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

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Abstract

One of the key practical challenges facing by tax reforms are their short-run welfare consequences. In this paper 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 transition between steady states. 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 conventional case with no choice. It takes about twenty years for half of the population to pay their taxes under the new tax code.

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1 Introduction

Multiple features of the current U.S. federal tax system make the study of tax reforms an important object of research. Many proposals for reformulating the tax code suggest eliminating individual and corporate income taxes and implementing a new tax system based on consumption (Zodrow and Mieszkowski (2008)). Several authors show 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. This result mainly comes from the fact that taxing consumption does not distort saving desicions at the margin. Ventura (1997) and 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 capital income tax system.

However, except for few papers like (Altig et al., 2001), (Peterman, 2013), (Fehr and Kindermann, 2015),..., the short-run welfare consequences of such a reform have not been addressed and the transitional cohorts who are also affected with the change in the tax regime are usually neglected in the existing literature. Peterman (2013), for example, shows that changing the tax structure to the regime that maximizes the long-run welfare can induce huge welfare costs for generations who are alive at the reform year. The central problem is that although consumption-based tax reform leads to welfare gains in the long run, achieving these gains typically involves welfare losses for generations who are alive at the time of the tax reform. Therefore, these individuals would favor the status quo over the reformed tax regime. It is challenging to implement a consumption tax reform that is simultaneously welfare improving for both current generations and those born in the long run.

This paper addresses the aforementioned challenge. I build an equilibrium life-cycle model with heterogeneous households and endogenous 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 both feasible and welfare improving for households alive at the time of the policy change. The key to this result is to allow for a voluntary rather than compulsory switch to the new tax regime for generations alive at the time of the policy change. With this method, all households who are alive during the first period of the transition can choose their preferred tax system: the benchmark tax system or the consumption tax system. More specifically, I endogenize households' move to the new tax system, and quantify the aggregate as well as welfare implications of this kind of reform.

This paper is built on the tradition of analyzing transitional dynamics in overlapping generation economies, in the spirit of Auerbach and Kotlikoff (1987). The specific tax reform exercise that I study in this paper is replacing the current federal income tax system with a flat consumption tax system in a revenue neutral way[1].

I compute the perfect-foresight transition path, with the initial state parametrized to the U.S economy with the current U.S. federal tax system (hereafter the benchmark tax system). Government revenue is kept constant along the transition and in the new steady state. Thus, the result that I obtain do not depend on an issuance of government debt to finance the new regime. The model features within-cohort heterogeneity, with differences arising from agents' permanent productivity types, which also evolve as they age. Therefore, I can study effects of the new tax system on different birth cohorts and different income groups.

First, I 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, right after 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, are taxed using the reformed tax code (a flat consumption tax). Doing a conventional reform in my calibrated model illustrates the tension; future generations born in the long run benefit from the reform while more than 75% of the generations who are alive at the time of the reform experience welfare losses.

Then I introduce a flexible form of revenue-neutral transition, which I will refer to as the **gradual tax reform**. In the gradual tax reform, all households who are alive at the time of the policy change have the option to choose 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. And for all households who are born after the reform, the new tax code (the flat consumption tax) applies.

In principle, welfare effects for all generations depend on their ages, productivity abilities, and asset holdings. Changing the tax base from income to consumption, changes the distribution of tax burden across generations. In the simple tax reform, during the first transition period, the younger, more productive agents are largely unaffected, or they experience welfare gains. However, the elderly agents face welfare losses independent of

[1]In this tax reform, the current federal tax system, a nonlinear income tax and capital tax, is replaces with a flat-rate consumption tax such that the tax revenue stays constant. The social security system stays the same under both tax structure.

their productivity types. That is due to the fact that older generations, who possess a large share of capital stock and do not have a labor income, face a higher tax burden in the consumption tax system. This group are mainly consuming out of their wealth which they saved from their after-tax income. Therefore, consumption taxes are levied on their wealth, placing a higher burden on older agents. Likewise, the low-productivity agents lose given the non-linear features of the current tax system. Altogether, in the first period of transition, 75.6% of agents experience welfare losses and only 24.6% of the population enjoy welfare gains and hence, would 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 transition, welfare losses are negligible and about 95% of the population experience welfare gains and favor the tax reform. However, these gains are not for free, and the most important difference lies in the speed of the transition to the new steady state. 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. Another consequence of introducing the tax reform gradually is that adopting the new tax system is a protracted process. Because of the revenue-neutral nature of the reform, the consumption tax rates are 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 affects their welfare.

Various methods have been proposed in the literature to tax consumption (e.g. Hall and Rabushka (1985), Ventura (1999), ...). Since consumption is defined as income net of savings and investments, 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. 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). Therefore, one way to implement the tax reform with the proposed gradual method is to have everyone report their income and savings and let them choose their preferred tax system, assuming they have a choice.

The paper is organized as follows: Section 1.1 provides a review of the related literature. Section 2 presents the life-cycle model. Section 3 discusses its parametrization. Sections 4 and 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.

1.1 Related Literature

The long-run welfare implications of various tax reforms are the focus of many studies (see, e.g., 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)). Except for Altig et al. (2001), these studies mainly focus on the long-run effects of modifying the tax code and do not explore the effects of tax structure on generations living through the initial transition periods to the new steady state.

One of the pioneering papers that considers the 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 and he assumes a completely inelastic supply of labor.

Altig et al. (2001), Auerbach and Kotlikoff (1983), Nishiyama and Smetters (2005), Peterman (2013) and Fehr and Kindermann (2015) are among the few 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 the consequences of a revenue-neutral move from an income tax system to some alternative consumption-based tax system, such as 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. Also, Fehr and Kindermann (2015) show that the characteristics of the optimal tax systems change when we account for the welfare effects of the transitional generations.

The point of departure of this paper is to examine short-run as well as long-run consequences of the reforms while highlighting the difficulties and to suggest a practical solution grounded in economic theory. The method of gradual tax reform is a practical way to implement any structural tax reform. Notice that although the method is 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. One potential context is reforming the social security system, see Huggett and Ventura (1999), Conesa and Krueger (1999) among others, for discussions. 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 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.

My paper is also related to the literature that focuses on studying taxation in the dynamic general equilibrium model, such as those proposed by Conesa and Krueger (2006), Guner et al. (2012), Badel and Huggett (2014), and Guner et al. (2016).

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 , that is $N_{t+1} = (1+n)N_t$. 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 production technology is represented by a Cobb-Douglas production function that 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 public consumption, and C_t is aggregate private consumption.

2.4 Individual Constraints

All agents are born with no assets and face mandatory retirement at age $T+1$; that is 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 efficiency units that combines the 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. In what follows, I call the agent with the productivity shock z, the type z agent.

A agent of age j and type z with $e(z,j)$ efficiency units 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 equals 0 at working ages and 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 the government engages in three activities: it spends resources (consumes G), it levies taxes (to finance 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. 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, for which, the tax is levied on labor and capital income as well as social security transfer during the retirement periods:

$$I \equiv \omega e(z,j)l + ra + b_{j,t} \ \ , \ \ for\ all\ \ z\ \ and\ \ j.$$

This means that in the benchmark case, the total income tax liability for an agent with income I is

$$T = T_f(I) + \tau^k ar,$$

where T_f is a strictly increasing and 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 reformed 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 consumption and receive a lump-sum transfer. Thus, in the reformed case, the total tax liability for the agent is

$$T = \tau^c\, c + TR,$$

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

2.6 Recursive Formulation

In this section 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 changes when the economy is out of the steady state, that is, in the transition from the old steady state to the new steady state.

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. Time subscripts are dropped as I describe the stationary equilibrium. 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 is the permanent productivity shock for the agent that determines her type. The set $\mathscr{X}$ is defined as $\mathscr{X} = [0, \infty) \times \mathcal{Z}$. Therefore, the state vector for any agent is (x, j).

Given the prices (w, r) and the tax regimes ($\Upsilon \in \{B$ *(the benchmark tax system)* , R *(the reformed tax system)*$\}$), an agent with state (x, j) optimally chooses 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 the next period $a(x, j)$, in such a way that these choices solve the following dynamic programming problem:

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

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

subject to

$$c + a' \leqslant a(1 + r) + we(z, j)l(1 - \tau^{ss}) - \Gamma^{\Upsilon}(c, l, a')$$

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

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

$$v(x, j) = \max_{c,a'} \Big\{ u(c, 0) + \beta v(x', j + 1) \Big\} \tag{2}$$

subject to

$$c + a' \leqslant a(1+r) + b_j - \Gamma^{\Upsilon}(c, l, a')$$

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

and

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

Where $\Gamma^{\Upsilon}(c, l, a')$ is the total tax the agent pays, depending on the tax code of the economy and her optimal choices. The definition of a stationary recursive competitive equilibrium for this class of models is by now standard.[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: a flat-rate capital income tax and a non-linear income tax. In period 0, the economy is at the steady state with this tax system.

I assume that the change in the tax system takes place at the beginning of period 1, before any economic choices have been made. I consider the consumption tax reform being implemented in two potential ways: simple tax reform and gradual tax reform.

Simple Tax Reform: At the beginning of period 1, 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 1 onward, all agents have to pay their taxes according to the new tax code (the one that uses consumption as the tax base).

Gradual Tax Reform: Let period 1 be the period in which the tax reform occurs. At the beginning of period 1, before any economic choices have been made, the government announces it is replacing the benchmark tax system with the consumption tax system, with a specific condition: all agents who are alive at period 1 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, or if they want to switch at all. The switch is irreversible. All those born after period 1 have to pay their taxes according to the new tax code (the consumption tax code). With this implementation method, it takes time for the economy to reach the point at which the

[2]Equilibrium definition is provided in appendix A.

entire population is paying taxes under the new tax code, in other word, adoption of the new system is a gradual process.

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. However, the transition path and the decision problems of the agents depend on the method of implementation.

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.

2.6.2 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. The first group comprises all agents who are alive at the time of the policy change and have not yet switched to the new tax system. 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 describe 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 the agent can choose between the two tax systems. Therefore, $q = 0$ indicates the agent belongs to the first group and she can choose her preferred tax code, and $q = 1$ indicates 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 states x and q must 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 $a_{t+1}(x, j, q)$. Furthermore, if $q = 0$, that is if the agent has the option of choosing between two tax systems, she must also choose her preferred tax code. Therefore, optimal decision rules solve the following dynamic programming problem:

- $q = 1$:

$$v_t(x_t, j, q_t = 1) = \max_{c_t, l_t, a_{t+1}} \Big[u(c_t, l_t) + \beta v_{t+1}(x_{t+1}, j+1, q_{t+1} = 1) \Big]$$
$$s.t. \quad c_t + a_{t+1} = w_t e(z_i, j) l_t (1 - \tau^{ss}) + (1 + r_t) a_t + b_{t,j} - \Gamma_t^R.$$

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

- $q = 0$:

$$v_t(x_t, j, q_t = 0) =$$
$$\max \left\{ v_t(x_t, j, q_t = 1), \max_{c_t, l_t, a'_t} \Big[u(c_t, l_t) + \beta v_{t+1}(x_{t+1}, j+1, q_{t+1} = 0) \Big] \right\}$$
$$s.t. \quad c_t + a'_t = w_t e(z_i, j) l_t (1 - \tau^{ss}) + (1 + r_t) a_t + b_{j,t} - \Gamma^B.$$

For the case of $q = 0$, the first part in the maximization problem is the value of choosing the new tax system and the second part is the value of staying in the old tax system.

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

3 Parametrization

The parameters of the model have been calibrated so that the initial steady state of the economy replicates selected features of the U.S. economy over the period of 1990 to 2005. The model period is 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 ($T = 8$), and die at age 85 ($J = 12$), so their life length is 12 model periods and they face mandatory retirement

after 8 periods of working. I consider an annual population growth rate of 1.12%, which corresponds to the average population growth rate for the United States form 1990 to 2005.[3]

3.2 Technology and Preferences

To set the values for parameter α, the capital share and δ, the depreciation rate, I follow the standard method of Cooley and Prescott (1995). To align my model economy with the data, I define the notion of capital to include the stock of fixed private capital, the stock of consumer durables, the stock of inventories, and the stock of land.[4] The capital-to-output ratio averages 2.89 over $1990-2005$, at the annual level. The parameter α is set to 0.37, which is the average of the capital share. The depreciation rate is determined endogenously to be 0.073 at the annual level such that the model generates the average investment-to-capital ratio found in the data over the same period.

The intertemporal elasticity of labor supply γ is set to 1. Notice that the macro estimates of the elasticity of labor supply tend to be higher than those from the micro literature. As shown by Keane and Rogerson (2015) the value for γ at the macro level is larger than 1. I have exercises with a higher value for γ (2.5 instead of 1) and a lower value for γ (0.5 instead of 1, to correspond to the micro estimates for this elasticity) in the discussion section.

The value of parameter β, which is the discount factor is determined endogenously to 0.965 at the annual level, such that the model generates the same capital to output ratio as I calculated from the data.

3.3 Labor Endowments

Each agent has a labor efficiency profile $e(z, j)$, which consists of two components: a common age-dependent component, and a fixed productivity type that each agent is born with. This can be think of as a permanent productivity shock at the time of birth.

To estimate the efficiency profile, I use the available observations on wage (hourly earning). The age-dependent component is estimated by regressing log hourly wages of households on a polynomial in age together with time effects. Data for these purposes is from the Current Population Survey (CPS) for the years 1990–2005. The sample consists

[3]See the Economic Report of the President 2012, Table B.34.

[4]The stock of durables is from Current-Cost Net Stock of Fixed Assets and Consumer Durable Goods, BEA, Table 1.1. August 2015, the stock of inventories is from Economic Reports of the President 2012, Table B.1., and the stock of land is from Flow of Funds accounts, balance sheet tables

of households whose heads aged between 25 and 64 years old. All individuals in the sample earn hourly wages above half of the federal minimum wage, and they work at least 260 hours per year, as in Heathcote et al. (2010).

For the permanent productivity shock, agents draw z from a log-normal distribution function. Parameters of the distribution is determined using the same sample of data from the CPS, and selecting the households whose heads are between 25 and 29 years old, and calculating the yearly standard deviation of the log hourly wages for these households. I normalize the distribution by its mean and set the standard deviation σ_z to 0.53, which is the average of the yearly standard deviation of the log hourly wages calculated from the data. The permanent productivity shock is approximated with seven states for reporting the results in the following sections.

3.4 Taxation

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

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

where $t(\tilde{I})$ is an average tax function and $\tilde{I}$ is the income which is normalized by household income, that is income I divided by the mean household income in the economy. Parameter λ defines the level of tax rate and parameter τ governs the curvature or progressivity of the system. A larger τ creates a more progressive system. To set values for these parameters, I use the Guner et al. (2014) estimates for all households: $\lambda = 0.902$ and $\tau = 0.036$.

The tax rate τ^k levied on capital income is used to proxy the U.S. corporate income tax. It is estimated as the rate that reproduces the level of tax collections from corporate income taxes after the major reforms of 1986. The average corporate tax revenue as a percentage of GDP is 1.8% for $1990 - 2005$.[5] Using the technology parameter and specifications of output in my model, I obtain $\tau^k = 10.54\%$. Finally, the parameter τ^{SS}, the payroll tax rate levied on labor income to finance social security benefits, is set to 10.46%, which is the average of the ratio of the contribution to social security to labor income for $1990 - 2005$.[6]

[5]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 "

[6]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.

Table 1: Parameter Values

Parameter	Values	
β	0.9685	Discount Factor, target K/Y
τ^k	0.1054	Calibrated Capital Income Tax Rate
τ^{SS}	0.1046	Calibrated Payroll Tax Rate
n	1.12%	Average Population Growth Rate
γ	1	Frisch Elasticity
α	0.37	Capital Share
δ	0.073	Depreciation Rate, target I/Y
σ_z	0.53	Std. Deviation of Permanent Shock
λ	0.902	Federal Income Tax Level Parameter
τ	0.036	Federal Income Tax Curvature Parameter (Guner et al. (2014))

This table summarizes values of parameters with brief descriptions. The upper panel shows the parameters that are calibrated endogenously using the model and the lower panel shows the parameters that are chosen exogenous to the model. For detailed explanations see the text.

4 Findings: Steady State

Both simple and gradual reforms start from the same initial steady state and end in the final steady state of the consumption tax system. First, I 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 reforms.

Table 2 shows how the main aggregate variables are compared across the two steady states. The first column describes the initial steady state of the economy in which the benchmark tax system (with a non-linear income tax and a flat capital income tax) is the formal tax code. The second column characterizes the steady state of the economy under the consumption tax system. Note that the generated tax revenues are 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.

Table 2 shows that replacing the benchmark tax system with a consumption tax system leads to 26.4% higher capital accumulation in the steady state. The capital-output ratio increased by 13.8%. Removing the increasing marginal tax rate on capital income motivates agents to accumulate more assets. As a result of an increase in the capital accumulation, and only a modest increase in labor supply, the interest rate decreases by 12.5%. This means the

Table 2: Comparing Aggregate Variables at the Steady States with Different Tax Regimes

Variables	Benchmark Tax System	Consumption Tax System
τ_c	0	15.3
τ_k	10.54%	0%
τ	0.036	0
λ	0.911	1
Output	100	110.8
Capital Stock	100	126.4
Labor Supply	100	102.5
K/Y	2.89	3.29
Household Income (Avg.)	100	107.6
CEV	.	4.2%

Table 2 compares 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 normalize the aggregate variables at the steady state of the benchmark economy to 100.

wage rate increases; which is translated into an 11% rise in the retirement benefits, coming from the increase in the average labor income. Output increases by 10.8% due to higher levels of capital stock and labor supply. These are standard effects of replacing a non-linear tax system with a proportional one.

The increase in the size of the economy has implications for the 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 an ex-ante 4.2% higher level of consumption in each period of her life (CEV measure), as opposed to an agent born in the steady state of the economy with the benchmark tax system. Figure 1 decomposes the aggregate welfare gain into the welfare gains for various productivity types. As mentioned earlier, the permanent productivity shock is approximated with seven states, which I call types, where type 1 has the lowest productivity shock (about 1/3 of the median productivity shock), and type 7 has the highest productivity shock (about 3 times of median productivity shock).

Figure 1 reveals that the largest welfare gain from switching to the consumption tax system accrues to the most productive agents. Higher productivity-type agents are naturally those with the higher income. The progressive nature of the nonlinear income tax in the benchmark economy has relatively unfavorable effects on agents with higher levels of income. Therefore, the most productive agents clearly benefit the most from replacing a progressive

Figure 1: Distribution of Long-run Welfare Effects of the Consumption Tax Reform

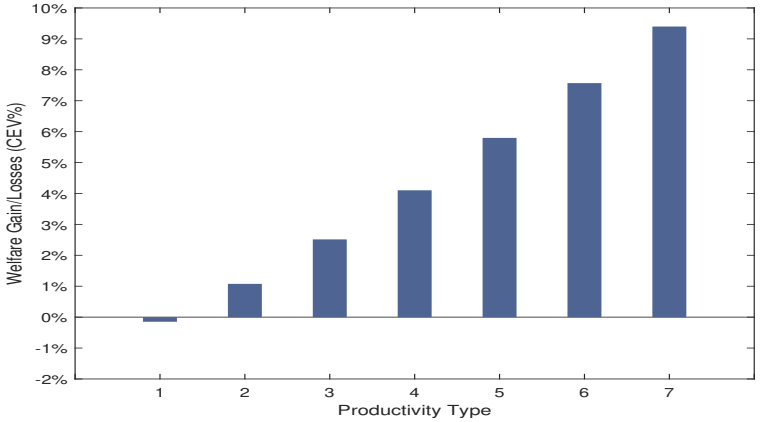


Figure 1 shows the distribution of long-run welfare gains/losses of having a consumption tax reform, measured in consumption equivalent variation, for agents with different permanent productivity shock. The permanent productivity shock is approximated with seven states, each state is called a productivity type and is 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 relative to the newborn in the steady state of the benchmark economy.

income tax with a flat tax. The least productive group has a welfare loss of less than 1%, and the welfare gains increase with the increase in productivity.[7]

5 Findings: Transitional Dynamics

In this section I turn to the discussion of transitional dynamics and short-run welfare effects of both conventional and gradual tax reforms. The conventional tax reform, which I call the simple reform, represents the case in which all agents, even those who have planned their lives based on the benchmark tax system, would have to switch to the new tax system immediately after its implementation. I consider this reform to be the baseline for comparison with the gradual tax reform which phases in the new tax system and phases out the benchmark tax system more gradually. Notice that both reforms are revenue neutral; that is, the economy generates the same level of tax revenue along the transition and in the new steady state as in the initial steady state.

[7]In the discussion section, I show that by providing a lump-sum transfer to all agents at the new tax system, even the least productive type enjoys the tax reform.

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 shows the transition path for the interest rate, and the lower graph shows the evolution of aggregate labor supply.It can be seen from figure 2 that under the simple tax reform, the economy reaches its new steady state after about 7 model periods or 35 years.

With the consumption tax system, the accumulated capital is 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 a 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 in the interest rate and a decrease in wage rate.

In subsequent periods, higher capital accumulation kicks in, which results in further increase 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 are documented quantitatively in table 3. Notice that the labor supply rises by 3.6% immediately after the policy change. Because of this, output increases by 2.4% in the first period. This means that about 22% of the total increase in the output is realized in the initial period of the tax reform.

Five periods into the reform, the capital stock is 23.3% larger than its initial steady state value and output is 9.8% larger. Further along the transition, after 10 periods, output exceeds its initial steady state level by 10.8%, and the capital stock is 26.4% larger. Over the long run the capital stock is 26.4% higher than its initial steady state and the output is 10.8% larger. As the economy expands, the required consumption tax rate declines. Along the transition, the consumption tax rate falls from 17.6% initially to its long-run level of 15.3%.

Welfare: Figure 3 shows the welfare effects, measured by the consumption equivalent variation, during the first transition period for three groups of agents: the most productive agents, the least productive agents, and agents with the median productivity. This graph

Figure 2: Transition Path for Aggregate Macroeconomic Variables in the Simple Tax Reform, and the Gradual Tax Reform

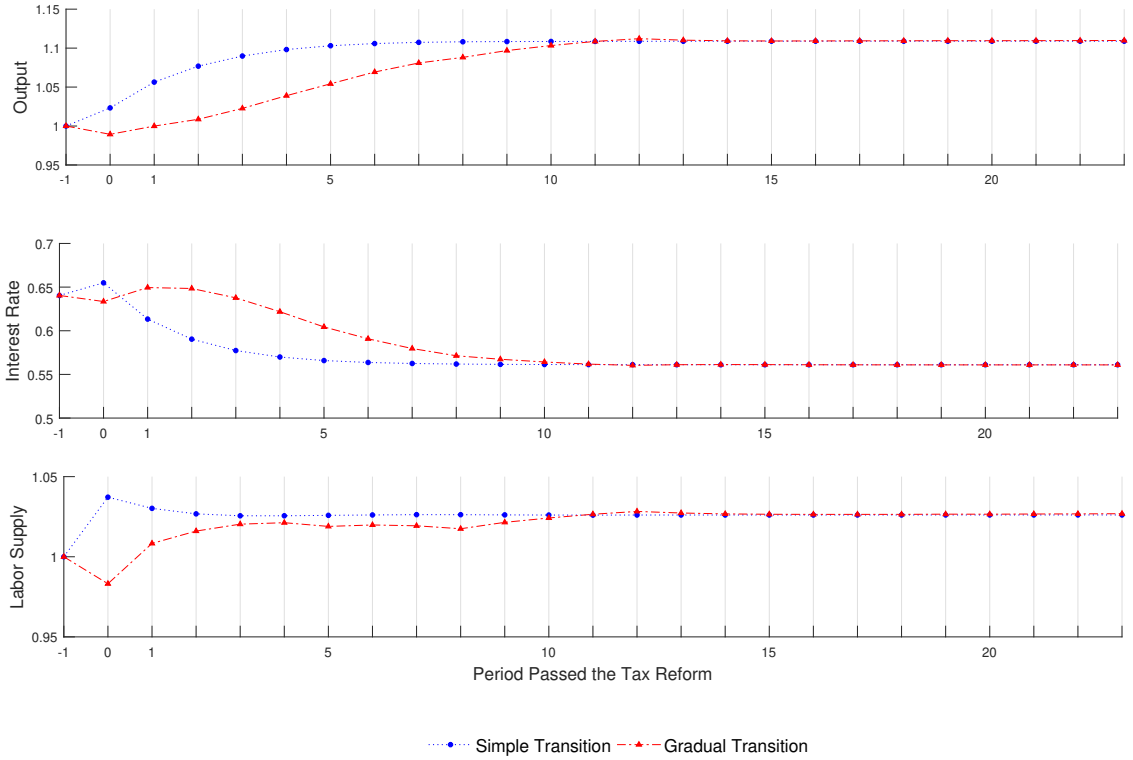


Figure 2 shows the evolution of the macroeconomic aggregates under both the simple and the gradual tax reforms.

confirms that the welfare consequences for agents vary significantly with their ages and productivity types.

Notice that all retired agents, independent of their productivity type, face welfare losses. In fact, older agents are the biggest losers of the reform, with agents age 65 or higher losing about 4% to 9%. This is due to the considerably different tax burden these agents face under the consumption tax system. Changing the timing of tax payments over the life cycle significantly alters the burden of taxation across generations. Under the benchmark tax system, the tax burden for retirees 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 agents, and the fact that each agent has to pay a flat-tax rate on each unit of consumption, the tax burden of retirees is comparable to that of working agents.

Table 3: Comparison of Aggregate Variables Along Transition Path

	Periods in the new system	Output	Capital Stock	Labor Supply	Interest Rate	Consumption Tax Rate
	1^a	102.4	100.00	103.6	0.68	17.6%
Simple	5	109.8	123.3	102.6	0.57	15.6%
Tax Reform	10	110.8	126.4	102.5	0.56	15.3%
	35	110.8	126.4	102.5	0.56	15.3%
	1^a	98.9	100.00	99.6	0.63	$23.7\%^b$
Gradual	5	103.8	108.8	102.0	0.62	20.1%
Tax Reform	10	109.6	125.1	102.2	0.56	16.4%
	35	110.8	126.4	102.5	0.56	15.3%

Table 3 provides snapshots of the economy right after the policy change (^{a}) , 5 periods into the transition, 10 periods into the transition and at the new steady state for both simple tax reform and gradual tax reform. ^{b}, in the gradual tax reform, no one chooses to switch to the new tax system at the first period of transition, therefore, the consumption tax rate in the first period is irrelevant. I reported the consumption tax rate at the second period in the table.

Agents who are in their retirement periods at the time of the tax reform, have already played their roles as major contributors to the tax revenue during their working years. With the change in the tax system, they are now expected to provide a considerable share of the tax revenue in their retirement years as well. Also, due to the initial jump in the labor supply, which induces a drop in the capital labor ratio, and a drop in the wage rate there will be a small drop in the average level of labor income at the first period of transition. Since social security benefit is tied to the average labor income, the social security benefit for retired agents is slightly lower which in turn contributes to the welfare losses they experience in the first period of transition.

Among young agents, welfare changes are increasing in the productivity type. Whereas agents with higher productivity types experience welfare gains, less productive agents are negatively affected 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, more productive agents, who have higher income in the this setup, benefit more from replacing the progressive income tax with a flat-rate consumption tax. This explains why young agents with higher productivity, experience welfare gains while less productive agents lose, even though they would have higher wage and higher social security benefit in their

Figure 3: Welfare Gains/Losses at the First Period of Transition in the Simple Tax Reform

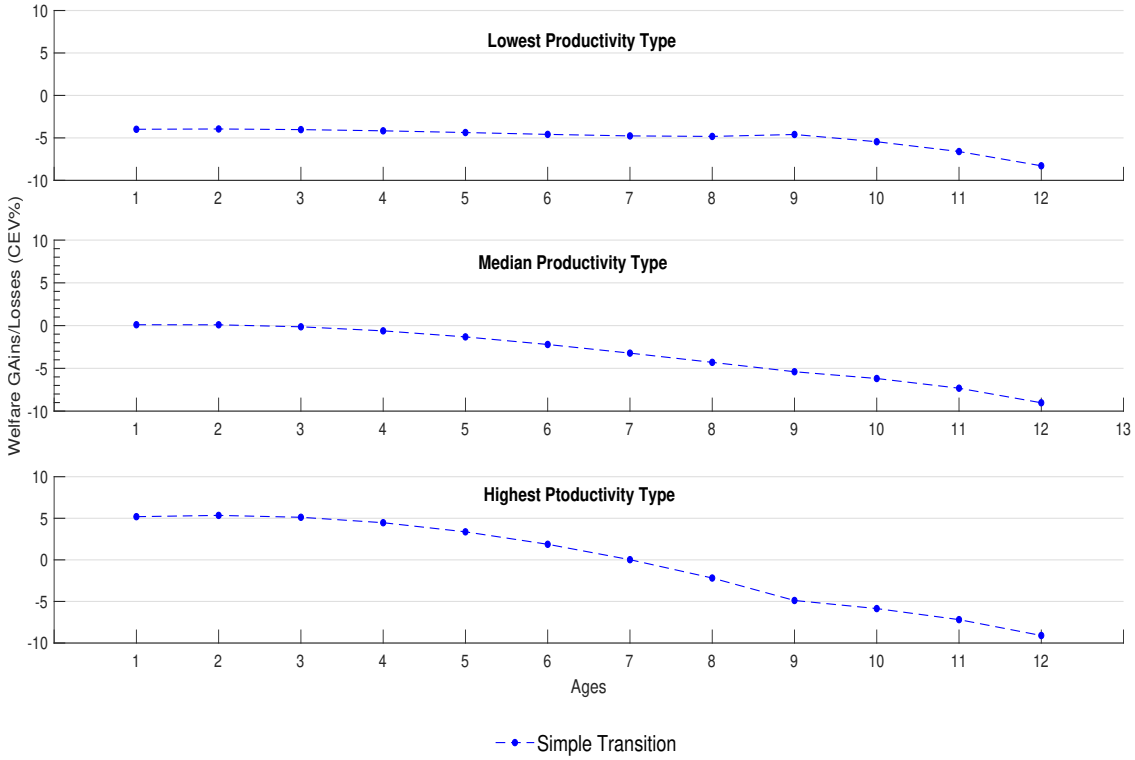


Figure 3 shows the welfare gains/losses, measured in consumption equivalent variation, in the first period of implementing the simple tax reform, for the highest, the lowest and the median productivity type agents.

retirement years.

Overall, my quantitative experiment shows that under the simple tax reform, only 25.6% 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 14.2% of the weighted sum of the welfare losses borne by the losers. These results show that long-run welfare gains mask the asymmetry in the distribution of 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 takes place, choose their preferred tax code. Figure 2 shows the evolution of macroeconomic aggregates in the gradual tax reform (the red dotted line with

Figure 4: Rate of Adopting the New Tax Regime

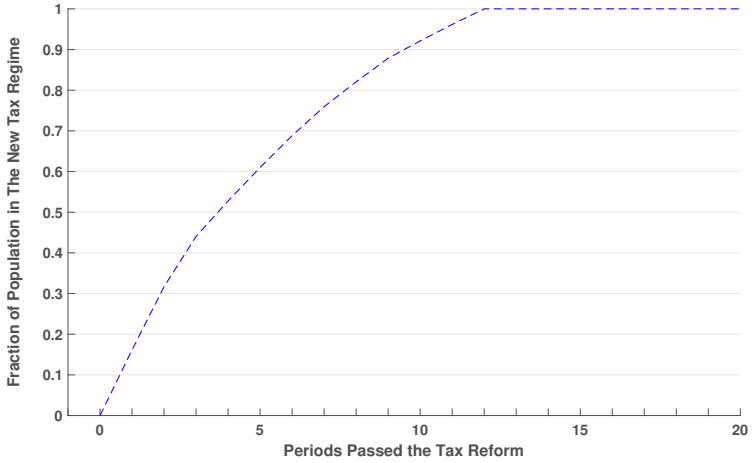


Figure 4 shows the fraction of the population who are paying their taxes according to the new tax system at each period of transition.

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 12 model periods or 60 years, and it takes about 5 model periods or 25 years for the economy to materialize half of the increase in the output. In the simple tax reform, this happens after 5 years or within one period of transition.

This slower rate of convergence can be explained by looking at the rate at which the consumption tax regime is being adopted in the economy. Figure 4 shows the fraction of population who pay their taxes according to the new tax code at each period of transition. In the first period, during which the change of policy occurs, no one chooses to pay tax under the new tax code, and it takes about 4 model periods or 20 years for half of the population to pay taxes under the consumption tax system. As this figure shows, it takes 12 model periods for this economy to have the whole population paying taxes according to the new tax code.

Younger, more productive agents are among the first to adopt the new tax system. These are the cohorts who experience higher income in their life cycles and are therefore affected more severely by the non-linearity of the income tax. Hence the flat-rate consumption tax system is 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 of all productivity types choose to stay in the benchmark tax system

Figure 5: Comparison of the Consumption Tax Rate at Each Period of Transition to the New Steady State, in the Simple Tax Reform and Gradual Tax Reform

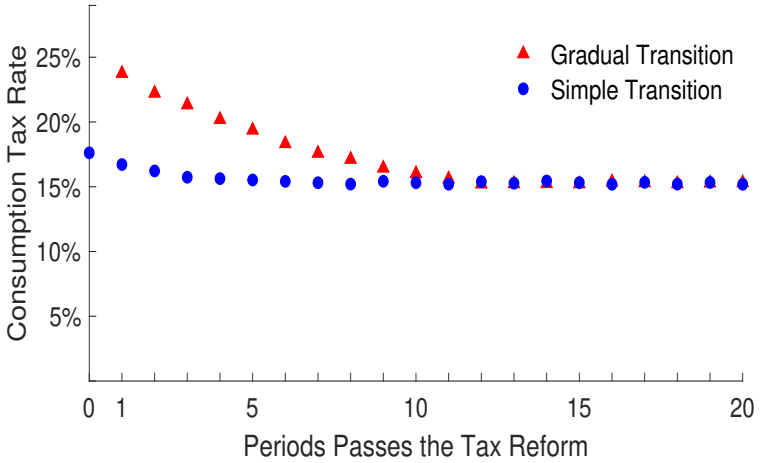


Figure 5 compares the consumption tax rate at each period of transition, that is needed to generate a constant tax revenue, in the simple tax reform and the gradual tax reform. Note that the in the gradual transition, there is no consumption tax rate at the first period as no one decided to switch to the new system and pay consumption tax right after it has been implemented.

over the rest of their lives. As mentioned before, these agents have already made their economic choices and paid income taxes under the benchmark tax scheme, assuming the tax burden would be negligible in their retirement years. Switching to the new tax system increases their tax burdens and is not beneficial for this group.

Having just a fraction of population in the new tax system during the initial periods of the tax reform induces higher consumption tax rates during these periods compared to the simple tax reform as shown in figure 5. Further along the transition, more agents will be willing to pay consumption taxes. As a result, the endogenous consumption tax rate eventually declines to its steady-state value of 15.3%.

The gradual tax reform slows down the emergence of beneficial features of the consumption tax code in the economy, a fact that is quantified in the second panel of table 3. For example, immediately after the tax reform, except for a slightly lower labor supply and output, there are not any noticeable differences in the economy. The small decrease in the labor supply is due to younger agents who slightly reduce their labor supply in anticipation of higher wage in the future. These are mostly from the lower productivity types, who will not switch to the new system over their lifetime. Based on table 3, it takes about four model periods for the economy to realize a 22% increase in output, the amount

realized after the first period in the simple tax reform. Five periods into the transition, output increases by 3.8% from its initial steady state compared to 9.8% in the simple tax reform, and the capital stock increases by 8.8% compared to 23.3%.

Hence, with the gradual tax reform, it takes longer for the economy to benefit from the 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 compared to the simple reform.

Welfare: Figure 6 shows the welfare gains and losses, measured in consumption-equivalent variation, during the first transition period for all agents who are alive when the tax reform takes place. Table 4 reports a group of these values. As I mentioned before, the young and relatively more productive agents are those who opt out to the consumption tax code during the initial periods of the transition. This is mainly due to the fact that these agents are the higher income groups in this setup. Therefore, they are affected more severely with the progressivity of the non-linear tax system and gain a lot by switching to a flat-rate tax regime. If they were to switch in the first period they would have faced a pretty high consumption tax rate, as they would be the only group who would opt for it. Therefore, the younger more productive agents defer their decisions of switching to subsequent periods in which the consumption tax rate is lower. Also, they marginally reduce their labor supply in anticipation of their switch which in turn raises the wage rate (we can see a small drop in the interest rate in the second graph of figure 2). Affecting the wage rate is one mechanism through which the agents who will eventually switch affect the non-switchers in this model. As a result of a slightly lower labor supply and a slightly higher wage rate, the average labor income is reduced by less than 1%. As the social security tax rate is fixed, this effect creates a very small reduction in the social security benefit which could describe the welfare effects of retired agents of age 12 that are barely negative (see table 4).

As we go further into the transition and more agents opt in the new tax system which rewards capital accumulation, capital stock increases faster than the increase in the labor supply and as a result wage rate increases and converges to its new level at the new steady state. The younger agents from the relatively less productive group get to stay in the benchmark tax system with the gradual tax reform and therefore benefit from the progressivity of the income tax regime. Also, as labor income increases along the transition, these agents enjoy a higher social security benefit during their retirement periods. This explains the small welfare gains they experience in the first period of transition.

Table 4: Welfare Gains/Losses for 9 Age-productivity Groups During the First Period of Transition for the Simple Transition and the Gradual Transition

		Welfare Gains/Losses (CEV%)	
		Simple Transition	Gradual Transition
The Lowest Productivity Type	age 1	-3.94	1.39
	age 6	-4.49	1.19
	age 12	-8.22	0.00
The Median Productivity Type	age 1	0.14	-0.54
	age 6	-2.13	-0.12
	age 12	-8.99	0.00
The Highest Productivity Type	age 1	5.23	1.63
	age 6	1.95	0.10
	age 12	-9.07	0.00

Table 4 reports the value of welfare gains and losses for 9 age-productivity groups of agents at the first period of transition, for both simple and gradual tax reform.

Younger agents from the median productivity group are the only ones who are experiencing a very small welfare losses in the first period of the gradual tax reform. This group are neither high nor low income group and their tax burden are comparable under both tax regimes. Also the weight of capital income and labor income are relatively similar in their income. During the transition, after the first period, interest rate gradually decreases and wage rate gradually increases. Unlike high or low productivity groups, for which one of these general equilibrium effects is dominant, for the median productivity type, these effects that are determining their income level are comparable. The aggregate result of these general equilibrium effects turns out to be a small welfare loss in the first period of transition, as it is shown in the middle graph of figure 6.

Overall, comparing the welfare effects of the gradual tax reform with their counterparts in the simple tax reform confirms that allowing 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 reduces it to the 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.

Figure 6: Welfare Gains/Losses at the First Period of Transition, in the Gradual Tax Reform and the Simple Tax Reform

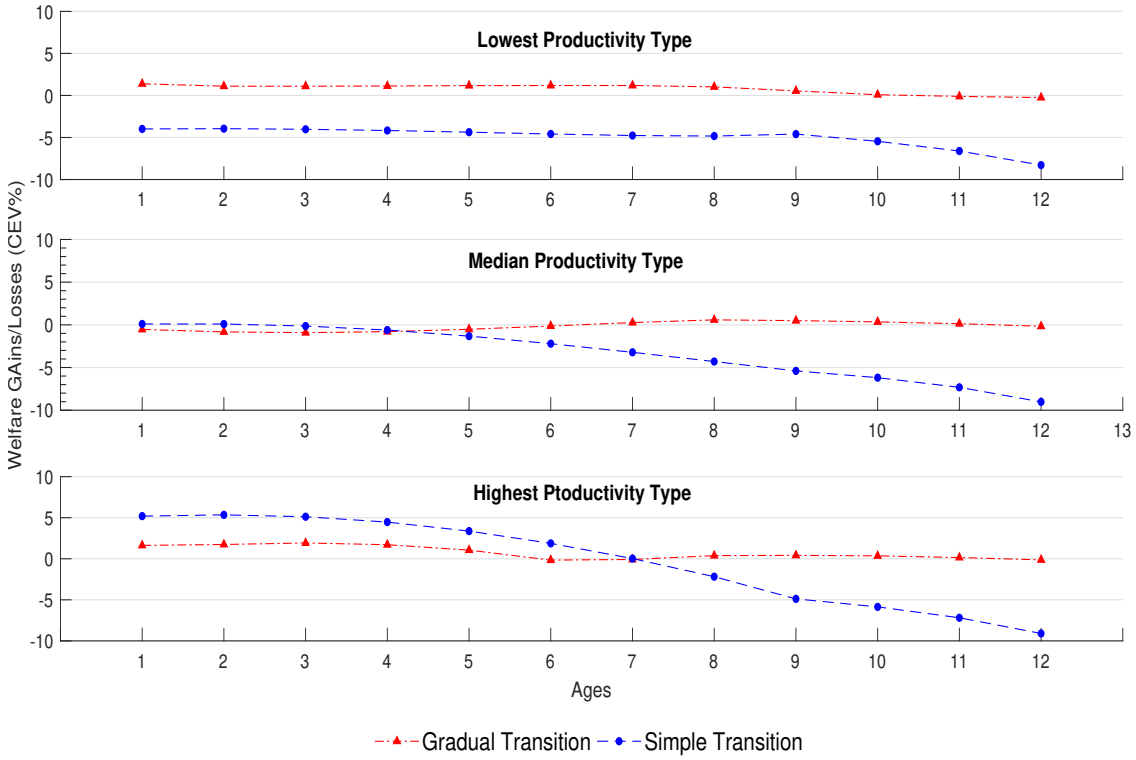


Figure 6 compares the welfare gains/losses for three types of agent at the first period of transition, measured in consumption equivalent variation, in the simple tax reform (circle dots) and the gradual tax reform (triangle dots).

6 Discussion

In this section, I run five exercises. First, I rerun the experiment using a consumption tax system that features a lump-sum transfer for everyone, 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 set up in which factor prices are fixed, to understand the roles of endogenous factor prices on the results. Third, I investigate the sensitivity of my results to the labor supply elasticity by conducting the experiment with a higher and a lower value for γ. Forth, I explore whether announcing the change of policy in advance would help ameliorate the negative short-run welfare consequences of the tax reform. Fifth and finally, I compare my method with the one in which the old tax system is

Table 5: Comparison of Aggregate Variables for Consumption Tax Reforms with Transfers

	Benchmark Tax System	Consumption Tax System (Without Transfer)	Consumption Tax System (0.1% Transfer)	Consumption Tax System (1% Transfer)	Consumption Tax System (2.5% Transfer)
Consumption Tax Rate (τ^c)	.	15.3	15.5%	16.8%	19.1%
Output	100	110.8	110.6	110.0	109.1
Capital Stock	100	126.5	126.1	125.6	124.8
Labor (efficiency units)	100	102.6	102.3	101.7	100.8
K/Y	2.89	3.29	3.29	3.30	3.30
Household Income (Avg)	100	107.6	107.3	106.8	105.8
Aggregate Welfare Gain (CEV%)	.	4.2%	4.3%	4.8%	5.6%

Table 5 provides a comparison of changes in the aggregate variables in the steady state of the reformed economy, for the consumption tax systems with 0%, 0.1%, 1%, and 2.5% transfer.

phasing out while the new tax system is phasing in over a certain number of periods.

6.1 A Linear Progressive Consumption Tax

Although proportional consumption taxes have received a great deal of attention in the literature, it is important to note that consumption-based taxes can also be progressive. In particular, giving the same lump-sum transfer to all households is one way of converting a flat consumption tax system into a progressive one. In this section, I rerun the experiment, replacing the benchmark tax system with a consumption tax system that features constant lump-sum transfers to all agents. The goal of this exercise is to examine whether having the transfer alleviates the negative short-run welfare consequences of the tax reform, and to study how the gradual tax reform performs in this context.

I consider three levels of transfers: 0.1%, 1% and 2.5% of the gross domestic product (GDP) per capita of the steady state of the benchmark economy. The transfer of 0.1% of GDP per capita, is the minimum level of transfer required to have every one, with different productivity levels, to prefer being born in the steady state of the new tax system over the steady state of the benchmark economy. The higher level transfers, 1% and 2.5% of GDP per capita, are chosen to demonstrate how things change as transfers increase. Note that in these exercises, transfers, like government consumption, are financed by taxes. Thus, providing higher levels of transfers, induces higher tax rates to keep the government budget balanced.

Figure 7: Comparison of Welfare Effects by Type across Steady States: Consumption Tax System with Transfer

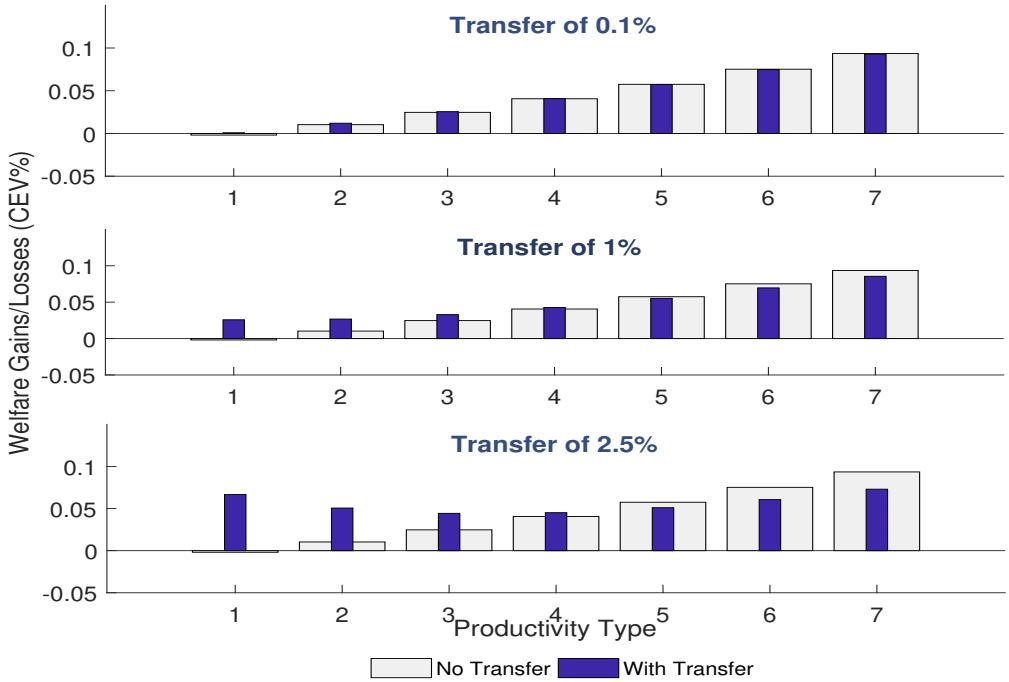


Figure 7 shows the distribution of welfare gains/losses of switching to a consumption tax system at the steady state of the reformed economy. Each graph compares the distribution of the welfare effects for two cases: the consumption tax system without any transfer (the baseline case) and the consumption tax system with a lump-sum transfer equivalent to 0.1%, 1% and 2.5% of GDP per capita of the benchmark economy, for all households.

Table 5 reports the value of the aggregate variables with changes in the consumption tax rates for the three levels of transfer as well as the one without any transfer. As we expected, the need to finance the higher level of transfers pushes the consumption tax rate well above the case without any transfer. Therefore, in cases with transfers the output effects are substantially lower relative to the case without transfers. In other words, the long-run increase in the capital stock and the level of output are lower in tax systems with a higher level of transfers. The growth in the labor supply is lower as well.

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 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

Figure 8: Comparison of the Welfare Effects of the Simple tax Reform at the First Period of Transition: for Consumption Tax Systems with Transfers

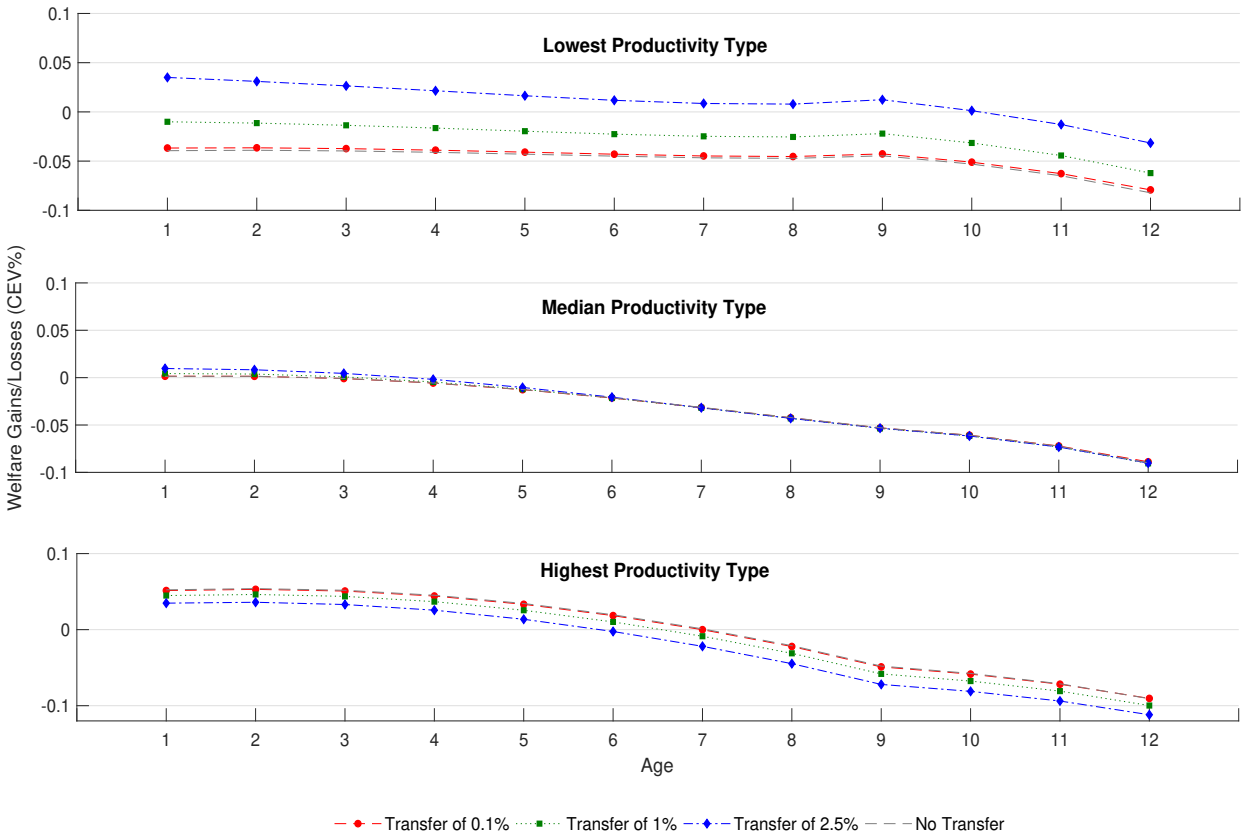


Figure 8 compares the welfare consequences of implementing a consumption tax reform with various levels of transfer, at the first period of transition for three types of agent.

distribution of welfare gains, we see that the welfare gains for less productive agents who are relatively poor are increasing in the level of transfer, whereas the gains for agents with higher levels of productivity, decline with the rise of the transfer. In other word, the effect of transfers declines as income increases. Poor agents benefit the most from transfers, and richer agents bear the burden of financing the transfers.

Figure 7 plots the short-run welfare consequences of the consumption tax reform with different levels of transfers. The upper graph shows the welfare effects for agents at the lowest productivity level, and the middle and lower graph show the welfare effects for agents at the median and the highest productivity levels. The figure confirms that the welfare of the least productive agents, who are the poorest in the economy, increases with the rise in level

Table 6: Welfare Gains/Losses at the First Period of Transfer for the Simple Transition and the Gradual Transition: Three Levels of Transfer

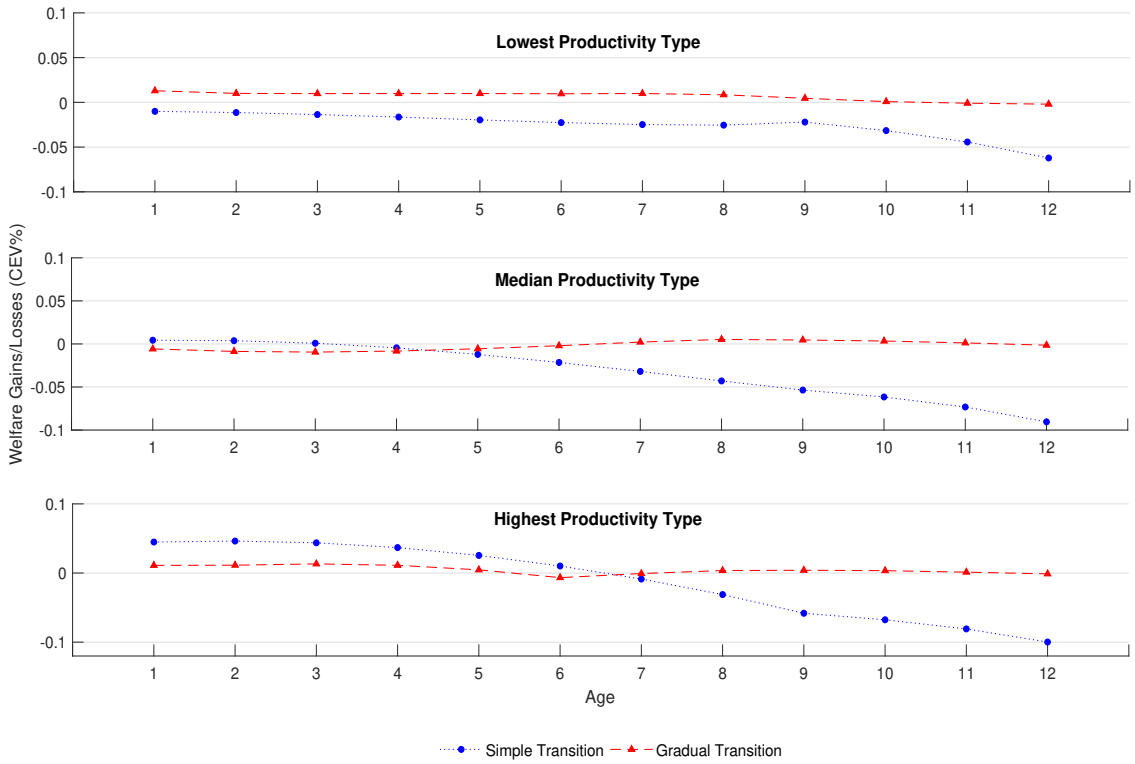
			Transfer of 0.1%	**Transfer of** 1%	**Transfer of** 2.5%
Lowest Productivity	age 1	Simple Reform	-3.6	-1.0	3.5
		Gradual Reform	1.3	1.3	1.0
	age 6	Simple Reform	-4.3	-1.9	1.2
		Gradual Reform	1.1	1.0	0.6
	age 12	Simple Reform	-7.9	-6.2	-3.2
		Gradual Reform	0.0	0.0	0.0
Median Productivity	age 1	Simple Reform	0.1	0.4	0.9
		Gradual Reform	-0.5	-0.5	-0.6
	age 6	Simple Reform	-2.1	-2.1	-2.0
		Gradual Reform	-0.1	-0.2	-0.2
	age 12	Simple Reform	-8.8	-9.0	-9.0
		Gradual Reform	0.0	0.0	0.0
Highest Productivity	age 1	Simple Reform	5.1	4.5	3.5
		Gradual Reform	1.5	1.1	0.3
	age 6	Simple Reform	1.8	1.0	-0.2
		Gradual Reform	-0.2	-0.1	0.0
	age 12	Simple Reform	-9.0	-9.9	-11.1
		Gradual Reform	0.0	0.0	0.0

Table 6 reports the welfare gains and losses for a selection of age-productivity groups at the first period of transition of both simple and gradual tax reforms, with three levels of transfers: 0.1%, 1% and 2.5%.

of transfer. 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 belong to the middle income group, the cost and benefit of the transfer have no noticeable effect on their welfare gains. Finally, the welfare gains for the most productive agents, who have the highest income in the model economy, decline with the rise in transfers. These groups 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 the most preferable setup for them. A selection of these welfare effect comparison is reported in table 6.

One thing to notice from figure 7 is that even though including transfers mitigates the short-run welfare losses for poor agents, it does not significantly decrease the welfare losses observed under the simple tax reform. In fact, welfare losses could be as large as 12% 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

Figure 9: Comparison of the Welfare Consequences of a Consumption Tax Reform with 1% Transfer, at the First Period of Transition, In the Simple Tax Reform and the Gradual Tax Reform



This figure shows the welfare gains and losses for agents at the first period of implementing a consumption tax system with a lump-sum transfer equivalent to 1% of GDP per capita in the simple tax reform (circle dots) and the gradual tax reform (triangle dots).

losses as large as 6%. Also, even with a 2.5% transfer, agents with higher productivity, as well as agents in their retirement years, still face welfare losses. This suggests that a gradual method could be a relevant method for implementing a progressive consumption tax reform. Figure 9 shows how the gradual tax reform alters the welfare consequences of implementing the consumption tax reform with a transfer equivalent to 1% of output per capita of the benchmark economy . This graph confirms that implementing the reform gradually improves the welfare of agents who are alive at the time of the policy change (see also table 6).

Table 7: Comparison of Aggregate Variables with Fixed Factor Prices

	Benchmark Tax System	Consumption Tax System (Baseline Case)	Consumption Tax System (Fixed Factor Prices)
Consumption Tax Rate (τ^c)	.	15.33%	13.25%
Output	100	110.89	130.78
Capital Stock	100	126.59	212.68
Labor (efficiency units)	100	102.60	98.29
K/Y	2.89	3.29	4.69
Household Income (Avg)	100	107.65	122.59
Aggregate Welfare Gain(CEV%)	.	4.27%	3.92%

Table 7 provides a comparison of changes in the aggregate variables in the steady state of the reformed economy, between the baseline case and the case with fixed factor prices.

6.2 The Case with Fixed Factor Prices

To understand the roles of endogenous factor prices, I rerun my experiment in a partial equilibrium setup. I fix the interest rate and wage rate at their levels in the steady state of the benchmark economy, and compute the transition path without requiring market-clearing conditions for labor and capital markets. Table 7 shows how the aggregate variables are compared across steady states assuming fixed factor prices. The second column reports variables for the baseline case where prices can adjust, and the third column reports variables for the steady state of the economy where prices stay unchanged at their initial values.

With fixed factor prices, capital stock is twice as large 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.

The wage rate is fixed at a lower level compared to that of the closed economy. As we can see on table 7 labor supply is slightly lower than its initial level. Part of this, is the due to the wealth effect of the high capital income. In the consumption tax system, the capital accumulation margin is not taxed; this creates a substitution effect that induces delaying consumption, as well as leisure, which increases the labor supply. In the closed economy, as more capital is accumulated, 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

Figure 10: Rate of Adopting the New Tax Regime in the Fixed Factor Prices Case

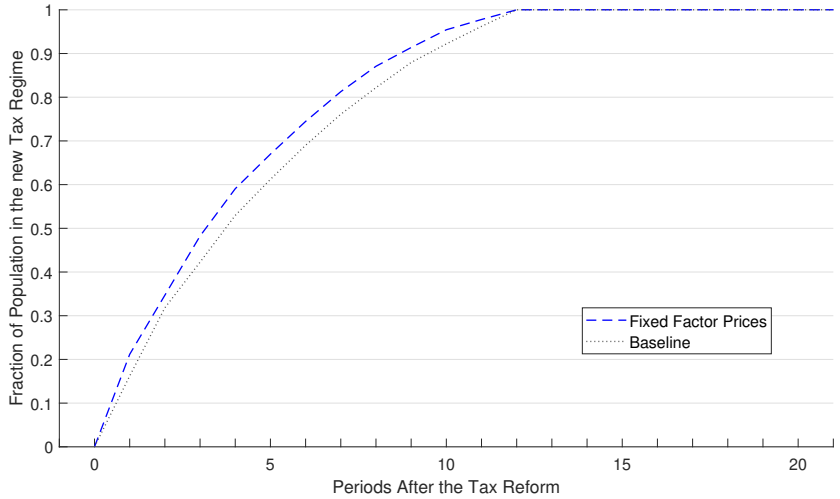


figure 10 shows the fraction of population who are paying taxes based on the new tax code for the fixed factor prices case and the baseline case

that labor supply increases. However, in the setup with fixed factor prices, wage is constant and 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 slightly decreases over the long run. Figure 11 shows the transition path of aggregate output and aggregate labor supply for both simple and gradual tax reform. During the simple transition, we do see the initial jump in the labor supply coming from the substitution effect of the new tax system. Moving further into the transition, the enforced wealth effect coming from the capital accumulation in the subsequent periods pushes down the labor supply to a lower level than the starting point.

In the gradual reform case, there is no initial jump in the labor supply, as no one choose to opt for the new tax reform in the first period of transition. However, younger agents from the median to higher productivity groups choose to switch in this case. In fact, as we can see in figure 10 the adoption rate of the new tax system is slightly steeper in this case. In anticipation of the switch, these agents reduces their labor supply in the first period. As they started to switch from the second period of transition labor supply increases over a few periods while the wealth effect pushes it down to its level in the new steady state. Higher labor supply with fixed wage rate result in a higher average labor income during those periods. The higher average labor income in turn increases the social security benefit and this highlights one mechanism through which switchers affects non-switchers in the absence of any general equilibrium effect.

Figure 11: Transition Path for Aggregate Macroeconomic Variables in Simple and Gradual Tax Reform with Fixed Factor Prices

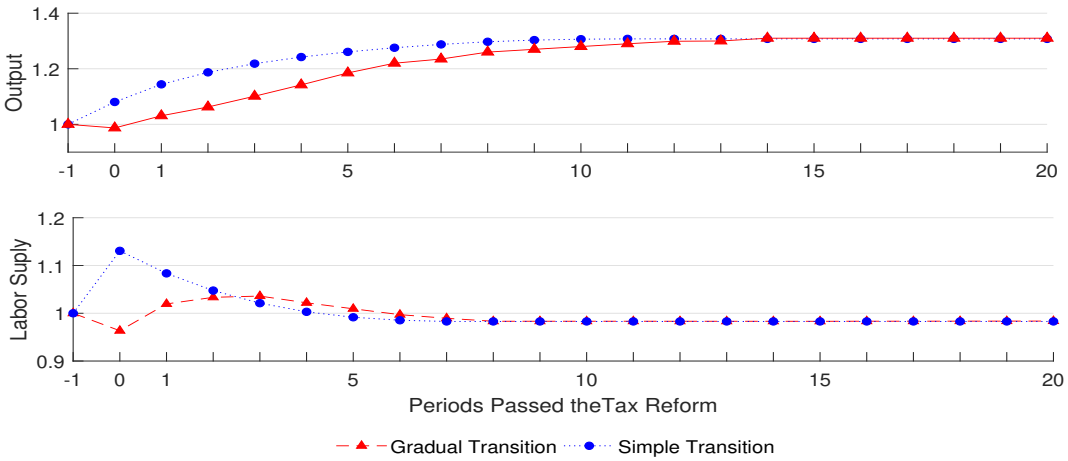


Figure 11 shows the evolution of macroeconomic aggregates under both simple tax reform and gradual tax reform keeping factor prices fixed.

Compared to the general equilibrium benchmark, average household income is higher with fixed factor prices. The long-run aggregate welfare gain is lower in the partial equilibrium setup, and the distribution of welfare gains across productivity types is more dispersed. The least productive agents are having 3% welfare losses in this scenario compared to 0.2% losses in the baseline case. And the most productive agents enjoy 10.6% welfare gains relative to 9.4% in the baseline case.

As wage does not increase in this setup, and the aggregate labor supply is lower due to the wealth effect, the social security benefit is lower by 11% relative to baseline case. Less productive agents who live mainly on their labor income and social security transfers, are deprived of higher wages and higher retirement benefits with fixed factor prices. Thus, they endure larger welfare losses. Also, 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 a major source of income, enjoy greater welfare gains.

Figure 12 plots the short-run welfare effects for the highest, median, and lowest productivity types at the first transition period, 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 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

Figure 12: Welfare Effect of a Consumption Tax System: Fixed Factor Prices

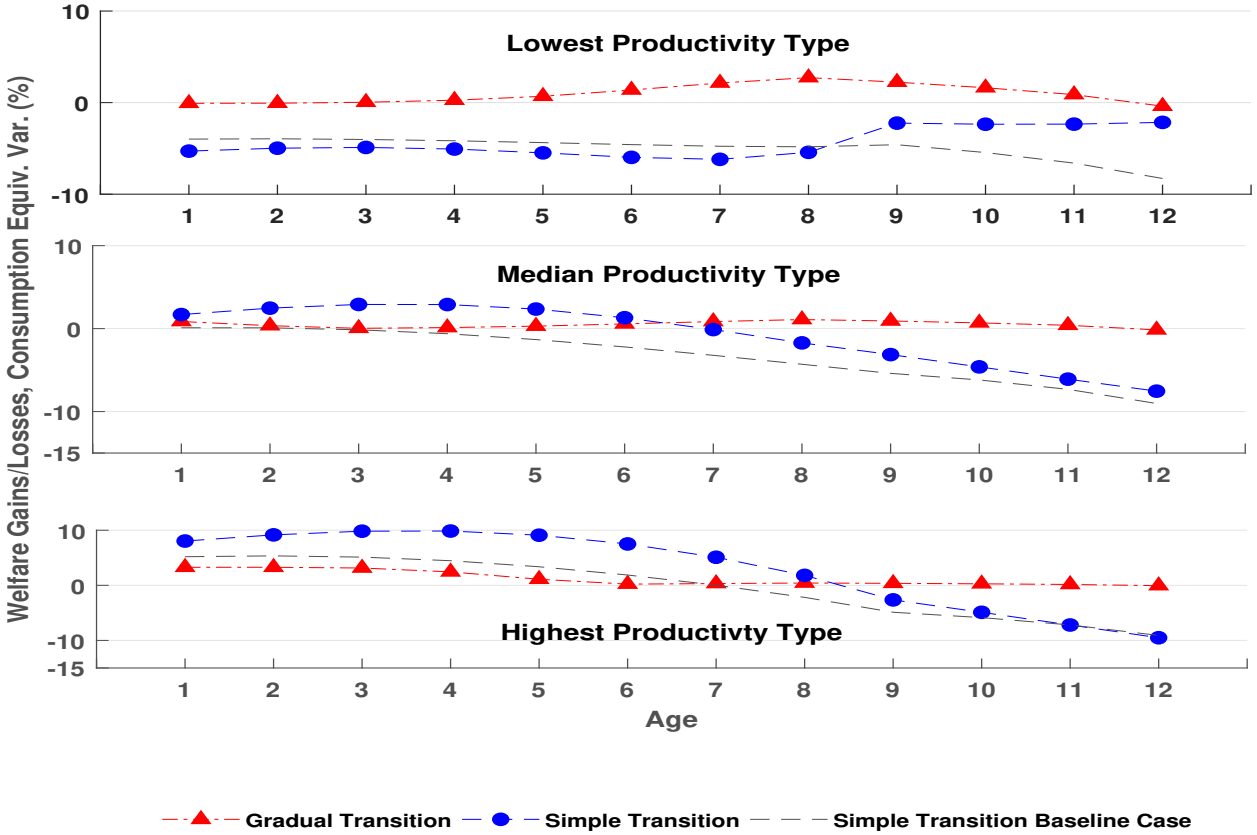


Figure 12 shows the welfare gains/losses for agents at the first period of implementing a consumption tax system, with fixed factor prices, in the simple tax reform (circle dots) and the gradual tax reform (triangle dots).

driven primarily by a change in factor prices. In fact, in the first period of transition with the fixed factor prices 74.2% of the population experience welfare losses and the aggregate welfare effect in the first period of transition is -2.7% (CEV).

However, endogenous factor prices slightly affect the distribution of welfare effects for generations alive at the first transition period. By comparing welfare effects for the simple transition when factor prices cannot adjust (blue dotted line in figure 12) with their analog in the baseline case where factor prices can adjust (gray dashed line in figure 12) we see that older generations of the lowest productivity type experience smaller welfare losses in the open economy setup compared to the closed economy (see the first column in table 8). Fixed prices, and in particular, fixed wage rate, can explain this observation. In the closed economy, at

Table 8: Welfare Gains/Losses for a Selection of Age-productivity Groups During the First Period of Simple and Gradual Transition: Fixed Factor Prices, Two Levels of Frisch Elasticity

			Fixed Factor Prices	**With $\gamma = 0.5$**	**With $\gamma = 2.5$**
Lowest Productivity	age 1	Simple Reform	-5.3	-3.9	-5.9
		Gradual Reform	0.0	1.3	1.8
	age 6	Simple Reform	-5.9	-3.2	-5.4
		Gradual Reform	1.3	2.4	2.1
	age 12	Simple Reform	-2.1	-8.9	-7.0
		Gradual Reform	0.0	0.1	0.0
Median Productivity	age 1	Simple Reform	1.7	-0.4	-0.0
		Gradual Reform	0.8	-0.8	0.0
	age 6	Simple Reform	1.3	-1.5	-2.1
		Gradual Reform	0.5	0.0	0.1
	age 12	Simple Reform	-7.5	-9.4	-7.3
		Gradual Reform	0.0	0.0	0.0
Highest Productivity	age 1	Simple Reform	8.0	3.7	6.9
		Gradual Reform	3.2	0.1	3.2
	age 6	Simple Reform	7.5	1.9	3.8
		Gradual Reform	0.2	0.0	0.8
	age 12	Simple Reform	-9.4	-9.5	-7.2
		Gradual Reform	0.0	0.0	0.0

Table 8 reports the value of welfare gains and losses for 9 age-productivity groups of agents at the fist period of transition for both simple and gradual tax reform. The first column reports the welfare effects for an economy with fixed factor prices (section 6.2), and the second and the third column report these values for an economy with a lower and a higher elasticity of labor supply compared to the baseline case (section 6.3).

the first transition period, labor supply jumps; this pushes down the capital-labor ratio and therefore decreases the wage rate and affects aggregate labor income. Retired generations receive social security benefits that are proportional to their average labor income. This in fact, describes another channel through which these groups are affected by the change in the tax regime. In the exercise with the partial equilibrium setup, prices are fixed and cannot react to the change in the capital-labor ratio; as a result, average labor income in the first transition period is about 10% higher in the small open economy compared to the closed economy. This translates into higher social security benefits for retirees in the open economy and justifies the observed trend in welfare cost. Also, the slightly positive welfare gains for retired agents from the lower productivity group is coming from the higher labor supply

Table 9: Comparison of Aggregate Variables for a Higher and a Lower Value of Elasticity of Labor Supply

	Benchmark Tax System	Consumption Tax System (with $\gamma = 1$)	Consumption Tax System (with $\gamma = 2.5$)	Consumption Tax System (with $\gamma = 0.5$)
Consumption Tax Rate (τ^c)	.	15.3%	15.1%	15.4%
Output	100	110.8	112.64	109.9
Capital Stock	100	126.4	128.77	125.3
Labor (efficiency units)	100	102.6	103.7	101.7
K/Y	2.89	3.29	3.30	3.29
Household Income (Avg)	100	107.6	108.8	106.7
Aggregate Welfare Gain(CEV%)	.	4.2%	4.6%	4.1%

Table 9 provides a comparison of changes in the aggregate variables in the steady state of the reformed economy, for three levels of the labor supply elasticity: $\gamma = 1$ (the baseline case), $\gamma = 2.5$, and $\gamma = 0.5$. Note: at each case, the benchmark economy is re-calibrated with the new value for γ and the percentage change reported on the table is calculated using the corresponding benchmark economy.

during the initial periods of the transition which increases the labor income and therefore the social security benefit. Overall, Figure 12 confirms that the gradual implementation of the reform can address short-run welfare consequences even with fixed factor prices.

6.3 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 so far I set the intertemporal elasticity of labor supply, γ equal to 1, which is close to the lowest macro estimates of this parameter. Keane and Rogerson (2015) argues that different mechanisms at play in aggregate settings suggest values of labor supply elasticity higher than 1. In this section, I examine the 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 rerun the experiment. And then I do everything with a lower value, $\gamma = 0.5$ which is close to the midpoint of micro estimates for this elasticity.

As shown in table 9 the higher value of labor supply elasticity slightly magnifies the change in the macroeconomic aggregate variables in the long run. In fact comparing $\gamma = 1$ with $\gamma = 2.5$, the output, capital stock, and labor supply are all higher by about 2 percentage points for the higher value of γ. In particular, having higher labor supply elasticity makes

Figure 13: Distribution of Long-run Welfare Effect of Consumption Tax Reform with Different Values for Labor Supply Elasticity, γ

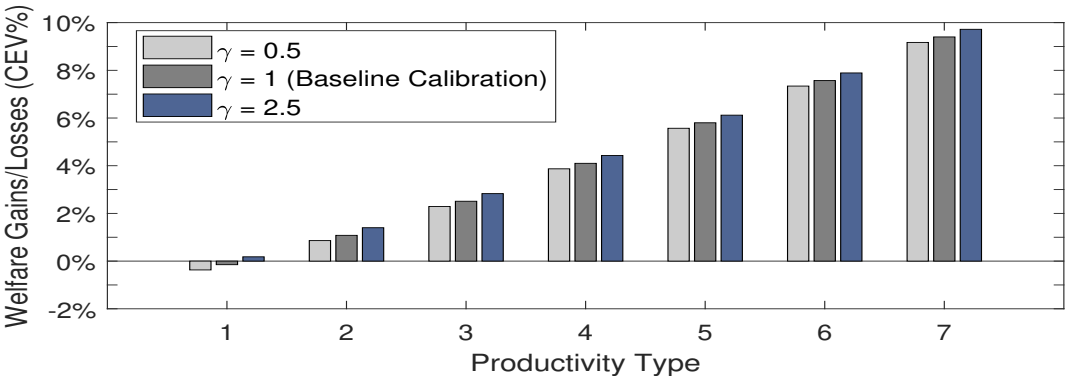


Figure 13 compares the aggregate welfare effect of consumption tax reform in for three levels of Frisch elasticity γ. In the baseline calibration, this elasticity is set to 1.

agents to amplify their reaction to the change in 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 for $\gamma = 2.5$.

As we can see, in the low-elasticity case, the lower value for labor supply slightly compresses the changes in the macroeconomic aggregate variables in the long run. Having lower labor supply elasticity means the reaction to the change in the tax structure is less pronounced compared to the higher elasticity cases. As a result, the percentage increase in the value of the output, aggregate capital and the aggregate labor supply are lower compared to the case with $\gamma = 1$ and $\gamma = 2.5$. Consequently, the consumption tax rate required to generate the same level of tax revenue as in the benchmark economy is higher with lower value for γ. As we see in table 9, the aggregate welfare gain increases with γ, which is due to the fact that consumption tax rate decreases and the average household income increases with γ. Figure 13 compares the welfare gain of each type for different values of γ and we see the same pattern here as well.

Figure 14 and table 8 (the second and the third columns) compare the welfare consequences of the consumption tax reform in the first transition period, under the simple tax reform and the gradual tax reform for all three level of γs. Comparing welfare effects during the simple transition, the welfare losses for older generations are lower with higher level of γ. This is simply due to the fact that the higher elasticity means the initial jump in the labor supply is more pronounce which in turn affect the social security benefit and the

Figure 14: Welfare Gains/Losses of a Consumption Tax Reform at the First Period of Transition with $\gamma = 2.5$ and $\gamma = 0.5$

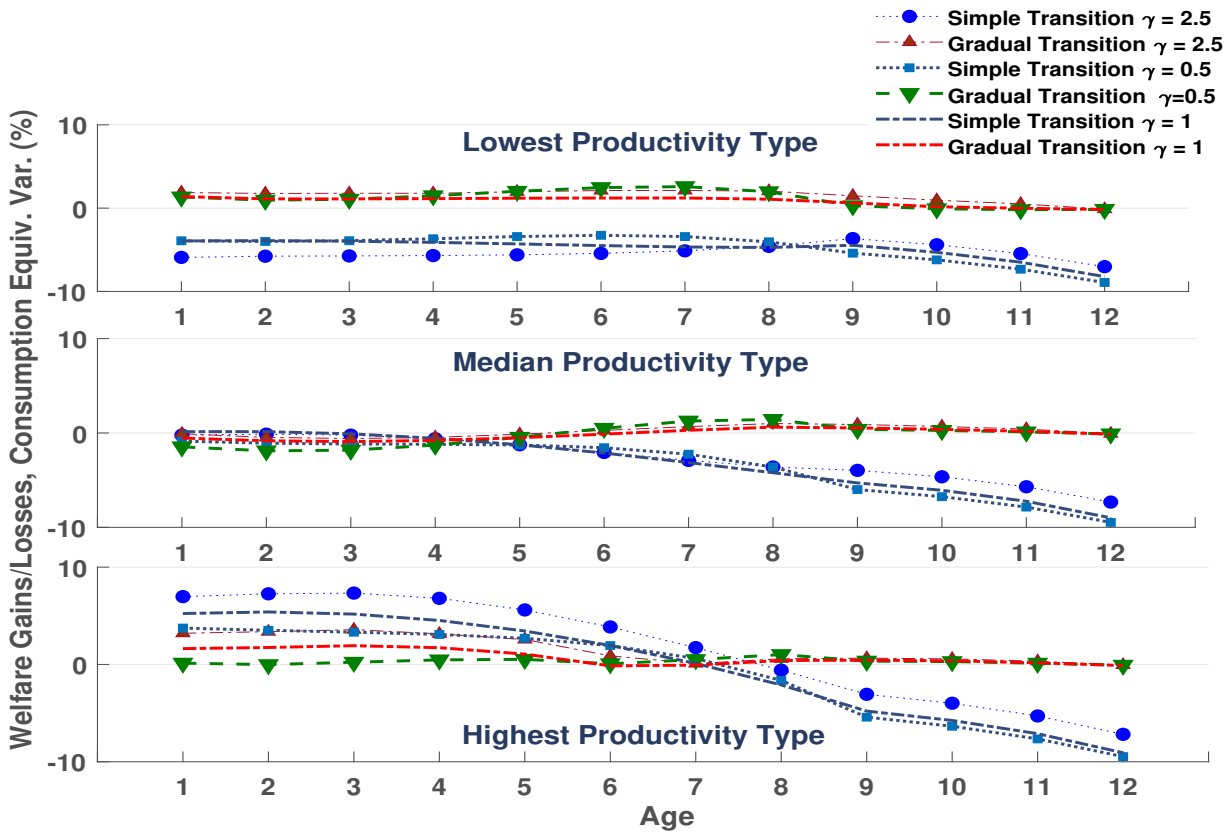


Figure 14 shows the welfare gains/losses for agents at the first period of implementing a consumption tax system under the simple tax reform (circle dots) and the gradual tax reform (diamond dots), with a higher labor supply elasticity ($\gamma = 2.5$) and a lower labor supply elasticity ($\gamma = 0.5$).

interest rate or return on capital. Income for older generations comprised of capital income and social security benefits which are both increasing with γ. For younger generations, welfare effects are mainly determined through the effect of the consumption tax rate and the wage rate. With higher labor supply elasticity the initial drop in the wage rate is higher, also the consumption tax rate is lower. For younger agents of higher productivity groups who have higher capital accumulation rate, the effect of lower tax rate is dominant and the welfare gains are larger with higher γ. For younger generations of lower productivity groups the wage rate effect is dominant as labor income is the main source of income. Therefore, for these groups the welfare losses increase with γ. Comparing welfare effects along the gradual transition we see that while the effects are almost the same for all

three levels of elasticity, younger agents of higher productivity groups experience higher gains with higher γ. This can be explained with lower level of consumption tax rate.

Overall, looking at figure 14 it can be seen that the pattern of welfare effects is similar in all three cases, and that the gradual tax reform can address the short-run welfare effects of the tax reform here as well.

6.4 Anticipated Tax Reform

Major policy changes such as tax reforms, which 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 to alleviate the brunt of the change.

In my major computation, I treat the tax reform as being an unanticipated policy change. To explore the extent to which announcing the policy change beforehand would change short-run welfare consequences of the reform, I conduct the following exercise. Assume that in period 0, 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, and everyone has to pay their taxes according to the new tax code.

Figure 15 compares the short-run welfare effects of the simple tax reform in the first transition period for both anticipated and unanticipated reforms. It can be seen that announcing the tax reform one period ahead, does not appear to mitigate the welfare consequences at the first implementation period. 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 must 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 0. Thus, in the first transition period, the welfare costs are slightly lower for those who own a 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 transition period, the jump in the labor supply places a higher downward pressure on wage compared to the unanticipated case. This means for those living mainly on labor income, the welfare costs are bigger. Figure 15 reflects these results.

Figure 15: Welfare Gains/Losses of a Consumption Tax Reform at the First Period of Transition: Anticipated Policy Change

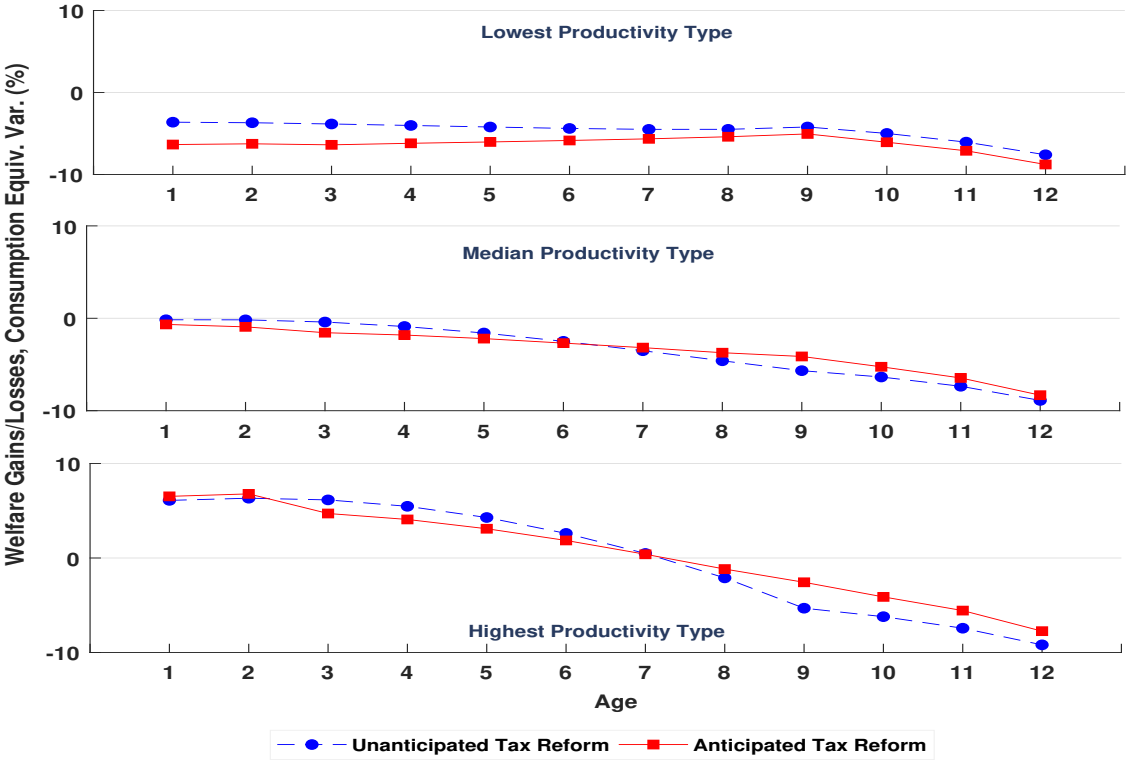


Figure 15 compares the welfare gains/losses for agents at the first period of a consumption tax reform between an unanticipated tax reform (circle dots) and an anticipated tax reform (square dots) in which the tax reform is announced one period ahead. The welfare effects are reported for a simple tax reform.

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.

6.5 Phasing Out the Current Tax System

One of the procedures 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[8]. In this section, I compare the performances of a phase-in phase-out method of implementing a tax reform with the gradual method that I propose in this paper.

[8]For examples see (Conesa and Krueger, 1999).

Figure 16: Consumption Tax Rate Along the Transition

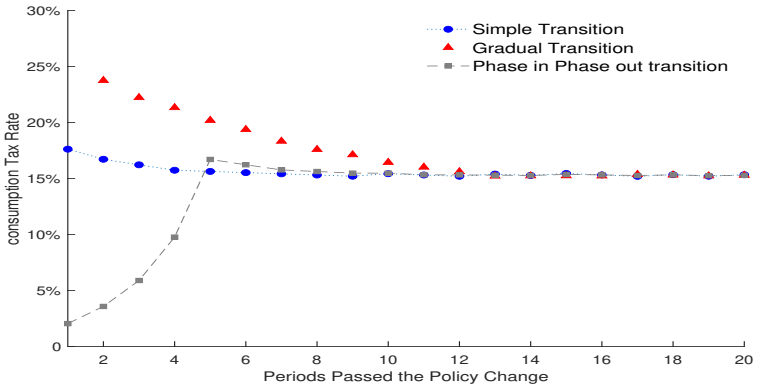


Figure 16 compares the consumption tax rate at each period of transition, needed to generate a constant tax revenue, in the simple tax reform, the gradual tax reform and the phase-in/phase-out tax reform .

More specifically, using the model, I simulate a revenue-neutral transition from the old tax system to the new system where the old tax regime is being phased out exponentially over five model periods (20 years), and the consumption tax system is introduced and the consumption tax rate is adjusted to keep the tax revenue constant. Figure 16 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 the sixth period, the consumption tax system is the only tax regime and everyone pays taxes under this tax code. Hence, the dynamic of the consumption tax rate in this setting closely resemble that of the simple tax reform.

Figure 17 compares the transition path of aggregate output, labor supply and interest rate during transition for simple, gradual and phase-in phase-out reform. As shown in the last graph, during the first five period of transition in the phase-in phase-out case, labor supply increases gradually. During these periods the effective marginal tax rate of the progressive income tax system were gradually decreasing which results in reducing the marginal distortion on the saving and labor supply. Also the tax rate on the consumption was gradually increasing, providing higher incentive for saving through the substitution effect. These two effects explain the gradual increase in the aggregate labor supply. At period 6, when all agents are paying their taxes according to the consumption tax code, the substitution effects kicks in and we see a similar pattern as in the simple transition.

Figure 17: Transition Path for Aggregate Variables During Transition: Phase-in Phase-out Case

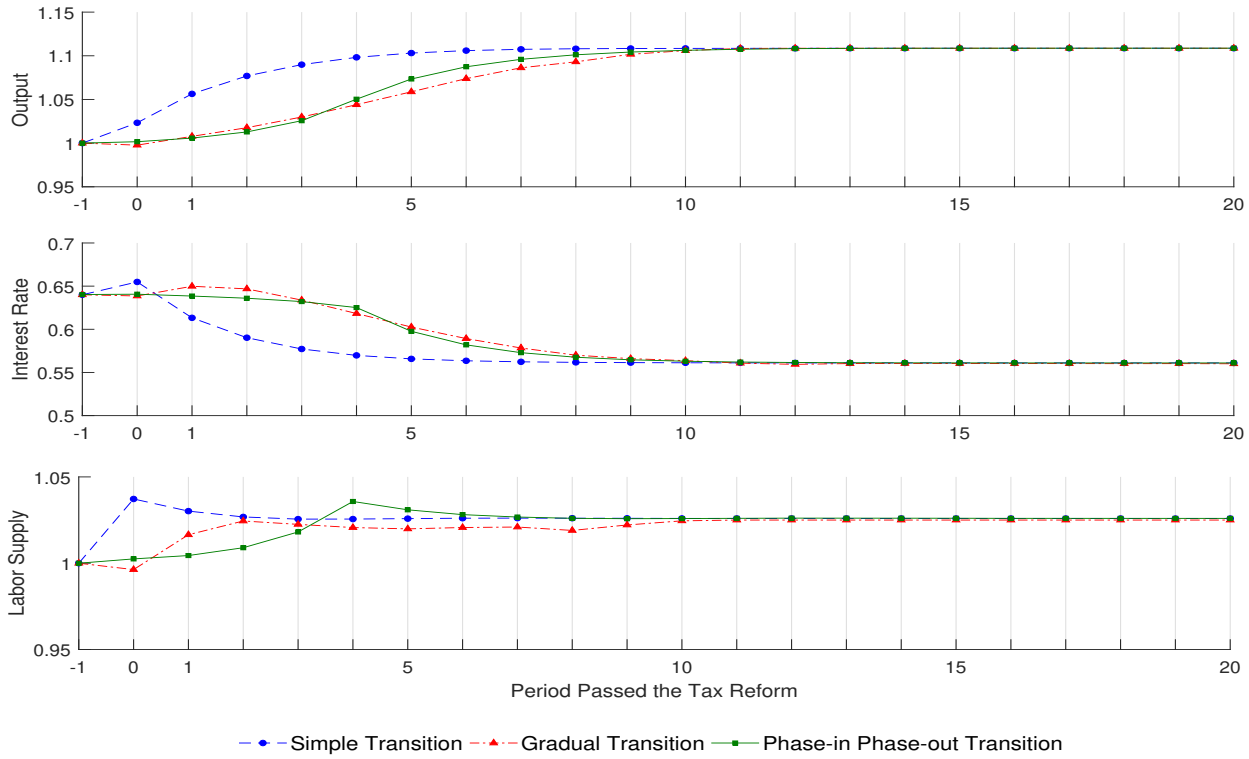


Figure 17 plots the transition path for aggregate output, interest rate and aggregate labor supply during transition for simple and gradual reform and the phase-in phase-out case.

Transition path for both interest rate and aggregate output in the phase-in phase-out case are similar to those in the gradual reform. This pattern confirms that phasing in the new tax system while phasing out the original tax system alleviates the magnitude of changes of aggregate variables during the first period of transition. However, still 86.4% of population experience welfare losses.

Figure 18 and table 10 compare the short-run welfare effects of the tax reform across simple reform, gradual reform and phase-in phase-out reform. Comparing the short-run welfare consequences across agents with different productivity types at different ages, we see that the welfare effects on younger agents are mostly similar under the simple tax reform and the phase-in/phase-out tax reform, which suggests the additional burden of paying a consumption tax is being offset by the reduction in income taxes. The only exception is the younger agents of higher productivity types who are facing a lower gain relative to the

Figure 18: Welfare Gains/Losses of a Consumption Tax Reform at the First Period of Transition: Phase-in Phase-out Case

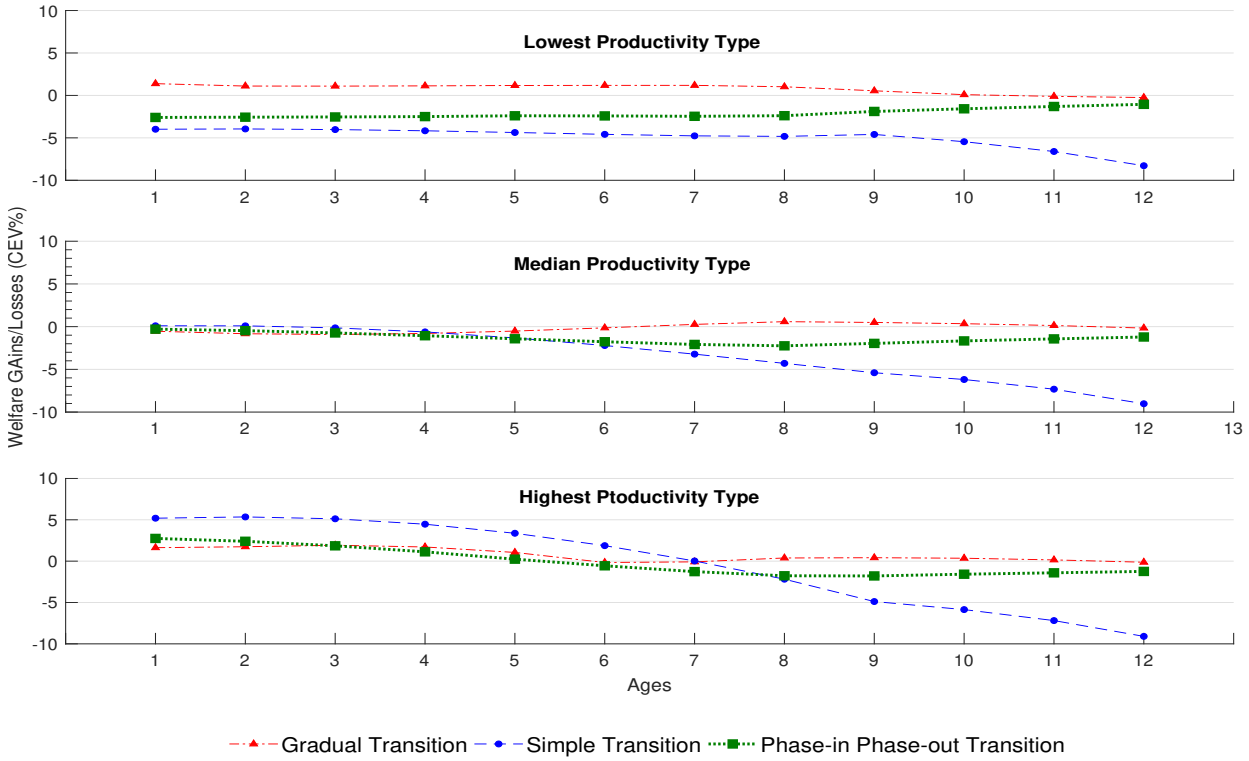


Figure 18 compare the short-run welfare effects of the tax reform across simple reform, gradual reform and phase-in phase-out reform.

simple case. .These agents are the high income group who benefit a lot from opting out of a progressive tax system into a flat-rate tax system. In the phase-in phase-out case, even though the effective marginal tax rates they face are decreasing overtime it is not possible for them to avoid the progressive tax regime entirely which explains the lower welfare gains compared to the simple reform.

Relatively older agents are better off with the phase-in phase-out tax reform than they are with the simple tax reform. But they would still prefer the gradual tax reform. The tax burden for these agents under the old tax system is much lower compared to the tax burden for the younger agents, whereas it is almost the same for both groups under 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.

Table 10: Welfare Gains/Losses for a Selection of Age-productivity Groups During the First Period of Simple Reform, Gradual Reform, and Phase-in Phase-out Reform

		Simple Reform	**Gradual Reform**	**Phase-in Phase-out Reform**
Lowest Productivity	age 1	-3.9	1.4	-2.6
	age 6	-4.5	1.2	-2.4
	age 12	-8.2	0.0	-1.0
Median Productivity	age 1	0.1	-0.5	-0.2
	age 6	-2.1	-0.1	-1.7
	age 12	-8.9	0.0	-1.2
Highest Productivity	age 1	5.2	1.6	2.7
	age 6	1.9	0.1	-0.5
	age 12	-9.7	0.0	-1.2

Table 10 reports the value of welfare gains and losses for 9 age-productivity groups of agents at the first period of transition for both simple and gradual tax reform. The first column reports the welfare effects for the simple reform, the second column reports the welfare effects for the gradual reform and the third column reports these effects for the phase-in phase-out reform.

Aggregating the welfare effects of the reform over all agents at the first period of transition, we can see that the phase-in phase-out reform improves the welfare consequences over the simple reform, but it still under-performs the gradual tax reform on that dimension[9].

To sum up, although phasing out the old tax system while phasing in the new tax system gradually improves the short-run welfare effects for some groups, it still creates considerable aggregate welfare losses at the first transition period. Implementing the consumption tax reform with this approach, still causes more than 62% of population to experience welfare losses at the first period of transition.

6.6 Additional Discussions

There are three minor points worth discussing here. First, in the benchmark setup of the model, social security system is designed such that the social security benefits are distributed evenly among all retired agents in the economy. This type of specification can lead to a program that is more progressive than the actual program. However, this specification changes neither the distribution of welfare effects at the first period of transition nor the

[9]The exact performance of the phase-in phase-out reform certainly depends on how fast the old system is being replaced with the new system, in this exercise I have only one possible case which I use to compare the gradual method with this method.

age-productivity profile of the losers. To confirm this, I did a simple exercise using two economies. In one of them the social security program provides a uniform transfer for all retirees and in the other one, the social security benefits are conditioned on the skill type. The comparison between the short-run and the long-run welfare consequences of a consumption tax reform across these two economies reveals that the distribution of welfare effects are quite similar while the quantitative values of the gains and losses are slightly lower in the modified version. Note that conditioning the social security benefits on the skill types reduced the progressivity of the system. In my set up, this would negatively impact the low productive types which have lower income while reducing the incentives of the high income groups to provide more labor supply and capital accumulation due to wealth effect coming from higher social security benefits. This exercise confirms that modifying the specification of the social security system neither addresses the main problem with the simple tax reform nor reduces the effectiveness of the method of gradual tax reform.

Second, in the demographic specification of the model, in order to simplify the calculations, I abstracted from modeling mortality risk. An inevitable consequence of this specification is that I have a higher fraction of retirees in my model relative to what we see in the data. We know retirees are among those who are facing welfare losses in the simple reform, and we may worry that overrepresentation of this group may have a noticeable effect on the results. To check the sensitivity of my results to the fraction of retirees in the model, I ran a simple exercise in which the weight of each age-productivity group is changed in a way that I have a mortality adjusted weight for the retirees in the model. Therefore, the fraction of retirees in the model coincides with that in the data. With the new calibration I ran the benchmark exercise of the model and then compared results with the ones from the benchmark calibration. I found that adjusting the weight of retirees in the model could marginally change the quantitative aggregate results, like total welfare losses at the first period of transition or the fraction of population facing welfare losses right after the reform. However, this adjustment would not significantly affect the main results and we still have a majority of population facing welfare losses at the beginning of the reform.

In fact, if retirees comprised a lower fraction of population in the model, the first difference would be a slightly higher consumption tax rate during the transition and in the new steady state. This is coming from the fact that retirees are pure consumers and having a lower fraction of retirees would require a higher consumption tax rate to generate the same level of tax revenue. This in turn, affects the younger agents of median productivity to face

a small level of welfare losses, and be added to the fraction of population facing welfare losses in the first period of transition. In other words, we could have a lower welfare loss due to having fewer retirees but that could induce some of the younger agents to switch from being indifferent to facing losses. Hence, even though the quantitative results may be slightly different by taking into account the mortality risk, the main problem with the simple reform would still be there which can be addresses by using the method of gradual tax reform.

The third and final point is that with the gradual tax reform, moving consumption over the life-cycle makes it possible for the agents to effectively take advantage of choosing when to switch to the new tax regime. Therefore, the elasticity of substitution for consumption could affect the extend to which agents can gain from the gradual implementation of a consumption tax reform. In other words, lowering the elasticity of substitution for consumption can limit the short-run welfare gains for the ones who switch in the gradual tax reform.

7 Conclusion

A central concern in all discussions of tax reform is 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 the 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 suggested gradual tax reform, generations alive at the time of the policy change have the option to choose 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. Whereas younger 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. One can think of the essence of this method as an "optional grandfathering" method.

I use a heterogeneous agent model to quantitatively evaluate the effects of this reform. The comparison between the predicted short-run welfare effects of the gradual tax reform and those of the conventional 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.

Overall, my exercise 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 used as a practical guideline for implementing any types of policy reform that provides higher welfare in the long run.

Acknowledgment

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8 Appendix: 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.

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 $T^{\Upsilon}(x,j)$, $\Upsilon \in \{$*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) $r = F_1(K,L) - \Upsilon$
   (b) $w = F_2(K,L)$
3. Markets clear :
   (a) $\sum_j \mu_j \int_x \big(c(x,j) + a(x,j)\big) d\psi_j + G = F(K,L) + (1-\Upsilon)K$
   (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 are fully funded by payroll taxes :

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

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 [10].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 $t = 0$ [11]

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

if $t \geq 1$

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

[10]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 for her in this period.

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

Everyone dies at age J so

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

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 $\{(c_t(x, j, q),\ l_t(x, j, q),\ a_t(x, j, q), q_t(x, j, q))^J_{j=1, x \in \mathcal{X}}\}^\infty_{t=1}$ [12], 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 :

[12] $q_t(x, j, q)$ 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 $q_t(x, j, q = 1) = 1$.

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

2. Factor prices are determined competitively:

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

3. Markets clear:

   (a) $\sum_{q\in\{0,1\}} \sum_j \left[\int_x (c_t(x,j,q) + a_t(x,j,q)) d\psi_t \right] + G_t = F(K_t, L_t) + (1-\Upsilon)K_t$

   (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 with 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:

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