Tax Reforms: Winners and Losers

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"*You either live under a rock or you walk in the sunshine. That's pretty much how it goes.*"

Sixto Rodriguez

"*The secret of happiness is: Find something more important than you are and dedicate your life to it.*"

Daniel Dennett

Abstract

A long stream of literature has been devoted to studying the level effects and implementability of tax reforms. The heterogeneous agents framework allows us to study aggregate effects of tax reforms, the channels by which these effects propagate and the picture of who are the winners and losers of their implementation. Taking advantage of the rich fiscal side of our model, we study the implementation of different tax reforms, including changes to labour tax progressivity. We show, within an incomplete-markets model featuring consumer credit, that both reforms that finance lump-sum transfers and those that are revenue neutral have important level effects. Even in tax reforms designed to lessen the tax bill of poorer agents, the depletion of capital stock leaves them worse off.

Resumo

O estudo dos efeitos de nível e implementabilidade de reformas fiscais têm já uma longa tradição na literatura. O quadro de agentes heterogéneos permite o estudo dos efeitos agregados das reformas fiscais, dos canais pelos quais estes efeitos se propagam e de quem ganha ou perde com elas. Aproveitando a ampla descrição do sector fiscal do nosso modelo, estudamos a implementação de diferentes reformas fiscais, incluindo alterações na progressividade do imposto sobre o trabalho. Mostramos que, no âmbito dum modelo com mercados incompletos e crédito, tanto reformas que financiam transferências de montante fixo como aquelas em que a carga fiscal total se mantém igual implicam importantes níveis de efeito. Também no caso de reformas fiscais especificamente desenhadas para diminuir os importos cobrados aos níveis salariais mais baixos, implicou uma redução da utilidade para os agentes mais pobres devido à delapidação do volume de capital.

Acknowledgements

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Contents

List of Figures

1 Introduction

The subject of taxation as been widely studied by economists since Adam Smith. The standard theory of optimal taxation aims at maximizing a social welfare function subject to different constraints. In one of the field's foundational works, Ramsey (1927) conducts a search for the optimal tax rates when different rates are available for different goods, broadly concluding that the rates should be inversely proportional to the respective goods' elasticity of demand.

Following this line of thought, and if the restriction on the type of taxes was not considered, the used models provided a clear choice of the optimal schedule: lump-sum taxation. Its features allow for a complete financing of the public expenditure without affecting the marginal utility of consumption or leisure (and thus decision-making). However, in real life this type of tax is highly unpopular because not everybody is equal. This unpopularity stems to the fact that levying the same amount of tax indiscriminately implies a higher utility penalty for poorer citizens.

Recognizing this heterogeneity within populations and moving towards more realistic tax policies, Mirrlees (1971) considers a model where labour income is taxed differently at variable rates. Under some conditions the higher skilled workers would be lead to consume less than the lower skilled, leading the higher skilled to work less than their capability. The optimal marginal tax schedule suggested is then almost linear but reaching a maximum at rather low income levels and steadily dropping thereafter. It is highly unlikely that such a schedule would be met with praise from society. This insight gave rise to the discussion on the efficiency-equity trade off.

Other than efficiency, another issue to study in taxation theory is of paramount importance: given the power of choice, what tax schedule will a society choose?

Roberts (1977), for example, shows under what conditions the model in Mirrlees (1971), allows for the existence of a decision set. On the other hand, Alesina and Rodrik (1994) propose a model where, for societies with high wealth inequality, the democratic voting process over capital tax levels tends to impair growth. Notice that, in order to ensure tractability, these models only allow for the consideration of one tax at a time.

There is, however, a class of macroeconomic models with heterogeneous agents that may be enriched with several tax sources and still be managed. These are the idiosyncratic productivity shocks models developed by Aiyagari (1993) to study precautionary savings in an incomplete markets setting.

The present work aims at further contributing to the study of the democratic implementability of tax reforms by using the rich heterogeneous agents structure present in the framework to compute and track the welfare implications of a same tax reform in different individuals.

It is a general equilibrium, incomplete-markets model with physical capital. Households are heterogeneous in wealth and labour productivity, saving to insure against negative shocks and borrowing to smooth consumption during productivity slumps. The interest of borrowing is the same as the price of capital as there is no financial sector or intermediation costs. Households decide the consumption and labour levels in the present period as well as the asset level for the next period. There is an exogenous fixed borrowing constraint.

The fiscal authority operates with balanced budget levying taxes on consumption, capital and labour income, as well as raising lump-sum taxes.

In heterogeneous agent frameworks labour income is typically modelled as a flat rate (e.g. Bewley (1977),Krueger, Mitman, and Perri (2016)). In order to address the point made above about the different welfare implications of taxing all the agents at the same rate we decided to change this. We instead opted for including an equal sacrifice labour income tax function as presented by Berliant and Gouveia (1994). It is an effective tax function in the sense that it captures not only the statutory tax rates of each income bracket but also the different deductions and exceptions present in tax codes. It is worth noting that this is also a further step in adapting the models to what is observed in real life.

We calibrate the stationary equilibrium for the US and German economies. The main simulations will have as object single tax increases in the US.

We will then exhaustively describe the evolution of the economic variables and the effects on welfare, both at the aggregate and individual level, for each scenario.

As might be general knowledge, the increase of taxes tends to impair economic activity by making the production inputs harder to obtain/costlier to provide. More surprising, is that the attempts made at funding insured income programs through taxation, never seemed to deliver an increase of certainty even comparable to the decrease of consumption. As an example, the funding of handouts through a capital tax increase implied a welfare loss due to foregone consumption of -0.01 to gain about 0.005 with the reduction of uncertainty.

A type of reform that is often debated, the revenue neutral increase in progressivity of labour tax, proved to have important consequences in the level of output and consumption. Also noteworthy, is that the agents whose taxes were lowered also saw a decrease in consumption.

In fact, the best tax reform in terms of making the agents with low assets better-off was the increase in consumption tax.

Lastly we will do a simulation of a complete shift of the German tax code to the one present in the US. Here we found that, within the model, the US tax mix is better than the German one for all productivity levels and wealth classes (and especially so for the poorer agents) even though it features more uncertainty and inequality.

We find that, even though evaluating an economy based on GDP and Gini values has some indicative power, we have to dig down to the agent level if we want to understand the impacts of a tax reform and what support we can hope to have for it.

This work is structured as follows: Section 2 presents the model. Section 3 describes the calibration of the model. Section 4 presents the results of the tax reform experiments. Section 5 concludes.

2 Model

In our study we will be using an infinite horizon general equilibrium model. Households have the same preferences and choose consumption, labor intensity and how much to save/borrow.

These households are heterogenous in wealth and, following Real Business Cycle philosophy, in exogenous idiosyncratic productivity shocks. This model is part of the incomplete markets models first studied by Bewley (1977) and Aiyagari (1993) and is built based on the one presented in Antunes and Ercolani (2016).

The fiscal side of the model is very rich, featuring an authority that taxes consumption, capital and labor income. It can also transfer or levy lump-sum taxes in order to keep the budget balanced at all times. The public expenditure path is exogenous.

2.1 Households

The economy is populated by a continuum of measure one of infinitely lived households, with the same preferences. The households' within-period utility is denoted by:

$$u_{(c,n)} = \frac{c^{1-\sigma}-1}{1-\sigma} - \chi\frac{n^{1+\psi}}{1+\psi} , \tag{2.1}$$

where c is consumption and n is labor. σ is a parameter describing the curvature of utility with respect to the consumption of goods (alternatively it can be interpreted as the coefficient of risk aversion), ψ describes the curvature of the utility with respect to amount of labor (or Frisch elasticity of labor supply) and χ controls the disamenity of work.

Households' individual states are defined by their asset holdings a and their productivity z. z follows a finite state Markov process with support Z and transition probability $P = \Pi(Z,Z') = Pr(z^i_{t+1} = z'|z^i_t = z)$.

Each household solves the optimization problem

$$v_{(a,z,\theta)} = \max_{c,n,a'} u_{(c,n)} + \beta\mathbb{E}[v_{(a',z',\theta')}|z] , \tag{2.2}$$

subject to:

$$(1+\tau_c)c + a' = (1 + r(1 - \tau_k \mathscr{I} a \geq 0))a + wnz - \text{ltax}(wnz) + Tr \ , \tag{2.3}$$

$$\theta' = H(\theta) \ , \tag{2.4}$$

$$a \geq \underline{a} \ , \tag{2.5}$$

where θ is the measure of households, defined in a grid of possible asset holdings and idiosyncratic shocks. $H(\theta)$ is the forecasting function used by households in predicting next period's measure.

$\mathscr{I}_{a\geq 0}$ indicates positive assets enabling taxing at rate τ_k. The price of capital is denoted by r. $\underline{a}$ is the natural borrowing limit, here set exogenously.

The wage rate is denoted by w and $\text{ltax}(wnz)$ is the labor tax function. In order to capture the progressive nature that these taxes usually exhibit we used a tax function described in Berliant and Gouveia (1994). The tax function is obtained from the theory of equal sacrifice, and its shape is:

$$\text{ltax}(y) = b_0(y - (y^{-b_1} + \bar{b})^{-1/b_1}) \ , \tag{2.6}$$

where y is income, b_0 is a factor of proportionality, b_1 defines the curvature (related to the coefficient of risk aversion) and $\bar{b}$ is the utility sacrificed (equal for every agent). The three last parameters are obtained through adjusting data of household income with actually paid tax. This means that it is not a statutory function but rather an effective function. Not only it captures the different tax rates per tax bracket, it also accounts for deductions and exclusions that the agents benefit from.

2.2 Firms

There is a single representative firm, producing one single good (Y) used for private consumption, capital goods and government spending. The firm's technology is represented by the following

Cobb-Douglas function:

$$Y = AK^{\alpha}N^{1-\alpha} \ , \tag{2.7}$$

where A is the TFP (Total Factor Productivity), which in our model follows an exogenous process. K is the aggregated available capital and N the aggregate efficient labour. α is the capital share of production.

The firm takes prices as given and optimizes resources (N and K) according to:

$$w = (1-\alpha)A\left(\frac{K}{N}\right)^{\alpha} \ , \tag{2.8}$$

$$r^K = \alpha A\left(\frac{N}{K}\right)^{(1-\alpha)} \ , \tag{2.9}$$

where $r = r^K - \delta$ and δ is the rate of capital depreciation.

2.3 Government Sector

The public sector follows an exogenously set level of expenditure and keeps a balanced budget under the equation:

$$G = \tau_c \int cd\theta + \tau_k r \int_{a\geq 0} ad\theta + \int ltax(wnz)d\theta - Tr \ . \tag{2.10}$$

In case the collected taxes mismatch the level of government consumption, the balancing will be done through lump-sum transfers/taxes.

2.4 Equilibrium

We will consider a standard steady-state equilibrium where households maximize utility subject to given prices, firms maximize profits subject to given prices and all markets clear.

We define the recursive competitive equilibrium as a belief system H, prices (r,w), a measure defined over set of possible states θ and individual policy functions $(a', c, n) = (a_{(a,z,\theta)}, c_{(a,z,\theta)}, n_{(a,z,\theta)})$, assuming a transition matrix P for idiosyncratic productivity, a set of government policies

$(\tau_c, \tau_k, b_0, b_1, \bar{b}, Tr, G)$, a natural borrowing limit $\underline{a}$ and that any deviation to default is not coordinated among agents.

- Each agent solves the optimization problem 2.2;
- Firms maximize profits according to prices 2.8 and 2.9;
- Government balances budget according to 2.10;
- All markets clear : $K' = \int a_{(a,z,\theta)} d\theta \quad \text{(capital)}$

  $N = \int n_{(a,z,\theta)} z d\theta \quad \text{(labor)}$

  $\int c_{(a,z,\theta)} d\theta + K' + G = (1-\delta)K + AK^{\alpha} N^{(1-\alpha)} \quad \text{(goods)}$;
- The belief system H is consistent with the aggregate law of motion implied by the individual policy functions;
- The measure θ is constant over time.

The equilibrium with transition follows from what was just exposed. In our case, it will entail the gradual or sudden modification of public spending leading to an abrupt, perfectly credible and deterministic tax reform supporting the new steady-state expenditure level. Perfect foresight about the aggregate variables evolution is assumed.

For an accurate description of the computational method used to solve the model refer to Appendix A in Antunes and Ercolani (2016).

3 Steady-State Calibration

In order to study different tax systems and compute the transition in the event of a tax reform, we will separately calibrate the model for the steady-state of Germany (DE) and the United States (US).

However, to prevent having too many sources of differentiation, general variables (such as the discount factor, agent preferences, idiosyncratic shocks, etc.) will be set to the value obtained in the US calibration for both countries.

The parameters used in the model are listed in Table 3.1, together with their meaning and the source/target.

The model is calibrated for an yearly frequency, and the discount factor β is set as to obtain an yearly net return of capital of 4%.

As in Flodén and Lindé (2001) we will use an AR(1) process to describe the idiosyncratic productivity shocks (these productivity shocks define the wage rate, wz, that each agent earns):

$$log(z_t) = \rho log(z_{t-1}) + \eta_t \tag{3.1}$$

where ρ defines the persistence of the process and η_t is a serially uncorrelated and normally distributed perturbation with variance σ_t^2. Both parameters are set as to match the yearly autocorrelation and variance of labour productivity, which are 0.9136 and 0.0426, respectively (as estimated by Flodén and Lindé (2001)). We use the Rouwenhorst method as in Kopecky and Suen (2010) with 5 levels of productivity to discretize the AR(1) process. The implied transition probability matrix, P, is characterized by all non-zero entries allowing for productivity to transit from an extreme value to the other in consecutive periods (although with very small probability). The transition matrix and the productivity levels, z, are presented in Table 3.2. The description of the shocks will be considered the same for the US and Germany.

Since our model features only unsecured credit, we calibrate the model's credit to the average of the pre-crisis period unrevolved credit to output ratio of 8%. This is achieved by setting the exogenous natural borrowing limit to -6.25. Again, both Germany and the US are set to the same target and control variable values.

Table 3.1: Parameters of the model.

Parameters	Value US	Source	Value DE	Source
A	1	Normalization	1	Normalization
α	0.36	Share of capital in production	0.36	Share of capital in production
δ	0.06	Annual depreciation	0.025	Annual depreciation
σ	2	Standard in the literature	2	Standard in the literature
ψ	0.67	Hall (2009)	0.67	Hall (2009)
β	0.96348	4% yearly net return on capital	0.96348	4% yearly net return on capital
ρ	$0.9136^{-1/4}$	Flodén and Lindé (2001)	$0.9136^{-1/4}$	Flodén and Lindé (2001)
σ_η	0.11	Flodén and Lindé (2001)	0.11	Flodén and Lindé (2001)
χ	0.4	Set level of labor	0.4	Set level of labor
τ_c	0.052	Mendonza, Razin, and Tesar (1994)	0.147	Mendonza, Razin, and Tesar (1994)
τ_k	0.4	Mendonza, Razin, and Tesar (1994)	0.242	Mendonza, Razin, and Tesar (1994)
b_0	0.276	Gouveia and Strauss (1994)	0.532	Lim and Hyun (2004)
b_1	0.752	Gouveia and Strauss (1994)	1.348	Lim and Hyun (2004)

Table 3.2: Productivity parameters of the model.

$$P = \begin{bmatrix} 0.838 & 0.151 & 0.010 & 3\times10^{-4} & 3\times10^{-6} \\ 0.038 & 0.843 & 0.114 & 0.005 & 3\times10^{-5} \\ 0.002 & 0.076 & 0.849 & 0.076 & 0.002 \\ 8\times10^{-5} & 0.005 & 0.114 & 0.843 & 0.038 \\ 3\times10^{-6} & 3\times10^{-4} & 0.010 & 0.151 & 0.838 \end{bmatrix} \quad z = \begin{bmatrix} 0.362 \\ 0.602 \\ 1 \\ 1.661 \\ 2.760 \end{bmatrix}$$

As mentioned above, the calibration of the fiscal variables will differ between the German and US cases. With these differences we hope to obtain accurate descriptions of the two economies.

Consumption and capital tax rates are set to the values found in the literature. Moreover, in the steady-state the government budget is balanced and transfers are zero. We are then left with the choice of the level of effective labour tax that achieves the correct GDP-share of government consumption.

The labour tax parameter $\bar{b}$ relates to the sacrificed utility that is required from agents, so it will be the one used for this target adjustment. The target for the US economy is 21% of government consumption and 36% for Germany.

These differences translate into different levels and progressivity of the labour income tax for the German and US cases. Figure 3.1 shows us some of these features. Except for the very lowest levels of income, the German labour income tax is higher than the American. In fact, the maximum tax rate is 51% in Germany but only 24% in the US.

The differences also influence the wealth distribution of each economy. For the US case we have a total of 24.4% of borrowers, around a third of them being in the borrowing limit (8.4% of total population). These estimates are close to the empirically observed by Ábraham and

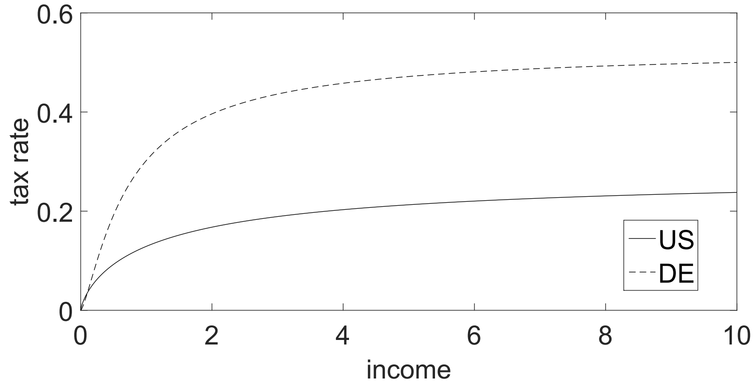


Figure 3.1: Labour income tax rates

Cárceles-Poveda (2010). In Germany, the percentage of borrowers is 21% and 6.5% are in the borrowing limit. These differences can be noted in the marginal distributions in Figure 3.2.

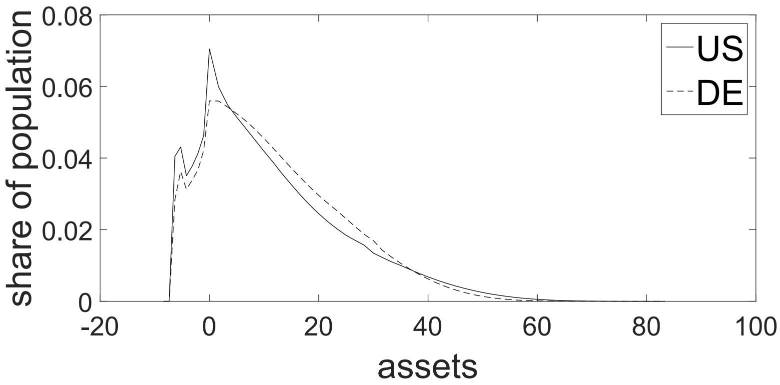


Figure 3.2: Marginal assets distributions

In Table 3.3 we present the empirical and model output values of the wealth quintiles and Gini for both American and German economies.

We can see in the presented values that the profile of wealth distribution maps relatively well to the observed values. For instance, the US presents itself as a more unequal economy than Germany, while in both countries the first quintile is a net borrower and the last quintile holds more than half of the assets (see Castaneda, Díaz-Gimenéz, and Ríos-Rull (2003) and Bundesbank (2013)). On the other hand, the model does not generate enough inequality, being specially inept at replicating the big concentration of wealth of the fifth quintile. This seems to be a drawback of every version of the heterogeneous incomplete assets and idiosyncratic shocks proposed by Aiyagari (1993).

In Figure 3.3 we can see the differences between the Lorenz curves of each model economy. In Germany the first third of people have a net zero asset position, while in the US this is only

Table 3.3: Wealth dispersion in the model and in data.

Country		Gini index	Quintiles				
			First	Second	Third	Fourth	Fifth
US	Data	0.78	-0.39	1.7	5.7	13.4	79.5
	Model	0.69	-2.97	1.74	11.69	28	61.54
DE	Data	0.76	-0.48	1.34	5.67	17.16	76.29
	Model	0.62	-2.28	3.49	13.49	27.22	58.09

achieved at 50% of the people. Also, for the same cumulative share of people, the Germans hold more wealth than their American counterparts.

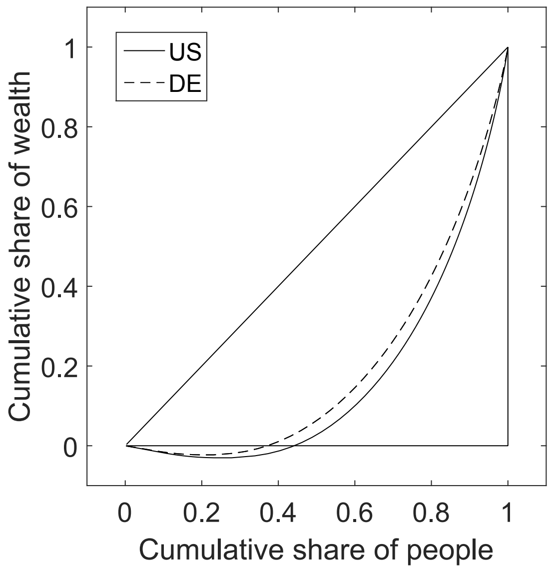


Figure 3.3: Lorenz curves

4 Results

In this chapter, we present the results for the transitional dynamics.

All the experiments are executed by setting the simulation horizon to 300 periods, each of the periods representing one year. We then compute the path of prices and policy functions that maximize agents' utility under perfect foresight while maintaining the equilibrium.

The first set of exercises consists in unexpected tax changes done to the US steady-state. The initial steady-state (in $t = -1$) is considered to be the one obtained in the US steady-state calibration. The final steady-state is the one that sees no big changes in variables after the tax reform transition period. For the cases where these reforms increase tax collection, the extra revenue will be transferred equally to every agent.

The second set of exercises of tax reform is a complete overhaul of the German system into the US one (including taxes and government expenditure). The initial steady-state is that obtained for Germany's steady-state calibration. The final steady-state is the one obtained for the US.

For each experiment we will analyse the welfare implications in an aggregate level and compare those with the insights that the heterogeneous agents framework allows. Furthermore, following the evolution of support during the reform period will allow us to conclude on its intertemporal consistency.

4.1 Welfare Measurement

Since our model features heterogeneous agents we will see different consumption, labour and asset responses for the different agents. It is plausible to infer that the changes in welfare will also be different.

We will use the permanent percent consumption a household would receive/forego to make it indifferent between the new and old policies as measure of the welfare gain. This is a *consumption equivalent* interpretation of the welfare variation.

Let $v^A_{c,n,a'}$ be the utility of a given agent in the state A and $v^B_{c,n,a'}$ the utility of the same agent in the state B. A permanent consumption percentage variation that makes the agent indifferent between the states A and B implies $v^A_{c(1+\Delta),n,a'} = v^B_{c,n,a'}$, where Δ is the permanent consumption gain.

In order to obtain the value of the gain Δ we will compute the first order Taylor expansion of v^A around $\Delta = 0$:

$$v^A_{c(1+\Delta)} \approx v^A_c + \frac{\partial v^A_c}{\partial \Delta}\Delta \tag{4.1}$$

Where:

$$\frac{\partial v^A_c}{\partial \Delta} = \mathbb{E}_0\left[\sum_{t=0}^{+\infty} c_t^{1-\sigma}\right] \tag{4.2}$$

And finally:

$$\Delta = \frac{v^B_{c,n,a'} - v^A_{c,n,a'}}{\mathbb{E}_0\left[\sum_{t=0}^{+\infty} c_t^{1-\sigma}\right]} \tag{4.3}$$

We will consider the welfare impacts of our experiments to address two different questions:

- does a majority of people want a certain reform to be applied?
- is the support for the proposed reform intertemporaly consistent?

First, we compute how many people in the initial distribution would be better off if they were in the same position in the final steady-state. The positive welfare gains will give us a first indication of steady-state to steady-state support for the reform.

Second, we will consider the welfare evolution during the transition period. Here the question being posed is "are the agents better off now than they were in the initial steady-state?". In the case that they are worse-off they will prefer to abort the reform. In the case they are better off, they would support continuing with the reform.

The measurement of support used is net support and it is defined as follows: we consider that the 10% of agents that have lower utility change are indifferent to the reform. The remaining 90% are asked whether they are in favour or against the reform and the difference between the aye and nay sayers is the net support. We assume they compare their welfare conditional of (a,z) with what they had if they remained in the original steady-state.

Note that the last measure does not consider whether the welfare change of the agents is big or small. To keep track of the magnitude, we will report the welfare changes of the representative agents of the 25^{th}, 50^{th} and 75^{th} percentiles.

Our heterogeneous agents setting offers a very straightforward division between agents based on the asset holdings: lenders and borrowers. When it is found of interest we will compare the welfare effects in these two groups.

Finally, following Violante (2015), we will take further advantage of the used model features by decomposing the aggregate welfare change in three different effects: level (measuring whether a tax reform changes the level of consumption), uncertainty (concerning the effects that the reform may have on providing insurance or reducing volatility) and egalitarian (due to the concave shape of the value function, a more equal wealth distribution should increase welfare.

The *welfare gain of increased consumption* is ω^{lev} and solves:

$$(1+\omega^{lev})C^A \equiv C^B \tag{4.4}$$

where $C^A = \int c^j(a,\varepsilon)d\lambda^j$ is the average consumption of economy j.

The certainty equivalent consumption bundle $\bar{C}^j$ solves: $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t^j) = \sum_{t=0}^{\infty} \beta^t u(\bar{c}^j)$.

The price of uncertainty p_{unc}^j solves $\sum_{t=0}^{\infty} \beta^t((1-p_{unc}^j)C^j) \equiv \sum_{t=0}^{\infty} \beta^t u(\bar{c}^j)$. We define the *welfare gain of reduced uncertainty* as:

$$\omega^{unc} \equiv \frac{1-p_{unc}^B}{1-p_{unc}^A} - 1 \tag{4.5}$$

The cost of inequality p_{ine}^j is $\sum_{t=0}^{\infty} \beta^t((1-p_{ine}^j)\bar{C}^j) \equiv E_0 \sum_{t=0}^{\infty} \beta^t u(c_t^j)$, where E_0 stands for the initial distribution . The *welfare gain of reduced inequality* is:

$$\omega^{ine} \equiv \frac{1-p_{ine}^B}{1-p_{ine}^A} - 1 \tag{4.6}$$

4.2 US Parameter Experiments

4.2.1 Raising the consumption tax

In this first experiment, the government unexpectedly raises the consumption tax by 1% above the steady-state level (5.2% to 6.2%). The government expenditure will be kept constant and the extra revenue obtained will be transferred in a lump-sum fashion.

Comparing the two steady-states, we find a net support of -62% signalling opposition to this reform. However, we also know that around 13% of the population supports it.

Figure 4.1 shows the evolution of some macroeconomic variables. The labour level is the one that suffers the biggest changes, starting with a steep fall and then recovering to a level closer to the original steady-state. The net return on capital drops by about 6 basis points but, unlike the labour level, ends the transition with a positive basis point change. Capital, output and consumption drop throughout the entire transition. It is also worth to notice that the capital stock begins at exactly zero because the capital level for $t = 0$ is set at $t = -1$ (thus behaving as an exogenous variable in the first period). Lastly, the wage level is slightly raised at the beginning but ends practically in the initial level.

A first explanation for these evolutions is the following: the increase in the consumption tax will unexpectedly affect the consumption of $t = 0$. This implies that the equilibrium output level will also drop. In period 1, the capital will not be able to adapt immediately so the compensation will be done by using less labour. The shrinking of labour increases the wages while reducing the net return on capital. From period 1 on, the capital stock evolves until a new equilibrium value which is lower than in the original steady-state.

This view of the aggregate variables allows us a first evaluation of the tax reform. Since GDP is used as the usual proxy to good economic activity and general welfare, we could say that this reform is not desirable because the output is always below the original value.

Let us now make a different question: how many people would support the tax reform during the transition? This will allow us to evaluate the intertemporal consistency of a reform.

Figure 4.2 shows us the evolution of support, opposition and also the amount considered indifferent. Somewhat surprisingly, during the first 3 years of the reform the net support is positive (albeit small). This may be related to the initial increase in wages that might benefit the agents that strongly depend on their labour earnings. As time goes by this effect dies down and the net support for the reform turns negative, suggesting that such a reform is not intertemporaly consistent.

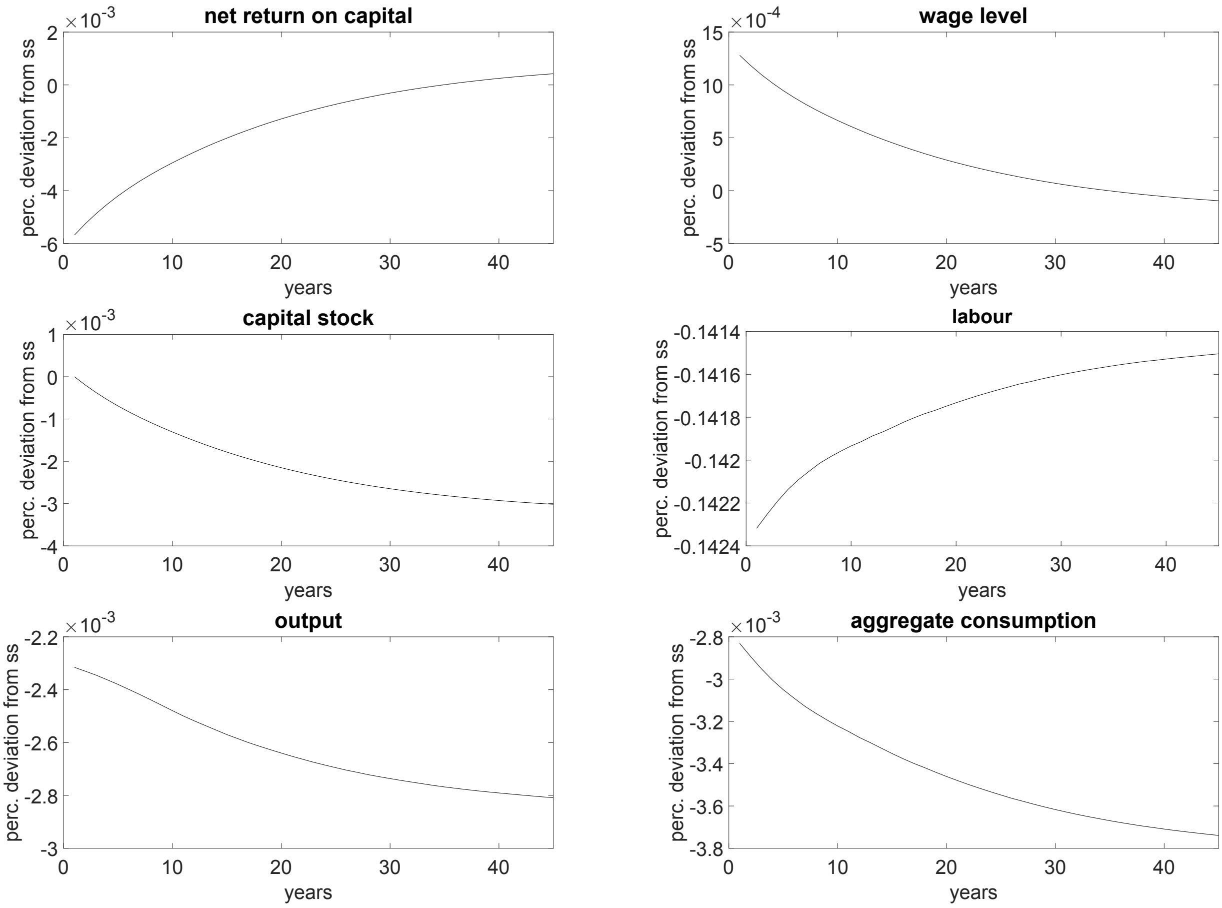


Figure 4.1: Aggregate variables - consumption tax reform

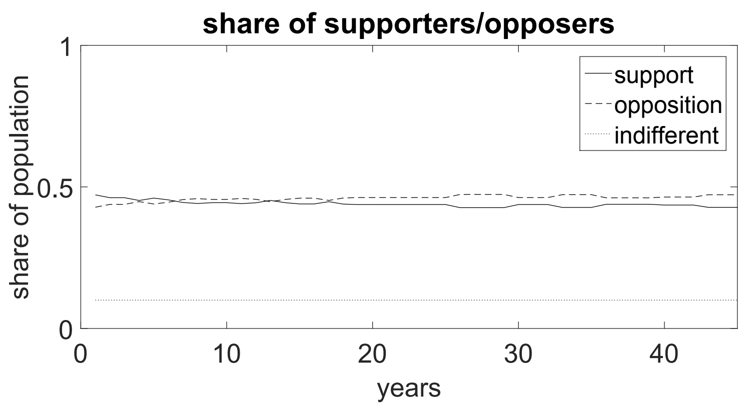


Figure 4.2: Net support - consumption tax reform

In order to confirm our suspicion that the increase in wage benefits the people with less asset holdings, we show in Figure 4.3 the welfare gains in selected years of the simulation. As expected, the lowest the agent's asset level, the largest the welfare gain. Not so expected is the fact that even after 45 years, the median voter has a positive welfare gain. In fact, later in the simulation, the median voter ends up with negative welfare gain.

Lastly, we will answer the question of the sources of the welfare changes (in the aggregate level).

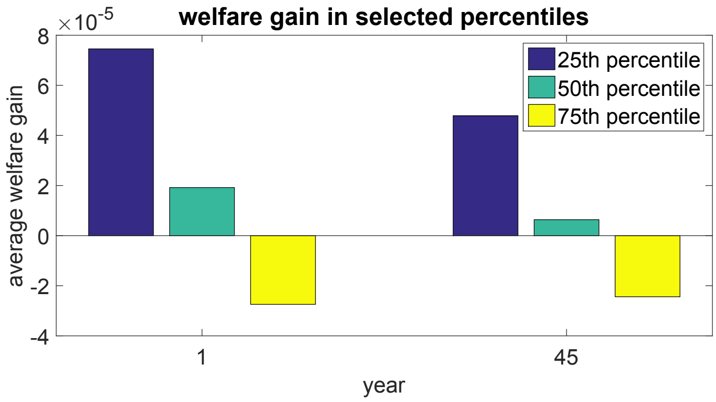


Figure 4.3: Welfare gain for selected percentiles - consumption tax reform

Figure 4.4 shows that the welfare loss in consumption level is not even closely dampened by the gains in uncertainty and inequality. Notice that this point of view is very closely related with the approximation of general welfare with GDP, as consumption enters that measure directly and neither uncertainty and inequality do.

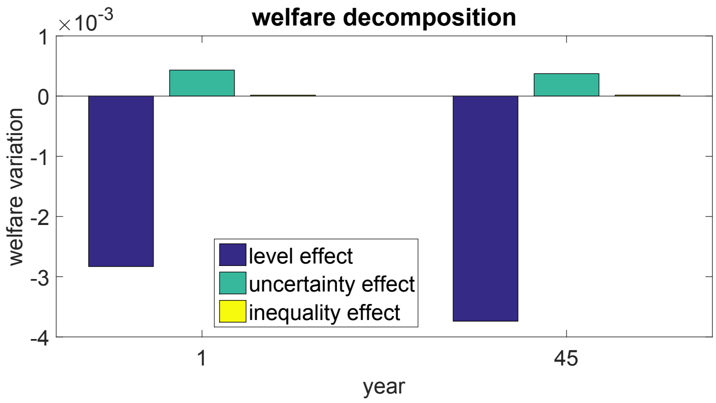


Figure 4.4: Welfare decomposition - consumption tax reform

4.2.2 Raising the capital income tax

In this experiment we will unexpectedly raise the tax on capital income by 1% (40% to 41%) and the extra revenue will be transferred to every agent equally.

A steady-state to steady-state analysis tells us that the net support for this reform is at a huge -90%. This may come as unexpected as one might assume that the people with hardly any or negative assets holdings would benefit from the transfers obtained from the taxes that the asset holders pay.

Our first look at the aggregates in Figure 4.5 suggests that this tax reform is a bad idea as the output is always bellow the original steady-state level. It also suggests that the proposed reform will make holding capital less inviting, as the overall economy will start eating its capital stock. Given this reduction of the capital set for the upcoming periods, the population will tend to consume more. After about 8 years, the consumption drops below the initial steady-state level. Output always suffers from this change in investment and consumption behaviours.

Capital and labour reach new equilibrium levels, where wage is below the initial steady-state level and the net return on capital is above it.

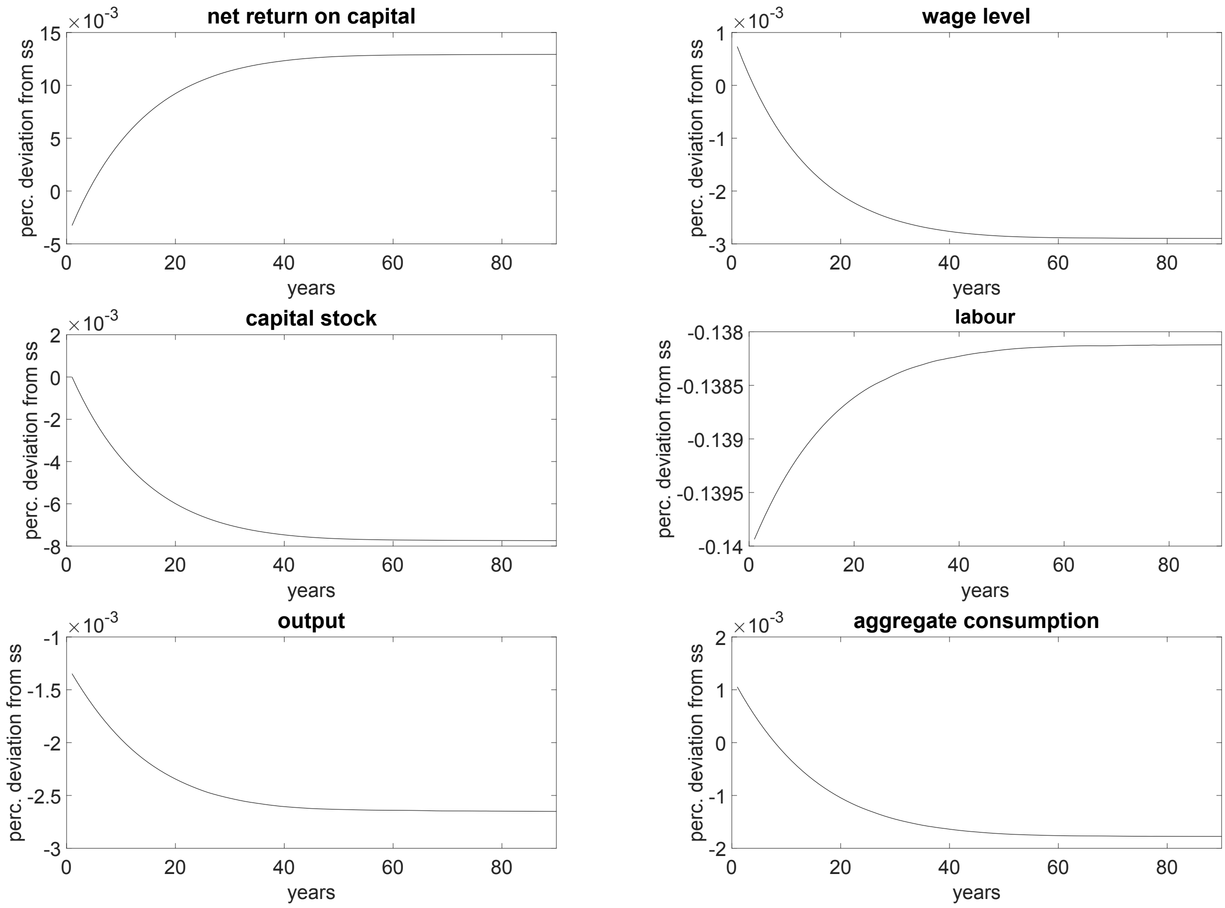


Figure 4.5: Aggregate variables - capital tax reform

What happens then to net support when the reform is under-way? Figure 4.6 shows that during the period where the agents are dissaving because holding capital became less desirable, there is some support for the reform, although it is always less than the opposition. After 10 years, the dissaving is basically done and the support is zero.

Figure 4.7 shows who profited from the capital tax change. Just like in the consumption tax reform, the early increase in wages helps people with less assets. However, after a while, the decrease in capital holding tends to increase the net return on capital and depress wages. In fact, by year 45, the agents in the lower percentiles suffer a bigger welfare penalty than the ones in the above percentiles.

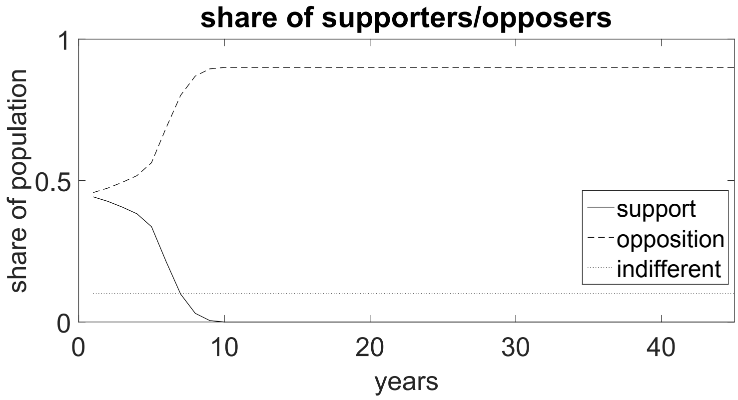


Figure 4.6: Net support - capital tax reform

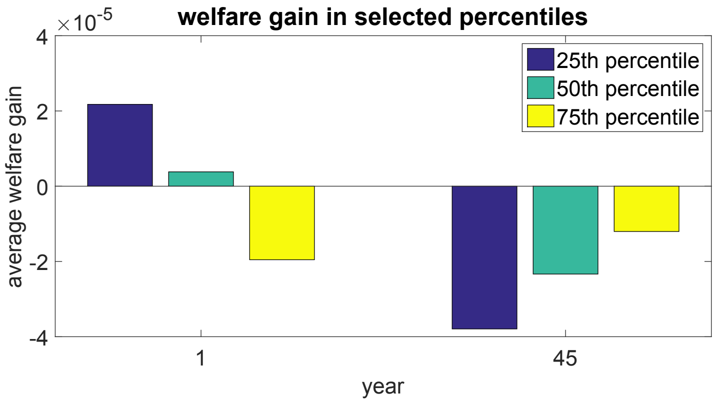


Figure 4.7: Welfare gain for selected percentiles - capital tax reform

To further describe the situation we show the Gini coefficient evolution (Figure 4.8). It makes it clear that a change in the capital tax rate did change the asset distribution making it more equal (albeit by little).

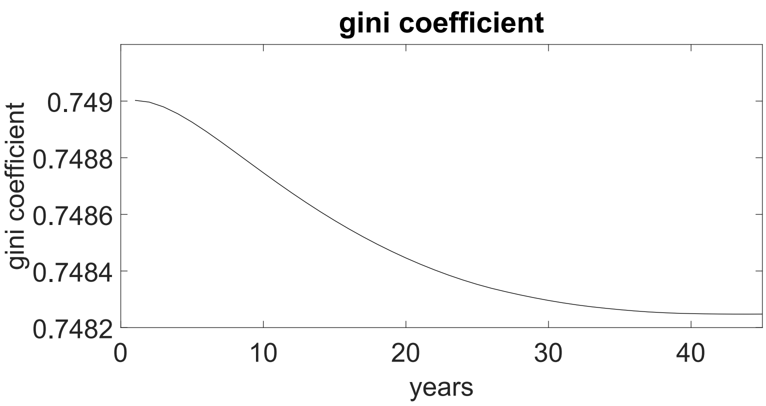


Figure 4.8: Gini coefficient - capital tax reform

So did this asset reshuffle improve the welfare gains related to uncertainty and inequality? Figure 4.9 suggests that these gains were rather small.

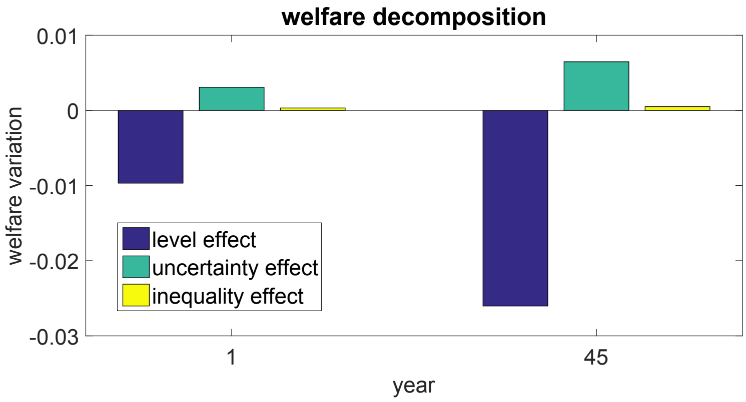
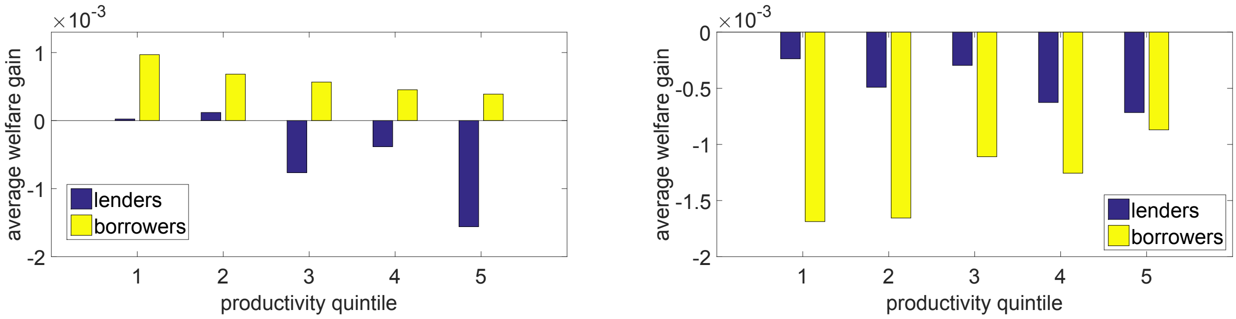


Figure 4.9: Welfare decomposition - capital tax reform

Since we are talking about taxes on capital one might want to entertain the following question. The net return on capital increased, but the tax on those returns increased too. So are lenders better or worse off? And what about the borrowers? Figure 4.10 shows that in year 1 the decrease of net return on capital left the borrowers better off. After it recovered they were again dragged to the negative. The lenders, on the other hand, are always penalized by the increase in tax.



(a) Welfare gains at t=1 **(b)** Welfare gains at t=45

Figure 4.10: Welfare gain for lenders and borrowers per productivity level - capital tax reform

4.2.3 Increasing the labour income tax progressivity - revenue neutral

For this simulation we took a more purpose minded approach. Instead of simply changing the labour income tax level by one percent we changed the parameters with an objective in mind. We took the maximum labour income that the agents with lowest productivity earn, we changed the function so as to lower the tax rate for the wages below this threshold and increase for the rest. We also kept the amount of money the state obtains with this tax: the reform is revenue neutral in the final steady-state. Notice that during the transition period the budget may have to be balanced with the lump-sum taxes/transfers.

A comparison between the income tax rates before and after the reform can be seen in Figure 4.11. Notice that until a gross labour income of about 2.3, the agents pay less tax under the reformed tax code. This comprises around 74% of the population. For agents above the 2.3 threshold the rate increases.

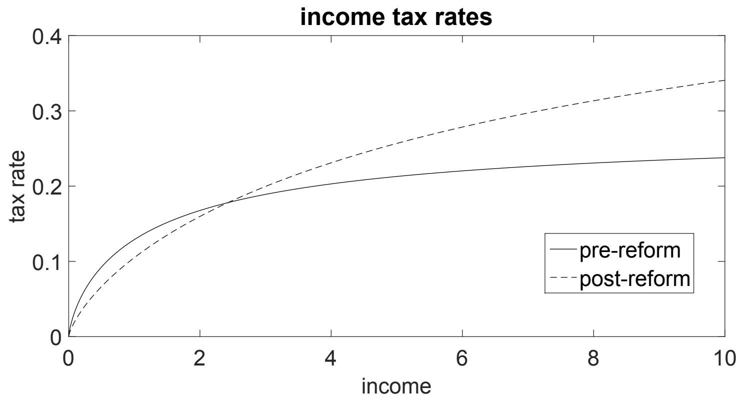


Figure 4.11: Income tax rates before and after the increased progressivity reform (revenue neutral)

A first steady-state to steady-state evaluation shows a negative net support of 70% with around 10% of people supporting the reform.

Figure 4.12 shows us the evolution of the aggregate macroeconomic variables throughout the transition. The fact that labour is not as profitable to a big section of the population will lead to a break in the labour levels. This initial reaction by the agents will increase the wage rate and decrease the net return on capital.

The main holders of capital, however, will shed off some of their stock in order to compensate for the lower labour liquid income they now get. This capital stock and labour level movement reaches equilibrium at a point where the net return of capital is larger than in the steady-state, while the wage is smaller. This may hint at an overall penalty for the agents that strongly rely on their labour income.

Figure 4.13 shows the disaggregated evolution of some variables. First of all, the decrease in wages and labour implied an average lower liquid total income for every productivity level. This is particularly revealing for the impact in the lowest productivity level: even though their asset position increases and pays better (due to the increase in the net return on capital) and their wages are less taxed, the liquid income is still under the steady-state value.

Because the top levels shed off some of their capital, the lower levels will have the opportunity to purchase it as can be seen in the following figure. In fact, the percentage of indebted agents of productivity 1 shrinks from 61% to 59%. For agents of productivity 2 the improvement is even better, from 46% to 42%.

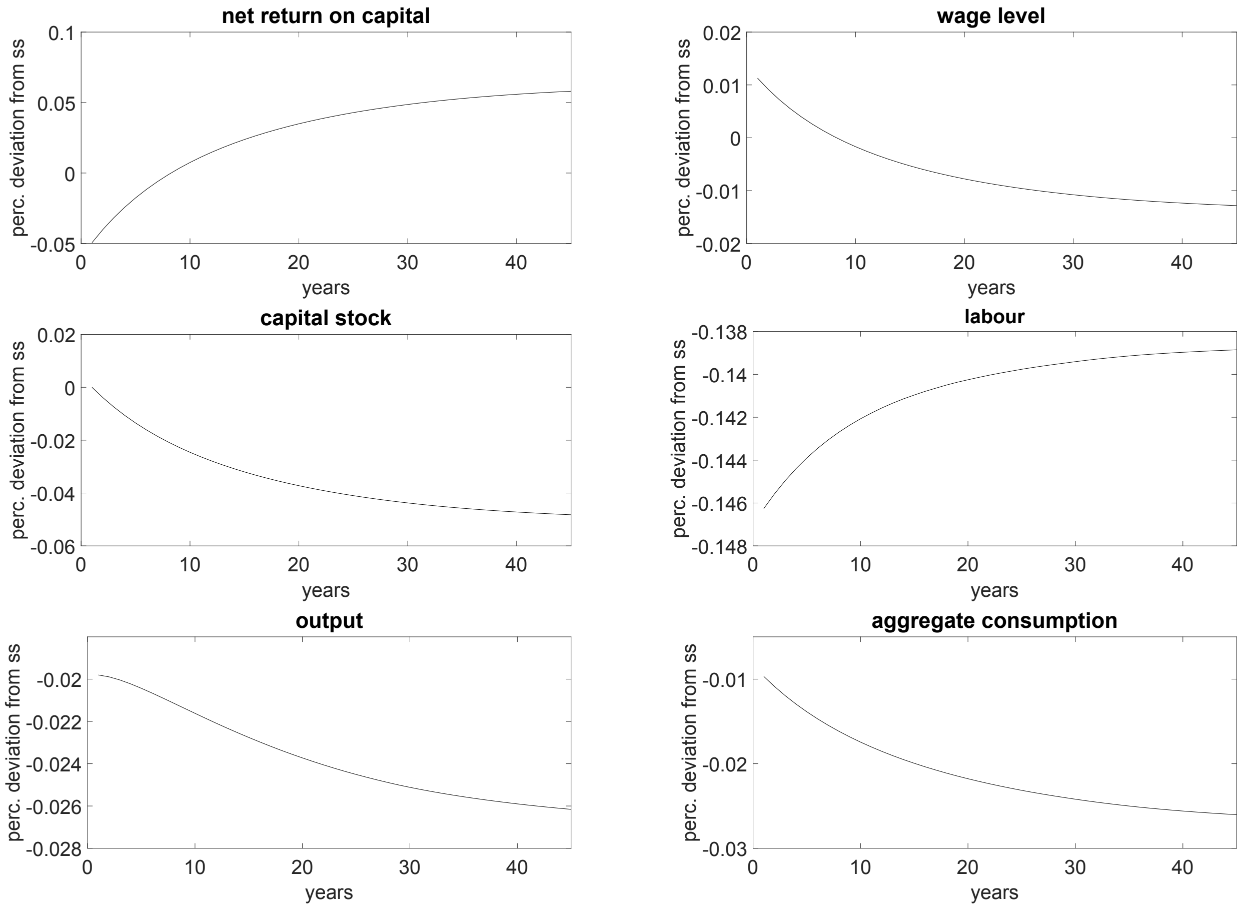


Figure 4.12: Aggregate variables - labour tax reform (revenue neutral)

Another point to be made concerns the labor level each productivity level provides. Notice that the downwards movement of wages more than offset the tax decrease for agents in the lowest productivity level. In fact, the new arrangement only managed to increase labor levels for the agents in the second and third productivity classes.

Finally, we can see that there is an initial improvement of consumption for the lower productivity agents that gradually decreases to a value under the initial steady-state.

The impact in the Gini index of this policy is of some magnitude, it decreases from 0.75 to 0.73. How does this translate into the welfare decomposition?

For the first time, Figure 4.14 shows that a reform may have a considerable effect on the welfare related to uncertainty. Even though the effect in equality was lower it also increased. However, the consumption level effects continue to dominate, and these are clearly negative.

Also noteworthy is that a reform which kept public revenue constant still had considerable level and distributive effects. Output and aggregate consumption both dropped by 0.026%.

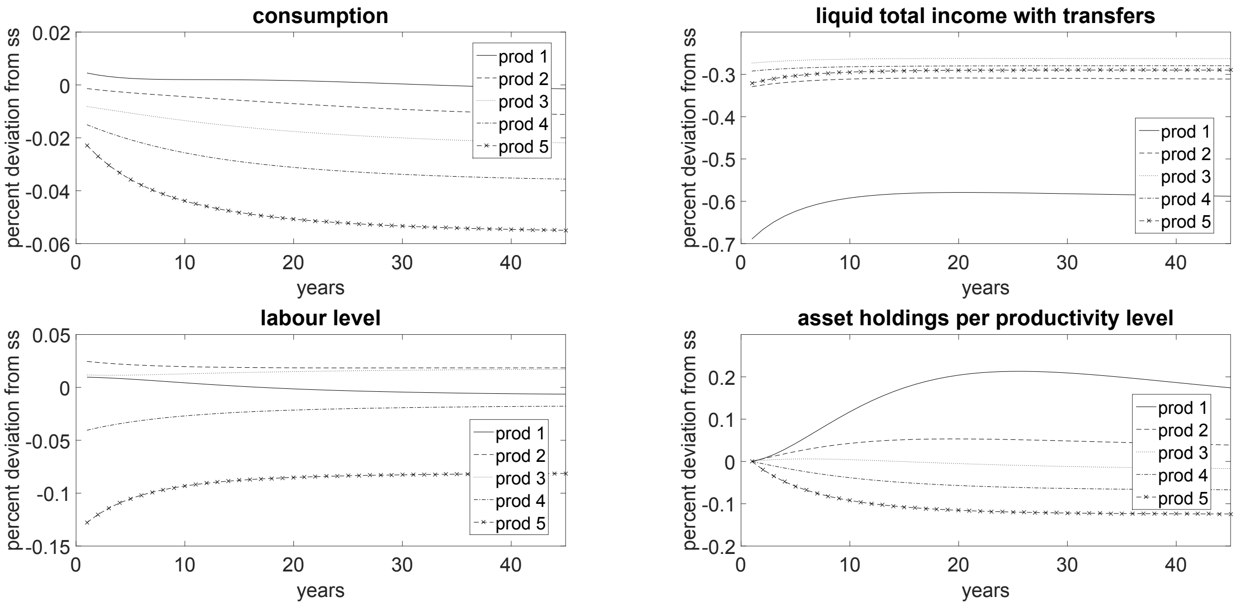


Figure 4.13: Productivity level variables - labour tax reform (revenue neutral)

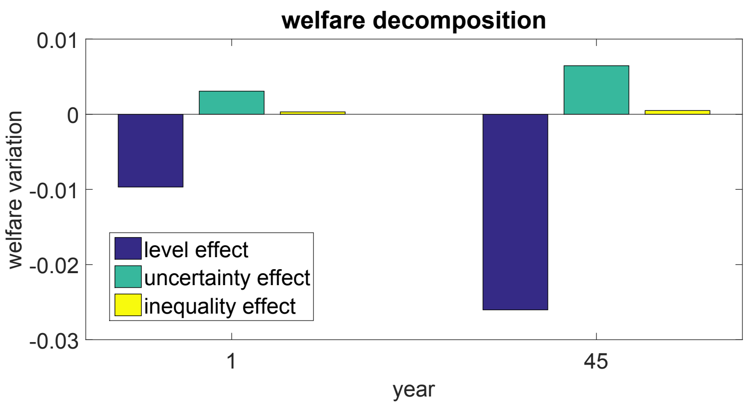


Figure 4.14: Welfare decomposition - labour tax reform (revenue neutral)

4.2.4 Increasing the labour income tax - transfers

In this experiment, we increase the labour tax by a significant amount. We changed the parameter b_0 to 0.576 from 0.276. This implies that the maximum tax rate one may be called on to pay is around 50%. The extra revenue will be used to finance lump-sum transfers for every agent.

The steady-state comparison suggests a negative net support of 43% with around 22% support.

Figure 4.15 shows the evolution of some selected macroeconomic variables. Their movements are very similar to the ones observed in the last experiment except they present wider variations as the reform was more radical.

Let us then analyse the movement of the variables for each of the 5 productivity levels in Figure 4.16. It is worth noting that the liquid total income increased for every productivity level. We

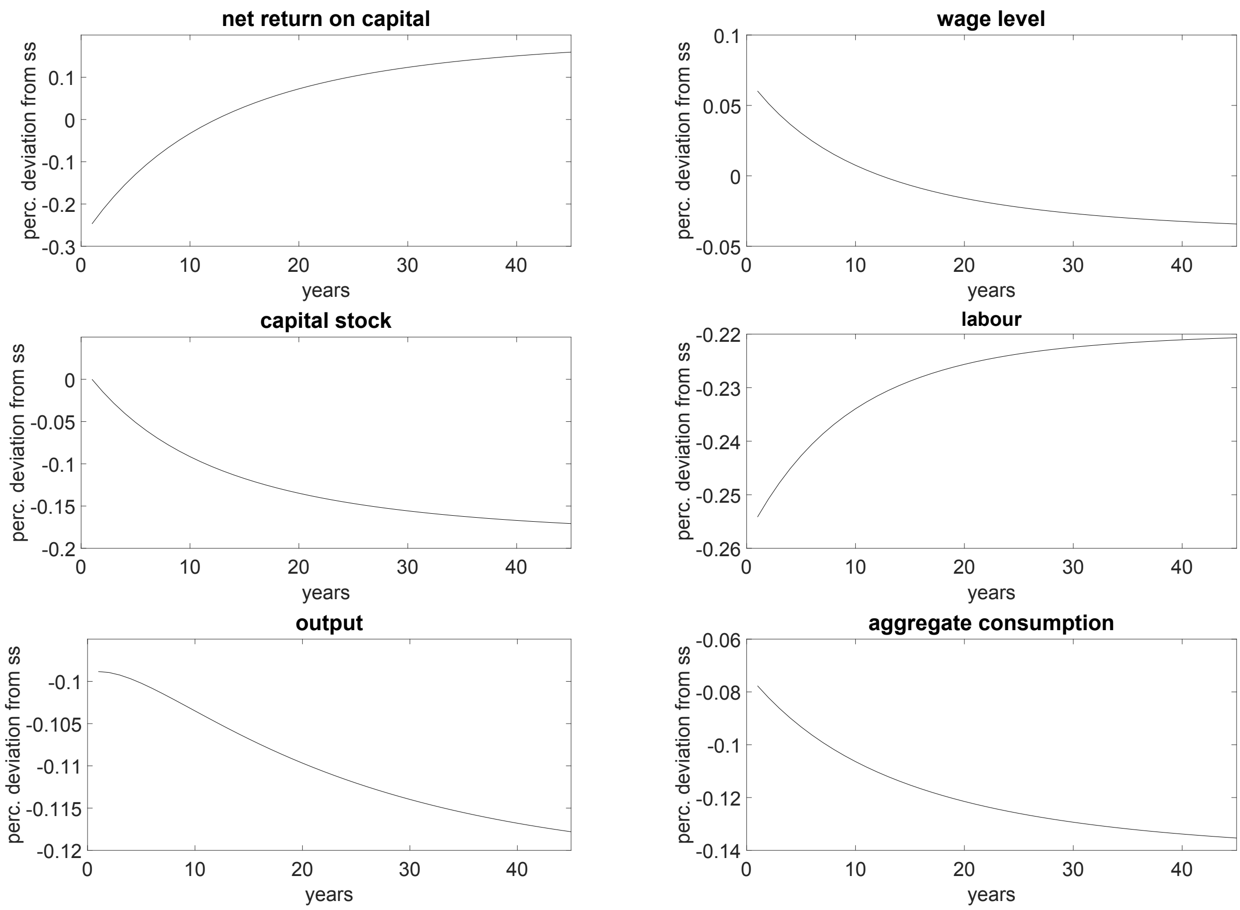


Figure 4.15: Aggregate variables - labour tax reform (transfers)

can also see that everybody works less and the asset distribution becomes more equal. However, the consumption falls for everyone. Whereas in the revenue neutral reform the consumption of the lowest productivity workers basically did not change, in this option it falls quite steeply.

Let us now analyse the asset dimension looking at the welfare gain per percentile (Figure 4.18). As we can see there are hardly any winners during this transition.

It might be assumed that a lump-sum transfer would do a great deal for the welfare connected to uncertainty and inequality. Even though the reduced uncertainty effect does take place, again it is overshadowed by the consumption level one. The inequality effect is indeed very residual.

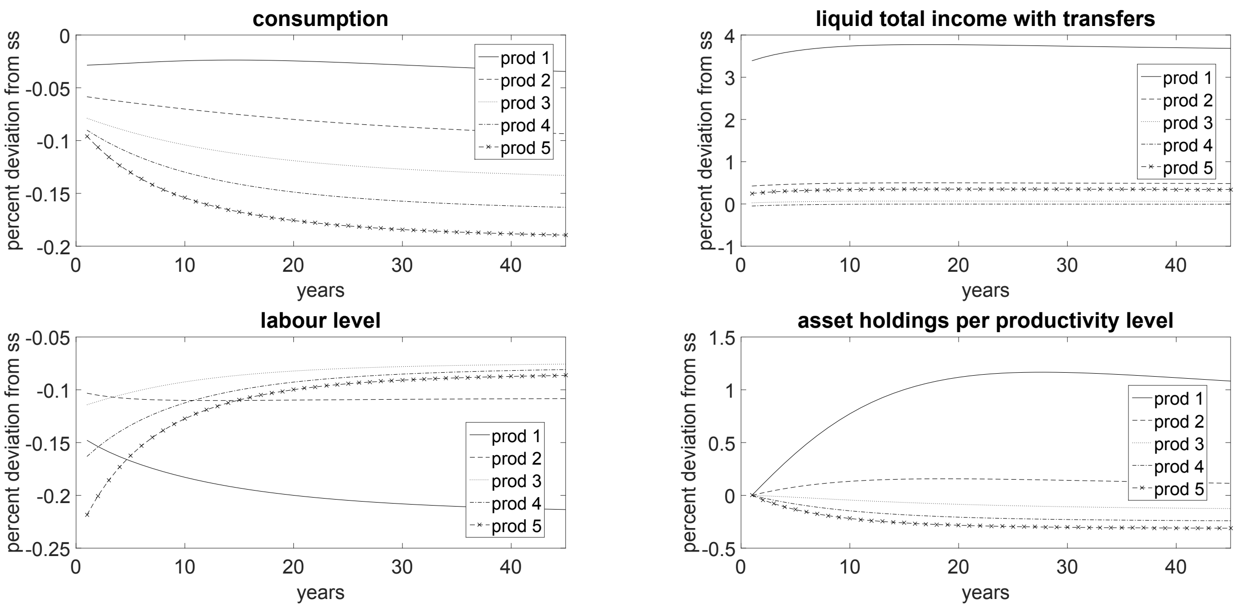


Figure 4.16: Productivity level variables - labour tax reform (transfers)

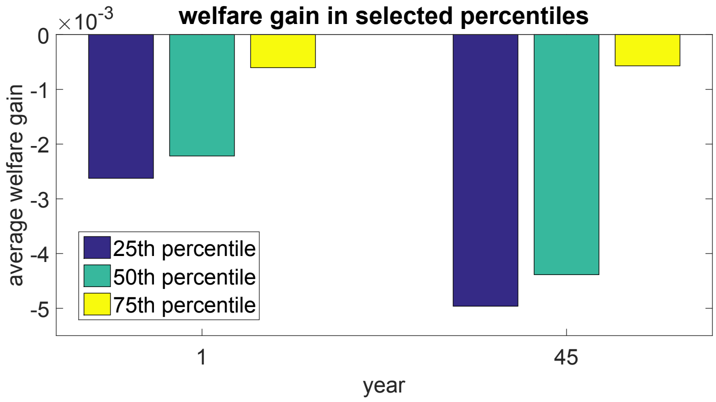


Figure 4.17: Welfare by wealth percentile - labour tax reform (transfers)

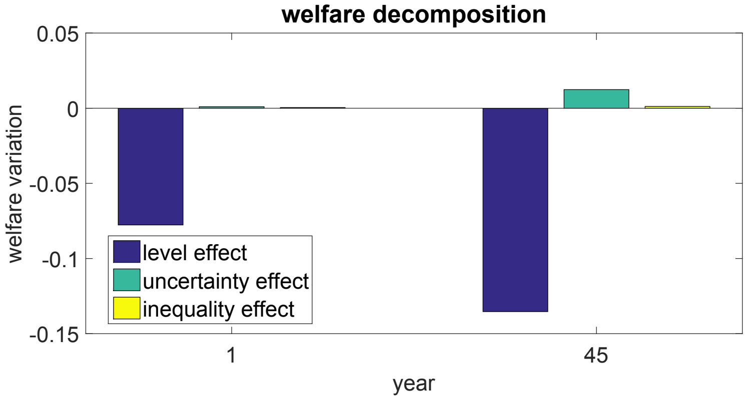


Figure 4.18: Welfare decomposition - labour tax reform (transfers)

4.3 Germany/US tax reform

In this section we will assume a more radical overhaul of the tax code.

Considering the steady-state on steady-state welfare we find that every agent would rather live in the American situation. This corresponds to an utilitarian welfare gain of 0.28 for changing from Germany to the US.

We will, thus, conduct an experiment whereby the German fiscal authority reforms in order to behave exactly like the American one (both in taxes and expenditure). This reform is done overnight with no previous warning. Any excess or lack of tax income will be balanced by direct and equal transfers.

This is a stylized case, where the tax reform is applied suddenly and unexpectedly. Other cases where a credible pre-announcement of the reform is made were also performed, but the results did not vary significantly from the ones described bellow.

Figure 4.19 shows the evolution of the aggregate variables throughout the transition period. Faced with a lower governmental expenditure the agents will find it easier to increase consumption and this will lead them to work less. The downward movement of labour increases the wages and depresses the net return on capital.

Given this decrease on the return on capital and the increased tax burden on capital, the capital stock will start to decrease. This will counter-balance the evolutions of the net return of capital and wages, and labour will also slightly recover. The values of capital stock, labour and wages all end up below their initial levels while the net return on capital reaches a final level a little above the initial.

Notice that the output is always below the initial level even though aggregate consumption is always above it. Both the depletion of the capital stock and the steep reduction of the government expenditure makes it possible. Our basic "bigger GDP, bigger welfare" rule seems then to have been challenged.

Throughout the transition the support for the reform remains overwhelming.

Figure 4.20 helps us make sense of the way different agents see what is happening. Notice how an overall drop of the capital stock in fact translates to an accumulation of capital at the top and a depletion of the capital stock for the bottom productivity levels.

We can also clearly see why going ahead with the reform is not tempting for the lower level agents. At the beginning they enjoy lower labour levels and higher consumption, only to see

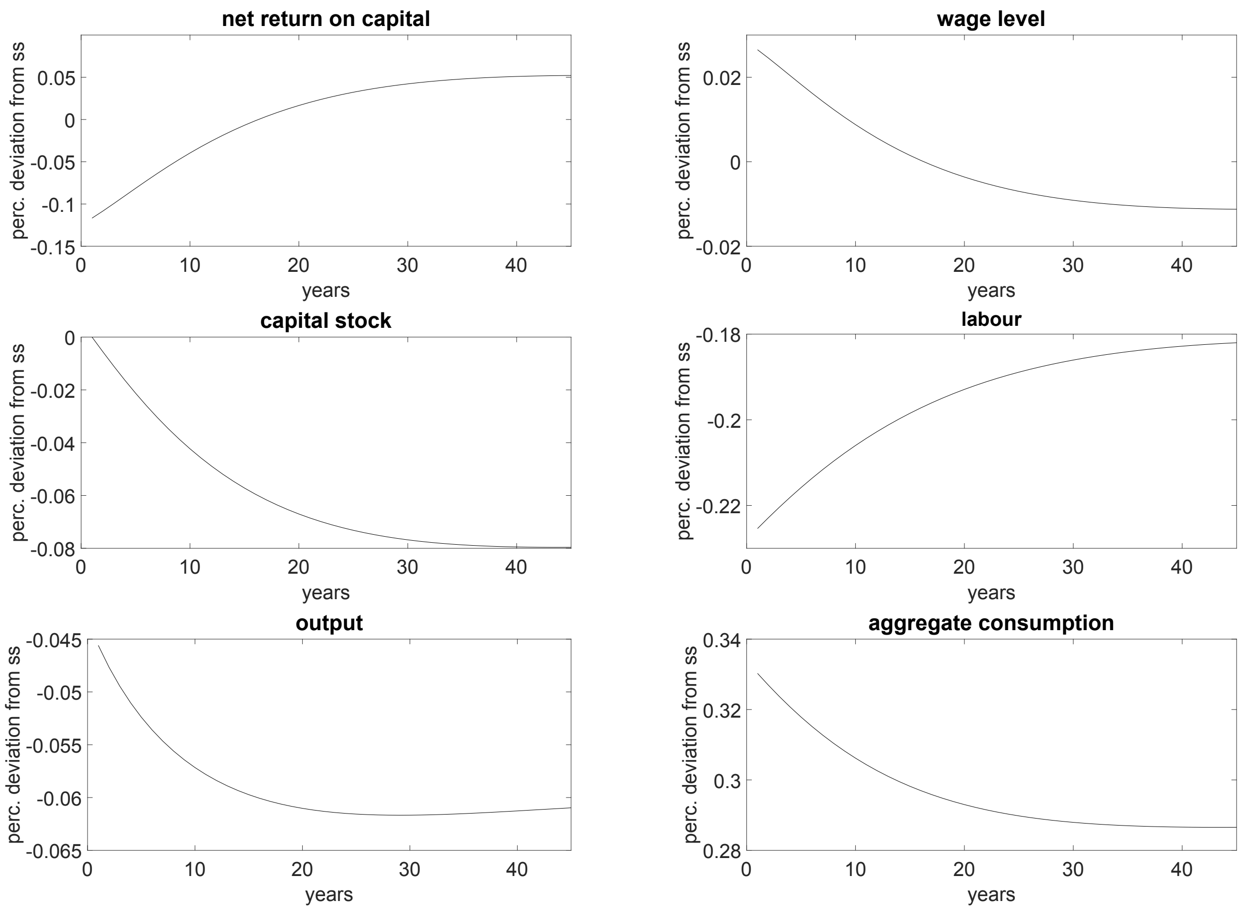


Figure 4.19: Aggregate variables - Germany to US tax reform

these two variables grow worse with time. For the lowest productivity level we actually witness an increase in the worked time.

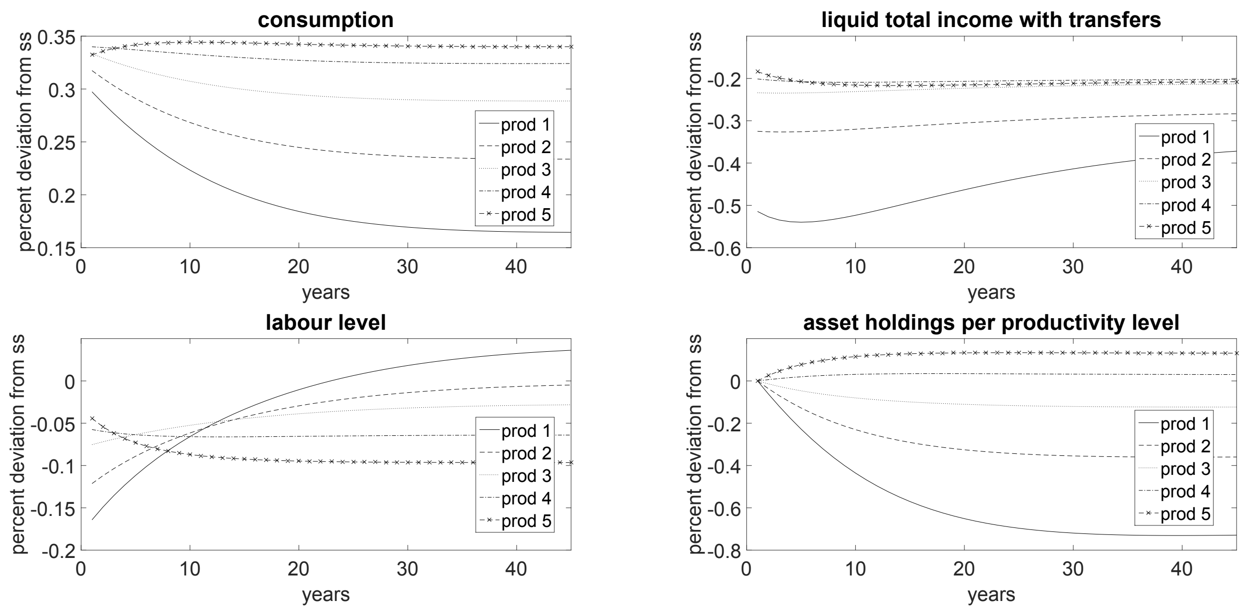
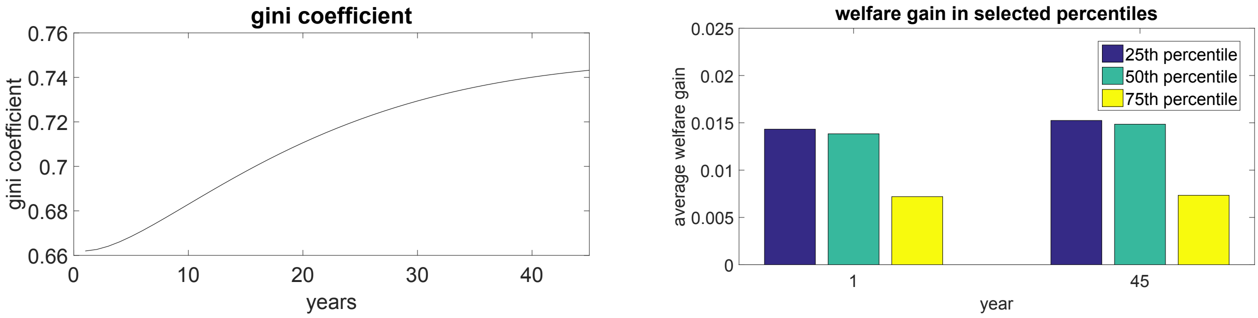


Figure 4.20: Productivity level variables - Germany to US tax reform

Figure 4.21 clearly shows the increase in the Gini coefficient. However, the welfare gains are bigger for the agents with less capital holdings. This may be a symptom that the higher level of capital taxation offsets the effects of the better return on capital.



(a) Gini coefficient **(b)** Welfare gain per wealth percentile

Figure 4.21: Gini coefficient and welfare gain by percentile - Germany to US tax reform

Finally, let us analyse whether the larger wealth dispersion negatively affected the uncertainty and inequality sides of the welfare gains. The consumption part of the welfare gain clearly overshadows the other two sides. However, after some time the uncertainty effect becomes negative. The contribution of inequality to the welfare gain is always negative. These measures can be seen in Figure 4.22.

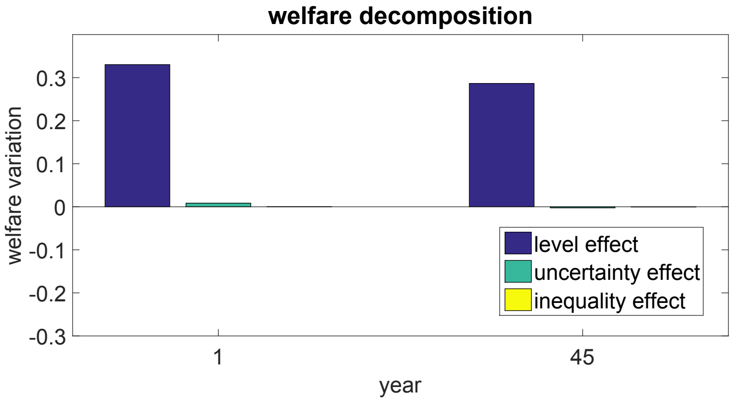


Figure 4.22: Welfare decomposition - Germany to US tax reform

5 Conclusion

This study shows that the incomplete market heterogeneous agents framework is a useful tool to study fiscal reforms. The fact that we could replicate some of the main differences between two economies simply by changing the tax regime speaks to the richness of these models.

Furthermore, we show that taking an aggregate view of the economy may lead us to lose sight of important dynamics, such as the uncertainty effects on welfare. It would also have prevented us from digging in and finding who the winners and losers in each decision are.

Regarding the particular simulations, it seems that the net return on capital transmission channel always overpowered the wage one, meaning that the wealthy agents always find themselves winning more (or losing less) than the agents with less assets. This proved to be the case even in the radical increase of labour tax to provide insured earnings for everybody.

Lastly, we are in position to evaluate the accuracy of two of the usual indicators of welfare. Since the consumption level accounts for a very large part of welfare gains and it directly enters GDP calculation, it seems that GDP is generally a good proxy for aggregate and agent-level welfare. On the other hand, as the uncertainty and inequality effects are of much smaller magnitude, the Gini index does not seem to be a particularly good indicator of welfare of poorer agents (or of the economy as a whole).

These conclusions are only valid for the framework and model used. Further study of the proposed reforms should be conducted using other methods so that the conclusions can be compared.

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