Journal of Economic Dynamics & Control 34 (2010) 2109–2125

Contents lists available at ScienceDirect

Journal of Economic Dynamics & Control

journal homepage: www.elsevier.com/locate/jedc

Short-run fiscal policy: Welfare, redistribution and aggregate effects in the short and long-run

Sagiri Kitao [*,1]

Federal Reserve Bank of New York, 33 Liberty Street, New York, NY 10045-0001, USA

ARTICLE INFO

Article history:
Received 25 June 2009
Accepted 3 May 2010
Available online 16 May 2010

JEL classification:
E2
E62
H24
H6

Keywords:
Short-run fiscal policy
Life-cycle model
General equilibrium

ABSTRACT

This paper quantifies the effects of two short-run fiscal policies, a temporary tax-cut and rebate transfer, that are intended to stimulate economic activities. A reduction in income taxation provides immediate incentives to work and save more, raising aggregate output and consumption. A temporary rebate is mostly saved and increases consumption marginally. Both policies improve the overall welfare of households and the rebate policy benefits especially low-income households. In the long-run, however, the debt accumulated to finance the stimulus and a higher tax to service the debt can crowd out capital and lower output and consumption, causing welfare to deteriorate.

1. Introduction

Temporary fiscal policy to stimulate economic activities and enhance the recovery is an important issue in the current policy debate. The stimulus package enacted as the economy underwent the recent recession is composed of various policies including a temporary tax-cut, rebate check transfers to tax-payers and increased government purchases and investment in certain areas. This paper studies the impact of two of such short-run fiscal policies on life-cycle decisions of households and aggregate variables, in the short and long-run: (1) temporary income tax-cut and (2) temporary rebate transfer, both financed by debt during the policy period. A tax-cut is expected to give households more incentives to work and invest in order to exploit temporarily higher after-tax returns, raising the output and stimulating growth. A rebate transfer will increase personal disposable income and enable households to enjoy more consumption. Quantitative effects, however, of the policies are not obvious. A simple life-cycle theory tells us that an increase in net income may not lead to a rise in consumption if people realize that the policy is temporary and the cost will fall on them in the future. Once the policy ends, the government is left with a higher level of debt, which has to be serviced by taxation. Depending on the expected duration of the policy and how it is expected to be financed, most of the additional income may be added to savings.

In order to understand and quantify transitional and long-run effects of stimulus policies and their welfare consequences, we build a dynamic general equilibrium model of overlapping generations. Given fiscal policies and factor prices, households make

* Tel.: +1 212 720 7339; fax: +1 212 720 1844.
E-mail address: sagiri.kitao@gmail.com

[1] The views expressed in the paper are those of the author and do not necessarily reflect those of the Federal Reserve Bank of New York or the Federal Reserve System.

0165-1889/$ - see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.jedc.2010.05.011

optimal decisions on consumption, saving and labor supply over the life-cycle. Households are heterogeneous in age, wealth, earnings ability which is fixed throughout life and employment status. They face mortality risks and the length of life is uncertain. Once reaching the retirement age, they receive social security benefit from the government. The markets are incomplete and households can insure against employment and mortality risks only imperfectly by accumulating riskless assets.

We let households face an unexpected change in the fiscal policy, a temporary tax-cut and a rebate transfer, and re-optimize their life-cycle decisions. In baseline experiments, we assume that the stimulus is financed by government debt during the policy period and the income tax will adjust to service the debt and absorb the fiscal imbalance once the stimulus is over. We study how heterogeneous households respond to the policy change and how the aggregate economy reacts and makes a transition to a new economy with a higher level of debt. By explicitly computing the transition dynamics, we are able to evaluate welfare effects of a policy on households that are currently alive as well as future generations.

We find that the two short-run policies of a tax-cut and rebate transfer have similar long-run effects on welfare as well as aggregate variables and life-cycle profiles of household decisions. The short-run effects, however, turn out to be very different in both macro variables and welfare. A tax-cut stimulates saving and work effort of households, who try to exploit temporarily high after-tax returns from renting capital and labor. With a five-percent tax-cut, the aggregate output can rise by 3–4% depending on the duration of the policy. Nearly all households gain from the policy as they enjoy the temporary benefit, while the cost is postponed and shared with future generations. A rebate policy has little impact on the labor supply. Although the disposable income of households will rise with the rebate, a large part of the extra income will be saved and most of the new saving is absorbed by the additional debt issued by the government. Consumption will rise but only marginally. Short-run welfare effects are positive for the majority of households and low-income households gain more from the rebate policy than the tax-cut, since the benefit of the latter is proportional to the income level while the rebate is a lump-sum. In the long-run, the economy suffers from a higher level of debt that is accumulated to finance the temporary benefit. It crowds out private capital, raising the interest rate, and a higher tax to service the additional debt will further discourage saving and labor supply. Output and consumption decline in the long-run and welfare effects are negative for future generations.

After we identify the policy effects in the baseline economy, we consider a "recession" scenario where the economy is hit by aggregate shocks in productivity and unemployment risks, which is accompanied by the two stimulus policies. It is shown that the tax-cut can mitigate the negative effects of the recession but the higher borrowing and the need to service and repay the debt can significantly reduce the level of economic activities in the medium run and delay a full recovery.

We also consider alternative ways to finance the transition at the end of the stimulus, by having the consumption tax absorb the fiscal imbalance, and by adjusting the income tax as in the baseline case while also driving the debt down to the initial steady state level.

Our work builds on the vast literature that studies effects of fiscal policy in an economy in which the Ricardian equivalence fails to hold. Since Barro (1974) demonstrated the conditions for the equivalence, numerous studies have explored the issues and shown empirical evidence against the theory due to reasons such as the absence of lump-sum taxation as studied in Auerbach and Kotlikoff (1987), Trostel (1993) and McGrattan (1994), the existence of borrowing constraint as in Hubbard and Judd (1986), Altig and Davis (1989) and Heathcote (2005) and the lack of perfect intergenerational altruism as in Poterba and Summers (1987).[2] The model in this paper is calibrated to match key micro and macro features of the US economy and incorporates these factors.

Our paper is also a contribution to the literature that quantitatively studies the effect of fiscal policy in a so-called "Bewley model" of incomplete markets with heterogeneous agents using a dynamic general equilibrium approach. See, for example, Castañeda et al. (1999), Nishiyama and Smetters (2005), Conesa and Krueger (2006), Cagetti and De Nardi (2009) and Conesa et al. (2009) for the study of tax reforms.[3] These papers study the effects of a permanent change in fiscal policy and our paper focuses on the effect of short-run policies along the transition as well as in the long-run.

There is a long transition of literature that studies optimal fiscal policies focusing on the role of taxation and government debt in response to exogenous shocks to the government budget, beginning with Barro (1979) and Lucas and Stokey (1983) and more recently by Aiyagari and McGrattan (1998) and Aiyagari et al. (2002). Chari et al. (1994) use a model with capital and study the optimal capital and labor taxes in response to business cycle fluctuations, where the tax on private assets absorbs the shocks to revenues. Another line of literature analyzes the optimal income taxation in a complete market without aggregate risks, including Chamley (1986) and Judd (1985) using an infinitely-lived agent model and Erosa and Gervais (2002) and Garriga (2003) in a life-cycle model.

Several papers study the effects of temporary fiscal policies on household decisions and macro variables including equilibrium prices. The model and methodology used in our paper are grounded on Auerbach and Kotlikoff (1987), who study the effect of a temporary tax-cut using a representative agent overlapping generation model.[4] Altig and Davis (1989)

[2] Bernheim (1987) offers a comprehensive survey.

[3] See Bewley (1986), Aiyagari (1994), Huggett (1993) and İmrohoroğlu (1989) for classic works that developed the Bewley class of models.

[4] Our model differs from Auerbach and Kotlikoff (1987) in several ways. (1) We incorporate uncertainty in income and mortality and the saving is driven by life-cycle as well as precautionary reasons. (2) We model heterogeneous households, rather than a representative agent in Auerbach and Kotlikoff (1987), and agents differ in the dimensions of wealth, labor productivity and earnings ability besides age. A policy redistributes not only across generations but also across key socio-economic dimensions. We analyze welfare effect of a policy on heterogeneous agents and cross-sectional redistribution across them. (3) We explore the effects on the life-cycle profiles of individual decisions, rather than solely focusing on macro aggregates. Finally, our paper compares the effects of two policies to stimulate the economy; tax-cut and rebate transfer policies in response to aggregate shocks.

build a three-period model to study the role of government debt and fiscal policies, focusing on the roles of borrowing constraint and altruism. Baxter and King (1993) use a quantitative general equilibrium model with a representative agent to analyze temporary and permanent changes in fiscal policy and explore the effects of alternative financing schemes. More recently, Heathcote (2005) uses an infinitely-lived agent model to investigate the effect of a tax-cut, modeled as persistent shocks to the tax rates, and quantifies the roles of distortionary taxation and liquidity constraint.[5] We use a full-blown life-cycle model with the maximum life length of 81 years (age 20–100), which incorporates uncertainties about income through unemployment risks and life expectancy and socio-economic heterogeneity among households to account for redistributional effects of short-run fiscal policies.

Recent short-run policies implemented under various stimulus acts have generated a line of empirically-motivated literature that attempts to assess the impact of actual policies. Auerbach (2002) simulates the behavioral responses of households to the phase-in reduction in income taxes under the Economic Growth and Tax Relief Reconciliation Act (EGTRRA) of 2001. House and Shapiro (2006) study effects of the EGTRRA and the Jobs and Growth Tax Relief Reconciliation Act (JGTRRA) of 2003 and compare the changes in the macroeconomic variables during the policy period in data with simulated outcomes. Shapiro and Slemrod (2003, 2009) use survey techniques to assess the effect of tax rebates distributed in 2001 and 2008.

The organization of the paper is as follows. Section 2 presents the model and calibration details are given in Section 3. Section 4 conducts policy analysis and presents our numerical findings. Section 5 presents sensitivity analysis. Concluding remarks are given in Section 6.

2. Model

This section presents the model, the description of the household problem and the definition of the stationary competitive equilibrium. The details of the short-run fiscal policies are given in Section 4.

2.1. Demographics

The economy is populated by overlapping generations of individuals of age $j=1,2,\dots J$. The lifespan is uncertain and agents of age j survive until the next period with probability s_j. J is the maximum possible age and $s_J=0$. Agents can supply labor in the market until the mandatory retirement age j_R. The size of a new cohort grows at a constant rate g. We assume no altruism and all accidental bequests are collected and distributed as a lump-sum transfer to the entire population and denoted by b.

2.2. Endowment

Individuals are endowed with one unit of time in each period of their lives. Each period they face a stochastic unemployment risk. An individual's employment state n follows a two-state Markov chain implied by a 2×2 transition matrix P_n. If $n=e$, the agent has a job and can choose to work l hours, with $l\in[0,1]$. If $n=u$, the agent is unemployed and receives unemployment benefit γ that depends on the earnings at the previous job.

Earnings of an employed agent are given as $w\varepsilon_j zl$. w is the market wage and l denotes endogenously chosen hours of work. The labor productivity of households differs along two dimensions. The first component is ε_j, age-dependent productivity that evolves deterministically over the life-cycle. We assume $\varepsilon_j=0$ for retirees at age $j\geq j_R$. The second component is z, which represents the difference in education or innate abilities among households that are not affected by employment shocks or by ages and it is fixed throughout life. Households enter the economy with no assets.

2.3. Preference

Households value consumption and leisure and order the sequence $\{c_j,1-l_j\}_{j=1}^J$ according to a time-separable utility function

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

where β is a subjective discount factor and the expectation is with respect to uncertainty in longevity and employment.

2.4. Technology

Firms are competitive and produce output according to a constant returns to scale technology: $Y=F(K,L)=AK^{\alpha}L^{1-\alpha}$, where K and L are aggregate capital and labor inputs and α is the capital share. A represents the total factor productivity

[5] The appendix of Heathcote (2005) considers the role of imperfect intergenerational altruism in an overlapping generation model.

which we assume is constant in steady state and normalizes units in the model economy. Capital depreciates at rate $\delta \in (0,1)$. Firms rent capital and hire labor efficiency units from households in competitive markets, where factor prices r and w are equated to marginal productivities.

2.5. Government policy

The government purchases an exogenous amount of goods and services G and supplies an amount of one-period risk-free debt D, which, by no arbitrage, carries the same return r in equilibrium as claims to physical capital. The expenditure G and the payment of the principal and interest on the debt $(1+r)D$ are financed by the revenue from taxes on income and consumption and newly issued debt. The income tax is given by a function $\mathcal{T}(y)$ of income y, that is a sum of labor and capital income. The consumption tax is proportional and denoted by τ_c.

The government operates a pay-as-you-go social security system, which provides each retiree with a constant benefit ss. The system is assumed to be self-financed by a proportional tax τ_{ss} on earnings of working households and the payroll tax rate is determined to balance the budget of the program. The unemployment benefits depend on the labor income at the previous job y_L, through the function $\gamma = \Gamma(y_L)$. The benefits are financed by a proportional tax τ_g on earnings.

2.6. Market structure

Markets are incomplete and households cannot perfectly insure against employment and mortality risks by trading state-contingent assets or annuities. They can, however, accumulate one-period riskless assets to imperfectly self-insure against uncertainty. We assume that agents are not allowed to borrow against future income. The tight borrowing constraint guarantees that agents do not die in debt in a model with a mortality risk at any age.

2.7. Households

Households are heterogeneous in five dimensions summarized by a state vector $x = \{j,a,z,n,\gamma\}$, where j represents age, a assets accumulated and carried over from the previous period, z fixed ability type, $n \in \{e,u\}$ employment status and γ unemployment benefit provided by the government if the agent is unemployed ($\gamma = 0$ if n=e). In every period agents choose $\{c,l,a'\}$, that is, consumption, work hours and savings in order to maximize the life-time utility (1).

We compute the household's problem recursively. The value function $V(x)$ of an agent in state x is given by

$$V(x) = \max_{c,l,a'} \{u(c,1-l) + \beta s_j E[V(x')]\} \tag{2}$$

subject to

$$c + a' = (1+r)(a+b) + w\varepsilon_j zl - \Upsilon,$$

$$a' \geq 0, \tag{3}$$

where Υ denotes the net payment from a household to the government, which include income taxes $\mathcal{T}(y)$, consumption, social security and unemployment insurance taxes, social security benefit for retirees and unemployment benefit for unemployed workers:

$$\Upsilon = \tau_c c + (\tau_{ss} + \tau_g) w\varepsilon_j zl + \mathcal{T}(y) - \gamma - I_{j \geq j_R} \cdot ss, \tag{4}$$

$$y = w\varepsilon_j zl + r(a+b) + \gamma. \tag{5}$$

Social security benefit ss is paid once households reach the retirement age. $I_{j \geq j_R}$ is an indicator function that takes a value 1 if $j \geq j_R$ and 0 otherwise. The state of unemployment benefit in the next period is determined as $\gamma' = \gamma$ if $n = u$ and $\gamma' = \Gamma(w\varepsilon_j zl)$ if n=e.

2.8. Competitive equilibrium

Definition 1. A stationary competitive equilibrium is an equilibrium in which per capita variables, demographics, and government policies are constant, and aggregate variables grow at a constant rate of g, and where the following conditions are satisfied: given the demographics $\{s_j\}_{j=1}^{J}$ and $\{g\}$ and government policy $\{G,D,\tau_c,\tau_{ss},\Gamma(y_L)\}$, households' decision rules $\{c,l,a'\}$ in each state x, factor prices $\{w,r\}$, income tax function $\{\mathcal{T}(\cdot)\}$, social security benefit $\{ss\}$, unemployment insurance tax $\{\tau_g\}$, a lump-sum transfer of accidental bequests $\{b\}$ and the measure $\{\mu(x)\}$ over the state space of households satisfy the following conditions.

1. Households' allocation rules solve their recursive optimization problems defined in Section 2.7.
2. Factor prices are determined competitively, i.e. w=$F_L(K,L)$ and $r = F_K(K,L) - \delta$.

3. The labor and capital markets clear:

$$L = \sum_x \varepsilon_j z l(x)\mu(x), \tag{6}$$

$$K + D = \sum_x [a(x) + b]\mu(x). \tag{7}$$

4. The income tax function satisfies the government budget constraint:

$$G + (1+r)D = \sum_x [\mathcal{T}(y(x)) + \tau_c c(x)]\mu(x) + D'. \tag{8}$$

5. The social security budget is balanced:

$$ss \sum_x \mu(x|j \geq j_R) = \tau_{ss} \sum_x w\varepsilon_j z l(x)\mu(x). \tag{9}$$

6. The unemployment benefits are financed by unemployment insurance tax on earnings:

$$\sum_x \gamma(x)\mu(x) = \tau_g \sum_x w\varepsilon_j z l(x)\mu(x). \tag{10}$$

7. The goods market clears:

$$\sum_x c(x)\mu(x) + K' + G = Y + (1-\delta)K. \tag{11}$$

8. The lump-sum bequest transfer is equal to the amount of assets left by the deceased:

$$b \sum_x \mu(x) = \sum_x a(x)(1-s_{j-1})\mu(x). \tag{12}$$

9. The distribution μ is time invariant. The law of motion for the distribution of households over the state space satisfies $\mu = R_\mu \mu$, where R_μ is a one-period transition operator on the distribution, i.e. $\mu_{t+1} = R_\mu \mu_t$.

3. Calibration

The model period is bi-monthly. Table 1 summarizes the parametrization of the model.

3.1. Demographics

Households enter the economy at age 20, retire from work at age 66 and live up to the maximum age of 100. We use the study of Bell and Miller (2005) for the age-dependent conditional survival probabilities in the US. The growth rate g of the new entrants to the economy is set at an annual rate of 1.2% to match the average population growth in the US during 1950–2000.

3.2. Preference, endowment and technology

Preference: We assume the following period utility function.

$$u(c, 1-l) = \frac{[c^\eta (1-l)^{1-\eta}]^{1-\sigma}}{1-\sigma}, \tag{13}$$

η determines the preference weight on consumption relative to leisure, which we calibrate so that workers on average spends one-third of their disposable time for market work. σ is set at 4.0. The calibrated values of σ and η imply that the intertemporal elasticity of substitution is approximately 0.5.[6] The subjective discount factor β is set so that the capital-output ratio in the benchmark model is 2.7.

Endowment: The deterministic age-dependent labor productivity ε_j is based on the earnings data of US Census (2005) for full-time male workers in different age groups. For the ability type z, we assume that there are two types of agents, that we call high and low. The ratio of the productivity of the two types is set at 1.8 and the fraction of the high type at 0.3, corresponding to the average college wage premium and a share of college graduates reported in Heathcote et al. (2010).

The transition matrix of employment status P_n is calibrated to match the average duration of unemployment at 3 months (1.5 model periods) and unemployment rate of 5%, based on the long-run average in 1950–2000 in the US.

Technology: The income share of capital α is set at 0.36. The annual depreciation rate δ is $0.081 = Inv./Y/K/Y - g$, which is implied by the equilibrium law of motion for the capital in the steady state, where we target an investment-output ratio $Inv./Y$ of 25% and an annual capital-output ratio K/Y of 2.7. The productivity parameter A is determined so that the average income is normalized to 1.0 in the benchmark equilibrium.

[6] The coefficient of relative risk aversion is given by $1-\eta(1-\sigma)$.

Table 1
Parameters of the model.

Parameter	Description	Values
Demographics		
g	Population growth rate (annual)	1.2%
$\{s_j\}_{j=1}^J$	Conditional survival probabilities	Bell and Miller (2005)
J	Maximum age	100 years old
j_R	Retirement age	66 years old
Preference		
β	Subjective discount factor (annual)	1.0031
η	Weight on consumption	0.380
σ	Risk aversion ($CRRA = 1-\eta(1-\sigma)$)	4.0
Technology and production		
α	Capital share	0.36
δ	Depreciation rate of capital (annual)	8.1%
Government		
$\{\kappa_0,\kappa_1,\kappa_2\}$	Income tax parameters (progressive part)	{0.258,0.768,5.173}
τ_y	Income tax parameter (proportional part)	5.39%
τ_c	Consumption tax rate	6.0%
G	Government spending	20% of GDP
D	Government debt	40% of GDP
τ_{ss}	Social security tax rate	10.6%
τ_g	Unemployment insurance tax rate	2.6%
$\Gamma(\cdot)$	Unemployment insurance benefit	50% replacement rate

3.3. Government

The government expenditures G is set at 20% of the aggregate output in the benchmark economy, which is the average ratio of government consumption expenditures and investment to GDP excluding transfers, at the federal, state and local levels (The Economic Report of the President 2007). The ratio of federal debt held by the public D to GDP is set at 40%, which is the value in 2008.

The income tax function $\mathcal{T}(\cdot)$ consists of two parts, a non-linear progressive income tax and a proportional income tax. The non-linear part captures the progressive income tax schedule in the US following the functional form studied by Gouveia and Strauss (1994), while the proportional part stands in for all other taxes, that is, non-income and non-consumption taxes, which for simplicity are lumped together into a single proportional tax τ_y levied on income. The tax function is given as

$$\mathcal{T}(y) = \kappa_0\{y-(y^{-\kappa_1}+\kappa_2)^{-1/\kappa_1}\}+\tau_y y. \tag{14}$$

To preserve the shape of the tax function estimated by Gouveia and Strauss, their parameter estimates $\{\kappa_0,\kappa_1\} = \{0.258, 0.768\}$ are used and the scaling parameter κ_2 is chosen within the model such that the share of government expenditures raised by the progressive part of the tax function equals 70%, which matches the fraction of total revenues financed by income tax at the federal, state and local levels in the US (OECD Revenue Statistics, 2007).[7] The proportional rate τ_y is chosen in equilibrium to balance the overall government budget. We assume a consumption tax rate of 6% based on Mendoza et al. (1994).

The social security tax rate τ_{ss} is set at 10.6%, corresponding to the part of the Old-Age, Survivors, and Disability Insurance (OASDI) taxes that is allocated to the Old-Age and Survivors Insurance (OASI) Trust Fund. The social security benefit ss is determined in equilibrium so that the program is self-financed in the benchmark economy.[8]

Unemployment benefits replace 50% of the earnings at the previous employment. The tax rate τ_g on earnings that covers the benefits in equilibrium is 2.6%.

4. Policy experiments

We now study the effects of short-run policies. Sections 4.1 and 4.2 analyze the effect of tax-cut and rebate transfer, respectively. We assume that the economy is initially in a steady state described and calibrated above and we call it as the "initial steady state" in period 0. In period 1, an unexpected temporary change in the fiscal policy is announced and

[7] Parameter κ_0 is the limit of marginal taxes in the progressive part as income goes to infinity, κ_1 determines the curvature of marginal taxes and κ_2 is a scaling parameter, which varies with the unit of measurement.

[8] We abstract from the dependence of social security benefit on the history of each household's earnings. Incorporating the dependence may increase the magnitude of responses in labor supply to a policy through additional incentive channels.

Table 2
Temporary income tax-cut: effects on aggregate variables.

Year	Capital	Labor	Output	Cons.	Interest rate (%)	Wage	Inv./Y (%)	Income tax τ_y (%)	Debt
Initial S.S.	100.0	100.0	100.0	100.0	5.39	100.0	25.0	5.39	100.0
5% tax-cut: 1 year									
6 months	100.3	105.6	103.7	102.4	5.86	98.1	26.4	0.39	103.9
1	100.7	105.5	103.7	102.5	5.81	98.3	26.4	0.39	107.8
2	100.8	99.9	100.2	100.4	5.31	100.3	24.9	5.41	107.8
5	100.5	99.8	100.1	100.2	5.33	100.2	24.9	5.45	107.8
10	100.2	99.8	100.0	100.1	5.35	100.1	24.9	5.50	107.8
30	99.3	99.8	99.6	99.7	5.43	99.8	24.9	5.63	107.8
Final S.S.	98.8	99.8	99.4	99.5	5.47	99.7	24.9	5.70	107.8
5% tax-cut: 5 years									
6 months	100.2	105.2	103.4	102.7	5.83	98.3	26.0	0.39	104.0
1	100.6	105.2	103.5	102.9	5.79	98.4	26.0	0.39	108.0
2	101.2	105.2	103.7	103.1	5.73	98.6	26.1	0.39	116.1
3	101.9	105.2	104.0	103.3	5.68	98.8	26.1	0.39	124.2
4	102.5	105.2	104.2	103.5	5.62	99.1	26.2	0.39	132.2
5	103.2	105.2	104.4	103.7	5.56	99.3	26.3	0.39	140.2
6	103.0	99.2	100.6	101.2	5.06	101.4	24.7	5.69	140.2
10	101.7	99.1	100.0	100.6	5.16	101.9	24.7	5.93	140.2
30	97.0	98.7	98.1	98.6	5.55	99.4	24.4	6.73	140.2
Final S.S.	93.7	98.4	96.7	97.0	5.83	98.3	24.2	7.25	140.2

The levels for capital, labor, output, consumption, wage and debt are normalized so that they take a value of 100.0 in the initial steady state.

implemented. It is a one-time change in the fiscal policy and there is no policy uncertainty thereafter. Once the temporary policy ends, the economy will make a transition to another steady state, which we call the "final steady state." In Section 4.3, we consider the same short-run policies in an economy that faces aggregate shocks.

Under both temporary policies, expenditures of the government G (not including the cost of rebate transfers) are assumed to remain at the same level as in the initial steady state.[9] In order to focus on the economic and welfare effect of changes in particular temporary policy, we assume that other government policies are unchanged during the transition. In particular, the tax and benefit of social security and unemployment insurance remain constant after the policy change. The following consolidated budget constraint of the government will be satisfied by an adjustment of a particular policy parameter during the transition, for example, by the increase (or decrease) in the government debt, as specified in each policy experiment. In Section 5.1, we consider alternative policies to finance the transition.

$$G+(1+r)D+ss\sum_x \mu(x|j \geq j_R)+\sum_x \gamma(x)\mu(x|n=u) = \sum_x [\mathcal{T}(y(x))+\tau_c c(x)]\mu(x)+D'+\tau_{ss}\sum_x w\varepsilon_j zl(x)\mu(x)+\tau_g\sum_x w\varepsilon_j zl(x)\mu(x). \quad (15)$$

The algorithm for the computation of the transition dynamics is described in Appendix A.

4.1. Temporary tax-cut

In this section we study the effects of a temporary reduction in income taxation. We consider a universal 5% tax-cut, by reducing the proportional part τ_y of the income tax function (14) by 5%. The tax-cut will last for one and five years under two policies that we consider. While the tax rate is kept low, the government budget constraint is satisfied by adjusting the amount of outstanding government debt. Once the tax-cut ends, the debt level is fixed thereafter and the tax rate τ_y will adjust to satisfy the government budget.

The effects on the macroeconomic variables during the transition and in the long-run are summarized in Table 2. The temporary tax-cuts bring strong incentive effects on households' optimal decisions as they try to exploit the temporarily high returns from renting additional capital and labor. Hours of work increase during the years of lower taxation and the aggregate labor supply rises by more than 5% under both policies. Households save more and the aggregate capital will rise during the low-tax periods.

The temporarily high income is used not only for savings but also for consumption, which increases by more than 2% in aggregate during the one-year tax-cut period and by about 3% during the five-year tax-cut. Relatively more resources, however, out of the additional income are allocated to savings due to the strong substitution effect, as households are willing to substitute future for the current consumption, faced with a higher after-tax return from savings. These results are consistent with the findings in Auerbach and Kotlikoff (1987). The investment-output ratio rises from 25.0% to 26.4% under the one-year tax-cut and 26.3% under the five-year tax-cut.[10] Mainly driven by the rise in labor supply, the economy enjoys a rapid economic growth and a higher output. In the first year, output increases by more than 3% under both

[9] Public expenditures continue to be treated as a "waste thrown into the ocean", which does not contribute to anything in the model.
[10] The investment-output ratio is defined as $(Y-C-G)/Y$.

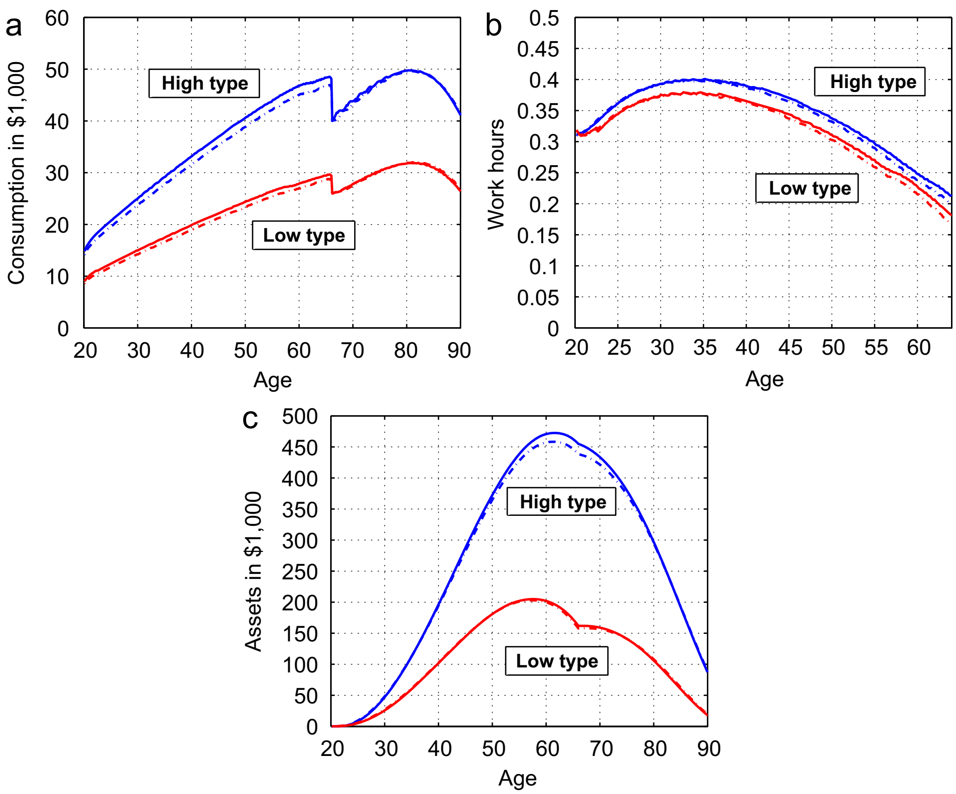

Fig. 1. Consumption, labor supply and wealth over the life-cycle: initial steady state (solid lines) and final steady state implied by a five-year tax-cut (dotted lines): (a) Consumption, (b) Labor supply and (c) Wealth.

tax-cuts. Since saving responds more slowly and relatively less than the labor supply, the capital-labor ratio falls, which leads to a higher interest rate and a lower wage during the policy periods.

The lost tax revenue during the tax-cut is financed by a new issue of government debt, which increases by about 8% with a one-year tax-cut and more than 40% with a five-year tax-cut. Once the temporary policy expires, the income tax will jump up, above the level that prevailed prior to the tax-cut, since the debt accumulated during the low-tax periods has to be serviced and adds to the government spendings. In response to the tax increase, the labor supply falls below the level prior to the tax-cut and capital also starts to decline though more gradually than labor. As a result, the interest rate falls and the wage rises immediately after the end of the tax-cut. As the income tax base shrinks, the tax rate continues to rise and reaches 5.70% and 7.25% in the final steady state. As a consequence of the higher government debt, the private capital is severely crowded out in the long-run and goes down by 1.2% and 6.3%, respectively, under the two policies. Since capital falls by much more than labor in the final steady state, the interest rate will be higher than in the initial steady state. Output goes down and stays at 0.6% and 3.3% below the original level before the tax-cut.

Fig. 1 displays the allocation of consumption, labor supply and wealth over the life-cycle, in the initial and final steady state implied by the five-year tax-cut.[11] Both consumption and labor are lower in the final steady state for most of the life-cycle. The wealth falls for both types of households but the decline is more pronounced for the high-type.[12] A lower wage and a higher tax reduce the after-tax return of work and discourage work effort, which together reduce the disposable income for consumption. Also, there is a reallocation of consumption and labor supply across ages. Fig. 2 shows the changes in consumption and labor supply in the final steady state relative to the initial steady state, expressed in log difference for high type workers.[13] Both types of households consume less at younger ages and relatively more at old ages in the final steady state. Labor supply shifts in the opposite direction and agents work slightly longer when they are very young but hours are much shorter at old ages. The differential effects on the life-cycle profiles are driven by the shift in factor prices. A higher interest rate in the final steady state due to the crowding out of capital increases the optimal growth

[11] Figures for the one-year tax-cut are very similar to those of the five-year tax-cut qualitatively though the policy effects are smaller quantitatively. They are not displayed here to save space and available upon request from the author.

[12] We do not allow for borrowing, but few households are borrowing constrained as shown in the figure, except for the very young households during the initial years of entry to the economy. Households in the model start to accumulate savings at the early stage of life-cycle due to the precautionary saving motives and retirement reasons, as in the life-cycle model of Gourinchas and Parker (2002).

[13] Figures for low type workers are not displayed here but they are very similar to those of high type workers.

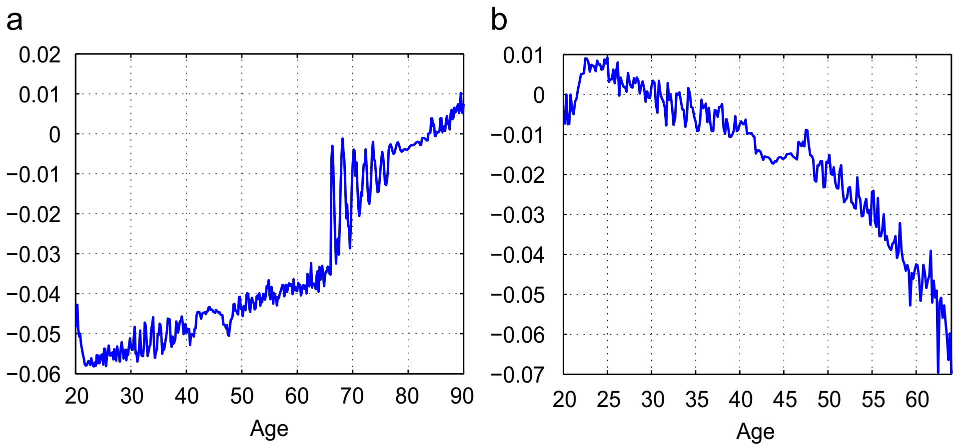

Fig. 2. Changes in consumption and labor supply in the final steady state relative to the initial steady state for high type workers (expressed in log difference): (a) Consumption and (b) Labor supply.

Table 3
Welfare effects of temporary income tax-cut.

Duration of tax-cut	1 year		5 years	
Type	Low (%)	High (%)	Low (%)	High (%)
Transitional welfare (*CEV*)				
All	0.21	0.24	0.91	0.99
Newborn	0.03	0.01	0.04	−0.06
Age 20–30	0.10	0.10	0.43	0.39
Age 31–40	0.24	0.25	1.05	1.10
Age 41–50	0.31	0.34	1.37	1.47
Age 51–65	0.31	0.34	1.23	1.38
Age 66 up	0.14	0.19	0.59	0.80
Measure of negative CEV				
Conditional on types	0.00	0.03	0.00	2.03
Long-run welfare (*CEV*)				
Newborn	−0.39	−0.42	−2.40	−2.62

rate of consumption, which also makes steeper the downward slope of labor supply during middle and old ages. Since both consumption and labor profiles become steeper and less smooth over the life-cycle, the changes in distribution across ages work negatively on welfare of households.

Transitional and long-run welfare effects of the two policies are summarized in Table 3. Welfare gain (or loss) is expressed in terms of consumption equivalent variation (CEV). It measures a percentage change in consumption across all possible states of the economy in the initial steady state that makes the household indifferent between the two economies with and without a policy change. A positive number implies that households are better off with the temporary policy and a negative number implies that they prefer to stay in the initial steady state.

As shown in the bottom row of the table, the long-run welfare effect is negative, −0.39% and −0.42% in consumption equivalence for the two types of households under the one-year tax-cut and −2.40% to −2.62% under the five-year tax-cut. As shown in Table 2, in the final steady state, aggregate consumption falls by 0.5% and 3.0%, respectively, under the two policies, due to the eventual crowd-out of capital and lower output. The marginal fall in labor (and an increase in leisure) is not large enough to wipe out the utility loss from lower consumption and the net welfare effect is negative in the long-run.

The welfare picture, however, changes dramatically in the short-run. The great majority of households in the economy will benefit from the temporary tax-cuts. Households that are alive at the time of the policy change will fully enjoy the short-term benefit of higher after-tax returns from work and saving, while the fiscal cost of the benefit is not shared equally and more will be borne by younger and future generations. The welfare effect is positive and larger for middle to old age households since they will also benefit from higher (pre-tax) return on their savings during the initial years of transition.

Table 4
Rebate transfer: effects on aggregate variables.

Year	Capital	Labor	Output	Cons.	Interest rate (%)	Wage	Inv./Y (%)	Income tax τ_y (%)	Debt
Initial S.S.	100.0	100.0	100.0	100.0	5.39	100.0	25.0	5.39	100.0
$2,000 rebate transfer									
6 months	99.9	99.9	99.9	100.1	5.38	100.0	24.9	5.39	111.0
1	99.9	99.9	99.9	100.1	5.39	100.0	24.9	5.39	111.1
2	99.9	99.7	99.8	100.0	5.37	100.1	24.8	5.63	111.1
5	99.7	99.7	99.7	99.9	5.39	100.0	24.8	5.65	111.1
10	99.4	99.7	99.6	99.8	5.41	99.9	24.8	5.68	111.1
30	98.8	99.7	99.3	99.5	5.46	99.7	24.8	5.74	111.1
Final S.S.	98.6	99.7	99.3	99.4	5.49	99.6	24.8	5.76	111.1
$5,000 rebate transfer									
6 months	99.9	100.0	100.0	100.3	5.40	100.0	24.9	5.39	127.4
1	99.9	100.0	100.0	100.2	5.40	100.0	24.9	5.39	127.7
2	99.7	99.2	99.4	99.8	5.33	100.2	24.7	6.15	127.7
5	99.2	99.1	99.2	99.5	5.38	100.0	24.7	6.21	127.7
10	98.4	99.1	98.8	99.2	5.45	99.7	24.6	6.29	127.7
30	96.7	99.0	98.2	98.5	5.60	99.2	24.5	6.45	127.7
Final S.S.	96.0	99.0	97.9	98.2	5.67	98.9	24.4	6.50	127.7

The levels for capital, labor, output, consumption, wage and debt are normalized so that they take a value of 100.0 in the initial steady state.

4.2. Rebate transfer

In this section we study the effect of a one-time rebate transfer. We consider a transfer of $2,000 and $5,000 to each household.[14] The additional expenditures for the transfer are financed by a rise in the debt, which absorbs the fiscal imbalance for one year after the transfer. As with the temporary tax-cut policies, the debt level is fixed thereafter and the income tax will adjust to satisfy the government budget constraint. The effects on macroeconomic variables are summarized in Table 4.

Since the tax schedule is fixed during the first year, there is no positive incentive effect or temporary boost in the labor supply or savings, as under the temporary tax-cuts. On the contrary, the labor supply declines slightly due to the income effect as the disposable income rises with the rebate transfer. The government debt has to rise in order to finance additional expenditures, which crowds out the private capital and the investment-output ratio falls under both policies. Note that, however, the total wealth of households, that is, the sum of the private capital and government debt held by households, rises upon the policy and it goes up by 1.4% and 3.5% under the two policies relative to the initial steady state, much larger than the small increase in consumption. The finding that most of a temporary rebate transfer is used to increase the saving is consistent with recent empirical evidence.[15] After the first year, the income tax rises to service the additional debt accumulated to finance the rebate. As with the temporary tax-cut, the higher tax will discourage work effort and saving, reducing the income tax base, and the proportional tax τ_y will rise and reach 5.76% and 6.50% in the final steady state.

In the long-run, the private capital declines by 1.4% and 4.0%, respectively, and the labor supply declines as well due to the higher distortionary taxation and a lower wage. The change in the life-cycle profiles of consumption and labor supply is similar to those under tax-cut policies, since the long-run effects on the economy are common in both policies, driven by higher debt and taxation, lower capital and higher interest rate.

Transitional and long-run welfare effects of the rebate policy are summarized in Table 5. As with the tax-cut, the long-run welfare effects are negative, especially under the rebate of $5,000, where capital goes down significantly and aggregate consumption declines by about 2%. The policies, however, bring a sizeable gain to some of the currently alive households that go through the transition. Unlike with the tax-cut, where the dollar benefit of the policy is proportional to the level of income, the rebate is a lump-sum and favors the low type households with lower income more than a tax-cut. Nearly all low type households enjoy a welfare gain from the policy, while about half of high type households experience a welfare loss. Under the $5,000 rebate policy, the average consumption equivalent variation for low-type workers is 0.52%, while it is close to zero for high type workers.[16]

[14] A rebate of $2,000 and $5,000 each corresponds to about 4.4% and 10.9% of average income (relative to GDP per capita of $46,000 in 2007).

[15] Shapiro and Slemrod (2009) use survey techniques to study the effect of the 2008 tax rebates provided under the Economic Stimulus Act of 2008. Only one-fifth of the respondents who received the rebate said the rebate would be used to mostly increase spending and the rest said they would use it to pay off debt or save more. See also Shapiro and Slemrod (2003) that study the effect of tax rebates in 2001 based on the Economic Growth and Tax Relief Reconciliation Act of 2001 and present similar findings.

[16] If we imposed a cap on the earnings as the recent rebate policy did, the difference in the welfare effect would be even larger.

Table 5
Welfare effects of rebate transfer.

Amount of transfer	$2,000		$5,000	
Type	Low (%)	High (%)	Low (%)	High (%)
Transitional welfare (CEV)				
All	0.26	0.08	0.52	0.05
Newborn	0.19	−0.02	0.12	−0.43
Age 20–30	0.10	−0.10	0.03	−0.48
Age 31–40	0.13	−0.03	0.16	−0.28
Age 41–50	0.20	0.06	0.39	0.00
Age 51–65	0.33	0.17	0.75	0.35
Age 66 up	0.63	0.39	1.52	0.91
Measure of negative CEV				
Conditional on types	0.00	42.42	0.01	53.71
Long-run welfare (CEV)				
Newborn	−0.46	−0.50	−1.42	−1.55

4.3. Aggregate shocks to the economy

In this section we study the effects of temporary tax-cut and transfer policies when the economy faces aggregate shocks that negatively affect economic activities. More precisely, we consider what we call a "recession" that is triggered by an exogenous decline in productivity and a rise in unemployment risks.

In period 1, the shock hits the economy and the total factor productivity in production falls and households face an elevated risk of being unemployed. The inflow rate to unemployment and the likelihood of remaining unemployed both rise by 50%. The transition probabilities between employment and unemployment remain at this level for one year and gradually return to the initial steady state level during the following year. The unemployment rate will rise from 5% in the initial steady state to the peak of 9.5% after a year of the shock before it starts to fall and returns to the original level.[17] The one-time productivity shock that hits the economy is persistent with the persistence coefficient of 0.95 on a quarterly basis, in the range of estimates in the literature.[18] We assume that the productivity falls by 3% upon the shock, which together with the decline in employment implies the output decline of 4–5% during the first year of the recession in the baseline scenario that we discuss below. The output will reach a bottom of 7% below the steady state level during the second year.[19]

We consider different policy options to respond to the temporary shocks in the short-run, in particular, during the initial year of the recession and study how the economy responds to the stimulus policy under unfavorable economic conditions in the short run (within the year) and medium run (2–10 years).

We assume that the government will let the borrowing absorb the shock to the consolidated budget in Eq. (15) during the first year of the recession except for a five-year tax-cut policy in which the debt adjusts for five years. The magnitude of the adjustment will differ by the policies implemented during the year. Thereafter the government debt will gradually fall and return to the initial steady state level over the next five years and the income tax τ_y will adjust to satisfy the budget during the transition. Note that in this section we focus on short-run policies in response to short-run shocks, without long-run consequences. The economy will eventually converge to the final steady state, which is identical to the initial steady state.

In the baseline scenario without a short-run stimulus policy, all the government policies will remain unchanged during the first year of the recession except for the government debt. Table 6 summarizes the results. The top part of the table shows the changes in aggregate variables under the baseline scenario, in which no stimulus policy is implemented. Upon the shock, the returns on capital and labor fall immediately. Interest rate falls from 5.39% to 4.89% and wage rate falls by more than 2%. The government debt has to rise by about 5% to make up for the lower tax revenues due to the depressed economic activities. Investment falls immediately and output declines by about 5% in the first year. When the debt begins to fall, the income tax has to rise by about 2 percentage points.

If the government reduces the income tax to stimulate the economy during the recession, it can partially offset the negative effect of the shocks, as shown in the second and third blocks of Table 6. The labor supply will be above the initial steady state level during the policy period and the decline in capital and investment is greatly mitigated as well.[20] Once,

[17] This level of unemployment is in the same order of magnitude as to the peak level of unemployment rate in the recent recession.

[18] See for example Smets and Wouters (2007).

[19] Note that the model is "detrended" in that the productivity remains constant in the steady state. Adding the average output growth rate of 3%, the peak decline of output by 4% corresponds to the decline in the real GDP that the U.S. economy experienced during the second year of the recent recession that officially started in December 2007.

[20] The responses in the intensive margin, that is, the changes in the labor supply relative to the baseline case with no stimulus policy, are in the same order of magnitude as in the experiments without aggregate shocks.

Table 6
Short-run fiscal policy in a model with aggregate shocks.

Year	Capital	Labor	Output	Cons.	Interest rate (%)	Wage	Inv./Y rate (%)	Income tax τ_y (%)	Debt
Initial S.S.	100.0	100.0	100.0	100.0	5.39	100.0	25.0	5.39	100.0
Baseline: no stimulus policy									
6 months	99.7	98.4	96.2	98.8	4.89	97.7	22.8	5.39	101.8
1	99.1	97.4	95.6	98.4	4.89	98.1	22.5	5.39	104.8
2	98.0	96.6	94.9	97.3	4.98	98.5	22.6	7.37	103.9
5	96.7	98.6	96.7	97.7	5.41	98.2	23.8	6.57	101.0
10	96.4	99.8	98.1	98.2	5.64	98.4	24.6	5.82	100.0
30	98.6	100.1	99.5	99.4	5.52	99.5	25.0	5.46	100.0
5% *tax-cut*: 1 *year*									
6 months	100.0	104.0	99.8	100.9	5.35	95.9	24.3	0.39	105.6
1	99.8	102.7	99.1	100.5	5.28	96.5	24.1	0.39	112.5
2	98.4	94.7	94.0	96.6	4.78	99.3	22.2	8.92	110.0
5	96.3	97.1	95.7	96.9	5.31	98.6	23.4	7.91	102.5
10	95.7	99.6	97.8	97.9	5.69	98.2	24.5	6.00	100.0
30	98.2	100.1	99.4	99.2	5.56	99.3	24.9	5.49	100.0
5% *tax-cut*: 5 *years*									
6 months	100.0	103.8	99.7	101.1	5.33	95.9	24.2	0.39	105.6
1	99.7	102.8	99.3	100.8	5.30	96.4	24.0	0.39	112.5
2	99.3	104.0	100.4	100.9	5.51	96.3	24.8	0.39	125.4
3	99.3	104.9	101.4	101.3	5.65	96.4	25.3	0.39	136.2
4	99.5	105.1	101.9	101.5	5.69	96.7	25.6	0.39	147.3
5	100.0	105.0	102.2	101.6	5.67	97.2	25.8	0.39	158.1
6	99.1	90.1	91.6	95.2	4.45	102.5	21.0	13.91	146.5
10	94.7	90.8	90.9	93.6	4.96	101.1	21.3	14.18	100.0
30	97.7	100.2	99.2	99.0	5.61	99.1	25.0	5.53	100.0
$2,000 *rebate transfer*									
6 months	99.7	98.5	96.3	98.7	4.90	97.7	22.8	5.39	112.7
1	99.1	97.4	95.6	98.3	4.89	98.1	22.6	5.39	115.9
2	97.6	94.4	93.2	96.1	4.82	99.1	21.8	9.47	112.7
5	95.7	97.0	95.1	96.4	5.35	98.4	23.2	8.37	103.2
10	95.3	99.7	97.7	97.6	5.74	98.0	24.6	6.07	100.0
30	98.1	100.1	99.3	99.1	5.57	99.3	25.0	5.54	100.0
$5,000 *rebate transfer*									
6 months	99.7	99.0	96.6	98.5	4.94	97.5	23.2	5.39	129.1
1	99.2	97.8	95.9	98.0	4.91	98.0	23.0	5.39	132.3
2	97.1	90.4	90.7	94.2	4.49	100.5	20.8	12.87	125.8
5	93.4	92.9	91.9	93.9	5.19	99.1	22.0	11.84	106.5
10	92.7	99.5	96.6	96.4	5.97	97.1	24.4	6.54	100.0
30	96.9	100.0	98.8	98.5	5.67	98.9	24.9	5.72	100.0
For all experiments									
Final S.S.	100.0	100.0	100.0	100.0	5.39	100.0	25.0	5.39	100.0

The levels for capital, labor, output, consumption, wage and debt are normalized so that they take a value of 100.0 in the initial steady state.

however, the short-run stimulus ends, the economy will face a much higher tax that is required to repay and service the larger amount of debt, which negatively affects the economic incentives. Labor supply will fall sharply immediately after the 1-year and 5-year tax-cut policies end and it will remain lower during the transition in the medium run than in the baseline scenario without a stimulus.

If the tax-cut lasts longer, the government can alleviate the negative effects on output and consumption for a longer period, but the debt can rise by significantly more over time. As a result, the fiscal burden postponed to future can be much larger and severely harm the economic activities in the medium horizon.

The transfer policy does not have a strong impact on labor supply during the first year when tax rates are kept constant. The rise, however, in debt and the income tax once the policy ends will have a significant negative effect on both labor supply and savings of households. Unlike with the rebate policy in the economy without aggregate shocks that we studied in Section 4.2, the policy does not raise the consumption during the policy periods. Anticipating a significant increase in future taxes, households try to allocate more resources for saving than consumption.

5. Sensitivity analysis and extensions

5.1. Alternative financing schemes

In this section, we consider two alternative ways to finance the transition after the short-run fiscal policy ends. In Section 5.1.1, instead of adjusting the income tax once the stimulus is over, we let the consumption tax adjust and achieve the fiscal balance during the transition. In Section 5.1.2, we let the government drive down the debt that was accumulated to finance the stimulus and repay it gradually so that the outstanding debt will return to the initial steady state level over a five-year period. For both experiments, we present the results of a five-year tax-cut and a rebate of $5,000.

5.1.1. Adjustment in consumption tax

This section presents the effect of a five-year tax-cut and rebate transfer of $5,000, in which the consumption tax is adjusted to balance the government budget once the policy period ends. Results are summarized in Table 7.

The five-year tax-cut policy will stimulate the labor supply and savings in about the same magnitude as in the baseline case studied above. The labor supply will rise by 5% during the policy period and capital by about 3% in the last year of the policy. The medium to long-run effects, however, are very different. Without the distortionary effect of income taxation on work and saving incentives, the capital and labor do not fall as much when the transition is financed by the consumption tax. In the long-run, the consumption tax will reach 7.6%, but the capital and labor will be lower than the initial steady state only by 2.6% and 0.7%, respectively, while they declined by 6.3% and 1.6% when the income tax financed the transition. As a result, the aggregate consumption will be higher, only 1.3% below the original level compared to a decline of 3.0% in the baseline case. The transfer policy also has the effects that are similar to those in the baseline experiment in the short-run. The long-run negative effects on labor and capital are also mitigated by keeping the income tax lower at the initial steady state level.

The welfare effect of the policy is summarized in Table 8. The long-run welfare loss is significantly lower. When the income tax is adjusted during the transition, the five-year tax-cut brings about a welfare loss of 2.4% and 2.6% for the two types of households in the long-run, but with a consumption tax adjustment, welfare loss goes down to less than 1% in consumption equivalent variation. Similar qualitative observations can be made for the rebate policy financed by the consumption tax. The long-run decline in capital, labor and output is smaller and the welfare loss is smaller in the long-run. Currently alive households continue to have a welfare gain on average in both experiments, but the welfare gain for middle to old households is smaller than under the baseline experiments, since a rise in consumption tax will hurt the old more than the young while they do not benefit as much from a lower tax on earnings.

Table 7
Transition financed by consumption tax.

Year	Capital	Labor	Output	Cons.	Interest rate (%)	Wage	Inv./Y rate (%)	Cons. tax τ_c (%)	Debt
Initial S.S.	100.0	100.0	100.0	100.0	5.39	100.0	25.0	6.00	100.0
5% tax-cut: 5 year									
6 months	100.2	105.1	103.3	102.7	5.82	98.3	26.0	6.00	104.0
1	100.5	105.1	103.4	102.9	5.79	98.4	26.0	6.00	108.0
2	101.2	105.1	103.7	103.1	5.73	98.6	26.0	6.00	116.1
3	101.8	105.1	103.9	103.3	5.68	98.9	26.0	6.00	124.4
4	102.3	105.0	104.1	103.6	5.62	99.1	26.1	6.00	132.8
5	102.8	104.9	104.2	103.7	5.57	99.3	26.1	6.00	141.4
6	102.7	99.2	100.4	101.1	5.08	101.2	24.7	6.44	141.4
10	101.5	99.2	100.0	100.6	5.18	100.8	24.7	6.68	141.4
30	98.5	99.3	99.0	99.3	5.46	99.7	24.7	7.33	141.4
Final S.S.	97.4	99.3	98.6	98.7	5.56	99.3	24.7	7.60	141.4
$5,000 *rebate transfer*									
6 months	99.9	99.7	99.8	100.4	5.37	100.1	24.7	6.00	127.4
1	99.9	99.8	99.8	100.3	5.38	100.0	24.7	6.00	127.9
2	99.8	99.5	99.6	99.8	5.37	100.1	24.8	6.74	127.9
5	99.5	99.5	99.5	99.7	5.39	100.0	24.8	6.78	127.9
10	99.3	99.5	99.4	99.6	5.41	99.9	24.8	6.84	127.9
30	98.6	99.5	99.2	99.3	5.47	99.7	24.8	6.98	127.9
Final S.S.	98.2	99.5	99.1	99.2	5.50	99.5	24.8	7.04	127.9

The levels for capital, labor, output, consumption, wage and debt are normalized so that they take a value of 100.0 in the initial steady state.

Table 8
Welfare effects: transition financed by consumption tax.

Type	5 year tax-cut		$5,000 transfer	
	Low (%)	High (%)	Low (%)	High (%)
Transitional welfare (CEV)				
All	0.68	0.84	0.42	0.03
Newborn	0.26	0.27	0.57	0.14
Age 20–30	0.52	0.59	0.40	0.01
Age 31–40	0.89	1.04	0.30	−0.03
Age 41–50	1.01	1.19	0.25	−0.05
Age 51–65	0.75	0.96	0.28	−0.06
Age 66 up	0.23	0.45	0.91	0.34
Measure of negative CEV				
Conditional on types	0.29	0.00	0.00	72.84
Long-run welfare (CEV)				
Newborn	−1.04	−1.09	−0.68	−0.71

Table 9
Transition financed by income tax and debt returning to the original level.

Year	Capital	Labor	Output	Cons.	Interest rate (%)	Income wage	Inv./Y (%)	Tax τ_y (%)	Debt
Initial S.S.	100.0	100.0	100.0	100.0	5.39	100.0	25.0	5.39	100.0
5% *tax-cut*: 5 *year*									
6 months	100.3	105.6	103.7	102.5	5.85	98.2	26.4	0.39	103.9
1	100.7	105.6	103.8	102.6	5.82	98.3	26.4	0.39	107.8
2	101.5	105.6	104.1	102.9	5.75	98.6	26.5	0.39	115.7
3	102.2	105.6	104.4	103.1	5.68	98.8	26.5	0.39	123.6
4	103.0	105.6	104.7	103.3	5.62	99.1	26.6	0.39	131.6
5	103.7	105.4	104.9	103.4	5.53	99.4	26.7	0.39	139.6
6	102.9	93.1	96.5	98.3	4.53	103.7	23.2	11.07	131.7
10	98.6	93.1	94.9	96.8	4.88	102.1	22.8	11.39	100.0
30	99.5	100.1	99.9	99.9	5.44	99.8	25.0	5.38	100.0
Final S.S.	100.0	100.0	100.0	100.0	5.39	100.0	25.0	5.39	100.0
$5,000 *rebate transfer*									
6 months	99.9	99.5	99.7	100.5	5.35	100.1	24.5	5.39	127.5
1	99.8	99.5	99.7	100.5	5.36	100.1	24.5	5.39	128.0
2	99.7	97.1	97.7	99.2	5.15	101.0	23.7	7.85	122.4
5	99.6	97.5	98.0	98.9	5.20	100.8	24.1	7.78	105.6
10	99.8	100.2	100.1	100.0	5.43	99.8	25.1	5.30	100.0
30	100.1	100.0	100.0	100.0	5.38	100.0	25.0	5.37	100.0
Final S.S.	100.0	100.0	100.0	100.0	5.39	100.0	25.0	5.39	100.0

The levels for capital, labor, output, consumption, wage and debt are normalized so that they take a value of 100.0 in the initial steady state.

5.1.2. Debt returning to the original level

In the experiments we considered so far, we assumed that government debt absorbs the fiscal imbalance during the policy period and the level of the debt is fixed thereafter. In this section we consider an alternative scenario where the government debt will return to the initial steady state level over a five-year period once the policy ends. We assume that the government will repay the same amount of debt every period, that is, the outstanding debt will fall linearly during the five years. As in the baseline experiments, the proportional part of income tax τ_y is adjusted to achieve the budget balance during the transition. In the long-run, the economy will converge to a final steady state that is identical to the initial steady state.

We present the result for a five-year tax-cut of 5% and rebate transfer of $5,000. The debt will start to decline after five and one year once the stimulus ends in each case. Results are summarized in Table 9. The effects during the policy period are similar to the baseline case presented in Tables 2 and 4, not only qualitatively but also quantitatively. The income tax, however, has to rise more sharply after the stimulus ends in order to repay the debt and bring it to the initial steady state level. The labor supply and capital fall more significantly and the economy stagnates in the medium-run due to the negative incentive effects.

Table 10
Welfare effects: debt falls to the original level.

Type	5 year tax-cut		$5,000 transfer	
	Low (%)	High (%)	Low (%)	High (%)
Transitional welfare (CEV)				
All	0.15	0.14	0.47	−0.04
Newborn	−0.17	−0.23	0.89	0.45
Age 20–30	−0.11	−0.15	0.57	0.13
Age 31–40	0.05	0.03	0.25	−0.18
Age 41–50	0.20	0.21	0.11	−0.35
Age 51–65	0.46	0.44	0.26	−0.28
Age 66 up	0.20	0.24	1.23	0.49
Measure of negative CEV				
Conditional on types	28.36	31.38	0.12	61.83

As presented in Table 10, the average welfare gain from the transition will fall from the baseline case under both policies since the current generation will bear more of the fiscal costs associated with the short-run benefits, by having to repay the accumulated debt in the medium-run. More households that are currently alive will experience a welfare loss from the transition.

5.2. Labor supply elasticity

In the benchmark model, we used a non-separable preference of the Cobb–Douglas form as in (13), which is commonly used in the macroeconomic literature and quantitative studies of fiscal policies. The calibration implies a Frisch elasticity of labor supply at approximately unity. Though it lies in the range of the values used in the literature, the estimates vary across studies. The early studies of MaCurdy (1981), Altonji (1986) and Blundell and MaCurdy (1999) use sample data of men and estimate a small elasticity between 0.035 and 0.567. More recent estimates of the elasticity center around unity, including the study by Domeij and Floden (2006) and as surveyed in Browning et al. (1999). Imai and Keane (2004) estimate a model with human capital accumulation in a life-cycle model and estimate the elasticity at 3.8 using the National Longitudinal Youth Survey of 1979.

In this section, we use a preference that is separable in consumption and leisure of the following form

$$u(c,1-l)=\frac{c^{1-\sigma_1}}{1-\sigma_1}+\chi\frac{(1-l)^{1-\sigma_2}}{1-\sigma_2}. \tag{16}$$

We set the coefficient of relative risk aversion σ_1 at 2.0, equivalent to the baseline calibration and set the value of σ_2 at 4.0, which implies the average Frisch elasticity of labor supply at 0.5, when households allocate one-third of their disposable time to market work as we assumed before. We recalibrate the model to achieve the same calibration targets as in the baseline model.

We present the results for the tax-cut experiments. As presented in Table 11, with a lower elasticity of labor supply, households respond less in magnitude to the tax incentives provided by temporary policies. The qualitative effects, however, remain the same as in the baseline preference specification. In the case of five-year tax-cut, the labor supply increases by 3% during the policy period, driving a temporary increase in output of about 2%, while they rose by 5% and 4% under the baseline calibration. The effects of one-time transfer policies (not displayed here) are also very similar to those under the baseline calibration, though the magnitude is somewhat smaller.

6. Conclusion

This paper studied macroeconomic and welfare effects of two short-run fiscal policies; temporary tax-cut and rebate transfer. We have shown that a tax-cut will effectively provide households with incentives to work and save more and increase output in the short-run. A rebate policy does not have such incentive effects and consumption rises only marginally since most of the extra income is saved. While the short-run effects differ under the two policies, the long-run consequences are essentially the same. The economy that carries a large amount of government debt suffers from a higher tax to service the debt. Private capital is crowded out and output and consumption fall below the level prior to the temporary policies. The higher income tax gives disincentive for work and saving and generates more fiscal pressure as the income tax base shrinks. While the policies would gain a majority support from the currently alive households, future generations suffer from a welfare loss as they have to bear most of the cost of the temporary benefits. If the stimulus policies are implemented in a recession environment that is triggered by a decline in productivity and a rise in

Table 11
Short-run fiscal policy in a model with Frisch elasticity at 0.5.

Year	Capital	Labor	Output	Cons.	Interest rate (%)	Income wage	Inv./Y (%)	Tax τ_y (%)	Debt
Initial S.S.	100.0	100.0	100.0	100.0	5.39	100.0	25.0	5.37	100.0
5% *tax-cut*: 1 *year*									
6 months	100.2	103.2	102.1	100.4	5.65	99.0	26.3	0.37	41.8
1	100.6	103.1	102.2	100.5	5.61	99.1	26.3	0.37	43.6
2	100.6	99.7	100.0	100.3	5.31	100.3	24.9	5.44	43.6
5	100.3	99.8	100.0	100.2	5.34	100.2	24.9	5.46	43.6
10	100.0	99.8	99.9	100.1	5.37	100.1	24.9	5.48	43.6
30	99.4	99.9	99.8	99.9	5.44	99.8	24.9	5.53	43.6
Final S.S.	99.3	100.0	99.7	99.9	5.45	99.7	24.9	5.54	43.6
5% *tax-cut*: 5 *years*									
6 months	100.2	103.2	102.0	100.5	5.65	99.0	26.2	0.37	41.8
1	100.6	103.1	102.1	100.7	5.62	99.1	26.2	0.37	43.6
2	101.3	103.1	102.3	100.8	5.55	99.3	26.2	0.37	47.2
3	101.9	103.1	102.5	101.0	5.49	99.6	26.3	0.37	50.8
4	102.6	103.2	102.8	101.1	5.44	99.8	26.4	0.37	54.4
5	102.5	102.9	102.7	101.2	5.42	99.9	26.3	0.37	58.6
6	101.9	98.8	99.9	100.9	5.12	101.1	24.5	6.31	58.6
10	100.3	99.1	99.5	100.3	5.28	100.4	24.5	6.47	58.6
30	96.4	99.7	98.5	99.0	5.69	98.8	24.4	6.89	58.6
Final S.S.	95.1	99.9	98.2	98.5	5.83	98.2	24.4	7.04	58.6

The levels for capital, labor, output, consumption, wage and debt are normalized so that they take a value of 100.0 in the initial steady state.

unemployment risks, we show that a tax-cut can recover the incentives for work and saving and mitigate the negative effects of the aggregate shocks. The economy, however, may suffer even more in the medium run if the tax has to rise further to service and repay the debt accumulated to finance the stimulus.

Appendix A. Computation of the transition dynamics

Consider the case of a temporary tax-cut of $\tilde{N}$ periods financed by debt. Suppose that at time t=0, the economy is in the initial steady state implied by the benchmark fiscal policy. The proportional income tax rate τ_y is reduced to $\tilde{\tau}_y$ and set at this level for $\tilde{N}$ periods from t=1 to $\tilde{N}$. During the $\tilde{N}$ periods, the level of the government debt D_t is endogenously determined to satisfy the government budget constraint. After the $\tilde{N}$- th period, the tax rate τ_y becomes endogenous and the government debt is fixed throughout the transition. Assume that the economy converges to the final steady state in period t=N.[21]

1. Compute the initial steady state.
2. Guess on the sequence of general equilibrium variables $\{K_t, L_t, b_t\}_{t=1}^{N}$, and endogenous fiscal variables $\{D_t\}_{t=1}^{\tilde{N}}$ and $\{\tau_{y,t}\}_{t=\tilde{N}+1}^{N}$.[22] The guesses include the levels of these variables in the final steady state, $\{K_N, L_N, b_N, \tau_{y,N}\}$.
3. Compute the final steady state.
4. Compute the household decision rules along the transition, going backwards from period $N-1$ to 1. (Use the value functions in the final steady state computed in step 3 as the next-period values in period $N-1$.)
5. Compute the distribution along the transition. Start with the distribution in the initial steady state and compute forward from period 1 to N using the decision rules computed in step 4.
6. Compute the sequence of variables $\{K_t, L_t, b_t\}_{t=1}^{N}$ implied along the transition and check the government budget in each period. Update the guesses and go back to step 2. Repeat the iterations until the values of all the equilibrium variables converge and the government budget is satisfied every period.

[21] In practice, we choose the number of transition periods so that the economy converges to the final steady state well before the last period of the transition. In the experiments presented in this paper, we use 600 periods (100 years), which is arbitrary but long enough for the convergence in the experiments we considered.

[22] Note that the debt will be constant after the $\tilde{N}$- th period, i.e. $D_t = D_{\tilde{N}}$ for $t = \tilde{N}$ to N.

References

Aiyagari, S.R., 1994. Uninsured idiosyncratic risk and aggregate saving. Quarterly Journal of Economics 109, 659–684.
Aiyagari, S.R., Marcet, A., Sargent, T.J., Seppälä, J., 2002. Optimal taxation without state-contingent debt. Journal of Political Economy 110, 1220–1254.
Aiyagari, S.R., McGrattan, E.R., 1998. The optimum quantity of debt. Journal of Monetary Economics 42, 447–469.
Altig, D., Davis, S.J., 1989. Government debt, redistributive fiscal policies, and the interaction between borrowing constraints and intergenerational altrusim. Journal of Monetary Economics 24, 3–29.
Altonji, J.G., 1986. Intertemporal substitution of labor supply: evidence from microdata. Journal of Political Economy 94, 176–215.
Auerbach, A.J., 2002. The Bush tax cut and national saving. National Tax Journal 55, 387–407.
Auerbach, A.J., Kotlikoff, L.J., 1987. Dynamic Fiscal Policy. Cambridge University Press, Cambridge.
Barro, R.J., 1974. Are government bonds net wealth? Journal of Political Economy 82, 1095–1117
Barro, R.J., 1979. On the determination of public debt. Journal of Political Economy 87, 940–971.
Baxter, M., King, R.G., 1993. Fiscal policy in general equilibrium. American Economic Review 83, 315–334.
Bell, F.C., Miller, M.L., 2005. Life tables for the United States social security area 1900–2100. Office of the Chief Actuary, Social Security Administration, Actuarial Study 116.
Bernheim, B.D., 1987. Ricardian equivalence: an evaluation of theory and evidence. NBER Macroeconomics Annual, 263–304.
Bewley, T.F., 1986. Stationary monetary equilibrium with a continuum of independently fluctuating consumers. In: Hildenbrand, W., Mas-Colell, A. (Eds.), Contributions to Mathematical Economics in Honor of Gerald Debreu. North-Holland, Amsterdam, pp. 79–102.
Blundell, R., MaCurdy, T., 1999. Labor supply: a review of alternative approaches. In: Ashenfelter, O., Card, D. (Eds.), Handbook of Labor Economics, vol. 3A. North-Holland, Amsterdam, pp. 1559–1695.
Browning, M., Hansen, L.P., Heckman, J.J., 1999. Micro data and general equilibrium models. In: Taylor, J.B., Woodford, M. (Eds.), Handbook of Macroeconomics, vol. 1A. North-Holland, Amsterdam, pp. 543–633.
Cagetti, M., De Nardi, M., 2009. Estate taxation, entrepreneurship and wealth. American Economic Review 99, 85–111.
Castañeda, A., Díaz-Giménez, J., Ríos-Rull, J.-V., 1999. Earnings and wealth inequality and income taxation: quantifying the trade-offs of switching to a proportional income tax in the U.S. Working Paper, University of Minnesota.
Chamley, C., 1986. Optimal taxation of capital income in general equilibrium with infinite lives. Econometrica 54, 607–622.
Chari, V.V., Christiano, L.J., Kehoe, P.J., 1994. Optimal fiscal policy in a business cycle model. Journal of Political Economy 102, 617–652.
Conesa, J.C., Kitao, S., Krueger, D., 2009. Taxing capital? Not a bad idea after all!. American Economic Review 99, 25–48.
Conesa, J.C., Krueger, D., 2006. On the optimal progressivity of the income tax code. Journal of Monetary Economics 53, 1425–1450.
Domeij, D., Floden, M., 2006. The labor-supply elasticity and borrowing constraints: why estimates are biased. Review of Economic Dynamics 9, 242–262.
Erosa, A., Gervais, M., 2002. Optimal taxation in life-cycle economies. Journal of Economic Theory 105, 338–369.
Garriga, C., 2003. Optimal fiscal policy in overlapping generations models. Working paper, Florida State University.
Gourinchas, P.-O., Parker, J.A., 2002. Consumption over the life cycle. Econometrica 70, 47–89.
Gouveia, M., Strauss, R.P., 1994. Effective federal individual income tax functions: an exploratory empirical analysis. National Tax Journal 47, 317–339.
Heathcote, J., 2005. Fiscal policy with heterogeneous agents and incomplete markets. Review of Economic Studies 72, 161–188.
Heathcote, J., Storesletten, K., Violante, G.L., 2010. The macroeconomic implications of rising wage inequality in the United States. Working paper, New York University.
House, C.L., Shapiro, M.D., 2006. Phased-in tax cuts and economic activities. American Economic Review 96, 1835–1849.
Hubbard, R.G., Judd, K., 1986. Liquidity constraints, fiscal policy, and consumption. Brookings Papers on Economic Activity 1, 1–50.
Huggett, M., 1993. The risk-free rate in heterogeneous-agent incomplete-insurance economies. Journal of Economic Dynamics and Control 17, 953–969.
Imai, S., Keane, M.P., 2004. Intertemporal labor supply and human capital accumulation. International Economic Review 45, 601–641.
İmrohoroğlu, A., 1989. Cost of business cycles with indivisibilities and liquidity constraints. Journal of Political Economy 97, 1364–1383.
Judd, K.L., 1985. Redistributive taxation in a simple perfect foresight model. Journal of Public Economics 28, 59–83.
Lucas Jr., R.E., Stokey, N.L., 1983. Optimal fiscal and monetary policy in an economy without capital. Journal of Monetary Economics 12, 55–93.
MaCurdy, T.E., 1981. An empirical model of labor supply in a life-cycle setting. Journal of Political Economy 89, 1059–1085.
McGrattan, E.R., 1994. The macroeconomic effects of distortionary taxation. Journal of Monetary Economics 33, 573–601.
Mendoza, E.G., Razin, A., Tesar, L.L., 1994. Effective tax rates in macroeconomics: cross-country estimates of tax rates on factor incomes and consumption. Journal of Monetary Economics 34, 297–323.
Nishiyama, S., Smetters, K., 2005. Consumption taxes and economic efficiency with idiosyncratic wage shocks. Journal of Political Economy 113, 1088–1115.
Poterba, J.M., Summers, L.H., 1987. Finite lifetimes and the effects of budget deficits on national saving. Journal of Monetary Economics 20, 369–391.
Shapiro, M.D., Slemrod, J.B., 2003. Consumer response to tax rebates. American Economic Review 93, 381–396.
Shapiro, M.D., Slemrod, J.B., 2009. Did the 2008 tax rebates stimulate spending? American Economic Review: Papers & Proceedings 99, 374–379
Smets, F., Wouters, R., 2007. Shocks and frictions in US business cycles: a Bayesian DSGE approach. American Economic Review 97, 586–606.
Trostel, P.A., 1993. The nonequivalence between deficits and distortionary taxation. Journal of Monetary Economics 31, 207–227.