 0.39 | 0.65 |
| $r$, in % | 4.08 | 2.50 | 2.48 | 2.47 | 2.44 | 2.39 | 2.37 | 2.33 | 4.08 |
| | | (−38.1%) | (−39.2%) | (−39.6%) | (−40.3%) | (−41.5%) | (−42.0%) | (−42.9%) | (0.00%) |
| $Y$ | 2.04 | 2.19 | 2.21 | 2.23 | 2.24 | 2.26 | 2.29 | 2.30 | 1.95 |
| | | (7.4%) | (8.1%) | (9.0%) | (9.7%) | (10.9%) | (11.9%) | (12.8%) | (−4.0%) |
| $K$ | 6.75 | 8.62 | 8.68 | 8.78 | 8.88 | 9.01 | 9.12 | 9.24 | 6.46 |
| | | (27.7%) | (28.7%) | (30.2%) | (31.6%) | (33.5%) | (35.2%) | (37.0%) | (−4.3%) |
| $H$ | 0.30 | 0.29 | 0.29 | 0.30 | 0.31 | 0.32 | 0.33 | 0.34 | 0.29 |
| | | (−4.9%) | (−2.6%) | (−0.2%) | (2.1%) | (6.2%) | (10.8%) | (14.0%) | (−4.7%) |
| $L$ | 1.33 | 1.31 | 1.32 | 1.32 | 1.33 | 1.34 | 1.35 | 1.36 | 1.27 |
| | | (−1.5%) | (−0.8%) | (−0.2%) | (0.3%) | (1.2%) | (1.9%) | (2.5%) | (−4.0%) |
| $C1$ | 0.30 | 0.77 | 0.56 | 0.45 | 0.40 | 0.34 | 0.31 | 0.29 | 0.40 |
| | | (156.7%) | (82.7%) | (47.5%) | (30.0%) | (12.5%) | (0.7%) | (−5.0%) | (32.7%) |
| $C2$ | 0.87 | 0.45 | 0.67 | 0.79 | 0.85 | 0.92 | 0.97 | 1.00 | 0.90 |
| | | (−48.3%) | (−22.6%) | (−9.0%) | (−1.7%) | (6.2%) | (12.1%) | (15.4%) | (3.7%) |
| $K/Y$ | 3.30 | 3.93 | 3.93 | 3.95 | 3.96 | 3.98 | 3.99 | 4.01 | 3.30 |
| $(G+Tr)/Y$ | 0.28 | 0.26 | 0.26 | 0.26 | 0.25 | 0.25 | 0.25 | 0.25 | 0.29 |
| $C_1/C_2$ | 0.35 | 1.72 | 0.83 | 0.57 | 0.45 | 0.37 | 0.31 | 0.29 | 0.45 |
| $Gini_{earn}$ | 0.65 | 0.65 | 0.64 | 0.64 | 0.64 | 0.64 | 0.63 | 0.63 | 0.65 |
| $Gini_a$ | 0.78 | 0.80 | 0.79 | 0.79 | 0.78 | 0.78 | 0.77 | 0.77 | 0.72 |
| $Gini_{c1}$ | 0.29 | 0.45 | 0.42 | 0.39 | 0.37 | 0.34 | 0.32 | 0.30 | 0.36 |
| $Gini_{c2}$ | 0.55 | 0.55 | 0.56 | 0.56 | 0.57 | 0.58 | 0.58 | 0.58 | 0.55 |
| Consumption equivalent of steady state welfare gain, in % | | | | | | | | | |
| $\Delta$ | | −32.9 | −13.6 | −7.8 | −6.6 | −7.6 | −9.6 | −12.4 | 33.9 |
| $\Delta_{agg}$ | | −25.1 | −1.3 | 7.2 | 9.8 | 10.8 | 9.7 | 7.8 | 20.2 |
| $\Delta_{dist}$ | | −10.4 | −12.5 | −13.9 | −14.9 | −16.6 | −17.6 | −18.8 | 11.4 |
| Consumption equivalent of transition welfare gain, in % | | | | | | | | | |
| $\Delta$ | | −41.1 | −22.1 | −17.1 | −15.2 | −16.7 | −20.9 | −28.6 | 2.4 |

[a] $Y$ and $K$ are reported as domestic production (GDP) and domestic capital. GNP, calculated as the sum of labor income and capital income, equals 2.44, an increase of 19.61% relative to the benchmark. The total capital accumulated by households is 11.34, 68% higher than that in the benchmark.

Table 8 shows the steady state results for the benchmark economy and eight experiments, with $\tau_{c1}$ ranging from a subsidy of 60% to a tax of 60%. The one labeled as "Optimal", corresponds to the policy that generates the highest average welfare in the stationary equilibrium, with a subsidy on basic consumption goods of 4% and a tax on non-basic consumption goods of 68%. Notice that the difference in taxation across goods implies a large deviation from the principle of "uniform commodity taxation", see Deaton (1979) among others. The rationale for this deviation is the presence of non-homotheticities.

All the reforms involve the elimination of all income taxes, resulting in substantial increases in capital accumulation, ranging from 27.7% to 37.0%. At the optimal, aggregate capital increases by 31.6% relative to the benchmark economy. When consumption taxes become less progressive, namely a higher $\tau_{c1}$ and a lower $\tau_{c2}$, the aggregate capital experiences an even larger increase relative to the benchmark economy. Regarding labor supply, at the optimal the average hours worked increases by 2.1% and the effective labor increases by only 0.3%. The fact that average hours worked increase more than effective labor indicates that less productive households supply more labor.

More productive households increase labor supply as the consumption tax system becomes more progressive, whereas the opposite is true for less productive households. All things considered, the Gini of earnings ranges from 0.65 in the most progressive tax scenario to 0.63 in the most regressive case. Because at the optimal case low income families increase labor supply more than high income families, the resulted Gini index of earnings is 0.64, which is slightly lower than that in the benchmark economy.

As the tax burden shifts from non-basic goods $c_2$ to basic goods $c_1$, the middle class (quintiles Q3 and Q4) accummulate more capital. Overall, the Gini coefficient on wealth decreases with $\tau_{c1}$. At the optimal, it is very close to that in the benchmark economy.

The switch from income taxes to consumption taxes increases consumption inequality relative to the benchmark. As $\tau_{c1}$ increases the Gini coefficient of basic consumption decreases, while that of non-basic consumption increases. At the optimal the Gini index of $C_1$ increases to 0.37 (from 0.29 in the benchmark), while that $C_2$ increases to 0.57 (from 0.55 in the benchmark).

Table 9 provides more details of the distributive consequences of a subset of the reforms we considered. Compared to the benchmark, the reforms result in a redistribution of the tax burden towards those less well off.

Fig. 4 a shows the consumption equivalent of average welfare for the reforms discussed above (indexed by $\tau_{c1}$), with Fig. 4b and Fig. 4c being the corresponding aggregate components and redistributive components. The definition of the consumption equivalent of average welfare and its aggregate and redistributive components are in the spirit of Domeij and

**Table 9**
Distribution of earnings, wealth and the tax burden, in %.

| | Gini | Bottom % | | | Quintile | | | | | Top % | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | [1,5] | [6,10] | Q1 | Q2 | Q3 | Q4 | Q5 | [91,95] | [96,99] | [99,100] |
| | | | | | | Earnings | | | | | | |
| Data | 0.65 | −0.1 | 0.0 | 0.0 | −0.1 | 2.8 | 11.1 | 21.7 | 64.5 | 13.3 | 17.7 | 15.3 |
| Benchmark | 0.65 | 0.0 | 0.0 | 0.1 | 0.3 | 1.6 | 10.2 | 22.2 | 65.6 | 15.1 | 20.7 | 12.1 |
| Optimal | 0.64 | 0.0 | 0.0 | 0.1 | 0.3 | 1.8 | 10.7 | 22.8 | 64.4 | 11.0 | 20.1 | 10.9 |
| $\tau_{c1}=\tau_{c2}$ | 0.63 | 0.0 | 0.0 | 0.1 | 0.4 | 2.4 | 10.3 | 23.1 | 63.9 | 14.8 | 19.7 | 11.0 |
| Optimal PE | 0.65 | 0.0 | 0.0 | 0.1 | 0.4 | 2.2 | 9.1 | 22.6 | 65.6 | 12.5 | 20.2 | 11.4 |
| | | | | | | Wealth | | | | | | |
| Data | 0.78 | −0.2 | 0.0 | 0.0 | −0.2 | 1.3 | 5.3 | 13.5 | 80.2 | 14.1 | 25.7 | 25.8 |
| Benchmark | 0.78 | 0.0 | 0.2 | 0.0 | 0.8 | 1.9 | 1.7 | 11.0 | 84.6 | 21.6 | 30.4 | 12.8 |
| Optimal | 0.78 | 0.0 | 0.2 | 0.0 | 0.6 | 0.8 | 2.1 | 11.7 | 84.9 | 23.1 | 27.8 | 11.8 |
| $\tau_{c1}=\tau_{c2}$ | 0.77 | 0.0 | 0.2 | 0.0 | 0.5 | 0.8 | 2.5 | 12.4 | 83.8 | 22.8 | 31.2 | 7.6 |
| Optimal PE | 0.72 | 0.0 | 0.1 | 0.1 | 0.5 | 1.0 | 4.6 | 17.3 | 76.6 | 20.7 | 26.1 | 5.9 |
| | | | | | | $C_1$ | | | | | | |
| Data | 0.27 | 0.7 | 2.7 | 4.3 | 16.1 | 18.6 | 20.1 | 21.2 | 24.1 | 6.4 | 5.4 | 1.5 |
| Benchmark | 0.29 | 1.2 | 1.7 | 4.0 | 11.2 | 12.7 | 23.5 | 22.9 | 29.8 | 9.1 | 6.1 | 2.3 |
| Optimal | 0.37 | 1.1 | 1.5 | 3.0 | 8.7 | 10.9 | 21.5 | 23.1 | 35.7 | 7.5 | 7.5 | 3.1 |
| $\tau_{c1}=\tau_{c2}$ | 0.32 | 1.1 | 2.1 | 2.9 | 10.3 | 12.3 | 20.8 | 23.1 | 33.5 | 9.8 | 6.9 | 2.9 |
| Optimal PE | 0.36 | 1.2 | 3.1 | 2.3 | 11.8 | 11.9 | 20.1 | 23.7 | 32.6 | 7.3 | 7.3 | 2.7 |
| | | | | | | $C_2$ | | | | | | |
| Data | 0.44 | 0.3 | 0.7 | 2.0 | 6.8 | 10.4 | 15.7 | 23.5 | 43.6 | 11.5 | 11.5 | 4.1 |
| Benchmark | 0.55 | 1.5 | 1.2 | 1.3 | 6.4 | 7.1 | 22.3 | 25.5 | 38.9 | 11.6 | 8.1 | 3.4 |
| Optimal | 0.57 | 1.1 | 1.2 | 0.8 | 5.1 | 5.6 | 20.0 | 24.9 | 44.4 | 9.2 | 9.5 | 4.2 |
| $\tau_{c1}=\tau_{c2}$ | 0.58 | 1.2 | 1.3 | 0.4 | 5.5 | 4.7 | 19.3 | 25.6 | 44.9 | 12.8 | 9.5 | 4.4 |
| Optimal PE | 0.55 | 1.3 | 2.6 | 0.8 | 7.4 | 7.8 | 19.8 | 25.7 | 39.3 | 8.5 | 9.0 | 3.6 |
| | | | | | | Tax burden | | | | | | |
| Data | 0.74 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 5.9 | 18.0 | 75.8 | 16.9 | 25.0 | 15.3 |
| Benchmark | 0.66 | 0.6 | 0.5 | 0.3 | 2.1 | 2.6 | 10.6 | 20.9 | 63.8 | 14.0 | 21.6 | 12.0 |
| Optimal | 0.57 | 1.1 | 1.1 | 0.8 | 5.0 | 5.5 | 20.0 | 25.0 | 44.6 | 9.2 | 9.6 | 4.2 |
| $\tau_{c1}=\tau_{c2}$ | 0.52 | 1.2 | 1.5 | 1.0 | 6.6 | 6.5 | 19.7 | 25.0 | 42.2 | 12.1 | 8.9 | 4.1 |
| Optimal PE | 0.56 | 1.3 | 2.6 | 0.8 | 7.3 | 7.7 | 19.8 | 25.8 | 39.4 | 8.6 | 9.1 | 3.6 |

Heathcote (2004), with some differences because of the existence of a minimum consumption level and the stochastic discount factor. The definition and calculation algorithm of the welfare gain as well as its aggregate and redistributive components are discussed in online Appendix A.

Even though the reforms imply a substantial increase in output, they still result in welfare losses. At the optimal, the welfare loss is equivalent to 6.6% lower consumption. As $\tau_{c1}$ increases, the aggregate component of the welfare gain increases due to the larger increase in output, whereas the redistributive component decreases owing to the regressive tax treatment on basic and non-basic goods. Eventually, the two offsetting forces lead average welfare to peak at $\tau_{c1} = -0.04$ and $\tau_{c2} = 0.68$.

In order to further understand the welfare consequences of the reforms, Fig. 5a reports the welfare gains of the optimal reform by asset, labor productivity and discount factor. Fig. 5b and c shows the welfare gains corresponding to $\beta_1$ and $\beta_2$ households, respectively. Households who are impatient, have low wealth and high productivity experience welfare gains, whereas the rest of the population experience welfare losses. For example, take the super-productive households. Within that group, everybody below around \$150, 000 of wealth experiences welfare gains, while the lower return on assets generates welfare losses for those with welfare above that threshold. In addition, the heavier tax burden on low productivity/income households exposes them to larger welfare losses relative to high productivity/income ones.

Lastly, the welfare loss associated with more patient households ($\beta_2$) is larger than that with impatient households ($\beta_1$). Intuitively, relative to impatient ones, patient households accumulate more wealth, so they are more negatively affected by lower interest rates.

### *4.2. Transitional dynamics*

We now turn to the evaluation of the transitional dynamics. During the transition, we fix $\tau_{c1}$ to its optimal level and adjust $\tau_{c2}$ to balance the government budget period by period. We repeat this exercise for different levels of $\tau_{c1}$. The short run average welfare peaks at the same value as for the steady state exercise, $\tau_{c1} = -0.04$.

Fig. 6 presents the transition paths of the optimal consumption tax. On impact $\tau_{c2}$ shoots up due to the still smaller tax base. As time goes by, capital is accumulated, leading consumption to raise and the tax base to expand. Consequently, $\tau_{c2}$ gradually falls until converging to the new steady state level. In this reform, basic consumption $C_1$ is subsidized, so it immediately increases upon implementation of the reform. In contrast, non-basic consumption $C_2$ drops on impact, and then it slowly recovers converging to a level below that in the benchmark economy. Labor supply increases sharply on impact,

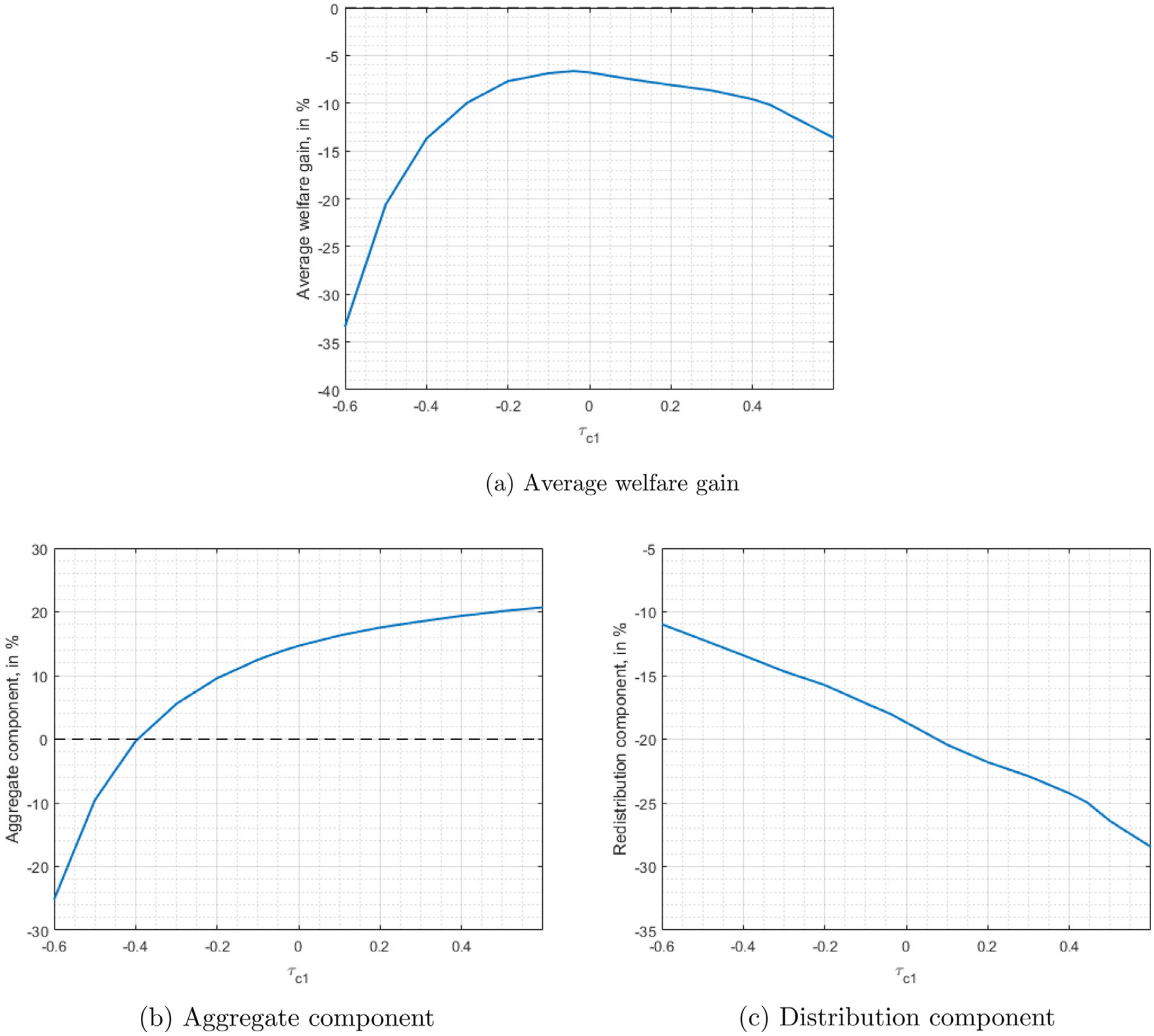


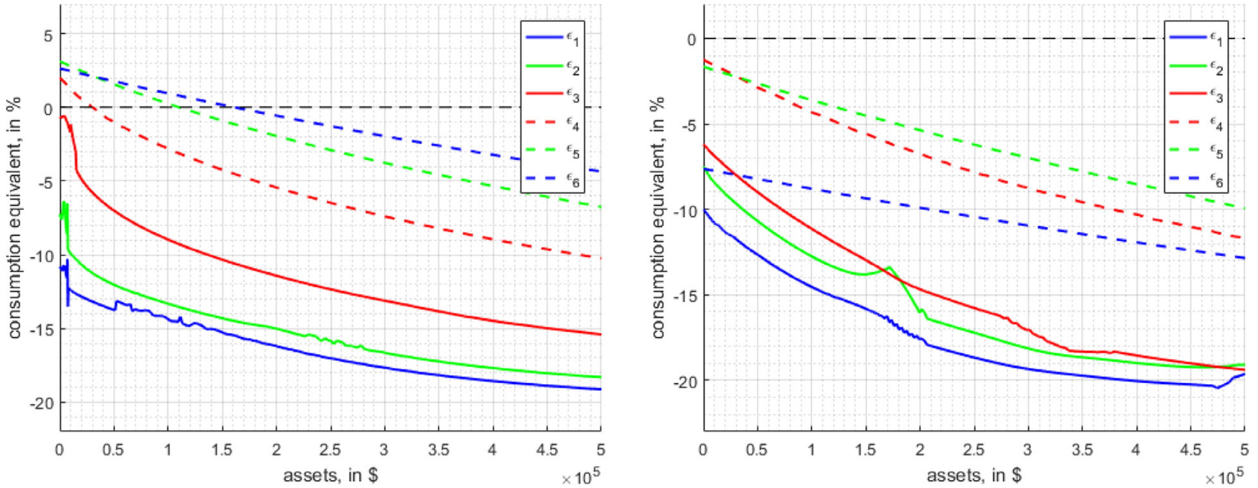

**Fig. 4.** Steady state welfare gain, in consumption equivalent %.

**Table 10**
During transition, percentage of people with welfare gain, in %, PE.

| | $\epsilon_1$ | $\epsilon_2$ | $\epsilon_3$ | $\epsilon_4$ | $\epsilon_5$ | $\epsilon_6$ | Total |
|---|---|---|---|---|---|---|---|
| % with welfare gain ($\beta_1$) | 0.0 | 0.0 | 0.0 | 0.0 | 39.6 | 5.0 | 7.5 |
| % with welfare gain ($\beta_2$) | 0.0 | 0.0 | 0.0 | 0.00 | 0.0 | 0.0 | 0.0 |
| % in total population | 9.1 | 19.3 | 22.5 | 28.2 | 18.6 | 2.3 | 100.0 |

and then it slowly decreases until reaching its steady state at a level 0.3% above the benchmark. In contrast, capital slowly increases until reaching a level 31.6% above the benchmark.

Thanks to the shifts in return to capital and return to labor, households with more assets are more negatively affected by the reform. Table 10 presents the percentage of population experiencing welfare gain during the transition. Out of impatient families, only 39.6% and 5.0% from the top two labor productivity levels are better off. In total, 7.5% of impatient households, or 6.0% of the total population, experience welfare improvements. In contrast, all patient families own or expected to accumulate wealth and they all experience welfare losses.




(a) Consumption equivalent of welfare gain, $\beta_1$ (b) Consumption equivalent of welfare gain, $\beta_2$

**Fig. 5.** Steady state welfare gain, by asset, labor productivity and discount factor, in consumption equivalent, %.

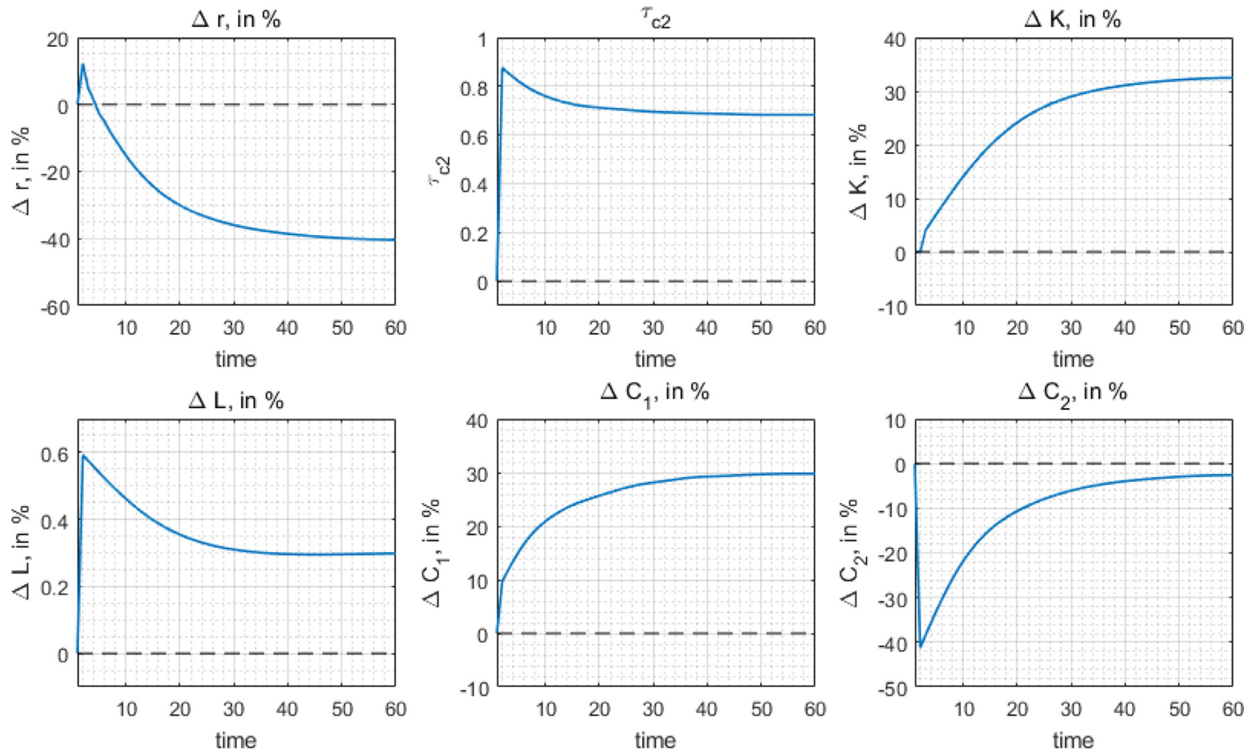
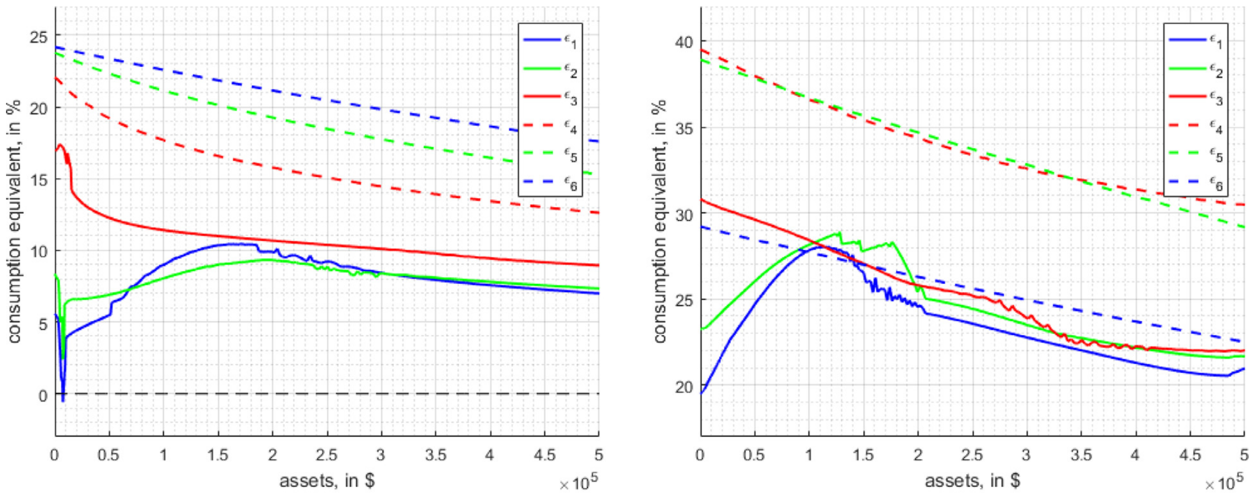



**Fig. 6.** Transition paths.

*4.3. The impact of changes in relative prices*

In the above general equilibrium environment, the majority experience welfare losses. If we shut down the general equilibrium channel, assuming a partial equilibrium economy, the welfare implications across households are radically different.

In this quantitative experiment, we fix the interest rate and the wage rate, whereas the tax rates are adjusted to balance the government budget. With $\tau_{c1} = -0.04$, the steady state tax rate on $C_2$ is 0.65. In the steady state aggregate wealth increases by 68.0% relative to the benchmark, more than twice the increase in general equilibrium. However, domestic capital falls, indicating that all that additional wealth is invested abroad at the benchmark interest rate. GNP grows by 20%, twice as much as in the general equilibrium case, and basic and non-basic consumption increase by 32.7% and 3.7%, respectively,




(a) Consumption equivalent of welfare gain, $\beta_1$ (b) Consumption equivalent of welfare gain, $\beta_2$

**Fig. 7.** Steady state welfare gain, by asset, labor productivity and discount factor, in consumption equivalent %.

**Table 11**
During transition, percentage of people with welfare gain, in %, PE.

| | $\epsilon_1$ | $\epsilon_2$ | $\epsilon_3$ | $\epsilon_4$ | $\epsilon_5$ | $\epsilon_6$ | Total |
|---|---|---|---|---|---|---|---|
| % with welfare gain ($\beta_1$) | 0.0 | 0.0 | 2.4 | 79.9 | 82.0 | 86.4 | 41.0 |
| % with welfare gain ($\beta_2$) | 90.5 | 88.9 | 86.3 | 73.3 | 59.1 | 473 | 76.6 |
| % in total population | 9.1 | 19.3 | 22.5 | 28.2 | 18.6 | 2.3 | 100.0 |

more than in the general equilibrium case. With a much larger tax base of $C_2$, the tax rate on non-basic consumption is lower as compared to the general equilibrium case. Moreover, hours worked fall by 4%. The steady state welfare gain is 33.9%, with an aggregate component of 20.2% and a redistributive component of 11.4%.

Fig. 7 presents the welfare gain by asset, labor productivity and discount factor. The tax reform reduces the tax burden disproportionately more for households with higher labor efficiency, resulting in larger welfare gains. In addition, more patient households benefit more from the reform as well, because of higher return on investment.

Finally, Table 11 shows the percentage of people who experience welfare gains on impact of the reform in the partial equilibrium economy. For less patient households, the percentage of the population with welfare gains increases with labor efficiency level. Altogether, 41.0% of the patient households experience a welfare improvement upon the implementation of the reform. In contrast, the proportion of more patient households experiencing welfare gains decreases with labor efficiency. Still, 76.6% of the patient households experience welfare gains from the reform.

Comparing to the steady state results we find that the reform comes at a substantial cost for many households. Even with generalized welfare gains in the long run, still only 48.1% of the population benefits from the transition. This reflects the fact that transiting to the new steady state involves working more and saving more in the initial periods of the transition.

## 5. Summary and conclusions

The standard argument in favor of a reform switching from income to consumption taxation argues that efficiency gains could be large. We find that a reform that subsidizes basic consumption by 4% and taxes the rest of consumption at 68% increases output per capita around 10%. We also find that inequality would increase, even though the magnitudes are not large. However, this policy results in lower welfare than in the benchmark economy with progressive income taxes.

Our results highlight once again the importance of transitional dynamics: Most of the individuals experience welfare losses with such a reform. The reform only benefits the most productive households with very low levels of wealth. The most productive individuals see very progressive income taxes removed and consequently their tax burden is lowered, but the return on their assets is lower. In contrast, the middle class experiences an increase in overall taxes paid and looses from the reform. As a result, only 6% of the population experiences welfare gains along the transition. When shutting down the general equilibrium channel, the welfare gains in steady state are generalized, but still less than 50% of the population experience welfare gains along the transition.

These results suggest that income tax progressivity is a powerful welfare-enhancing tool, even when compared to an environment where means-tested transfers and progressive consumption taxes are present. In subsequent work we explore the impact of allowing for Universal Basic Income as a non-distortionary redistributive instrument.

## Supplementary material

Supplementary material associated with this article can be found, in the online version, at 10.1016/j.jedc.2020.103991 .

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