If You Like It, You Can Keep It: Gradual Tax Reforms *

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Abstract

This paper addresses the key practical challenge that tax reforms face: short-run welfare consequences. I focus on a consumption-based tax reform for which, despite long-run welfare gains it generates, welfare for some groups such as retirees, or the working poor, falls during the transition. Using a life-cycle model with heterogeneous households, I show how to devise a transition path from the current U.S. Federal tax system to a consumption based tax system that improves the welfare of current as well as future generations. In a nutshell, all households alive at the time of the policy change can choose when they want to switch to the new tax system, or whether they want to switch at all. I find that implementing a tax reform with this feature improves the welfare of 95% of population in the short-run, compared to less than a quarter of population in the simple case with no choice. It would take about twenty years for half of the population to pay their taxes under the new tax code.

JEL classification: E20, E62, H20, H24.

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1 Introduction

Features of the current U.S. Federal tax system have made the study of tax reforms an important object of research. Many proposals for reformulating the tax code suggest eliminating individual and corporation income taxes and implementing a new tax system based on consumption (Zodrow and Mieszkowski (2008)). Several authors have shown that replacing the current Federal tax system with a system that levies taxes on all income with complete deductibility of savings, would increase the economy's long-run output and improve the welfare of people born in the new steady state. Altig et al. (2001) among others show that a newborn agent would prefer to be born into the steady state of the economy with a consumption tax system rather than the one with the progressive income tax and the capital income tax system .

However, the short-run welfare consequences of such a reform have not been studied extensively in existing literature. The problem is that along the transition from the current tax system to the new one, a majority of households who are alive at the time of the regime change, would face welfare losses. These individual would favor the status quo over the reformed tax regime. Although a consumption tax reform leads to welfare gains in the long-run, achieving those gains typically entails welfare losses for transitional generations Altig et al. (2001). Hence, it is challenging to implement a consumption tax reform that is simultaneously welfare-improving for both current and future generations.

To address this problem, I build a general equilibrium life-cycle model in which households, who are heterogeneous in their productivity, optimally choose life-cycle paths of consumption, savings and labor supply. Using this model, I show that a move from the current U.S. Federal income tax system to a flat consumption tax system can be feasible as well as welfare improving for households alive at the time of the policy change. The key to this result is that I allow for a voluntary rather than compulsory switch to the new tax regime for generations alive at the time of the policy change. In a nutshell, all households who are alive at the first period of the transition can choose their preferred tax system: the benchmark tax system or the consumption tax system. In this paper I explicitly endogenize households' move to the new tax system.

My paper builds on the tradition of analyzing the transition dynamics in overlapping generation economies, in the spirit of Auerbach and Kotlikoff (1987). I compute the perfect-foresight transition path, with the initial state imitating the current U.S. Federal

tax system -hereafter the benchmark tax system. I keep the government revenue constant along the transition, and in the new steady state in which households pay taxes on each unit of their consumption at a constant rate. The model features within cohort heterogeneity, with differences arising from agents' permanent productivity types, which also evolve as they age. I study the impacts of the new tax system on different birth cohorts and different income groups.

I first consider a *simple* form of revenue-neutral transition from the steady state of the benchmark economy toward the steady state of the economy with a flat consumption tax. In this version, after the date of the policy change, all households who are alive at the time of the tax reform, along with those who are born in the new tax system, will be taxed using the reformed tax code (a flat consumption tax).

Then I introduce a flexible form of revenue-neutral transition, which I refer to as the *gradual tax reform*. In the gradual tax reform, all households who are alive at the time of the policy change will have the option of choosing between the benchmark tax system and the consumption tax system, with one condition; having chosen the new tax system, they cannot go back to the old one. For all households who are born after the reform, the new tax code (the flat consumption tax) will apply.

In principle, welfare effects for all generations depend on their ages, their productivity abilities and their asset holdings. In the simple tax reform, at the first period of transition, the young, more productive agents are largely unaffected, or they experience welfare gains. However, the elderly agents face welfare losses independent of their productivity types. These groups are in possession of a big share of capital stock and carry most of the load. Consumption taxes would be levied on agents' wealth, which they save out of their after tax income, placing a higher burden on older and middle-aged high productivity agents. Also the low productivity agents would lose no matter what their ages. Altogether, in the first period of implementation, the agents experience sizable aggregate welfare losses. Only 24.6% of the population enjoy welfare gains, and would hence favor the tax reform.

By presenting all agents alive at the time of policy change with the choice of their preferred tax system, the gradual tax reform improves the welfare effects compared to the simple tax reform. In the first period of implementation, the aggregate welfare loss is down to almost zero and about 95% of the population experience welfare gains and enjoy

the tax reform. However, these gains are not free, and the important differences lies in the speed of the transition. With the gradual tax reform it takes 1.7 times longer for the economy to reach the new steady state implying that the beneficial effects of the new tax system materialize more slowly in the gradual tax reform (see table 3). Another consequence of introducing the tax reform gradually, is that it takes time for the entire population to be paying under the new tax code. Because of the revenue-neutral nature of the reform, the consumption tax rate will be higher in the initial periods of the transition. The higher consumption tax rate translates into a higher tax burden on those who are born in the new tax system and it affects their welfare.

Consumption is defined as income net of savings and investments. Hence one practical way of collecting consumption taxes would be to levy a flat-rate tax on the reported income with full deductibility of reported savings[1].

1.1 Related Literature

The long-run welfare implication of various tax reforms have been the focus of many studies (Hall et al. (1995); Ventura (1999); Altig et al. (2001); Díaz Giménez and Pijoan-Mas (2006); Domeij and Heathcote (2004); Nishiyama and Smetters (2007a); Lopez-Daneri (2016); are some examples). Most of these papers focus on long-run effects of modifying the tax code, and do not explore the effects of tax structure on generations living through the initial periods of the transition to the new steady state.

One of the pioneering papers that considers transitional effects of tax changes is Summers (1981). In this paper, Summers compares steady state utility for a model with fixed labor supply; his study also attempts to measure the efficiency consequences of an explicit transition from one tax system to another. Summers' transition analysis, however, is based on the assumption of myopic rather than rational expectation, he also assumes completely inelastic supply of labor. Altig et al. (2001) and Auerbach and Kotlikoff (1983) are two papers that analyze the consequences of tax reforms along the transition path.

Altig et al. (2001) use a general equilibrium simulation model with intragenerational heterogeneity to examine consequences of a revenue neutral move from an income tax

[1]Some specific forms of savings are tax deductible in the current tax code and are reported, like contributions to individual retirement accounts or contributions to 401(k).

system to some alternative consumption-based tax systems like a flat income tax and a flat-rate consumption tax system. They compute the entire transition path and conclude that the poor members of generations alive at the time of the policy change lose under the flat-rate consumption tax system.

My point of departure is to examine short-run as well as long-run consequences of the reform and in highlighting the difficulties, to suggest a solution. The method of gradual tax reform is a practical way to implement any structural tax reform. Notice that although the method has been discussed in the context of a consumption tax reform, it is a broadly applicable framework for implementing any policy reform that provides higher welfare in the long-run. This idea has been used to devise reforms to the social security systems (see Conesa and Krueger (1999)). In fact, several papers study the transitional dynamics of moving to a privatized social security and find sizable welfare gains in the long run along, along with considerable short-run welfare losses that cannot be compensated with the long-run gains, see Huang et al. (1997), Kotlikoff et al. (2002), Feldstein and Samwick (1998) and Nishiyama and Smetters (2007b) as examples.

And finally, my paper is related to literature that focuses on studying taxation in the dynamic general equilibrium models like those proposed by Conesa and Krueger (2006), Guner et al. (2012), Badel and Huggett (2014) and Guner et al. (2016).

The paper is organized as follows: section 2 presents the life-cycle model and section 3 discusses its parametrization. Section 4 and section 5 contain the main results. Critical discussions of the results including additional exercises and sensitivity analysis are presented in section 6, and section 7 concludes.

2 Model

I study a discrete time general equilibrium life-cycle economy with individual heterogeneity and endogenous labor supply.

2.1 Demographics

The economy is populated by J heterogeneous overlapping generations. Each period, a continuum of agents are born and live for J periods. Population at time t is denoted by N_t and grows at a constant rate n , i.e. $N_{t+1} = (1 + n)N_t$. The demographic structure is

stationary such that age j agents constitute a fraction μ_j of the population at each point in time.

2.2 Preferences

All agents value the path of consumption and leisure according to the following utility function:

$$\sum_{j=1}^{J} \beta^{j-1} u(c_j, l_j)$$

where c_j and l_j denote consumption and labor at age j.
The period utility function is

$$u(c_j, l_j) = \log(c_j) - \frac{l_j^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}}$$

where γ is the Frisch elasticity .

2.3 Technology

The technology is represented by a Cobb-Douglas production function which transforms capital K and labor L into output Y according to

$$Y = K^{\alpha} L^{1-\alpha}$$

where α is the capital share parameter. The resource constraint is

$$C_t + K_{t+1} - K_t(1-\delta) + G_t \leqslant K_t^{\alpha} L_t^{1-\alpha}$$

where δ is the depreciation rate of the capital stock, G_t is the public consumption and C_t is the aggregate private consumption.

2.4 Individual Constraints

All agents are born with no assets and face mandatory retirement at age $T+1$, i.e. they work for T periods and then live as a retiree for T^R periods.
The market return per hour of labor supplied by an age j agent at time t is given by $w_t e(z, j)$, where w_t is the wage rate that is common to all agents and $e(z, j)$ is a function

that represents the combined productivity effects of age j and a permanent productivity shock z with $z \in \mathcal{Z}$, $\mathcal{Z} \subset \mathscr{R}^{+}$. Each newborn agent draws a productivity shock z from the probability distribution $F(z)$ which remains constant during the working life cycle. I call the agent with the productivity shock z, the type z agent.
A j-age and z-type agent with productivity level $e(z,j)$, chooses consumption $c_{j,t}$, labor hours $l_{j,t}$ and level of asset holdings for next period $a_{j+1,t+1}$. The budget constraint is:

$$c_{j,t} + a_{j+1,t+1} \leqslant a_{j,t}(1+r_t) + (1-\tau^{ss})w_t e(z,j)l_t + b_{j,t} - Tj,t$$

$$c_{j,t} \geqslant 0\,, \quad \text{and} \quad a_{j+1,t+1} \geqslant \underline{a}\;\forall j$$

where $a_{j,t}$ is the asset holding at age j and time t , r_t is the risk free net return on asset holding , τ^{ss} is the constant flat social security tax rate on labor earning, $b_{j,t}$ is the social security benefit which is zero at working ages and equals a fixed benefit during the retirement periods and $T_{j,t}$ are taxes paid. The constraint $a_{j+1,t+1} \geqslant \underline{a}$ implies that agents are not allowed to borrow beyond a borrowing constraint.

2.5 Government , Taxes and Transfers

In this model economy, at each period of time the government engages in three activities: it spends resources (consumes G), it levies taxes (to finance the government consumption G) and it runs a balanced budget social security system.
The social security system is fully funded by social security taxes paid by working agents at a constant marginal tax rate τ^{SS} on their labor income. Social security benefits are distributed evenly among all retirees of different types and different ages i.e. the benefit for each retired agent does not depend on her earning history.
The government finances its consumption G merely through taxation. The current U.S. Federal tax system is taken as the benchmark case. In order to mimic its main features, taxes paid by each agent consist of two components: a flat-rate capital income tax and a non-linear income tax, where the tax is levied on labor and capital income

$$I_{z,j} \equiv \omega e(z,j)l_{z,j} + ra_{z,j}$$

This means that in the benchmark case, the total income tax liability for an agent of age j and type z with income $I_{z,j}$ is

$$T_{z,j} = T_f(I_{z,j}) + \tau^k a_{z,j} r$$

where T_f is a strictly increasing and a convex function that represents the nonlinear income tax scheme and τ^k is the flat capital income tax rate, which replicates the corporate tax in the Federal tax system. In the benchmark tax system, for an agent with income I, the marginal tax rate on capital income equals $T_f'(I) + \tau^k$, and the marginal tax rate on labor income equals $T_f'(I) + \tau^{SS}$.

In the reform scenario, a flat rate consumption tax replaces the U.S. Federal income tax, leaving the social security system unchanged. That is, the progressive income tax and the capital income tax are eliminated, and all agents pay a constant tax rate on each unit of their consumption.

Thus in the reformed case, the total tax liability for a type z agent at age j is

$$T_{z,j} = \tau^c c_{z,j} + TR$$

where TR is the fixed lump-sum transfer that agents receive at each period.

2.6 Agent's Problem : Recursive Formulation

In this part I state the decision problem of an agent in my economy in a recursive form. First I describe the decision problem for the agent when the economy is at the steady state. Then I demonstrate how the problem would change when the economy is out of the steady state i.e. in the transition from the old steady state to the new one.

2.6.1 Steady State

The state of each agent is fully described by the agent's asset holdings a, her type z and her age j[2] . Let the nonage-dependent part of the state vector be described by $x = (a, z),\ x \in \mathscr{X}$ where a is the current asset holding and z denotes the permanent productivity shock for the agent which determines her type. The set $\mathscr{X}$ is $\mathscr{X} = [0, \infty) \times \mathscr{Z}$. So the state vector for any agent is (x, j).

[2]In this part, time subscripts are dropped since I describe the stationary equilibrium

Given the prices (w, r) and the tax regimes ($\Delta \in \{$ *the benchmark tax system* , *the reformed tax system*$\}$), an agent with state (x, j) needs to optimally choose the amount of labor $l(x, j)$ to supply to the market, the amount of consumption $c(x, j)$ and the amount of saving or assets to carry over to next period $a(x, j)$, in such a way that these choices solve the following dynamic programming problem[3]:

- Working agents ($j \leqslant T$):

$$v(x, j) = \max_{c,l,a'} \Big\{ \log(c) - \frac{l^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}} + \beta v(x', j+1) \Big\} \tag{1}$$

  subject to

$$c + a' \leqslant a(1+r) + we(z, j)l(1-\tau^{ss}) - T^{\Delta}(x, j)$$

$$c \geqslant 0\,, \quad \text{and} \quad a' \geqslant \underline{a}$$

- Retirees ($T < j \leqslant T + T^R$):

$$v(x, j) = \max_{c,a'} \Big\{ \log(c) + \beta v(x', j+1) \Big\} \tag{2}$$

  subject to

$$c + a' \leqslant a(1+r) + b_j - T^{\Delta}(x, j)$$

$$c \geqslant 0\,, \quad \text{and} \quad a' \geqslant \underline{a}$$

  and

$$v(x, T + T^R + 1) = 0 \quad \forall x$$

The definition of a stationary recursive competitive equilibrium for this class of models is by now standard.[4]

[3] If $x = (a, z)$ then $x' = (a', z)$

[4] Equilibrium definition is provided in Appendix A

2.6.2 Tax reform

As the benchmark economy I take the model with the benchmark tax system, which mimics the features of the current U.S. Federal tax system: the flat-rate capital income tax and a the nonlinear income tax. In period zero, the economy is in steady state with this tax system.
I assume that the change of the tax system takes place at the beginning of period one, before any economic choices have been made.I consider the consumption tax reform being implemented in two potential ways: the simple tax reform and the gradual tax reform.

Simple Tax Reform : At the beginning of period one, before any economic choices have been made, the government announces that it has abolished the benchmark tax system and replaced it with the consumption tax system. From period one onward all agents have to pay their taxes under the new tax code (a constant tax rate on each unit of consumption).

Gradual Tax Reform : At the beginning of period one, before any economic choices have been made, the government announces that it is replacing the benchmark tax system and replaced it with the consumption tax system, with a specific condition: all agents who are alive at period one have the option of choosing between the benchmark and the consumption tax system. In particular all those who are alive at the time of the policy change can choose when they want to switch to the new tax system in their lifetime, or if they want to switch at all. The switch is irreversible. All those born after period two will have to pay their taxes under the new tax code (the consumption tax code). With this method of implementation, it takes some time for the economy to reach the point at which the entire population is paying its taxes under the new tax code.
In both methods of implementing the consumption tax reform, the initial point is the steady state of the economy with the benchmark tax system and the final point is the steady state of the economy with the consumption tax system. But the transition path and the decision problems of the agents depend on the type of the tax reform being

implemented.
In what follows, I state the decision problem for the agents in the *gradual tax reform*. However, the decision problem of the agents in the simple tax reform is nested as a special case of the gradual tax reform.

2.6.3 Out of Steady State

In the gradual tax reform, agents fall into two categories: those who have the option of choosing their preferred tax system, and those who have to pay their taxes under the new tax code. All agents who are alive at the time of the policy change and have not yet switched to the new tax system belong to the first group. The second group comprises all agents who are born in the new tax system as well as those who were alive at the time of the policy change and have already switched to the new tax system.
To state the agent's decision problem I need to distinguish between the two categories. To do this, I add an indicator variable q to the state vector of the agent. The indicator is a binary variable that signals whether or not the agent can choose between the two tax systems. So $q = 0$ demonstrates that the agent belongs to the first group, i.e. she can choose her preferred tax code, and $q = 1$ means there is no option available for the agent and she must pay her taxes under the new tax code. Now I can define the decision problem for the agents when the economy is out of steady state for each value of q.
At any period t, given the prices (w_t, r_t) , an agent of age j with state x and q needs to choose the amount of labor supply $l_t(x, j, q)$, the amount of consumption $c_t(x, j, q)$ and the amount of saving or assets to carry over to next period $a'_t(x, j, q)$, furthermore, if $q = 0$, i.e. the agent has the option of choosing between two tax systems, she needs to choose her preferred tax code as well $q'_t(x, j, q)$. So optimal decision rules solve the following dynamic programming problem:

- If $q_t = 1$:

$$v_t(x, j, q_t = 1) = \max_{c_t, l_t, a'_t} \Big[\log(c_t - \psi \frac{l_t^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}} + \beta v_{t+1}(x', j+1, q'_t = 1) \Big]$$

$$s.t. \quad c_t + a'_t = w_t e(z_i, j) l_t (1 - \tau^{ss}) + (1 + r_t) a_t + b_{t,j} - T_t^{Consumption}(x, j)$$

Notice that this case also describes the decision problem of agents in the simple tax reform. Recall in the simple tax reform, after the government has announced the change of tax policy, that all agents must pay their taxes under the new tax code.

- If $q_t = 0$:

$$
\begin{aligned}
v_t(x, j, q_t = 0) = \max_{q_t'} \Bigg\{ & \max_{c_t, l_t, a_t'} \Big[\log(c_t) - \psi \frac{l_t^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}} + \beta v_{t+1}(x', j+1, q_t' = 1) \Big], \\
& s.t. \quad c_t + a_t' = w_t e(z_i, j) l_t (1 - \tau^{ss}) + (1 + r_t) a_t \\
& \qquad + b_{j,t} - T_t^{Consumption}(x, j) \\
& \max_{c_t, l_t, a_t'} \Big[\log(c_t) - \psi \frac{l_t^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}} + \beta v_{t+1}(x', j+1, q_t' = 0) \Big] \\
& s.t. \quad c_t + a_t' = w_t e(z_i, j) l_t (1 - \tau^{ss}) + (1 + r_t) a_t \\
& \qquad + b_{j,t} - T_t^{Benchmark}(x, j) \Bigg\}
\end{aligned}
$$

In equilibrium, goods, capital and labor markets clear in each period. This determines corresponding factor prices of the period. The definition of a recursive equilibrium for this economy is provided in the appendix A.

3 Parametrization

The parameters of the model have been calibrated so that the initial steady state for the economy replicates selected features of the current U.S. economy. The model period is set to be 5 years. Table 1 summarizes the parameter choices.

3.1 Demographics

In my model, agents are born at age 25, retire from working at age 65 (i.e. $T = 8$) and die at age 85 (i.e. $J = 12$), so their life length is 12 model periods and they face mandatory retirement after 8 periods of working. I consider annual population growth of 1.09%[5],

[5]Economic Report of the President 2012, table B.34

which corresponds to the average population growth rate for the U.S. during the period $1960 - 2009$.

3.2 Technology and Preferences

To set the values for parameters α, the capital share and δ, the depreciation rate, I follow the standard method of Cooley and Prescott (1995). In order to align my model economy with the data I define the notion of capital to include stock of fixed private capital, stock of consumer durables[6], stock of inventories[7] and stock of land[8]. The capital to output ratio averaged 2.89 over the period of $1965 - 2007$, at the annual level. The parameter α is set to 0.34 which is the average of capital share. The depreciation rate is determined endogenously to be 0.074 at the annual level such that the model generates the average investment to capital ratio we see in the data over the same period.
The intertemporal elasticity of labor supply γ is set to 1[9].
The value of parameter β which is the discount factor is determined endogenously to 0.9675, in such a way that the model generates the same capital to output ratio as I calculated from the data.

3.3 Endowment

The labor productivity profile $e(z, j)$ for each agent, consists of two components, common age dependent component and a fixed productivity type that they born with. We can think of this as a permanent productivity shock that agents draw from a distribution when they are born. To estimate the productivity profile I used the available observations on wage (hourly earning). For the age productivity profile I regress the log hourly wage of households on a polynomial of age together with a time fixed effect. For this regression I used the data from the Current Population Survey (CPS) for the years 1980-2005. The sample I used consists of households with heads aged between 25 and 64.

[6]Table 1.1. Current-Cost Net Stock of Fixed Assets and Consumer Durable Goods, BEA, August 2015
[7]Economic Reports of the President 2012, table B.1
[8]Flow of Funds accounts, balance sheet tables
[9]Notice that the macro estimates of the elasticity of labor supply tend o be higher than those from the micro literature. As shown by Kean and Rogerson(2015) the aggregate settings mechanism suggest the value for γ larger than 1. I have an exercise with a higher value for γ (2.5 instead of 1) in discussion part

All individuals in the sample earn hourly wages above half of the Federal minimum wage, and they work at least 260 hours per year[10].

For the permanent productivity shock, I assume that z is drawn from a log-normal distribution function. To estimate the distribution I use the same sample of data from the Current Population Survey(CPS) and select the households with heads aged between 25 and 29 and calculate the yearly standard deviation of the log hourly wages for these households. I normalize the distribution by its mean and the standard deviation σ_z is set to 0.51, which is the average of the yearly standard deviation of the log hourly wages that I calculated from the data. The permanent productivity shock is approximated with seven states.

3.4 Taxation

Following Benabou (2002) , Heathcote et al. (2014) and others, I approximate the Federal income tax with a two parameter function

$$t(\tilde{I}) = 1 - \lambda(\tilde{I})^{-\tau}$$

$t(\tilde{I})$ is an average tax function and $\tilde{I}$ is income normalized by household income, i.e. income I divided by the mean household income in the economy. The parameter λ defines the level of the tax rate whereas the parameter τ governs the curvature or progressivity of the system. To set values for these parameters I used the Guner et al. (2014) estimates for all households which takes into account the Earned Income Tax Credit; $\lambda = 0.91$ and $\tau = 0.053$.

The tax rate τ^k levied on capital income is used to proxy the U.S. corporate income tax. It is estimated as the one that reproduces the level of tax collections out of corporate income taxes after the major reforms of 1986. The average corporate tax revenue as percentage of GDP is 1.9% for the 1987-2007 period[11]. Using the technology parameter and specifications of output in my model, I obtain $\tau^k = 10.54\%$. And finally the parameter τ^{SS} the payroll tax rate levied on labor income to finance social security benefits, is set to 10.25% which is the average of the ratio of contribution to social security to the labor

[10] As in Heathcote et al. (2010)

[11] Office of Management and Budget. "Fiscal 2017 Budget of the United States, Historical Tables: Table 2.3- Receipts by Source as Percentages of GDP: 1934–2016 "

income for the period of 1990-2014[12].

4 Findings, Initial and Final Steady States

Both simple and gradual reforms start from the same initial steady state and end in the final steady state of the consumption tax system. I first discuss the quantitative properties of these steady states and then turn to the transition dynamics and the welfare analysis for the simple and the gradual tax reform.

Table 2 shows how the main aggregate variables compare across the two steady states. The first column describes the initial steady state of the economy where the benchmark tax system (the one with the nonlinear income tax and the flat capital income tax) is the formal tax code. The second column of table 2 characterizes the steady state of the economy under the consumption tax system. I should mention that the generated tax revenue is the same across both steady states. The condition of generating a constant level of tax revenues is imposed to help pin down the consumption tax rate in the new steady state.

From table 2 we see that replacing the benchmark tax system with a consumption tax system leads to 27.6% higher capital accumulation in the steady state. The capital-output ratio increased by 14.5%. Removing the increasing marginal tax rate on capital income motivates agents to accumulate more assets. As a result of an increase in the asset accumulation, and only a modest increase in labor supply, the interest rate decreases by 25% and the wage increases; this is translated into an 11.3% rise in the retirement benefits. Output increases by 11.1% because of a higher level of the capital stock and also the labor supply.

This increase in the size of the economy has implications for welfare effects of the consumption tax reform. An agent born in the steady state of the economy with the consumption tax system would benefit from a 3.4% higher level of consumption in each period of her life, as opposed to an agent born into the steady state of the economy under the benchmark tax system. Figure 1 decomposes the aggregate welfare gain into the welfare gains for various productivity types. As I mentioned before, the permanent

[12]The contributions considered are those from the Old Age and Survivors Insurance. The Data comes from the Social Security Bulletin,Annual Statistical Supplement, 2015. Table 4.A1

productivity shock has been approximated with seven states, which I call types, with type one having the relatively lowest productivity shock and type seven having the highest productivity shock.

Figure 1 reveals that the largest welfare gain from switching to the consumption tax system accrues to agents with higher productivity. Higher productivity type agents are also higher income. The progressive nature of the nonlinear income tax under the benchmark tax system has relatively unfavorable impacts on agents with a higher level of income, so the most productive agents clearly benefit the most from replacing a progressive income tax with a flat tax.The lowest-productivity group has a welfare loss of 2.6% and the welfare gains increase with the increase in the productivity.[13]

5 Findings, Transition Paths

In this section I turn to the discussion of transitional dynamics and short-run welfare effects of both simple and gradual tax reforms. The simple tax reform represents a case in which all agents, even those who have planned their lives under the benchmark tax system, would have to switch to the new tax system right after it is implemented. I consider this reform to be a baseline for comparison with the gradual tax reform which brings in the new tax system while phasing out the benchmark tax system more gradually.

Notice that the reforms are revenue neutral, i.e. the economy generates the same level of tax revenue along the transition and in the new steady state.

5.1 Simple Tax Reform

Figure 2 shows the evolution of macroeconomic aggregates along the transition in the simple tax reform. The upper graph shows the evolution path for output, the middle graph has the transition path for the interest rate and the lower one shows the evolution of aggregate labor supply.

It can be seen from figure 2 that under the simple tax reform the economy reaches its

[13]In the discussion part I show that by providing a lump-sum transfer for all agents in the new tax system, even the lowest productivity type would enjoy the tax reform

new steady state after about 35 years. Under the consumption tax system, the accumulated capital is essentially untaxed which makes saving more attractive. Therefore, directly after initiating the reform there is a sharp increase in aggregate labor supply which is essentially the result of a substitution effect that induces delays in consumption as well as leisure, and creates the jump in the labor supply. However, as the aggregate capital stock is predetermined from the period before the policy change, the capital-labor ratio plunges sharply, resulting in an initial spike of the interest rate and a decrease in wage rate and the capital-output ratio.

In subsequent periods, higher capital accumulation kicks in, which results in further increases in output. This happens despite the fact that wealth effects mitigate some of the increase in the aggregate labor supply, which gradually decreases to its new steady state value. Also, after its initial surge, the interest rate falls and the wage rate rises, to their new steady state values.

All these trends have been documented quantitatively in table 3. Notice that the labor supply rises by 5% immediately after the policy change. Because of this, output increases by 3.3% in the first period. This means that about 30% of the total increase in output is realized in the initial period of the tax reform.

Five periods into the reform, the capital stock is 24.6% larger than its initial steady state and output is 10.8% larger. Furthur along the transition, after ten periods, output exceeds its initial steady state level by 11.3%, and the capital stock is 27.5% larger. Over the long-run the capital stock is 27.6% higher than its initial steady state and the output is 11.4% larger.

The circular points in figure 5 shows the consumption tax rate that endogenously adjusts to keep the generated tax revenue constant at each period along the transition. As the economy expands, the required consumption tax rate declines. Along the transition, the consumption tax rate falls from 16.1% initially to its long-run value of 14.1%.

Welfare Figure 3 shows the welfare effects, measured by the consumption equivalent variation, at the first period of transition for the three groups of agents: the most productive agents, the least productive agents and those with the median productivity level. This graph confirms that the welfare consequences for agents vary significantly

with ages and productivity types.

Notice that all agents who are in their retirement periods, independent of their productivity type, face welfare losses. In fact, old agents are the biggest losers of the reform, with agents age 65 or higher loosing about $4 - 8\%$. The rationale for this is the considerably different tax burden these agents face under the consumption tax system. As it has been emphasized by Summers (1981) changing the timing of tax payments over the life cycle significantly alters the burden of taxation across generations. Under the benchmark tax system, the retirees' tax burden is negligible compared to the tax burden of agents who are in their prime working ages. However, under the consumption tax system, because of the consumption smoothing behavior of the agents, and the fact that each agent has to pay a flat tax rate on each units of consumption, the tax burden of retirees is comparable to that of the working agents. So those agents who are in their retirement ages when the tax reform takes place, have already played their role as the major contributors to the tax revenue in their working periods. With the change of the tax system, they are then expected to provide a considerable part of tax revenue in their retirement as well.

Among the young agents, the welfare changes is increasing in productivity types. While agents with higher productivity shocks experience welfare gains, the less productive agents are negatively effected by the tax reform. The miscellaneous welfare effects stem from the progressivity of the income tax under the benchmark tax system. The nonlinear income tax scheme has an increasing marginal tax rate that adversely affects agents with higher earnings. Hence agents with higher productivity types who have higher income, benefit more from replacing the progressive income tax with a flat rate consumption tax. This explains why the young agents who are more productive experience welfare gains. The less productive agents, no matter their ages, lose, even though they would have higher wages and higher social security benefits in their retirement periods.

Overall, my quantitative experiment shows that under the simple tax reform, only 24.6% of the population who are alive at the time of the policy change, experience welfare gains, and the tax reform is detrimental for the rest. Also the weighted sum of the welfare gains of the winners is just 14% of the weighted sum of the welfare losses borne by the losers. These results are a quantitative suggestion that the long-run welfare gains masks the asymmetry in the distribution of the short-run welfare effects.

5.2 Gradual Tax Reform

The gradual tax reform phases out the benchmark tax system by letting agents, who are alive when the change of policy takes place, choose their preferred tax code. Figure 2 shows the evolution of macroeconomic aggregates in the gradual tax reform (the dotted line with triangular points). As shown in this figure, the transition to the new steady state is much slower. Convergence to the new steady state now takes about 60 years, and it takes 18 years for the economy to materialize half of the increase in the output[14].

Figure 4 shows the fraction of population who pay their taxes according to the new tax code in each period of transition. At the first period, which is the period in which the change of policy happens, no one chooses to pay taxes under the new tax code, and it takes about 18 years for the economy to have half of the population paying their taxes under the consumption tax system.

As expected, younger more productive agents are among the first to adopt the change of the tax system. These are the cohorts who experience higher incomes in their life cycles and are therefore effected more severely by a nonlinear income tax. The consumption tax system is thus more appealing to these groups, and they choose to switch to the new tax system in the initial periods of the tax reform.

The retired agents, no matter their productivity type, choose to stay in the benchmark tax system over the remainder of their life. As I mentioned before, these agents have already made their economic choices and paid income taxes under the benchmark tax scheme, assuming that the tax burden would be negligible in their retirement periods. Switching to the new tax system increases their tax burdens and would not be beneficial for this group.

Having just a fraction of population in the new tax system in the initial periods of the tax reform, induces higher consumption tax rates in these periods compared to the simple tax reform as shown in figure 5. As we go further into the transition, there will be more agents who are paying consumption taxes. As a result, the endogenous consumption tax rate eventually declines to its steady state value.

Gradual tax reform slows down the emergence of beneficial features of the consumption tax code in the economy, a fact that has been quantified in the second panel of table 3. For example, immediately after the tax reform, one barely notices any differences in the

[14]This happens in the first period of the simple tax reform

economy , it takes 2 model periods for the economy to realize 30% of increase in output, the amount realized in the same period in which the policy change goes into effect under the simple tax reform. Five periods into the transition, output increases from its initial steady state by 6.4% compared to 10.3% in the simple tax reform, and the capital stock increases by 13.9% compared to 24.6%.
Hence, with the gradual tax reform, it takes longer for the economy to benefit from desirable effects of the consumption tax system. Moreover, with the gradual tax reform, the endogenous consumption tax rate required to keep the tax revenue constant is much higher in the early years of the transition than in the case of the simple reform.

Welfare Figure 6 shows the welfare gains/losses, measured in consumption equivalent variation, at the first period of transition for all agents who are alive when the tax reform takes place. Comparing welfare effects of the gradual tax reform with their counterparts in the simple tax reform confirms that letting agents to choose their preferred tax regime enables them to avoid the unfavorable welfare effects of the tax reform. The gradual tax reform eliminates the adverse effects of changing the tax policy and brings down the impacts to general equilibrium effects, which happen to be small in this case.
My quantitative results show that under the gradual tax reform, 95% of the population who are alive at the time of the policy change, experience welfare gains, as opposed to 24.6% under the simple tax reform.

6 Discussion

In this part I run five exercises; First, I redo the experiment with a consumption tax system that features a lump-sum transfer for everyone, and thus retains some flavor of progressivity. The goal is to investigate whether the negative welfare consequences in the first period are driven by the lack of progressivity of the new tax system. Second, I simulate the model in a partial equilibrium in order to understand the roles of endogenous factor prices on the results. Third, I explore whether announcing the change of policy in advance would help ameliorate the negative short-run welfare consequences of the tax

reform. Fourth, I compare my method with the one in which the old tax system is phasing out while the new tax system is phasing in over a certain number of periods. Finally I investigate the sensitivity of my results to the labor supply elasticity by conducting the experiment with a higher value for γ.

6.1 A Flat Rate Consumption Tax With Lump-sum Transfers

While flat-rate consumption taxes have received a great deal of attention in the research, It is important to note that consumption-based taxes can also be progressive. In particular, giving a lump-sum transfer to all households is one way of converting a flat consumption tax system into a progressive one. In this part, I redo the experiment of replacing the benchmark tax system with a consumption tax system that features lump-sum transfers to all agents. The goal of the exercise is to examine whether having the transfer would alleviate the negative short-run welfare consequences of the tax reform, and how the gradual tax reform would perform in this context.

I consider three levels of transfers: 1%, 2.5% and 5% of the GDP per capita of the steady state of the benchmark economy. Transfers, like government consumption, are financed by taxes. This providing higher levels of transfers would induce higher tax rates to keep the government budget balanced.

Table 4 reports the value of the aggregate variables with induced changes in the consumption tax rate for the three different levels of transfer as well as the one without transfers. As we expected, the need to finance the higher level of transfers increases the consumption tax rate well above the case without any transfers. As a result, the output effects when there are transfers are substantially reduced relative to the case with no transfers. The long-run increase in the capital stock and level of output are lower in tax systems with a higher level of transfers. The labor supply decreases as well.

However, the aggregate welfare gain increases with the level of transfers. This reflects the fact that providing a fixed level of transfer changes the effective marginal tax rate of different agents, which then alters their tax burdens. This is illustrated in figure 7, which decomposes the aggregate welfare gains across agents with different levels of productivity. Looking at the distribution of the welfare gains, we see that the welfare gains for less productive agents who are relatively poor are increasing in the amount of transfers, while for the agents with higher levels of productivity, the welfare gains decline

with the rise of the transfer. This comes from the fact that the effect of transfers declines as income increases. Poor agents benefit most from transfers, while richer agents bear the burden of financing the transfers.

Figure 8 plots the short-run welfare consequences of the consumption tax reform with different levels of transfers. The upper graph shows the welfare effects for the least productive agents, the middle graph and the lower one shows welfare effects for agents with the median and the highest productivity types. The topmost graph confirms that the welfare of the least productive agents, who are the poorest in the economy, is increasing in the amount of transfers. This suggests that the transfer has a considerable effect on their income that outweighs the cost of financing it out of their taxes. For agents at the median productivity level, who are in the middle income group, the cost and the benefit of the transfer are such that there is no noticeable effect on their welfare gains, as shown in the middle graph of figure 8. The welfare gains for the most productive agents, who have the highest income in the economy, decline with the rise of transfers . These groups are the ones who bear the burden of financing transfers, while the amount they receive in transfers is negligible compared to their income; thus a consumption tax system with no transfers would be most preferable to them.

Although including transfers mitigates the short-run welfare losses for the poor agents, it does not significantly decreases the welfare losses observed under the simple tax reform. As figure 8 shows, the welfare losses could be as big as 12% (CEV) for the higher productivity types who are retired. Even among members of the lowest productivity group, who are the main beneficiary of the transfers, those who are retired face welfare losses as big as 6%. In fact, even with a 5% transfer, agents with higher productivity, as well as agents in their retirement periods are still facing welfare losses. This suggests that for implementing a progressive consumption tax reform, a gradual method could be relevant. Figures 9, 10 and 11 show how the gradual tax reform alters the welfare consequences of implementing the consumption tax reform with different levels of transfer. These graphs confirm that implementing the reform gradually improves the welfare for agents who are alive at the time of the policy change.

6.2 Small Open Economy

In order to understand the roles of endogenous factor prices, I redo my experiment in partial equilibrium. I fix interest rate and wage at their levels in the benchmark economy with the benchmark tax system, and compute the transition path without requiring market clearing conditions for labor and capital markets.

Table 6 shows how the aggregate variables compare across steady states with the small open economy assumption. The second column reports variables for the closed economy case where prices can adjust, and the third column lists the steady state of the open economy where prices stay unchanged at their initial values. With the fixed factor prices, capital stock is twice as big as its initial steady state value. As discussed earlier, taxing consumption encourages savings. When prices are fixed and cannot react to a higher level of capital accumulation, the high rate of return to capital reinforces this incentive, which in turn induces a huge expansion of the capital stock.

Wage is fixed at a lower level compared to that of the closed economy and we see that labor supply stays almost unchanged at its initial level. In the consumption tax system, the capital accumulation margin is not taxed; this creates a substitution effect toward delaying consumption, as well as leisure, which increases the labor supply. In the closed economy, as more capital is accumulated, the prices adjust such that higher wage exerts a downward pressure on labor supply through the wealth effect. In the long-run these two effects work together so that there is an increase in the labor supply. In the open economy, wage is constant , but the considerable amount of capital stock creates a wealth effect that seems to offset the substitution effect in such a way that the labor supply does not move in the long-run.

Compared to the general equilibrium benchmark, average household income is higher in the open economy case.

The long-run aggregate welfare gain is almost the same across both cases. However, the distribution of welfare gains across productivity types is more concentrated in the open economy case. In this case, the rate of return to capital stays unchanged instead of declining, so more productive agents for whom the return to capital is the major source of income, enjoy bigger welfare gains. On the other hand, the less productive agents who live mainly on their labor income and social security transfers, are deprived of higher wages and higher retirement benefits under the open economy assumption. Thus they must

endure larger welfare losses.

Figure 13 plots the short-run welfare effects for living generations of the highest, the median and the lowest productivity types at the first period of transition, for both simple tax reform and gradual tax reform. This figure confirms that keeping prices unchanged does not eliminate the negative effects of the tax reform on the agents who are alive at the time of the policy change. In other words, the short-run welfare consequences of the tax reform do not appear to be driven primarily by a change in factor prices.

However, endogenous factor prices effect slightly the distribution of the welfare effects for generations alive at the first period of transition. Comparing figure 13 with its analog in the closed economy, figure 6, we see that older generations of the lowest productivity type experience smaller welfare losses in the open economy compared to the closed economy. Fixed prices, and in particular, fixed wage, can explain this observation. In the closed economy, at the first period of transition, labor supply jumps; this pushes down the capital-labor ratio, and therefore decreases the wage rate and affects the aggregate labor income. The retired generations receive social security benefit which are proportional to the the average labor income. This creates another channel through which these groups are effected by the change of the tax regime. In the small economy case, the prices are fixed and cannot react to the change in the capital-labor ratio, as a result, the average labor income in the first period of transition is about 10% higher in the small open economy compared to the closed economy. This translates into higher social security benefits for the retirees in the open economy case, and justifies the observed trend in the welfare cost. Overall, figure 13 confirms the gradual implementation of the reform can address short-run welfare consequences even with fixed factor prices.

6.3 Anticipated Tax Reform

Major policy changes like tax reforms, that have profound impacts on the economic behavior of the population, are usually announced in advance. The idea is that by knowing that a specific reform will take place in the near future, agents can adjust their economic decisions in order to alleviate the brunt of the big change.

In my major computation, I treated the tax reform as being an unanticipated policy change. To explore the extent to which announcing the change of policy beforehand would change short-run welfare consequences of the reform, I conducted the following

exercise. Assume in period zero, that before any economic decisions are made, the government announces a change in the tax regime: starting from the next period, the benchmark tax system will be replaced with a flat rate consumption tax system, and everyone has to pay their taxes according to the new tax code.

Figure 14 compares the short-run welfare effects of the simple tax reform in the first period of transition for both anticipated and unanticipated cases. It can be seen that announcing the tax reform one period ahead, does not appear to mitigate the welfare consequences at the first period of implementation. Even with an anticipated reform, 62% of the population endure welfare losses.

By announcing the policy one period ahead, agents know that in the next period, they have to pay a flat tax on each unit of their consumption, and that their savings will be tax exempt. As a result, they increase consumption and decrease savings in period zero. Thus one sees that in the first period of transition, the welfare costs are slightly lowers for those who own the lion's share of capital (the older, more productive group), as they now hold lower levels of capital compared to the unanticipated case. However, as the capital stock is lower in the first period of transition, the jump in the labor supply places a greater downward pressure on wage compared to the unanticipated case. This means for those living mainly on labor income, the welfare costs are bigger. Figure 14 speaks to these results.

Overall, it can be seen that even the anticipated tax reform creates undesirable short-run welfare consequences for the living generations, and these welfare consequences could be alleviated by implementing the tax reform gradually.

6.4 Phasing Out the Old Tax System and Phasing In the New One

One of the procedures that has been discussed in the literature for replacing a major policy system is to gradually phase-out the old system and introduce the new system over a certain period of time[15]. In this part, I compare the performances of a phase-in/phase-out method of implementing a tax reform with the gradual tax reform that I proposed in this paper. More specifically, using the model, I simulate a revenue-neutral transition

[15]See For examples see (Conesa and Krueger, 1999)

from the old tax system to the new system where the old tax regime is being phased out exponentially over five model periods (twenty years), while the consumption tax system is introduced and the consumption tax rate is adjusted to keep the tax revenue constant. Figure 15 compares the consumption tax rates along the transition for the simple tax reform, the gradual tax reform and the phase-in/phase-out tax reform. In the phase-in/phase-out reform, during the first five periods where everyone pays taxes in *both* tax systems, the induced consumption tax rate is lower compared to the simple and the gradual reforms. Starting in period 6, the consumption tax system will be the only tax regime in the economy and everyone pays taxes under this tax code. Hence, the dynamic of the consumption tax rate in this setting resemble those of the rate under the simple tax reform closely.

The aggregate short-run welfare consequences of the three tax reforms are compared in figure 16. This figure shows that although the phase-in/phase-out tax reform improves the welfare effects upon the simple tax reform, it still under-performs the gradual tax reform in that dimension. Figure 16 decomposes the short-run welfare consequences of the three types of tax reform across agents with different levels of productivity. From the figure one can see the welfare effects on younger agents are mostly similar under the simple tax reform and the phase-in/phase-out tax reform, which suggests that the additional burden of paying a consumption tax is being offset by the reduction agents face in their income taxes. Relatively older agents are better-off with the phase-in/phase-out tax reform than they are with the simple tax reform. But they are worse-off with the phase-in/phase-out tax reform than with the gradual tax reform. The tax burden for these groups in the old tax system is much lower compared to the younger agents, while it is almost the same in the new tax system (recall these are the agents who choose to stay in the old tax system under the gradual tax reform). Hence, the welfare costs would be lower in the phase-in/phase-out reform as agents face a much lower consumption tax rate.

Overall, in spite of the fact that phasing out the old tax system while phasing in the new tax system gradually improves the short-run welfare effects of the consumption tax reform for some groups of agents, it still induces considerable aggregate welfare losses at the first period of transition with more than 62% of population experiencing welfare losses. Hence, the gradual tax reform that I proposed here, outperforms this method in addressing the short-run welfare consequences of the reform.

6.5 The Role of the Labor Supply Elasticity

We know that the macro estimates of the elasticity of labor supply are higher than micro estimates (Domeij and Floden (2006), Pistaferri (2003)). In my experiments I set the intertemporal elasticity of labor supply γ equal to 1. However, Keane and Rogerson (2015) argues that different mechanisms at play in aggregate settings suggest values of labor supply elasticity higher than 1. In this part I examine sensitivity of my results to the value of γ. More precisely, I set the value of γ equal to 2.5, re-calibrate the model and re-run the experiment.

As shown in table 5 the higher value of labor supply elasticity magnifies slightly the change in the macroeconomic aggregate variables in the long-run. In fact comparing the case of $\gamma = 1$ with the case of $\gamma = 2.5$, the increase is output, capital stock and labor supply are all higher for about 2 percentage points with the higher value for γ. In particular, having a higher labor supply elasticity, enables agents to amplify their reaction to the change of the tax code, so the output of the new steady state is higher and the consumption tax rate required to keep the government budget balanced is lower. Also the aggregate welfare gain is slightly higher with $\gamma = 2.5$.

Figure 12 compares the welfare consequences of the consumption tax reform in the first period of transition, under the simple tax reform and the gradual tax reform. Comparing this figure with figure 6, it can be seen that the pattern of the welfare effects is similar in the high and low elasticity cases, and that the gradual tax reform can address the short-run welfare effects of the tax reform here as well.

7 Conclusion

A central concern in all discussions of tax reform is about the dynamics of the transition path of the economy following the implementation of the reform. A major challenge that policy makers face when considering a consumption-based tax reform is how to solve initial resistance to the reform. This inertia is created by undesirable welfare consequences of the reform on generations alive at the time of policy change, which may make the reform too costly to be politically acceptable. I propose a practical method for implementing tax reforms, which addresses this issue by delaying the adoption of the new tax code. More precisely, in the gradual tax reform, generations alive at the time of the

policy change have the option of choosing between the benchmark tax system and the consumption tax system. Almost all current retirees, who would face a much heavier tax burden under the consumption tax system decide to stay in the old tax regime. Workers, especially more productive ones, who can take advantage of the flat rate consumption tax and exemption of their savings from taxation, opt into the new tax system faster.

Comparing the predicted short-run welfare effects of the gradual tax reform with those of the simple tax reform on generations alive at the first period of the reform, confirms that letting agents choose if and when they want to switch improves their welfare experiences significantly.

My experiment suggests that the gradual tax reform can address most of the unfavorable short-run welfare effects of the tax reform. Although I describe this method in the context of a consumption-based tax reform, it can be broadly used as a practical way of implementing any type of policy reform which provides higher welfare in the long-run.

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8 Tables

Table 1: Parameter Values

Parameter	Value	Description
β	0.967	Discount Factor, target K/Y
n	1.09%	Average Population Growth Rate (1990-2009)
γ	1	Frisch Elasticity
α	0.34	Capital Share (1965-2007)
δ	0.067	Depreciation Rate, target I/Y (1965-2007)
σ_z	0.51	Std. Deviation of Permanent Shock
λ	0.91	Federal Income Tax Level Parameter (Guner et al. (2014))
τ	0.053	Federal Income Tax Curvature Parameter (Guner et al. (2014))
τ^k	0.1054	Calibrated Capital Income Tax Rate
τ^{SS}	0.1025	Calibrated Payroll Tax Rate

Table 1 summarizes parameters values with brief descriptions. For detailed explanations see the text.

Table 2: Aggregate Variables for Different Tax Regimes

Variables	Benchmark Tax System	Consumption Tax System
τ_c	0%	14.06%
τ_k	10.54%	0%
τ	0.053	0
λ	0.911	1
Ouput	100	111.3
Capital Stock	100	127.6
Labor Supply	100	103.7
K/Y	2.89	3.31
Household Income (Avg.)	100	108.2
CEV	.	3.4%

Table 2 summarizes the aggregate variables of the economy under a revenue neutral consumption tax reform in the long-run (steady state comparison). The first part describes the tax structure and the second part describes effects of the tax reform on aggregate variables, I normalized the aggregate variables in the steady state of the benchmark economy to 100.

Table 3: Comparison of Aggregate Variables Along Transition Path

	Periods in the new system	Output	Capital Stock	Labor Supply	Interest Rate [a]	Consumption Tax Rate
	1	103.30	100.00	105.10	0.056	16.09%
Simple	5	110.84	124.63	103.71	0.042	14.34%
Tax Reform	10	111.30	127.55	103.76	0.041	14.07%
	36	111.32	127.67	103.77	0.041	14.06%
	1	100.19	100	100.81	0.053	23.35%[b]
Gradual	5	105.07	108.84	103.18	0.049	19.22%
Tax Reform	10	110.31	125.17	103.35	0.041	15.17%
	36	111.3	127.6	103.7	0.041	14.06%

Table 3 provides snapshots of the economy right after the policy change, 5 years into the transition, 10 years into the transition and at the new steady state for both form of implementation of the tax reform; the simple tax reform and the gradual tax reform.

[a] *, These are the calculated annual interest rate that are implied by the interest rate for the 5-year-period in the model.*

[b] *, As no one chooses to switch to the new tax system, the consumption tax rate in the first period is irrelevant, this entry shows the consumption tax rate in the second period*

Table 4: Comparison of Aggregate Variables for The consumption Tax Reform with Transfers

	Benchmark Tax System	Consumption Tax System (Without Transfer)	Consumption Tax System (1% Transfer)	Consumption Tax System (2.5% Transfer)	Consumption Tax System (5% Transfer)
Consumption Tax Rate (τ^c)	.	14.06%	15.49%	17.71%	21.42%
Output	100	111.3	110.7	109.8	108.3
Capital Stock	100	127.6	127.0	126.1	124.6
Labor (efficiency units)	100	103.7	103.1	102.2	100.7
K/Y	2.89	3.313	3.316	3.318	3.325
Household Income (Avg)	100	108.8	108.2	107.2	105.7
Aggregate Welfare Gain (CEV%)	.	3.4%	3.7%	4.1%	4.7%

Table 4 depicts a comparison of the changes in the aggregate variables in the steady state of the reformed economy, for the consumption tax systems with 0%, 1%, 2.5% *and* 5% *transfers.*

Table 5: Comparison of Aggregate Variables for Higher Elasticity of Labor

	Benchmark Tax System	Consumption Tax System (with $\gamma = 1$)	Consumption Tax System (with $\gamma = 2.5$)
Consumption Tax Rate (τ^c)	.	14.06%	13.82%
Output	100	111.3	113.2
Capital Stock	100	127.6	129.9
Labor (efficiency units)	100	103.7	105.4
K/Y	2.89	3.313	3.316
Household Income (Avg)	100	108.8	110.0
Aggregate Welfare Gain(CEV%)	.	3.4%	3.8%

Table 5 depicts a comparison of the changes in the aggregate variables in the steady state of the reformed economy, for two levels of the labor supply elasticity: $\gamma = 1$ *(the baseline case) and* $\gamma = 2.5$

Table 6: Comparison of Aggregate Variables under the Open Economy Assumption

	Benchmark Tax System	Consumption Tax System (Baseline Case)	Consumption Tax System (Small Open Economy)
Consumption Tax Rate (τ^c)	.	14.06%	12.35%
Output	100	111.3	129.9
Capital Stock	100	127.6	215.5
Labor (efficiency units)	100	103.7	100.0
K/Y	2.89	3.313	4.79
Household Income (Avg)	100	108.8	121.9
Aggregate Welfare Gain(CEV%)	.	3.37%	3.43%

Table 6 depicts a comparison of the changes in the aggregate variables in the steady state of the reformed economy, between the baseline case and the small open economy case.

9 Figures

Figure 1: Welfare gain distribution from consumption tax reform

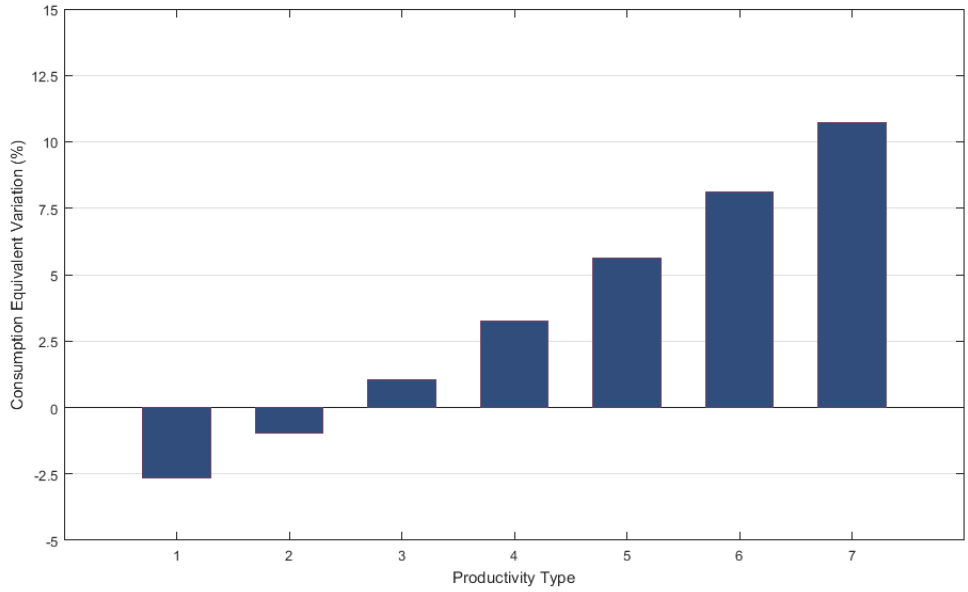

Figure 1 shows the long-run welfare gains distribution, measured in consumption equivalent variation, for agents with different permanent productivity shock, from the consumption tax reform. Permanent productivity shocks are approximated with seven states, each state is called a productivity type and represented with a number on the horizontal axis, with type 1 being the least productive agents. Each bar represents the amount of consumption growth that a newborn in the steady state of the reformed economy would have over the newborn in the steady state of the benchmark economy.

Figure 2: Evolution of the macroeconomic aggregates: simple tax reform, and gradual tax reform

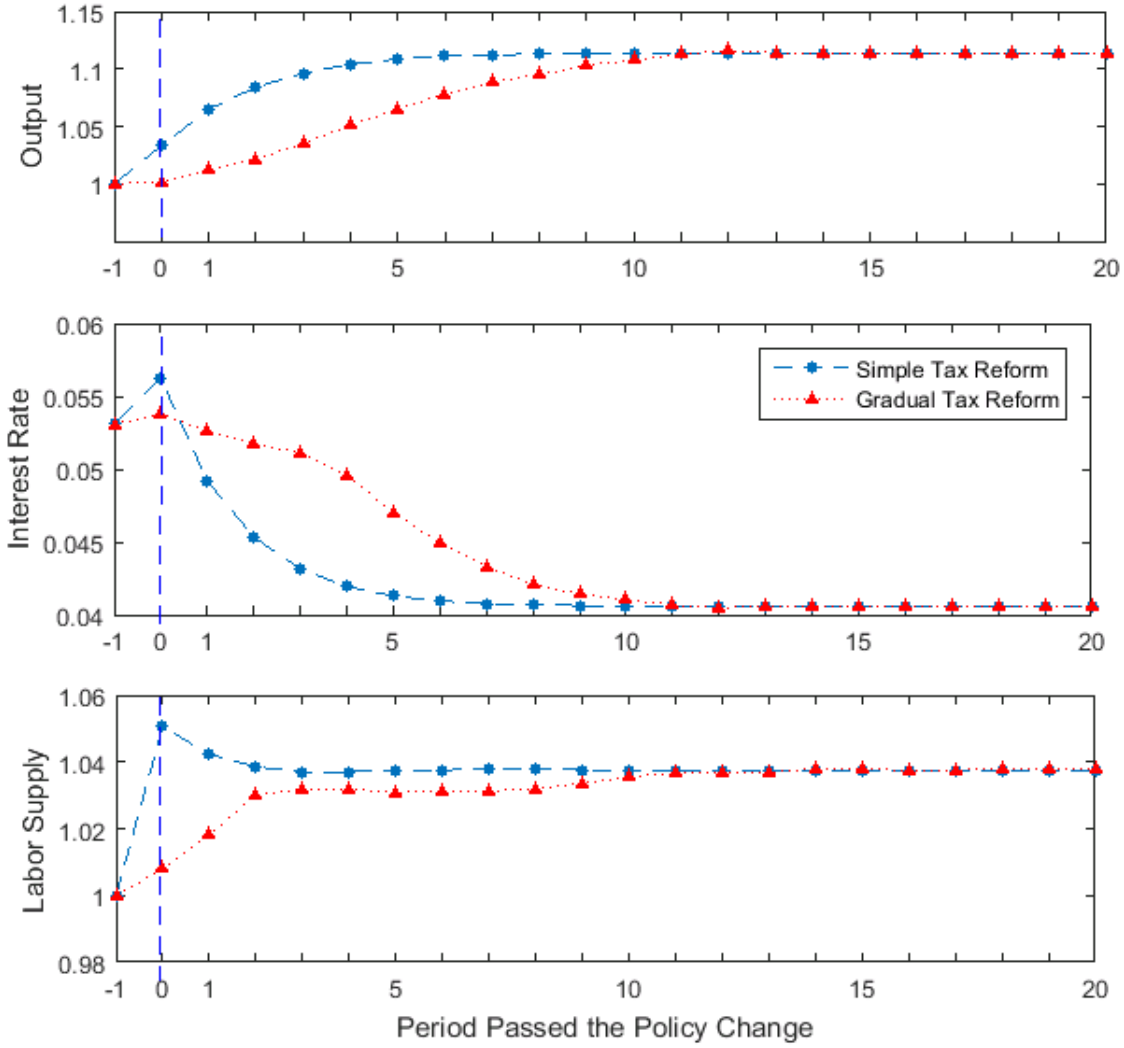

Figure 2 shows the evolution of the macroeconomic aggregates under both simple and gradual tax reforms.

Figure 3: Welfare gain at the first period of transition under simple tax reform

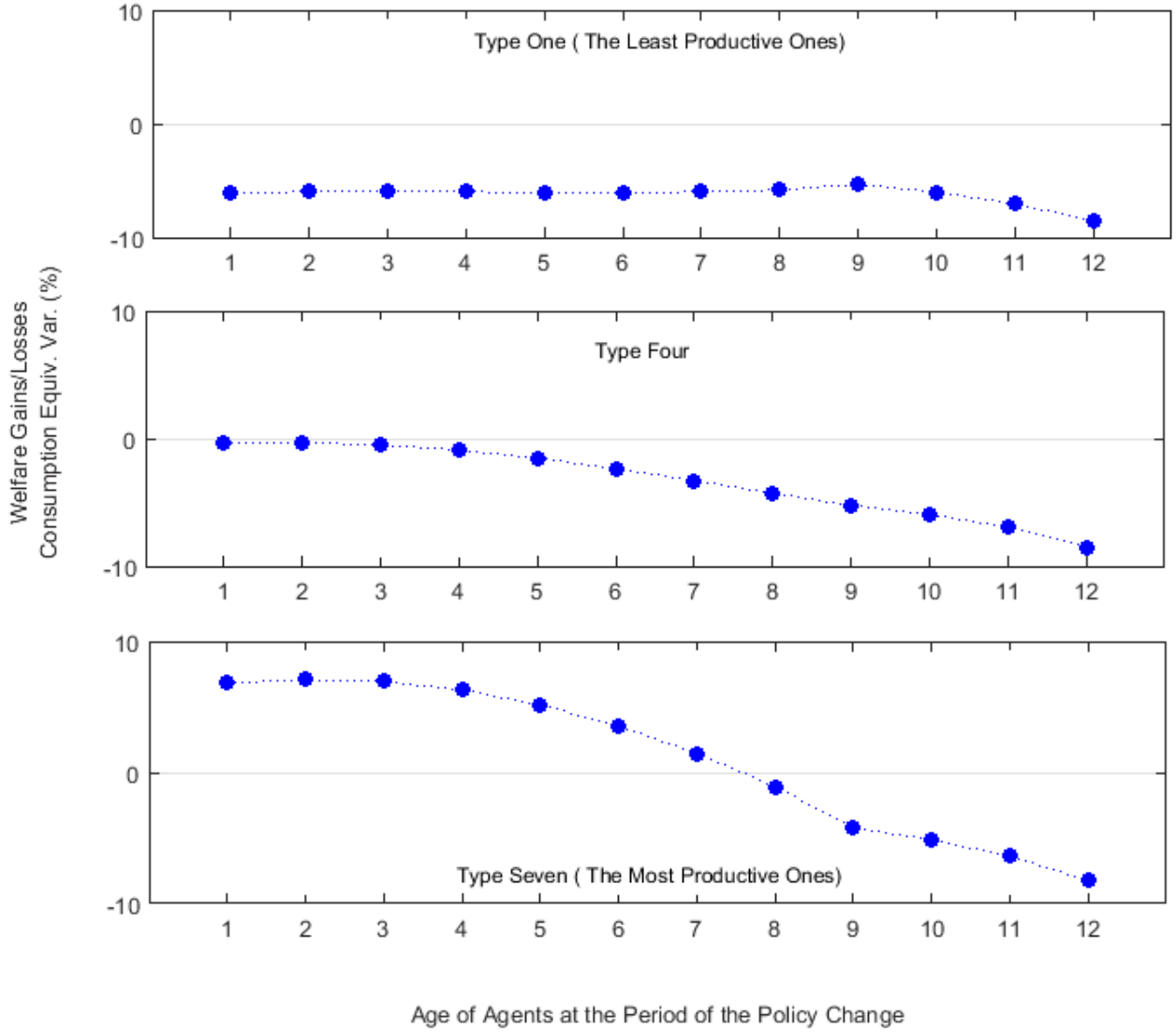

Figure 3 shows the welfare gains/losses, measured in consumption equivalent variation, in the first period of implementing the simple tax reform, for the highest, the lowest and the median productivity type agents.

Figure 4: Rate of choosing the new tax regime in gradual tax reform

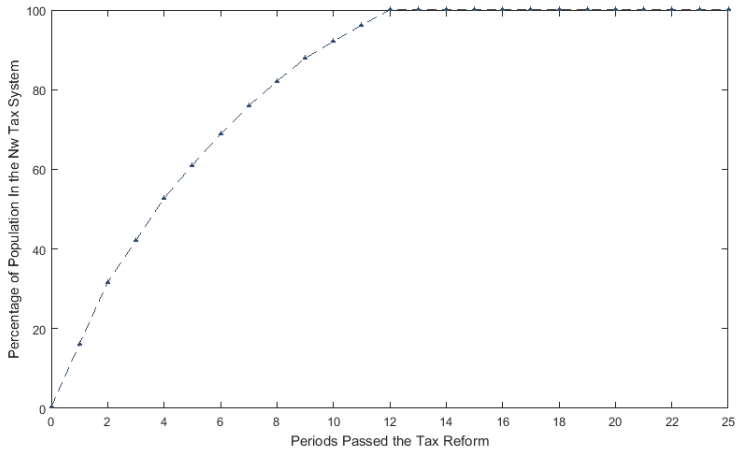

Figure 4 shows the fraction of the population who are paying their taxes under the new tax system in each period of transition. Notice that it takes nearly 3.5 model periods(18 years) for have half of the population in the new tax system

Figure 5: Consumption tax rate along the transition to the new steady state

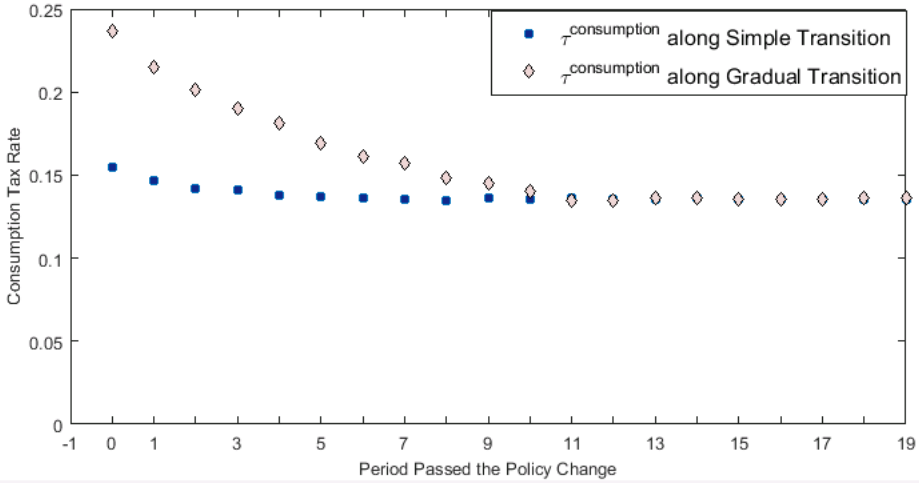

Figure 5 shows the consumption tax rate at each period of transition, that is required to have a constant tax revenue, under the simple tax reform and the gradual tax reform

Figure 6: Welfare effects of the gradual tax reform in the first period

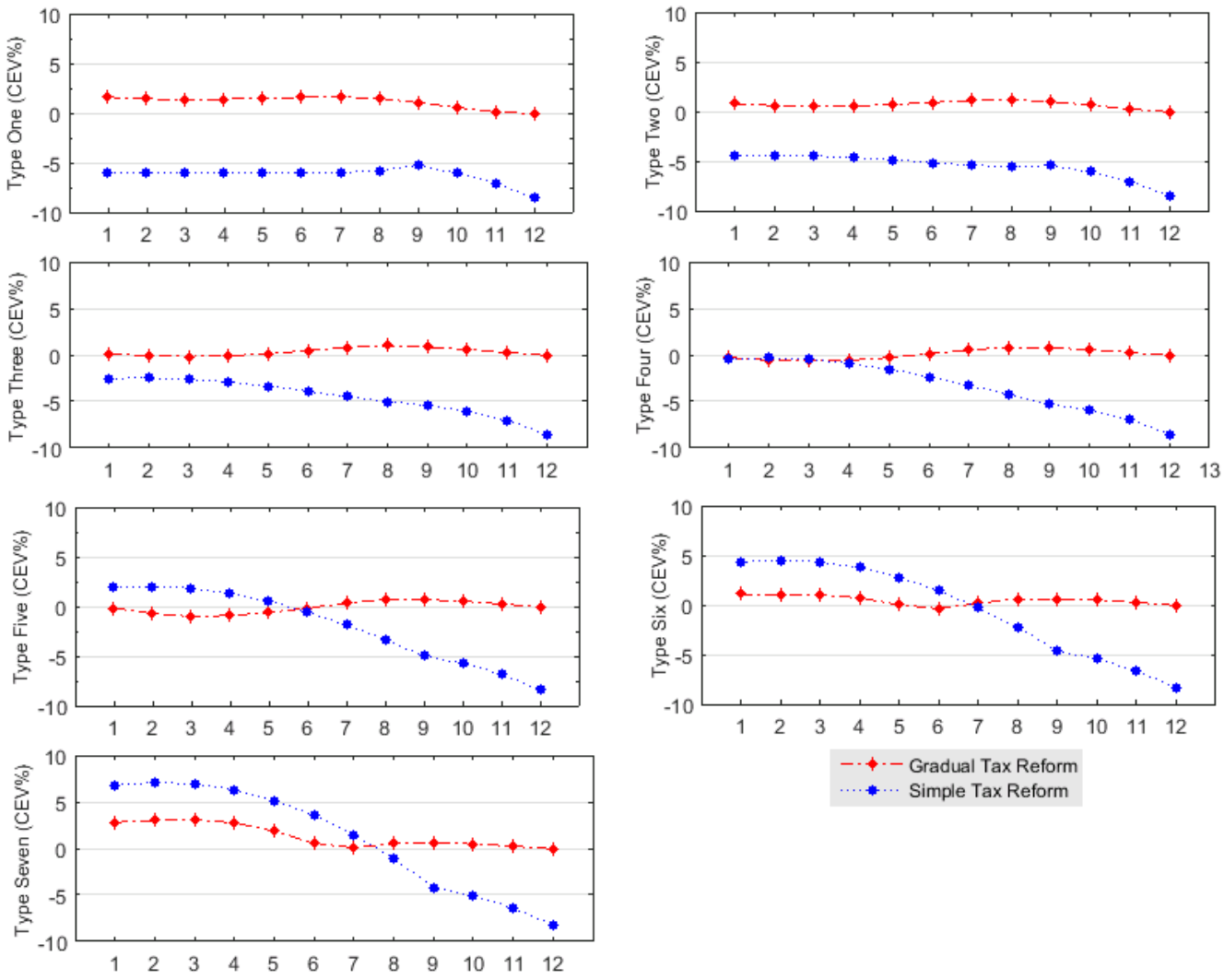

Figure 6 shows the welfare gains/losses for agents at the first period of transition, measured in consumption equivalent variation, under the simple tax reform (circle dots) and the gradual tax reform (diamond dots).

Figure 7: Comparison of aggregate welfare gains across steady states: Consumption Tax System with Transfer

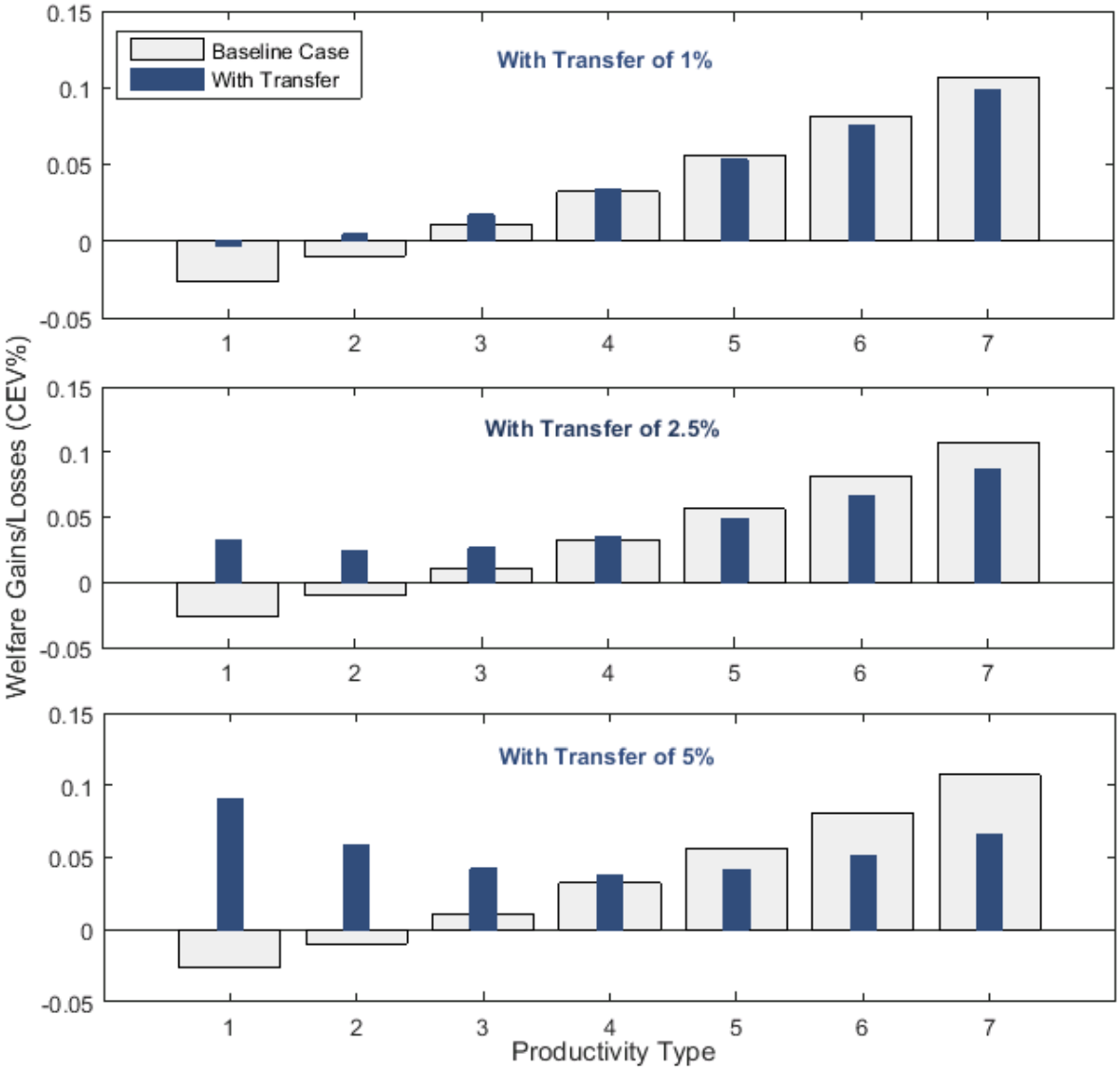

Figure 7 shows the distribution of the welfare gains in the steady state of the reformed economy. Each graph compares the distribution of the welfare effects for two cases: the consumption tax system without any transfer (the baseline case) and the consumption tax system with a lump-sum transfer of 1%, 2.5% *and* 5% *for all households.*

Figure 8: Comparison of the welfare effects of the simple tax reform in the first period: for the consumption tax systems with various levels of transfers

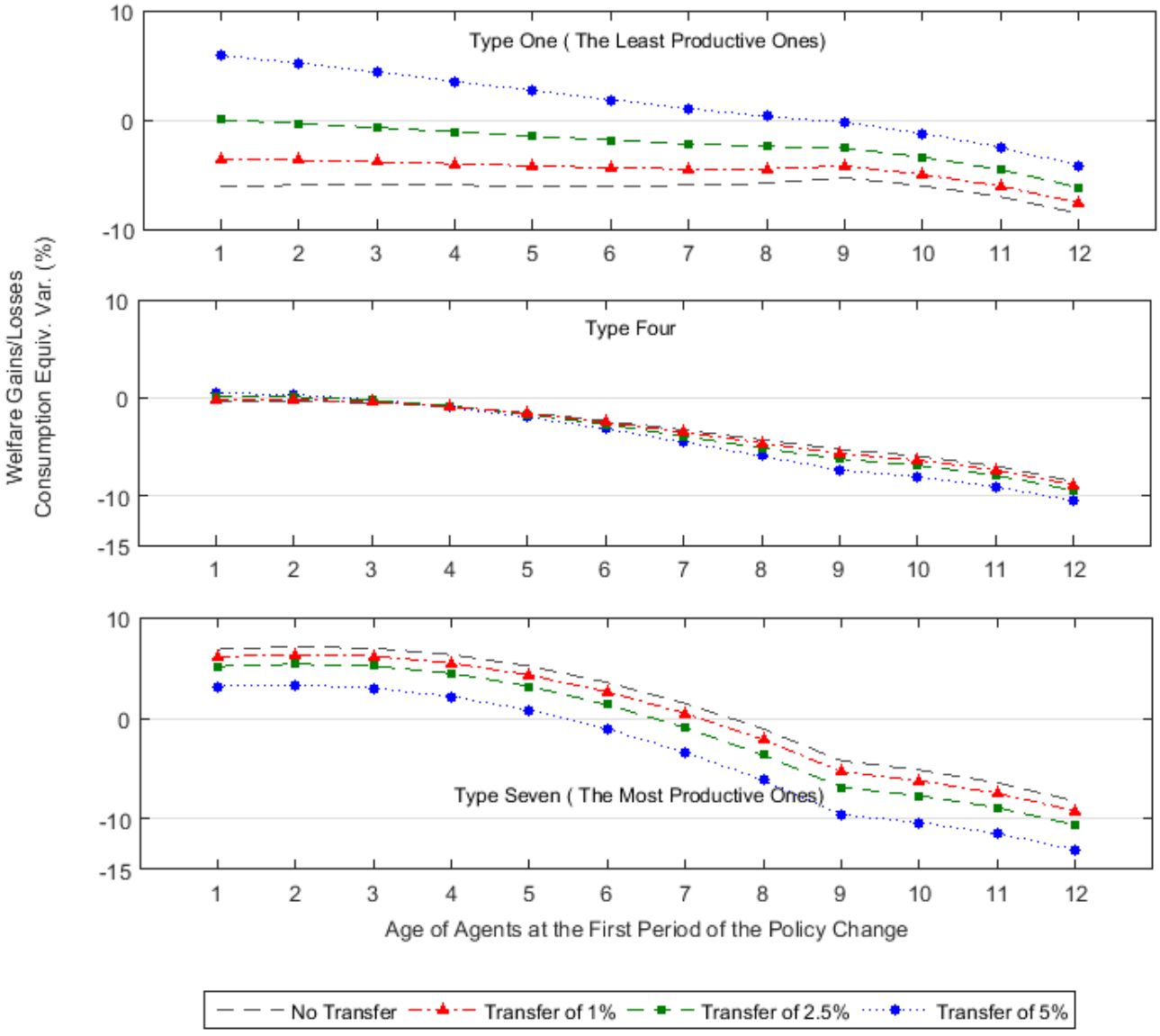

Figure 8 compares the welfare consequences of implementing consumption tax reforms with various levels of transfers, in the first period of implementation for the lowest, the highest and the median productivity type agents.

Figure 9: Welfare effects of the consumption tax system with 1% transfer

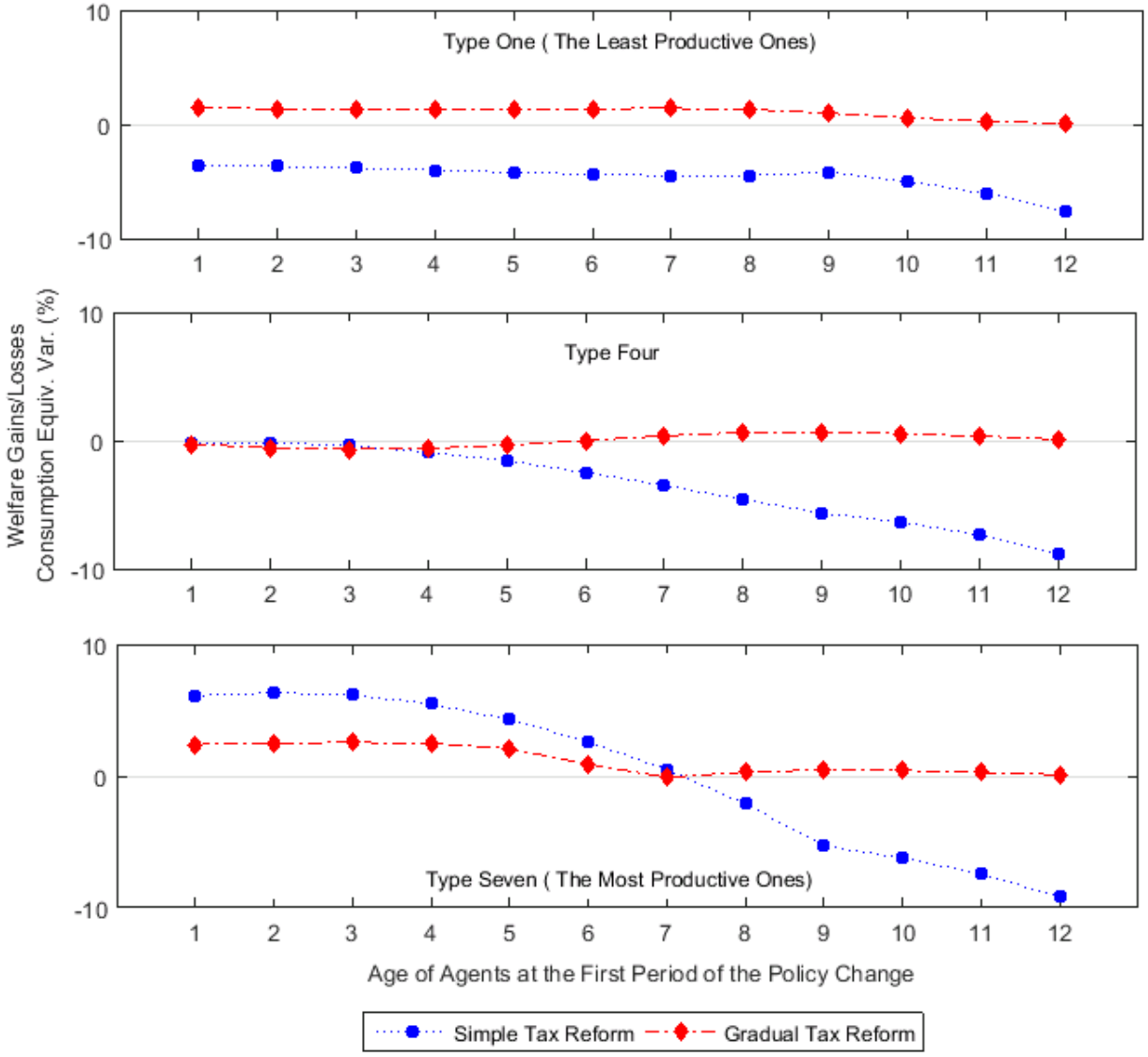

Figure 9 shows the welfare gains/losses for agents at the first period of implementing a consumption tax system with lump-sum transfers of 1% *(of the output per capita of the benchmark economy) under the simple tax reform (circle dots) and the gradual tax reform (diamond dots).*

Figure 10: Welfare effects of the consumption tax system with 2.5% transfer

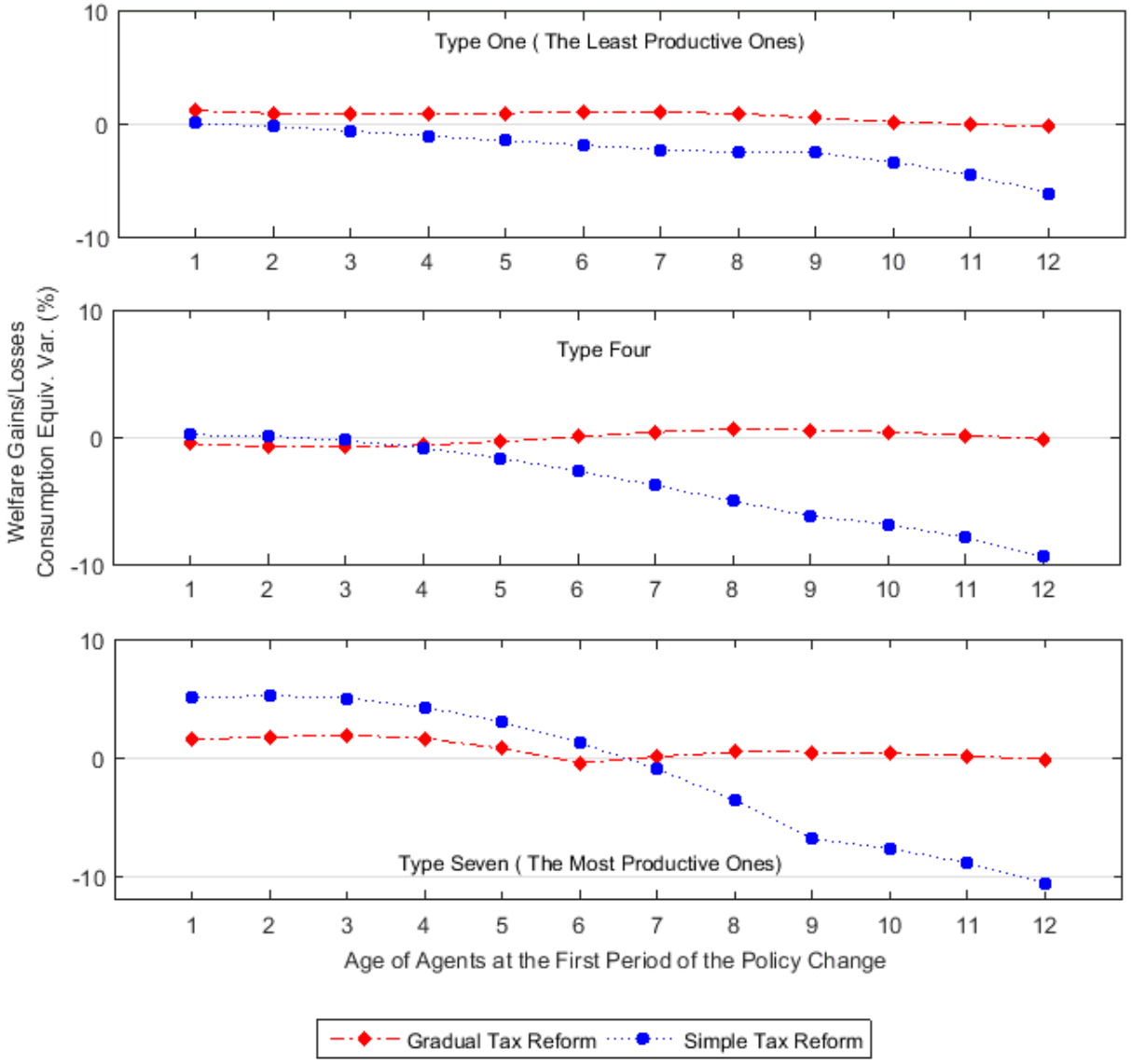

Figure 10 shows the welfare gains/losses for agents at the first period of implementing a consumption tax system with lump-sum transfers of 2.5% *(of the output per capita of the benchmark economy) under the simple tax reform (circle dots) and the gradual tax reform (diamond dots).*

Figure 11: Welfare effect of the consumption tax system with 5% transfer

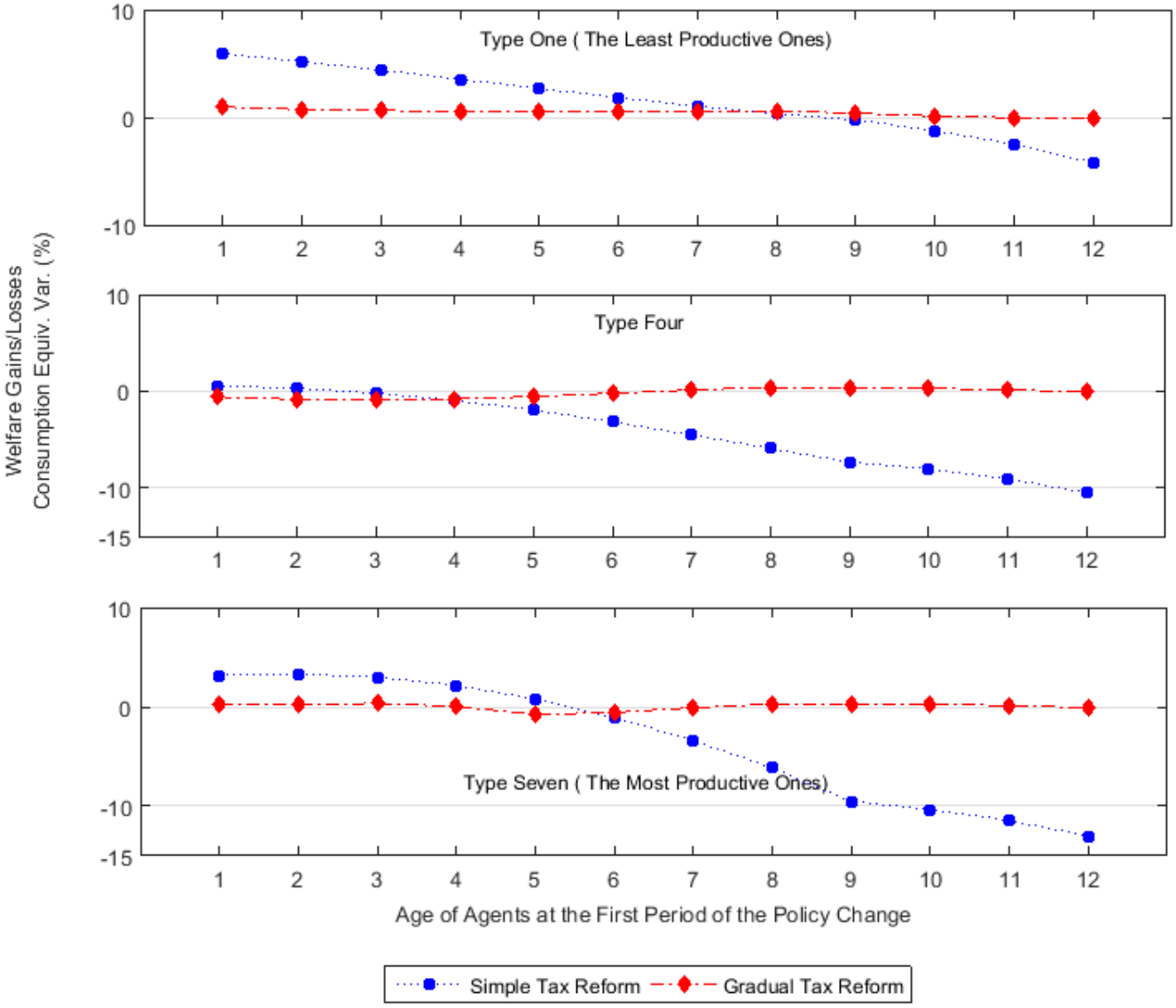

Figure 11 shows the welfare gains/losses for agents at the first period of implementing a consumption tax system with lump-sum transfers of 5% (of the output per capita of the benchmark economy) under the simple tax reform (circle dots) and the gradual tax reform (diamond dots).

Figure 12: Welfare effect of the consumption tax system with $\gamma = 2.5$

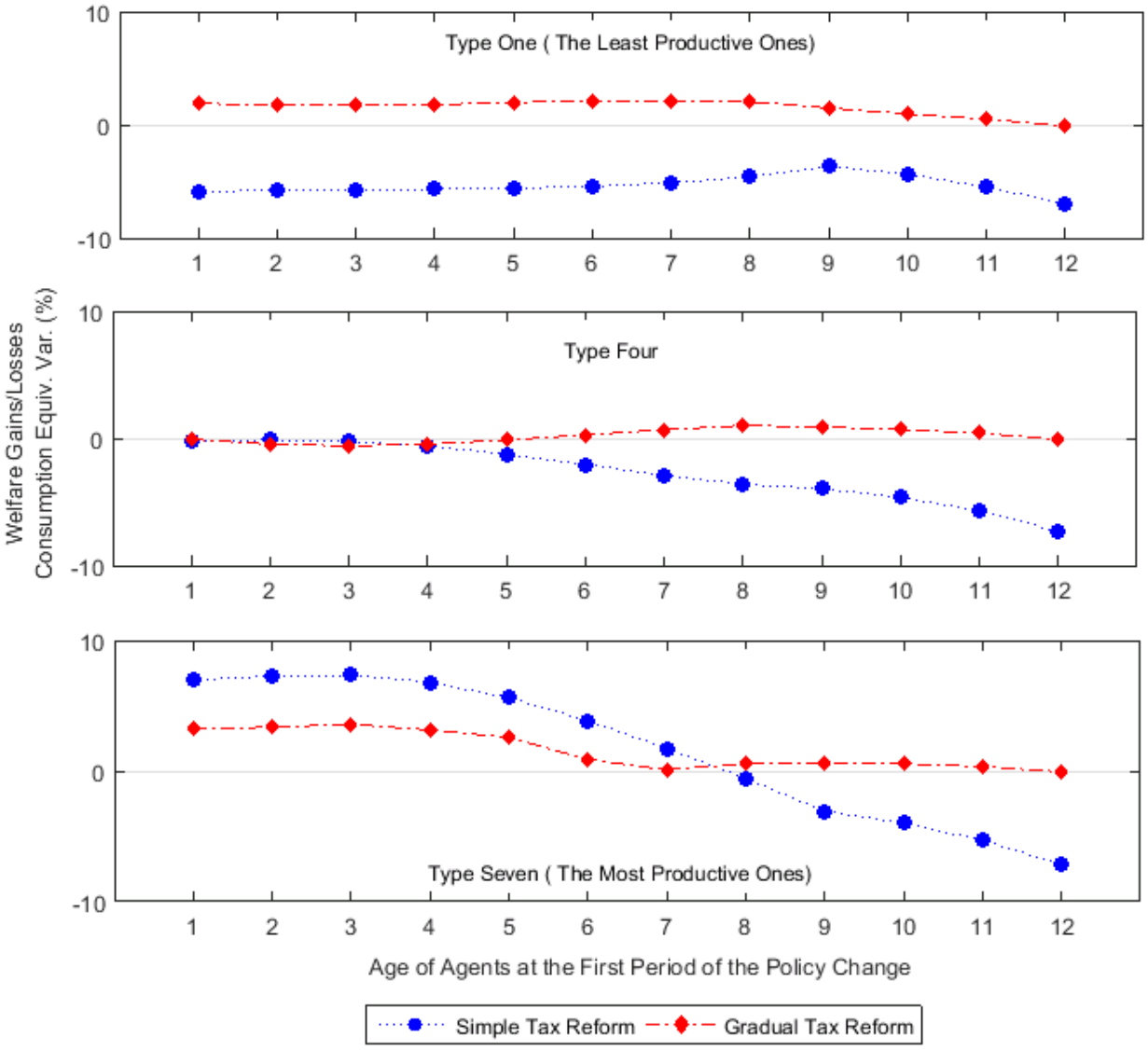

Figure 12 shows the welfare gains/losses for agents at the first period of implementing a consumption tax system under the simple tax reform (circle dots) and the gradual tax reform (diamond dots), with higher labor supply elasticity.

Figure 13: Welfare effect of the consumption tax system: small open economy

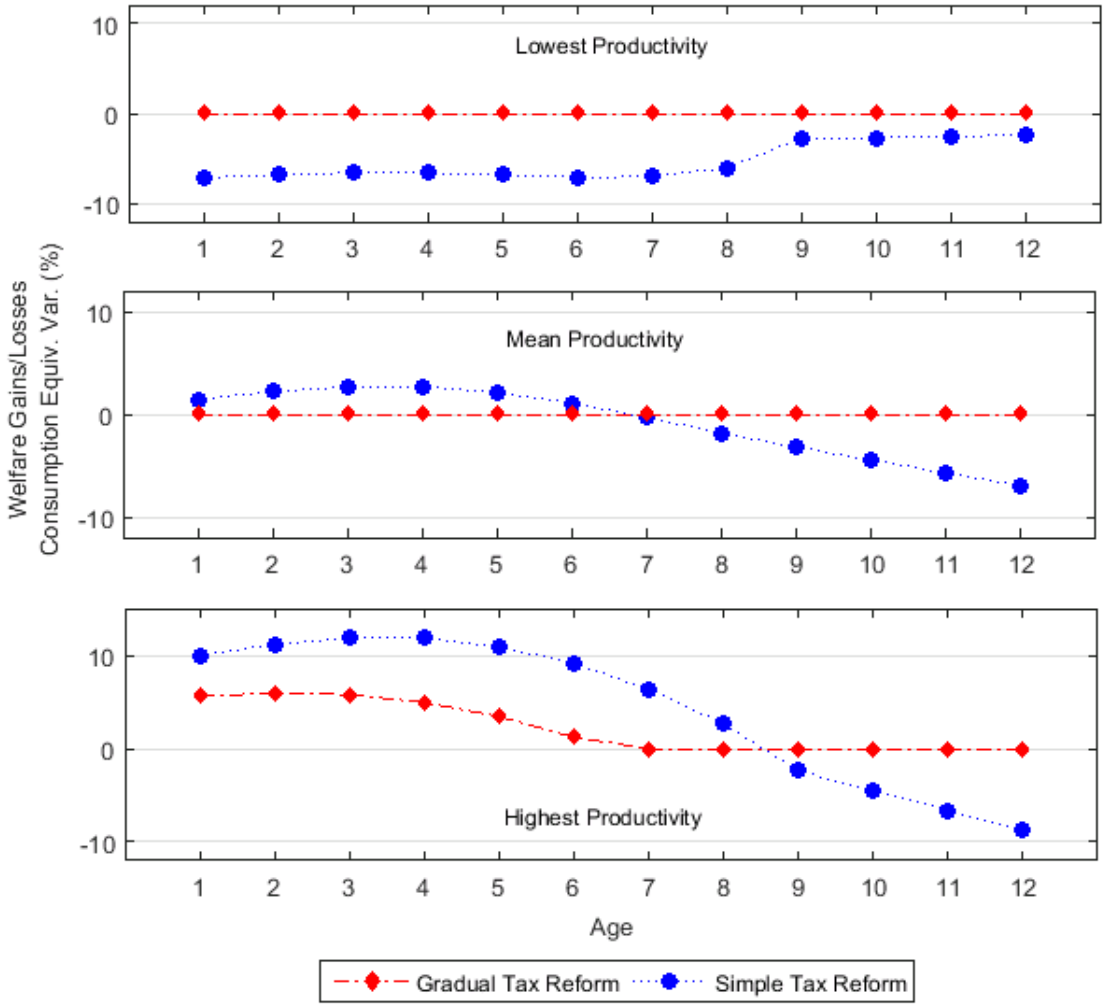

Figure 13 shows the welfare gains/losses for agents at the first period of implementing a consumption tax system, under the small open economy assumption, for the simple tax reform (circle dots) and the gradual tax reform (diamond dots).

Figure 14: Welfare effects of the consumption tax system in the first period: anticipated policy change

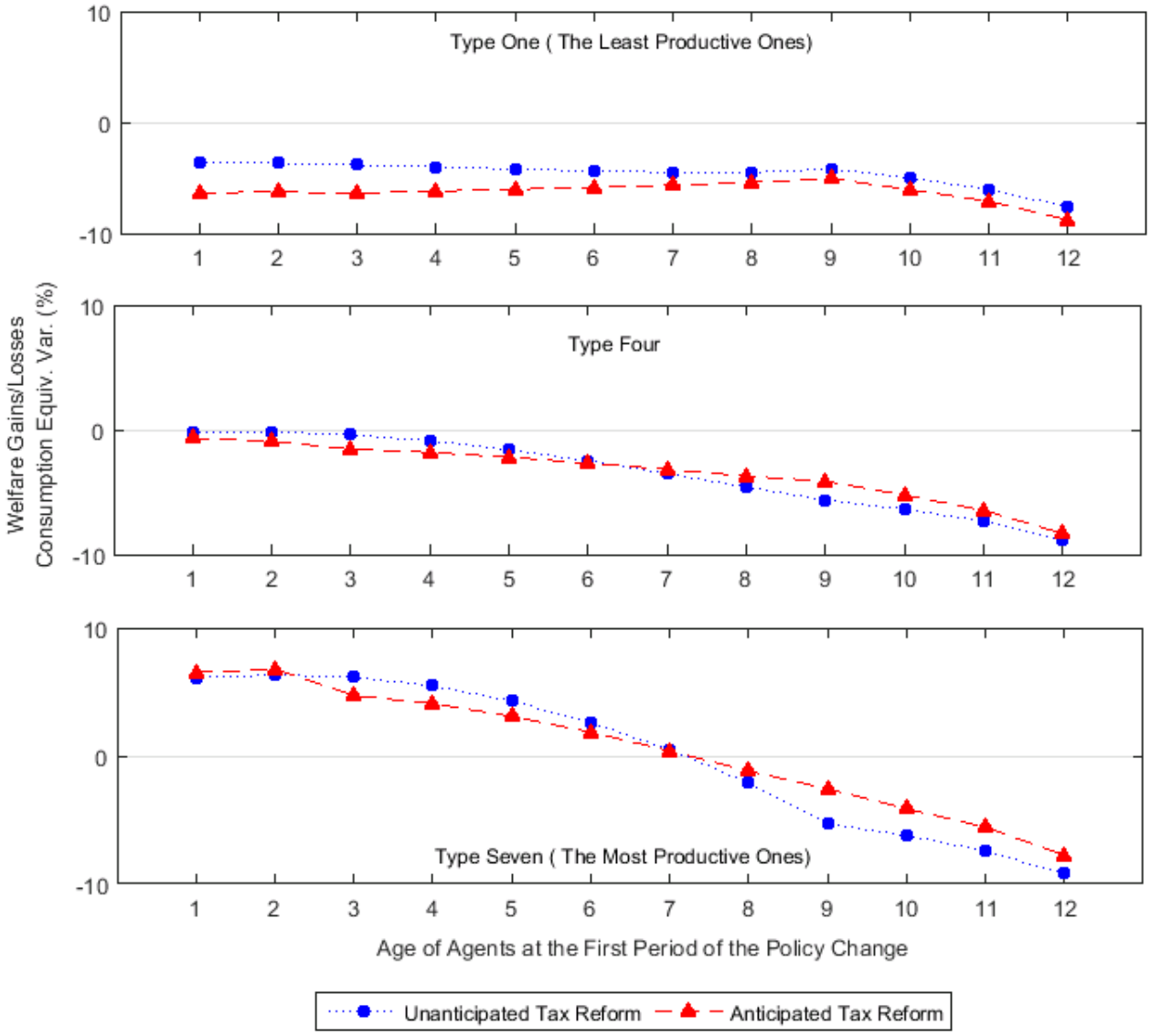

Figure 14 shows the welfare gains/losses for agents at the first period of implementing a consumption tax system under the simple tax reform (circle dots) and the gradual tax reform (diamond dots), for the case that tax reform is announced one period ahead.

Figure 15: Consumption Tax Rate Along the Transition

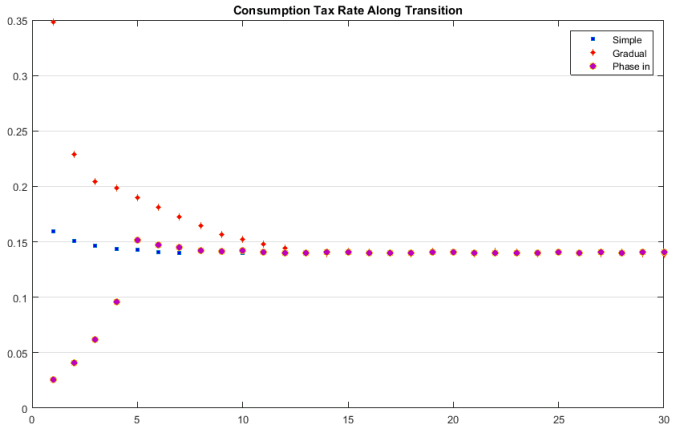

Figure 15 compares the consumption tax rate at each period of transition, that is required to have a constant tax revenue, under the simple tax reform, the gradual tax reform and the phase-in/phase-out tax reform

Figure 16: Comparison of aggregate welfare effects at the first period of transition

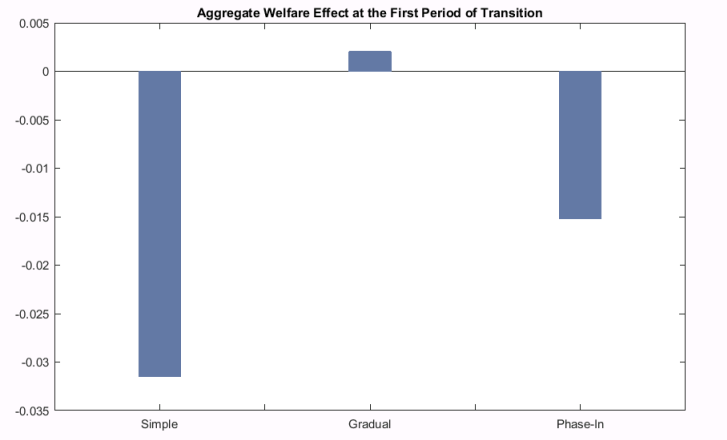

Figure 16 compares the aggregate welfare effects at the first period of transition across three tax reform; the simple tax reform, the gradual tax reform and the phase-in/phase-out tax reform

10 Appendix A: Equilibrium Definition

In this appendix I define the equilibrium for the steady states as well as for the economy during the transition when the equilibrium is not stationary.

10.1 Steady State

n the model economy, agents are heterogeneous with respect to their productivity types (permanent productivity shocks), their asset holdings and their ages. For aggregating, I need to define a probability measure ψ_j on subsets of the agent state space. The probability measure ψ_j describes the heterogeneity in assets and permanent productivity shocks within an specific cohort. Let $(\mathscr{X}, B(\mathscr{X}), \psi_j)$ be the probability space where $B(\mathscr{X})$ is the Borel $\sigma-$algebra on $\mathscr{X}$ and $\psi_j : [0,1] \to \mathscr{X}$ is a probability measure. The measure of agent with state $x = (a, z_i)$ within the cohort of age j is $\psi_j(x)$.

Definition of Equilibrium. A steady state equilibrium is a collection of decision rules $c(x,j), l(x,j), a(x,j)$, factor prices w and r, taxes paid $T^{\Delta}(x,j)$, $\Delta \in \{$*The benchmark tax system,The reformed tax system*$\}$, social security transfers b_j, aggregate capital K, aggregate labor L, government consumption G, a payroll tax τ^{ss} , a tax regime $\in \{$*benchmark tax system* , *reformed tax system*$\}$ and distributions $\{\psi_1, \cdots, \psi_J\}$ such that

1. $c(x,j), l(x,j)$ and $a(x,j)$ are optimal decision rules.
2. Factor prices are determined competitively:
   (a) $r = F_1(K,L) - \delta$
   (b) $w = F_2(K,L)$
3. Markets clear :
   (a) $\sum_j \mu_j \int_x \big(c(x,j) + a(x,j)\big) d\psi_j + G = F(K,L) + (1-\delta)K$
   (b) $\sum_j \mu_j \int_x a(x,j) d\psi_j = (1+n)K$
   (c) $\sum_j \mu_j l(x,j) e(z,j) = L$

4. Law of motion of distributions is consistent with individual decision rules:

$$\psi_{j+1}(\mathbf{B}) = \int_x P(x, j, \mathbf{B}) d\psi_j \quad , \quad \forall\, \mathbf{B} \in \mathscr{X} \text{ and } j = 1, 2, \cdots, J$$

where

$$P(x, j, \mathbf{B}) = \begin{cases} 1 & \text{if } (a(x, j), z) \in \mathbf{B} \\ 0 & \text{otherwise} \end{cases}$$

5. Government budget constraint is satisfied

$$G = \sum_j \mu_j \int_x T(x, j) d\psi_j$$

6. Social security benefits is fully funded by payroll taxes :

$$wL\tau^{ss} = \sum_{z=1}^{Z} \sum_{j=T+1}^{T+T^R} \mu_j b_j$$

10.2 Out of the Steady State

Let $\psi_t(A, Z; j, q)$ be the mass of individuals with asset holding $a \in A$, type $z \in Z$, age j who are paying their taxes in the system indexed by q [16].The probability measure ψ_t is defined for all A in $\mathcal{A}$, the class of Borel subsets of $\mathcal{R}$, all $Z \subset \mathcal{Z}$, all $j \subset \mathcal{J}$ and all $q \in \{0, 1\}$. The dynamic evolution of ψ_t is as follows.
For newborns, if $t = 0$ [17]

$$\psi_1(A, Z; 1, q) = \begin{cases} \mu_1 & \text{if } 0 \in A \text{ and } q = 0 \\ 0 & \text{otherwise} \end{cases}$$

if $t \geq 1$

$$\psi_1(A, Z; 1, q) = \begin{cases} \mu_1 & \text{if } 0 \in A \text{ and } q = 1 \\ 0 & \text{otherwise} \end{cases}$$

Everyone dies at age J so

$$\psi_{t+1}(A, Z; J + 1, q) = 0$$

[16]Remember $q = 0$ means the individual paid her taxes under the benchmark tax system in previous period and she has the option of choosing between alternative tax system for this period, and $q = 1$ means she has already switched to the new tax system and there is no option available fr her in this period

[17]μ_1 is the normalized portion of the newborns of all types in the total population alive at each period

For $1 < j \leq J$, ψ_t evolves according to the following recursion. for the case $q'_t = 0$

$$\psi_{t+1}(A, Z; j, q = 0) =$$
$$\int_{\mathcal{R}^+ \times \mathcal{Z}} (1 - q'_t(a, z, j-1, q = 0)) I(a'_t(a, z, j-1, q = 0) \in A) d\psi_t(a, z; j-1, q = 0)$$

This means the mass of individuals in the next period who have not yet switched to the new tax system, are those who had the option in the previous period and chose to stay in the old system.

Similarly, the mass of individuals in the next period who are paying their taxes under the new tax system i.e. who do not have the option of choosing between alternative tax systems, comprise (ι) those who are born after the policy change so they have to pay their taxes under the new tax system; ($\iota\iota$) those who have already switched to the new tax system in previous periods. Therefore

$$\psi_{t+1}(A, Z; j, q = 1) =$$
$$\int_{\mathcal{R}^+ \times \mathcal{Z}} I(a'_t(a, z, j-1, q = 1) \in A) d\psi_t(a, z; j-1, q = 1) +$$
$$\int_{\mathcal{R}^+ \times \mathcal{Z}} q'_t(a, z, j-1, q = 0) I(a'_t(a, z, j-1, q = 0) \in A) d\psi_t(x; j-1, q = 0)$$

Equilibrium. For the model economy that moves from the benchmark tax system (the one with a progressive income tax and a flat capital income tax) to the new tax system (the flat consumption tax), an equilibrium with perfect foresight transition dynamics is a collection of decision rules $\{(c_t(x, j, q)\ ,\ l_t(x, j, q)\ ,\ a_t(x, j, q), q_t(x, j, q))^J_{j=1, x \in \mathcal{X}}\}^\infty_{t=1}$ [18] , factor prices $\{w_t, r_t\}^\infty_{t=1}$, tax systems $\{T^\kappa_t(x, j)\}^\infty_{t=0, \kappa \in \{benchmark, consumption\}}$, aggregate capital $\{K_t\}^\infty_{t=1}$ and aggregate labor $\{L_t\}^\infty_{t=1}$ and government consumption $\{G_t\}^\infty_{t=1}$ and social security benefit $\{b_{j,t}\}^{T+T^R, \infty}_{j=T+1, t=0}$, with a collection of distributions $\{(\psi_1, \cdots, \psi_{T+T^R})\}^\infty_{t=0}$ such that, for all t :

1. Decision rules solve the decision problem for the agent.

2. Factor prices are determined competitively

[18] $q_t(x, j, q)$ is a decision rule only for those agents who are allowed to choose between the alternative tax systems at period t, i.e. agents who are alive at the time of the policy change and have not yet switched to the new tax system in periods before t. So $q_t(x, j, q = 1) = 1$

- $r_t = F_1(K_t, L_t) - \delta$
- $w_t = F_2(K_t, L_t)$

3. Markets clear :
   (a) $\sum_{q\in\{0,1\}} \sum_j \left[\int_x (c_t(x,j,q) + a_t(x,j,q)) d\psi_t \right] + G_t = F(K_t, L_t) + (1-\delta)K_t$
   (b) $\sum_{q\in\{0,1\}} \sum_j \int_x a_t(x,j,q) d\psi_t = K_{t+1}$
   (c) $\sum_{q\in\{0,1\}} \sum_j \int_x l_t(x,j,q) e(z,j) d\psi_t = L_t$

4. Law of motion of distributions is consistent agent decision rules, as described.

5. Government budget constraint is satisfied

$$G_t = \sum_q \sum_j \int_x (q_{t+1}(x,j,q) T_t^{consumption}(x,j,q) + (1 - q_{t+1}(x,j,q)) T_t^{benchmark}(x,j,q)) d\psi_t$$

6. Social security benefits equal taxes :

$$w_t L_t \tau^{ss} = \sum_{q\in\{0,1\}} \sum_{j=T+1}^{T+T^R} \int_x b_{j,t} d\psi_t(x,j,q)$$