Replacing income taxation with consumption taxation in Japan

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A R T I C L E   I N F O

A B S T R A C T

Over the past two decades, Japan has suffered from low economic growth and a large and growing debt to output ratio. Furthermore, Japan anticipates significant increases in future government expenditures due to an aging population. These problems have led Japan to introduce a consumption tax rate in an attempt to raise revenues, and, more recently, to reduce the statutory corporate income tax rate to raise investment and output growth. In this paper we study the growth and welfare consequences of a reduction in income taxation in Japan along with increases in consumption taxation to stabilize the debt to output ratio. In particular, we consider various unanticipated tax reforms using the model described in Hansen and İmrohoroğlu (2016). We find that while output per working age population is projected to be roughly constant between 2015 and 2021 in the benchmark equilibrium representing the status quo, under alternative policies considered, output could be as much as 15% higher by 2021.

1. Introduction

In the last ten to twenty years, policy makers in Japan have continuously grappled with two major policy issues: recovering from low rates of economic growth and achieving fiscal consolidation. Japan's economy has experienced dismal performance since the early 1990s. The rate of growth of real Gross Domestic Product (GDP) was 4.4% between 1972 and 1990, but has dropped to only 1.0% between 1991 and 2015. In an influential paper, Hayashi and Prescott (2002) coined the term "the Lost Decade" for the prolonged stagnation during the 1990s. The stagnation has continued until the current years making it the "Lost Decades."[1] Partly because large scale fiscal stimulus packages were conducted during the lost decade, Japan's economy has accumulated the highest net debt to output ratio among developed economies. Going forward, the debt to output ratio is expected to further rise due to the projected increase in government expenditures related to the aging of the Japanese society.

Other things being equal, a higher dependency ratio leads to higher expenditures on public health expenditures and pensions, which in turn adds to the fiscal imbalance. Fig. 1 displays the predicted time paths of the government purchases and transfer payments relative to GNP.[2] Both series exhibit a clear positive trend over the next couple of decades. This paper studies unanticipated changes in tax policy that involve lowering income tax rates (labor income tax rates as well as capital income tax rates) shifting away from income taxation toward consumption taxation. The goal is to study the growth consequences as well as the welfare consequences of such policy reforms. We carry out this analysis using the model developed in Hansen and İmrohoroğlu (2016). In that paper, the implications of policies aimed at reducing Japan's debt to output ratio are studied in an environment without uncertainty–one where economic agents have perfect foresight about future government policy. Here, a similar policy is used to stabilize debt in the long run, but, in addition, unanticipated changes in tax rates are assumed to be introduced at a specified date. What we find is that policies that generate a lot of additional growth in the short run do not necessarily lead to the highest welfare relative to a benchmark case, which is based on the policy studied in Hansen and İmrohoroğlu (2016). In particular, we find that policies that reduce

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[1] As pointed out in Hayashi and Prescott (2002), a slowdown of GDP growth during the 1990s and beyond has come together with a TFP slowdown. Though our paper treats TFP movements as exogenous, given that we focus on implications of changes in tax policy, a good number of economists have explored reasons behind the TFP slowdown. Caballero et al. (2008) argue that zombie-lending has created stagnation by enabling capital and labor to remain in firms that should instead go bankrupt, leading to lower aggregate productivity than would otherwise be the case. Kwon et al. (2015) use plant level data and find that resource misallocation, labor in particular, contributed negatively to aggregate productivity growth. Guner et al. (2008) develop a model that delivers an efficient size distribution of firms, and argue that departures from the efficient size distribution lead to lower productivity. Buera et al. (2013) develop a theory in which well-intended policies may have a sizable negative long-run effect on aggregate output and productivity.

[2] These time paths incorporate projections of future government purchases and transfer payments made by Fukawa and Sato (2009) that use detailed information from the Employees Pension Insurance, the National Pension, and the government-managed Health Insurance and Long-term Care Insurance.
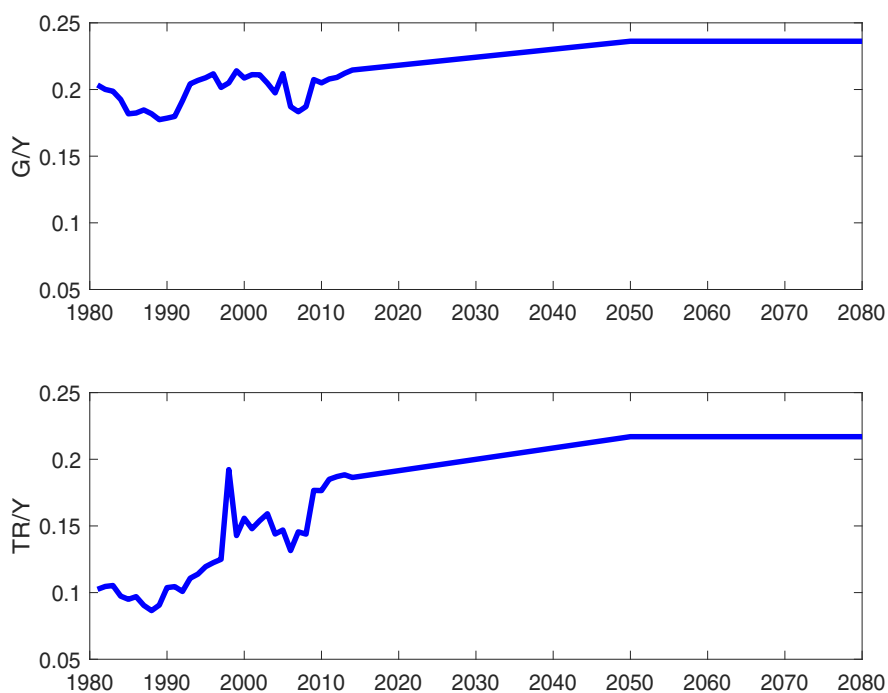
Fig. 1. Government Expenditures to GNP: Data 1981–2014, projections 2015–2050.

income taxation but postpone increasing consumption taxes until Japan's debt to output ratio reaches some threshold provides lower growth and higher welfare relative to a policy that raises consumption taxes simultaneously with the reduction in income taxes in order to replace lost revenue.

Our motivation is drawn from economic policies that have recently been introduced in Japan to achieve the two policy goals–higher growth and lower debt to output. The Japanese government has launched two economic policy packages independently, each of which involves tax reform. One involves reductions in the corporate tax rate and the other brings about increases in the consumption tax rate. The corporate tax reductions are a part of the policy package known as the "three arrows" proposed by Prime Minister Shinzo Abe in 2013.[3] In fiscal year (FY) 2014, the effective corporate income tax rate was 34.62%. It has since been reduced to 32.11% with plans for further reductions to 29.97% in FY 2016/2017 and 29.74% in FY 2018. The eventual goal is a tax rate of 25%.

The consumption tax in Japan was equal to 5% from 1997 to 2013. Given projected increases in social security benefits, however, the government announced a "Comprehensive Reform of Social Security and Tax" in 2013, stating that consumption tax rates would be raised eventually to 10% and the revenues would be secured as financial resources to fund social security. The consumption tax rate was raised from 5% to 8% in 2014 as planned, but a further increase from 8% to 10% that was scheduled for 2015 was postponed and is now scheduled for 2019. These tax reforms are being implemented independently. On the whole, however, they will change the Japanese tax structure so that it relies more on consumption taxation and less on income taxation.

The model economy we use is a neoclassical growth model built upon Hayashi and Prescott (2002), Chen et al. (2006), and Hansen and İmrohoroğlu (2016). Our model incorporates into an otherwise standard neoclassical growth model two features. The first is that government bond holdings are assumed to provide utility to Japanese households. The motivation for this is to account for large domestic holding

of Japanese Government Bonds at very low interest rates.[4] The second is a debt stabilization policy rule followed by the government. As in Hansen and İmrohoroğlu (2016), once the debt to output ratio reaches a critical level, the Japanese government automatically increases the consumption tax rate to stabilize the debt.[5]

In contrast to the experiments conducted in Hansen and İmrohoroğlu (2016) in which economic agents have perfect foresight, simulations here are conducted in two steps to reflect the unanticipated nature of the tax reforms studied. First, we compute the equilibrium future time path of endogenous variables including output, tax revenue, and welfare under the hypothetical scenario that no tax reforms are implemented. That is, the tax structure is unchanged from 2014 and beyond. Our simulations take as exogenous inputs forecasts of future government purchases and transfer payments made by Fukawa and Sato (2009) and projections of future population growth rates produced by the Japanese government.[6] Taking state variables for 2015 as given from the first step, the second step computes the equilibrium path from 2015 on under the assumption that an unanticipated tax reform is introduced in 2015.

The model-generated equilibrium path indicates that under no tax reform, Japan's economy will continue experiencing stagnant GDP growth and rapid government debt accumulation that quickly exceeds the critical level. When an unexpected elimination of corporate taxes is introduced in 2015 along with an increase in consumption taxes to replace the lost revenue, government debt still reaches the critical level at the same date, but the average annual growth rate of output per person over the following six years is one percent higher than if no

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[3] The "three arrows" consist of monetary easing, fiscal stimulus, and policies designed to increase economic growth. Reductions in the corporate income tax rates belong to the third arrow.

[4] Sakuragawa and Hosono (2010) employ an alternative approach that incorporates intermediation costs to obtain low equilibrium interest rates on government debt.

[5] In our theoretical model, there is no upper bound to the feasible debt to output ratio. However, we impose an upper bound under the assumption that for reasons not modeled, there is a practical upper bound to this ratio.

[6] Following Hansen and İmrohoroğlu (2016), our simulation incorporates projections made by the National Institute of Population and Social Security Research for the population growth rate, and projections made by Fukawa and Sato (2009) for health insurance and social security benefits that constitute important parts of the government purchases and transfer payments. Admittedly, Japan might choose to renege on the promises to retirees that underlie the forecasts of Fukawa and Sato (2009). However, our analysis will be done under the assumption that these promises will be kept.

reform is introduced. While reducing corporate tax rates is consistent with actual tax reforms proposed in Japan, we also study effects of replacing labor income taxation with consumption taxation for comparison purposes and find that further growth and welfare improvements can be achieved.

Reducing the capital income tax rate, however, jeopardizes fiscal consolidation by reducing tax revenue. In particular, we find that a 3.75 percentage point increase in the consumption tax rate is needed to replace the lost revenue if the capital income tax rate is reduced to 20%. However, in the long run steady state, the consumption tax is only about 80 basis points higher than it is in our benchmark where there are no reductions in the capital income tax rate other than those Japan has already implemented (a capital income tax rate of 34%). If the capital income tax rate is reduced to zero, the steady state consumption tax rate is 2.78 percentage point higher than in the benchmark. On the other hand, reductions in the labor income tax rate would require a much larger increase in the consumption tax to replace lost revenue. A decrease from a labor income tax rate of 33% in our benchmark to 20% would require a 13.17 percentage point increase in consumption taxes to replace the lost revenue. In the long run steady state, the consumption tax rate would still be 12 percentage points higher than in the benchmark.

Our paper is closely related to the two strands of the literature on tax structure. Both of them have attracted attention from a large number of macroeconomists over a long period of time. One strand, including Barro (1990), Easterly and Rebelo (1993), and Mendoza et al. (1997), examines growth implications of tax structure.[7] For instance, Barro (1990) theoretically shows that under some conditions income taxation may hamper economic growth. Along the line of his theoretical prediction, recent studies by Knellera et al. (1999) and Arnold (2008) document using the data of OECD countries that income taxation or property taxation reduces growth while consumption taxation does not. The other strand of literature, including Trabandt and Uhlig (2011), Nutahara (2015), and Hansen and İmrohoroğlu (2016), explores how tax structure matters for fiscal sustainability. Among them, our paper is closest to Hansen and İmrohoroğlu (2016) that studies how much either consumption taxation or labor income taxation must increase to stabilize the growing government debt in Japan.

The structure of this paper is as follows. Section 2 describes the details of our model. Section 3 describes the calibration of the model and the simulation methodology. The results obtained from simulating various tax reforms are presented in Section 4. Section 5 concludes.

2. Model

In this section we describe the details of our model, which is similar to the model of Hansen and İmrohoroğlu (2016). The notation employed uses upper case letters to denote variables that are per capita values that grow along a balanced growth path. Lower case letters denote variables that are stationary along a balanced growth path. The time period of the model is one year.

The economy is populated by a representative household with N_t members at time t. The size of the household is assumed to grow at a time-varying growth factor η_t so that $N_{t+1} = \eta_t N_t$.

The fiscal analysis in this paper takes as given time series on tax rates, government spending (G_t), transfer payments (TR_t), the working age population (N_t), and total factor productivity (A_t), where actual time series are used from 1981 to 2014. Forecasts and assumptions are used to extend these series to 2060 and beyond. In addition, we assume that the tax rates, the ratios of government purchases and transfer

payments to output, and the growth rates of N_t and A_t are all eventually constant and the economy converges to a balanced growth path. Hours worked (h_t), consumption (C_t), output (Y_t), the stock of capital (K_t), tax revenues, government debt (B_t), and the price of government bonds (q_t), from 1981 into the infinite future are endogenously determined by the model.

2.1. Government

The government is assumed to collect revenue from taxing household consumption at the rate $\tau_{c,t}$, labor income at the rate $\tau_{h,t}$, capital income at the rate $\tau_{k,t}$, and interest on government bonds at the rate $\tau_{b,t}$. Given time series for G_t and TR_t, the quantity of one-period discount bonds (B_{t+1}) that are issued by the government is determined by the following budget constraint (where all quantities are in per capita terms):

$$
\begin{aligned}
G_t + TR_t + B_t &= \eta_t q_t B_{t+1} + \tau_{c,t} C_t + \tau_{h,t} W_t h_t \\
&\quad + \tau_{k,t}(r_t - \delta)K_t + \tau_{b,t}(1 - q_{t-1})B_t.
\end{aligned} \tag{1}
$$

Here, in addition to variables already defined, W_t and r_t denote the wage rate and the return to capital, and δ is the depreciation rate of capital.

The government is also assumed to be subject to a "debt sustainability" rule that forces the government to retire debt when the debt to output ratio reaches some arbitrary value b_{max} that we specify. We denote the date at which this limit is reached by T_1. We include this feature for two reasons. First, the solution procedure we use for computing equilibrium paths requires that the economy ultimately converge to a steady state with a constant bond to output ratio. Without some additional constraint, this convergence would not be guaranteed. Second, while there is no natural limit to how much debt the government in our model can issue, such a limit almost certainly exists in actual economies.

Along a given transition path, taxes and transfers are initially determined according to calibrated values. These values may differ across the experiments that we conduct. Once the debt to output ratio hits the threshold level, b_{max} at T_1, two fiscal instruments–the level of transfers and the consumption tax rate–become endogenous in order to insure convergence to the terminal steady state that we specify. Denote the initial calibrated values for the consumption tax and transfers for each date t by $\tau_{c,t}^C$ and TR_t^C. In addition, denote the value of the consumption tax rate and the debt to output ratio in our steady state by $\overline{\tau}_c$ and $\overline{b}$. Given this, the actual values for $\tau_{c,t}$ and TR_t are determined as follows:

$$
\tau_{c,t} = \begin{cases} \tau_{c,t}^C & \text{if } t < T_1 (\text{i. e. } B_s/Y_s \leq b_{max} \text{ for all } s \leq t) \\ \overline{\tau}_c + \pi & \text{if } T_1 \leq t < T_2 (\text{ i.e. } B_s/Y_s > b_{max} \text{ for some } s \\ & \qquad \leq t \text{ and } B_t/Y_t > \overline{b}) \\ \overline{\tau}_c & \text{if } t \geq T_2 (\text{ i.e. } B_t/Y_t \leq \overline{b}), \end{cases} \tag{2}
$$

$$
TR_t = \begin{cases} TR_t^C & \text{if } t < T_1 \\ TR_t^C - 0.08 Y_t & \text{if } T_1 \leq t < T_2 \\ TR_t^C - 0.08 Y_t - \kappa(B_t - \overline{b} Y_t) & \text{if } t \geq T_2, \end{cases} \tag{3}
$$

According to Eq. (2), once the upper bound on debt is reached, the consumption tax is set equal to its steady state value, $\overline{\tau}_c$, plus some constant π, where π is the smallest basis point increase in this tax rate such that the debt to output ratio will begin to decline after date T_1. Once the debt to output ratio becomes less than or equal to $\overline{b}$, the consumption tax rate is set equal to its steady state value. We denote this date by T_2.

In addition, as shown in Eq. (3), at date T_1 transfers are reduced by 8% of output reflecting our assumption that "tax base broadening" will

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[7] There are also a number of theoretical papers including Judd (1985), Chamley (1986) that study the relationship between the level of output and tax rates.

be implemented at the time debt-reducing reform is required.[8] At date T_2 transfers are adjusted to retire (or augment) the stock of government debt [determined by Eq. (1)] so that the debt to output ratio converges to the desired steady state value, $\bar{b}$. Here, κ is a positive fraction that determines how quickly the bond to output ratio converges to its steady state value. We use a value of $\kappa = 0.1$ in our quantitative exercises.

2.2. Household's problem

The household at time 0 is endowed with initial holdings of per capita physical capital $K_0 > 0$, and real, one-period, zero-coupon, discount bonds B_0. In addition, each member of the household is endowed with one unit of time each period that can be used for market activities h_t or leisure $1 - h_t$. Given a sequence of wages, rental rates for capital and government bond prices $\{W_t, r_t, q_t\}_{t=0}^\infty$, as well as a sequence of tax rates on consumption expenditures, tax rates on income from labor, capital and holdings of government bonds, and per-capita transfer payments $\{\tau_{c,t}, \tau_{h,t}, \tau_{k,t}, \tau_{b,t}, TR_t\}_{t=0}^\infty$, the household chooses a sequence of per member consumption, hours worked, capital, and bond holdings $\{C_t, h_t, K_{t+1}, B_{t+1}\}_{t=0}^\infty$ to solve the following problem:

$$\max \sum_{t=0}^\infty \beta^t N_t \left[\log C_t - \alpha \frac{h_t^{1+1/\psi}}{1 + 1/\psi} + \phi \log(\mu_{t+1} + B_{t+1}) \right] \tag{4}$$

subject to

$$(1 + \tau_{c,t})C_t + \eta_t K_{t+1} + q_t \eta_t B_{t+1} = (1 - \tau_{h,t})W_t h_t + [(1 + (1 - \tau_{k,t})(r_t - \delta)]K_t + [1 - (1 - q_{t-1})\tau_{b,t}]B_t + TR_t, \tag{5}$$

where $K_0 > 0$ and B_0 are given initial conditions. The parameter β denotes the household's subjective discount factor. The disutility of work is described by $-\alpha < 0$ and $\phi > 0$ denotes the household's preferences for government bonds. We use ψ to denote the intertemporal elasticity of substitution (IES) of labor.

The household's maximization is subject to a budget constraint [Eq. (5)] where after-tax consumption expenditures and resources allocated to accumulation of capital and bond holdings are financed by after-tax labor income, after-tax capital income and holdings of capital, after-tax proceeds of bond holdings chosen in the previous period, and transfer payments from the government. Here K_{t+1} and B_{t+1} are per capita holdings of capital and bonds at time $t + 1$. $\eta_t K_{t+1}$ and $\eta_t B_{t+1}$ expresses the same quantities per capita at time t.

Since about 95% of the Japanese government bonds are held domestically, we assume that Japan is a closed economy where all debt is held by Japanese citizens, i.e. the members of the household in our model. In addition, Japanese government bonds historically have had yields less than the return to physical capital. As a result, we introduce government debt in the utility function, with $\phi > 0$.[9][10]

Finally, μ_{t+1} is a parameter that limits the curvature of the period

utility function over bonds. Essentially, it represents assets that might be perfect substitutes to Japanese government issued bonds in generating utility to households.[11] We allow this parameter to move at the same rate of balanced growth as the rest of the economy so that the detrended version is a constant. In particular, $\mu_t = \mu A_t^{1/(1-\theta)}$.

2.3. Firm's problem

A stand-in firm operates a constant returns to scale Cobb–Douglas production technology

$$N_t Y_t = A_t (N_t K_t)^\theta (N_t h_t)^{1-\theta}$$
$$N_{t+1} K_{t+1} = (1 - \delta)N_t K_t + N_t X_t.$$

Capital depreciates at the rate δ. The income share of capital is given by θ. A_t is total factor productivity which grows exogenously at the rate γ_t, so we have $A_{t+1} = \gamma_t A_t$. Per capita gross investment is denoted by X_t.

The firm is assumed to hire labor and rent capital from households each period to maximize profits, taking the wage rate W_t and rental rate r_t as given.

2.4. Equilibrium

Given a government fiscal policy $\{G_t, TR_t, B_t, \tau_{h,t}, \tau_{k,t}, \tau_{c,t}, \tau_{b,t}\}_{t=0}^\infty$, a debt sustainability rule $\{\kappa, \bar{b}, b_{max}\}$, and the paths of working age population $\{N_t\}_{t=0}^\infty$ and technology $\{A_t\}_{t=0}^\infty$, a competitive equilibrium consists of an allocation $\{C_t, h_t, K_{t+1}, B_{t+1}\}_{t=0}^\infty$, factor prices $\{W_t, r_t\}_{t=0}^\infty$ and the bond price $\{q_t\}_{t=0}^\infty$ such that

- the allocation solves the household's problem [Eqs. (4) and (5)],
- the government budget constraint and debt sustainability rule, given by Eqs. (1) - (3), is satisfied each period,
- the market for bonds clears,
- firms maximize profits and the labor market and capital rental markets clear, which implies that $W_t = (1 - \theta)A_t K_t^\theta h_t^{-\theta}$ and $r_t = \theta A_t K_t^{\theta-1} h_t^{1-\theta}$.
- and the goods market clears: $C_t + [\eta_t K_{t+1} - (1 - \delta)K_t] + G_t = Y_t$,

2.5. Detrended equilibrium conditions

In this subsection we derive the detrended equilibrium conditions to use in solving the model numerically. Given a trending per capita variable Z_t we obtain its detrended per capita counterpart by

$$z_t = \frac{Z_t}{A_t^{1/(1-\theta)}}.$$

The first set of detrended equilibrium conditions is given below.

$$\frac{(1 + \tau_{c,t+1})\gamma_t^{1/(1-\theta)}c_{t+1}}{(1 + \tau_{c,t})c_t} = \beta[1 + (1 - \tau_{k,t+1})(r_{t+1} - \delta)], \tag{6}$$

$$\frac{\phi}{\mu + b_{t+1}} + \frac{\beta\eta_t[1 - (1 - q_t)\tau_{b,t+1}]}{(1 + \tau_{c,t+1})c_{t+1}} = \frac{q_t \eta_t \gamma_t^{1/(1-\theta)}}{(1 + \tau_{c,t})c_t}, \tag{7}$$

$$\alpha h_t^{1/\psi} = \frac{(1 - \tau_{h,t})w_t}{(1 + \tau_{c,t})c_t}, \tag{8}$$

$$y_t = k_t^\theta h_t^{1-\theta}, \tag{9}$$

$$\eta_t \gamma_t^{1/(1-\theta)}k_{t+1} = (1 - \delta)k_t + x_t. \tag{10}$$

Eq. (6) is the typical Euler equation arising from the choice of capital stock at time t. The bond Euler equation is given by (7). The first order condition for hours worked is shown in Eq. (8). The production

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[8] As in Hansen and İmrohoroğlu (2016) we have abstracted from deductions, exclusions, and progressive tax rates that characterize the Japanese tax code. By setting income tax rates equal to the average marginal tax rate in Japan, the amount of revenue raised in our model exceeds that actually raised by the Japanese tax system by 8% of output. In our basic calibration, we assume this excess revenue is added to transfer payments as a lump sum tax rebate to households. Tax broadening in our context means that we eliminate this tax rebate and allow this revenue to be used to lower the level of debt each period.

[9] For example, consider a simplified version of the model in which the representative household solves $\max \sum_{t=0}^\infty \beta^t \{\log c_t + \phi \log b_{t+1}\}$ subject to $c_t + k_{t+1} + q_t b_{t+1} = w_t + r_t k_t + b_t + (1 - \delta)k_t$. The first order conditions are given by $\frac{1}{c_t} = \beta \frac{R_t}{c_{t+1}}$, $\frac{\phi}{b_{t+1}} - \frac{q_t}{c_t} + \frac{\beta}{c_{t+1}} = 0$, and $R_t = r_t + 1 - \delta$. Steady-state implies $q - \frac{1}{R} = \frac{\phi c}{b} > 0$, which means that the return on k, denoted by R, dominates that on b which is equal to $1/q$.

[10] While our assumption of bonds providing utility in a neoclassical growth model implies that capital earns a higher return than government debt, it also implies that the optimal quantity of debt is unlimited. Nakajima and Takahashi (2017) studies the optimal debt to output ratio for Japan using a micro-founded model similar to Aiyagari and McGrattan (1998) in which there are both costs and benefits associated with government debt.

[11] This parameter helps us to match the volatility of bond prices.

function and the law of motion for capital are given in Eqs. (9) and (10), respectively. The budget constraint for the household is given below in Eq. (11)

$$(1 + \tau_{c,t})c_t + \eta_t\gamma_t^{1/(1-\theta)}k_{t+1} + q_t\eta_t\gamma_t^{1/(1-\theta)}b_{t+1}$$
$$= (1 - \tau_{h,t})w_t h_t + [1 - (1 - q_{t-1})\tau_{b,t}]b_t + tr_t$$
$$+ [1 + (1 - \tau_{k,t})(r_t - \delta)]k_t. \tag{11}$$

The government budget equation is given by Eq. (12)

$$g_t + tr_t + b_t = q_t\eta_t\gamma_t^{1/(1-\theta)}b_{t+1} + \tau_{c,t}c_t + \tau_{h,t}w_t h_t$$
$$+ \tau_{k,t}(r_t - \delta)k_t + \tau_{b,t}(1 - q_{t-1})b_t. \tag{12}$$

Finally, the market clearing conditions are given below in Eqs. (13), (14) and (15)

$$r_t = \theta k_t^{\theta-1}h_t^{1-\theta}, \tag{13}$$

$$w_t = (1 - \theta)k_t^{\theta}h_t^{-\theta}, \tag{14}$$

$$c_t + x_t + g_t = y_t. \tag{15}$$

Hence we have 9 equations, (6) through (14), in 9 unknowns $\{c_t, x_t, h_t, y_t, k_{t+1}, b_{t+1}, q_t, w_t, r_t\}$ at each time period t.

2.6. Steady-state solution

In this subsection we describe how we compute the steady state equilibrium and how it depends on the experiments we consider in Section 4.

For a variable z_t, we will denote its steady state value with $\bar{z}$. Also, let $\hat{z}$ denote $\bar{z}/\bar{y}$, the ratio of $\bar{z}$ to the steady state value of output.

Imposing steady state, Eqs. (6) and (10) become $\hat{k} = \frac{\beta\theta(1-\tau_k)}{\gamma^{1/(1-\theta)} - \beta[1-(1-\tau_k)\delta]}$ and $\hat{x} = \eta\gamma^{1/(1-\theta)} + \delta - 1$.

Using projections from Fukawa and Sato (2009), we obtain de-trended values for g_t and tr_t and assume that these are constant after 2050. In particular, $\bar{g} = g_{2050}$ and $\bar{tr} = tr_{2050}$.

Given a value for $\overline{\tau_c}$, values for $\bar{h}, \hat{c}$ and $\bar{y}$ are given by $\bar{h} = \left[\frac{(1-\theta)(1-\tau_h)}{\alpha(1+\overline{\tau_c})\hat{c}}\right]^{\psi/(1+\psi)}, \hat{c} = 1 - \hat{x} - \hat{g}$, and $\bar{y} = \hat{k}^{\theta/(1-\theta)}\bar{h}$, where $\hat{g} = \bar{g}/\bar{y}$.

Using the steady state version of Eq. (7), we obtain

$$\bar{q} = \frac{\phi(1 + \overline{\tau_c})\bar{c} + \beta\eta(1 - \tau_b)\bar{b} + \mu}{\eta[\gamma^{1/(1-\theta)} - \beta\tau_b](\mu + \bar{b})}, \text{ where } \bar{b} = \hat{b}\bar{y}.$$

This plus the steady state version of the government budget constraint (12) can be used to obtain values for $\bar{q}$ and $\overline{\tau_c}$. The steady state government budget constraint can be written

$$\hat{g} + \hat{tr} + [1 - \bar{q}\eta\gamma^{1/(1-\theta)}]\hat{b} = \overline{\tau_c}\hat{c} + (1 - \theta)\tau_h + \tau_k(\theta - \delta\hat{k})$$
$$+ \tau_b(1 - \bar{q})\hat{b}.$$

We will assume that the values of $\bar{g}, \bar{tr}, \tau_b$ and $\hat{b}$ are the same across all steady states. However, the income tax rates τ_h and τ_k are different across experiments. As a result, all other aspects of the steady state, including the consumption tax rate $\overline{\tau_c}$ and steady state bond holdings $\bar{b}$, will differ across experiments.

2.7. Solution procedure

We take as given a value for k_{1981} and a sequence $\{\tau_{h,t}, \tau_{b,t}, \tau_{k,t}, \eta_t, \gamma_t, g_t\}_{t=1981}^{\infty}$, where the elements of this sequence are constant beyond some date. These constant values along with $\overline{\tau_c}$, $\bar{g} = g_{2050}$ and $\bar{tr} = tr_{2050}$ determine the steady state to which the economy ultimately converges. We use a shooting algorithm, similar to that in Hayashi and Prescott (2002), Chen et al. (2006) and Hansen and İmrohoroğlu (2016), to determine the value of c_{1981} (or, equivalently, k_{1982}) such that the sequence of endogenous variables

$\{c_t, x_t, h_t, y_t, k_{t+1}, b_{t+1}, q_t, w_t, r_t\}$ determined by Eqs. (6) through (14) converges to the steady state. That is, the shooting algorithm guarantees that the capital stock sequence satisfies the transversality condition. In addition, the fiscal sustainability rule determines the sequence of transfers and consumption taxes, $\{tr_t, \tau_{c,t}\}$, that guarantees that the bond to output ratio is equal to $\hat{b}$ in the steady state achieved in the limit.

While the above procedure is used to compute our benchmark transition, the primary topic of this paper is to consider the consequences of unanticipated policy changes in 2015. To do this, we first compute the transition path to the steady state for our benchmark calibration. Then, taking c_{2014} (or, equivalently, k_{2015}) as given, we compute a new transition from 2015 to the steady state associated with policy under consideration that was unanticipated prior to 2015. The full transition from 1981 is formed by splicing together the benchmark transition through 2014 with the alternative policy transition beginning with 2015.

3. Calibration

The structural parameters of our model are calibrated based on information from the sample period, which consists of annual data from 1981 to 2014. We take the capital-output and bond-output ratios in 1981 as initial conditions and use the sample paths for total factor productivity (TFP), population growth rates, tax rates, government purchases and transfer payments as exogenous inputs to the model. In addition we make assumptions about the values for these exogenous variables beyond the sample period in order to calculate equilibrium transition paths from 1981 toward the eventual steady state.

Population. Our measure of population, N_t, is working age population between the ages of 20 and 69. What matters for the equilibrium path computed, however, is not the level but the sequence of population growth factors (see Eqs. (6) to 15). We use the actual values between 1981 and 2014 and rely on official projections for 2015–2060. We assume that the population stabilizes by 2080 and implement this by linearly interpolating the last projected value for the gross growth factor, which is 0.9885, to converge to 1.0 by 2080. That is $\eta_t = 1$, $t \geq 2080$. The projections for 2015–2060 are the medium-fertility and medium-mortality variants of population forecasts calculated by the National Institute of Population and Social Security Research.

National Accounts. Our measure of output is real Gross National Product adjusted to include income from foreign capital, following Hayashi and Prescott (2002). In particular, we define the model's capital stock, K_t, as consisting of private fixed capital, held domestically and in foreign countries. We add net exports and net factor payments from abroad to measured private investment.

Government investment, including net land purchases, is assumed to be expensed. Therefore we treat it as part of government consumption and subtract depreciation of government capital from government consumption. We summarize these choices in Table 1.

Table 1
Adjustments to national account measurements.

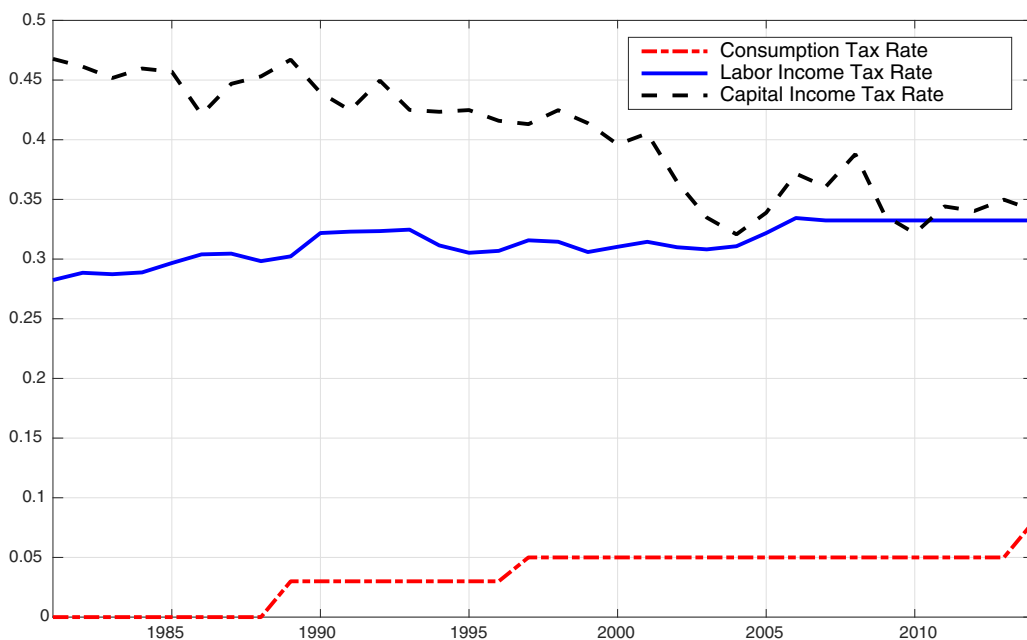|	
$C=$	Private Consumption Expenditures
$I=$	Private Gross Investment
	+ Change in Inventories
	+ Net Exports
	+ Net Factor Payments from Abroad
$G=$	Government Final Consumption Expenditures
	+ General Government Gross Capital Formation
	+ Government Net Land Purchases
	- Book Value Depreciation of Government Capital
$Y=$	$C + I + G$

Fig. 2. Tax rates.

Labor input. For h_t we take the product of employment per working age population and average weekly hours worked, normalized by dividing by 98, which is our assumption on discretionary hours available per week.

Government Accounts. Our measure of government purchases of goods and services, G_t in Table 1, also includes Japanese public health expenditures. Transfer payments, TR_t, includes social benefits (other than those in kind, which are included in G_t) that are mostly public pensions, plus other current net transfers minus net indirect taxes. We add 8% of output to our measure of transfers since our modeling of flat tax rates leads to higher tax revenue than in the data because we abstract from all deductions and exemptions that are present in the complicated Japanese tax code. That is, the tax revenue collected minus the 8% of output corresponds to the actual tax revenue collected by the government.

As we mentioned in the Introduction (see Fig. 1), Japan's already high debt to output ratio is projected to rise even further due to the aging of the population. Fukawa and Sato (2009) estimate an increase of 3 percentage points in the ratio of government purchases to output and a 4 percentage point rise in transfer payments to output from 2010 to 2050. According to Fukawa and Sato (2009), the projected increase in government purchases is nearly entirely due to the expected increase in public long term care expenditures, driven by the increased longevity of the population. Similarly, the projected increase in transfer payments are driven by expected increases in public pension expenditures.[12] These estimates are very similar to those calculated independently by İmrohoroğlu et al. (2016).[13]

Our calibration of the projected increase in government purchases and transfer payments combine the Fukawa and Sato (2009) estimates

with the realized values for 2010–2014. In particular, given the actual 2010 values for *G/Y* and *TR/Y*, we use Fukawa and Sato (2009) projections to obtain the 2050 ratios. Then, we use the observed ratios for 2010–2014 and linearly interpolate the ratios to 2050. This leads to increases of 2.06 and 3.06 percentage points in *G/Y* and *TR/Y*, respectively, from 2015 to 2050. Given that output is endogenous in our model, we obtain the levels of *G* and *TR* from the benchmark model in Hansen and İmrohoroğlu (2016) and use the same sequences of these expenditures in all experiments.

Tax rates. Our measure of labor income tax rates, $\tau_{h,t}$, for 1981–2014, comes from the estimates of average marginal labor income tax rates by Gunji and Miyazaki (2011). The last value is 0.3324 for 2007 and we assume that this same value holds for 2008 and beyond in the benchmark calibration.

The capital income tax rate, $\tau_{k,t}$, is constructed following the methodology in Hayashi and Prescott (2002). The value of this tax rate for 2014 is 0.3409 which is assumed to be unchanged in the benchmark equilibrium transition.

In alternative transitions, the income tax rates, $\tau_{h,t}$ or $\tau_{k,t}$ or both will change exogenously at part of a tax reform package.

A consumption tax rate of $\tau_{c,t} = 3\%$ was introduced in Japan in 1989, and it was raised to 5% in 1997 and to 8% in 2014. It is scheduled to rise to 10% in 2019. In all our experiments, we keep the consumption tax rate at 8% beyond 2014 and allow this tax rate to endogenously rise to a value consistent with fiscal sustainability given our assumptions on the debt to output ratio in the final steady state.

The tax rate on interest from government bonds, $\tau_{b,t}$, is equal to 20% for all time periods. This tax is imposed on the interest income from coupon-bearing bonds and is withheld (15% income tax plus 5% local tax) at the time the interest is paid.

Fig. 2 shows the tax rates used except for the tax on bond interest income, which is constant throughout at 20%.

Technology parameters. Given the data described above, the Cobb-Douglas production function allows us to calculate total factor productivity:

$$A_t = Y_t/(K_t^\theta h_t^{1-\theta}).$$

The capital income share, θ, is set equal to 0.3798, which is the sample (1981–2014) average of the annual ratio of capital income to

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[12] The projections in Fukawa and Sato (2009) are based on a system of about 40 regression equations (in addition to definitional relations and equations describing the evolution of the population in different age groups) which is estimated from Japanese data sources over the sample period 1980–2003. The population projections used are the same as those used in this paper. In addition, they assume a rate of growth of real GDP of about 2%.

[13] İmrohoroğlu et al. (2016) build a micro-data based large-scale overlapping generations model for Japan and incorporate the Japanese pension rules in detail. Using existing pension law and fiscal parameters and the medium variants of fertility and survival probability projections, they produce future time paths for government purchases and transfer payments.

our adjusted measure of GNP. Given this, we can compute the growth factor of TFP, $\gamma_t = A_{t+1}/A_t$, from the actual data between 1981 and 2014. For 2015 and beyond, we assume that $\gamma_t = 1.015^{1-\theta}$. This implies a growth rate of 1.5% for per capita output along the balanced growth path. Finally, we compute a time series for the depreciation rate of capital following the methodology of Hayashi and Prescott (2002) and set $\delta = 0.0816$, which is the sample average.

The working-age population growth factors are taken from the data for the sample period of 1981–2014. For 2015–2060, we take the population projections by the government projections consistent with their medium fertility, medium mortality projections. This implies a working-age population growth factor of 0.9885 for 2059. We assume that the growth factors linearly converge to 1.0 in 20 years so that the working-age population is stationary from 2099.

Preference parameters. There are five preference parameters, β, α, ψ, ϕ, and μ, in the utility function given by Eq. (4), where $\mu = \mu_t/A_t^{1/(1-\theta)}$. These are held constant throughout our analysis. The parameter ψ is the Frisch elasticity of labor supply, taken as 0.5, following Chetty et al. (2012).

For the three preference parameters β, α, and ϕ, we use the equilibrium conditions given in Eqs. (16), (17), and (18) for the sample period to obtain values for each year and, from that, averages over the sample.

$$\beta_t = \frac{(1 + \tau_{c,t+1})\gamma_t^{1/(1-\theta)}c_{t+1}}{(1 + \tau_{c,t})c_t\left[1 + (1 - \tau_{k,t+1})\left(\theta\frac{y_{t+1}}{k_{t+1}} - \delta\right)\right]} \quad (16)$$

$$\alpha_t = \frac{h_t^{-1/\psi}(1 - \tau_{h,t})(1 - \theta)y_t}{(1 + \tau_{c,t})c_t h_t} \quad (17)$$

$$\phi_t = \eta_t(\mu + b_{t+1})\left[\frac{q_t\gamma_t^{1/(1-\theta)}}{(1 + \tau_{c,t})c_t} - \frac{\beta_t[1 - (1 - q_t)\tau_{b,t+1}]}{(1 + \tau_{c,t+1})c_{t+1}}\right]. \quad (18)$$

Note, however, that the equilibrium condition in Eq. (18) contains the equilibrium price of government bonds, q_t. The empirical counterpart to q_t that we compute reflects the fact that government debt in actual economies is comprised of bond holdings of varying maturities while our model economy includes only one period discount bonds. In particular, let B_t be beginning of period debt and P_t be interest payments made in period t, both measured in current Yen. In addition, let F_t be the GNP deflator. We compute the price of bonds in period t as follows:

$$q_t = \frac{B_{t+1}/F_t}{(B_{t+1} + P_{t+1})/F_{t+1}}. \quad (19)$$

Using data on B_{t+1}, F_t, and P_{t+1} over the sample period, we compute q_t and feed the values into the equilibrium conditions above to calculate the sample values of the preference parameters.

The remaining preference parameter μ, which is the detrended value of μ_t, is chosen to minimize the sum of squared differences between the bond price implied by our model and its data counterpart.

Table 2 reports the values for the structural parameters.

Fiscal rule parameters. We now describe how we choose the parameters that govern the fiscal sustainability rule introduced earlier in Eq. (2). For $b_{\max}$, the maximum net debt to output ratio beyond which fiscal austerity kicks in, we use 250%. Although this value may seem too high for most advanced economies, for Japan, it may be more reasonable. Indeed, the (net) debt to output ratio for 2015 is already around 150%. In addition, setting $b_{\max}$ equal to 250% is consistent with the maximum sustainable debt to output ratio estimated by Hoshi and Ito (2014).

We assume that in all our experiments, the debt to output ratio along the balanced growth path, $\hat{b}$, is equal to 200%. We do not have a strong argument for what this parameter may be in the long run.

Table 2
Calibration of structural parameters.

Parameter	Value	
θ	0.3798	Sample Average, 1981–2014
δ	0.0816	Sample Average, 1981–2014
β	0.9680	Eq. (16), Sample Average
α	22.03	Eq. (17), Sample Average
ψ	0.5	(Chetty et al., 2012)
ϕ	0.12	Eq. (18), Sample Average
μ	1.1	Fit q_t for 1981–2014

However, in earlier work, Hansen and İmrohoroğlu (2016) conducted a sensitivity analysis over various values of $\hat{b}$ and found that this parameter had very little effect on the short run analysis which we are trying to emphasize in this paper.

As mentioned earlier, π in Eq. (2) is set equal to the smallest value such that additional revenue creation leads to debt retirement at date T_1 and guarantees convergence to $\hat{b}$, together with κ in Eq. (3) set to 0.1. The value of κ is the same in all our experiments, but π is specific to each experiment.

4. Quantitative experiments

4.1. Steady state tradeoffs

Fig. 3 shows the steady state tradeoff between using a capital tax (τ_k) versus a consumption tax (τ_c) to raise a given constant amount of revenue holding the labor tax rate constant.[14] In this figure, the labor tax rate is held constant at the calibrated level for years beyond 2014 ($\tau_h = 0.3324$). The fact that this curve is quite flat near the calibrated value for τ_k (the veridical line in figure) means that it is possible to reduce the capital tax rate without raising the consumption tax by much.

Similarly, Fig. 4 shows the same steady state tradeoff between the consumption tax rate and the labor income tax rate, holding τ_k at the calibrated level. In this case, the tradeoff between consumption taxation and income taxation is much steeper. In particular, a ten percent decrease in the labor income tax rate would require about a ten percent increase in the consumption tax rate in order to hold revenue constant.

While these steady state tradeoffs are illustrative, they provide no information as to the desirability of a policy change moving from income taxation to consumption taxation. In order to do this, we consider the welfare consequences of a such a change taking into account the transition that such a policy change would initiate. This is done in the next subsection.

4.2. Short run analysis

In this section we consider two different ways of implementing a policy that reduces income taxes beginning in 2015. In the first set of experiments, the consumption tax rate is assumed to rise at the beginning of 2015 in order to replace the lost revenue associated with the reduction in income tax rates. This means that more time will pass before the debt to output trigger in Eq. (2) is reached. We label this experiment as 'revenue-neutral'. In the second set of experiments, no increase in the consumption tax is implemented in 2015. We call this experiment 'delayed increase', in which the government is assumed to delay the increase in the consumption tax rate until the debt to output trigger $b_{\max}$ is reached. At this point, as in our benchmark calibration, it is assumed that the Japanese government must respond in some way to reduce the debt to output ratio. In particular, in our benchmark

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[14] Note that by holding revenue constant we actually mean holding the revenue raised by labor, capital and consumption taxation constant. The revenue from taxing the interest on government debt is affected slightly due to general equilibrium effects.
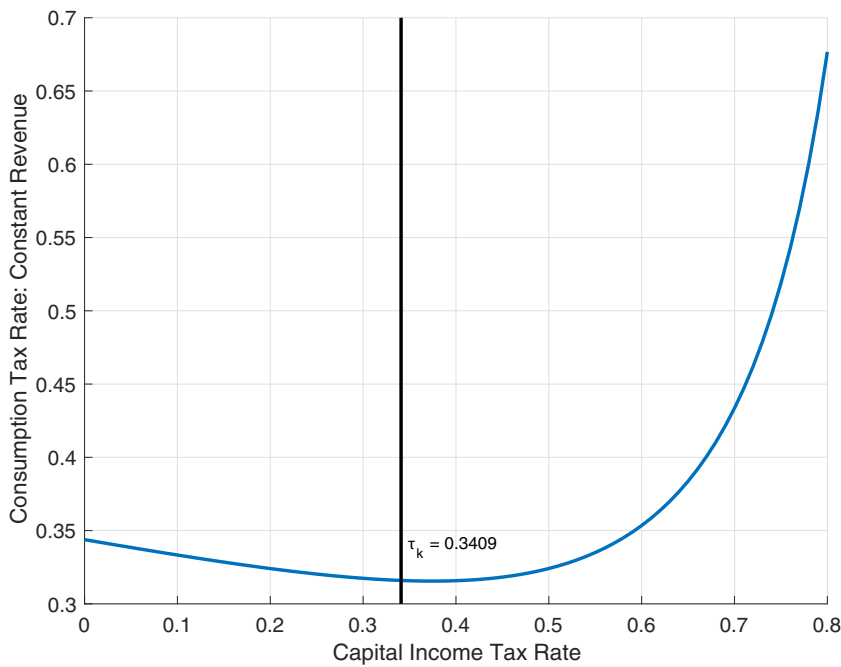
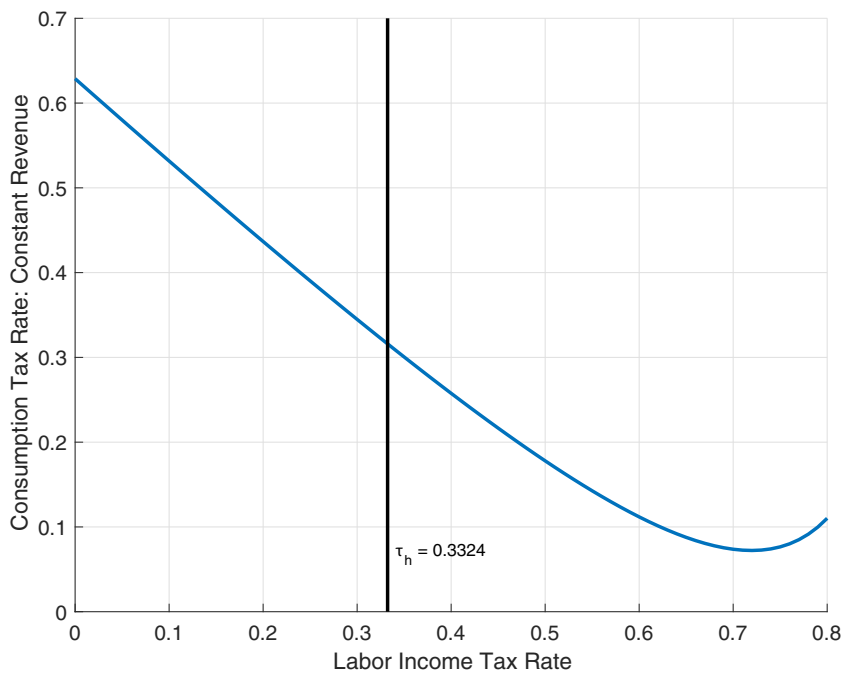**Fig. 3.** Steady state iso-revenue curve ($\tau_h = 0.3324$).

Fig. 4. Steady state iso-revenue curve ($\tau_k = 0.3409$).

calibration it does so by increasing τ_c.

For each of these two approaches, seven policy scenarios are considered. The first, which we label E1, is the same in both cases. This is our benchmark calibration in which there is no reduction in income tax rates and the consumption tax is increased once debt to output reaches $b_{\max}$. The other experiments are ones where τ_k and/or τ_h are reduced in 2015. Table 3 summarizes these experiments.

4.2.1. How the model's rule for fiscal sustainability works

In this subsection, we describe how our rule works to achieve fiscal sustainability in our benchmark transition. In alternative transition paths, the rule works in a similar fashion with slightly different parameters that again are selected to ensure convergence to the final steady state.

Table 3
Experiments.

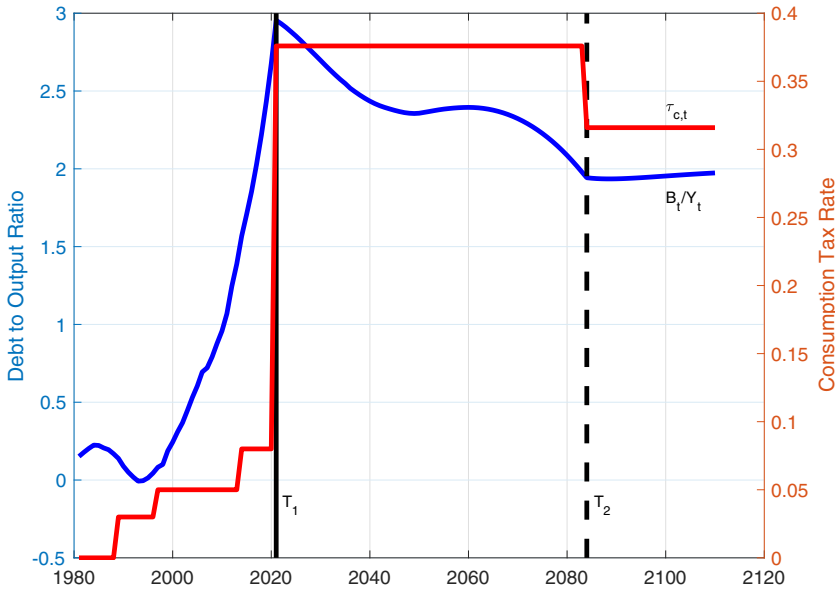|	For $t \geq 2015$	
	$\tau_{k,\,t}$	$\tau_{h,\,t}$
E1	0.3409	0.3324
E2	0.20	0.3324
E3	0.0	0.3324
E4	0.3409	0.20
E5	0.3409	0.0
E6	0.20	0.20
E7	0.0	0.0

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Fig. 5. Debt to output ratio and the consumption tax rate.

Table 4
Unanticipated reform with a revenue-neutral increase in τ_c.

	E1	E2	E3	E4	E5	E6	E7
$\tau_{c,\,2015}$	0.08	0.1175	0.1708	0.2117	0.4108	0.2493	0.5016
τ_{2015}	0.3818	0.4026	0.4298	0.3398	0.2912	0.3596	0.3340
T_1	2021	2021	2021	2021	2022	2021	2021
τ_{c,T_1}	0.3760	0.3941	0.4238	0.4667	0.6487	0.4985	0.7152
τ_{T_1}	0.5148	0.5211	0.5311	0.4546	0.3935	0.4661	0.4170
T_2	2084	2088	2109	2100	2106	2078	2141
τ_{c,T_2}	0.3160	0.3241	0.3438	0.4367	0.6287	0.4485	0.6752
τ_{T_2}	0.4927	0.4958	0.5032	0.4432	0.3860	0.4477	0.4031

E1: Benchmark, $\tau_{k,t} = 0.3409$ and $\tau_{h,t} = 0.3324$ for all $t \geq 2015$; E2: $\tau_{k,t} = 0.2$ and $\tau_{h,t} = 0.3324$ for all $t \geq 2015$; E3: $\tau_{k,t} = 0$ and $\tau_{h,t} = 0.3324$ for all $t \geq 2015$; E4: $\tau_{k,t} = 0.3409$ and $\tau_{h,t} = 0.2$ for all $t \geq 2015$; E5: $\tau_{k,t} = 0.3409$ and $\tau_{h,t} = 0$ for all $t \geq 2015$; E6: $\tau_{k,t} = 0.2$ and $\tau_{h,t} = 0.2$ for all $t \geq 2015$; E7: $\tau_{k,t} = 0$ and $\tau_{h,t} = 0$ for all $t \geq 2015$; T_1: Date when B/Y reaches 250%.; T_2: Date when B/Y is less than or equal to steady state value.; $\tau_{c,\,t}$: Consumption tax rate at date t.; $\tau_t = (\tau_{c,t} + \tau_{h,t})/(1 + \tau_{c,t})$ Effective tax rate at date t.; π in Eq. (2) equals $\tau_{c,T_1} - \tau_{c,T_2}$.

Until 2015, the economy moves along under the expectation that the tax system will not change except for the use of a higher consumption tax rate when the debt to output ratio exceeds 250%. Fig. 5 indicates that the first trigger, T_1 occurs in the year 2020 in this benchmark equilibrium transition E1. The consumption tax rate rises from 8% to 37.6% in order to begin to process of accumulating sufficient tax revenue to pay for the increasing public expenditures and to retire a fraction of the outstanding debt toward its steady state level. After decades of raising significant revenue, once the public expenditures stabilize in 2050 and sufficient debt is retired so that the debt to output is on its path to its steady state level of 200%, the second trigger occurs in 2084 and the consumption tax rate falls to its steady state level of 31.6%. We can now proceed to describe the short run quantitative findings in experiments E2 through E7.

4.2.2. Unanticipated reform with a revenue-neutral increase in τ_c

In experiments E2 through E7, τ_c is increased in 2015 to replace the lost revenue from reducing income tax rates in that year. In particular, Table 4 summarizes what happens in each of these cases. In particular, the table indicates what happens to the consumption tax rate, as well as

the effective tax rate, in 2015.[15] In addition, the changes in these tax rates at the two key dates, T_1 and T_2, are also indicated. Recall that T_1 is the first date at which the debt to output ratio exceeds b_{max} and T_2 is the first date that the debt to output ratio falls below $\bar{b}$ [see Eq. (2)]. At T_2 the consumption tax rate (and hence the effective tax rate) is set equal to its steady state value.

In experiments E2 and E3 the capital tax rate is lowered in 2015. The increase in τ_c needed to keep revenue constant is shown in the first row of the table. The next increase in τ_c is at date T_1. This happens in 2021 in the benchmark (E1) as well as in E2 and E3. Once this tax increase is in place, the debt to output ratio begins to fall. Once it falls below $\bar{b}$, at date T_2, the consumption tax rate is decreased to its steady state value. This happens in 2084 in the benchmark case, 2088 in E2 and 2109 in E3.

Next, experiments E4 and E5 show the tax changes that occur when only τ_h is decreased. As the table shows, a larger increase in the consumption tax is required in 2015 in order to compensate for the revenue lost from reducing τ_h than was required when reducing τ_k by the same amount. This matches what might be expected given the steady state results discussed previously. However, the effective tax rate actually falls when τ_h is decreased and τ_c increased in 2015. That is, while the consumption tax rate is increased in 2015, the distortion caused by labor/consumption taxation actually falls.

Finally, in experiments E6 and E7 both τ_k and τ_h are lowered in 2015. As expected, the change in τ_c required in 2015 is larger than in the cases where only one tax rate is lowered. In fact, the required increase in experiment E7 (both τ_k and τ_h reduced to zero), is equal to the sum of the increases seen in experiments E3 (only τ_k reduced to zero) and E5 (only τ_h reduced to zero). In particular, τ_c is increased by 9.08% in experiment E3, by 33.08% in E5, and by 42.16% in E7. A similar results holds for experiments E2, E4 and E6 where the tax rates on labor and capital are lowered to 0.2 rather than zero.

The transition paths for the capital stock, hours worked, and output are shown in Figs. 6, 7, 8. In particular, we compare the transitions for the benchmark case (E1), the case where the capital tax rate is set equal to zero in 2015 (E3), the case where the labor tax rate is set equal to zero in 2015 (E5) and the case where both tax rates are set equal to zero.

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[15] The effective tax rate measures the total tax distortion in the first order condition for labor [Eq. (8)]. In particular the effective tax rate is given by τ, where $1 + \tau = \frac{1 - \tau_h}{1 + \tau_c}$.
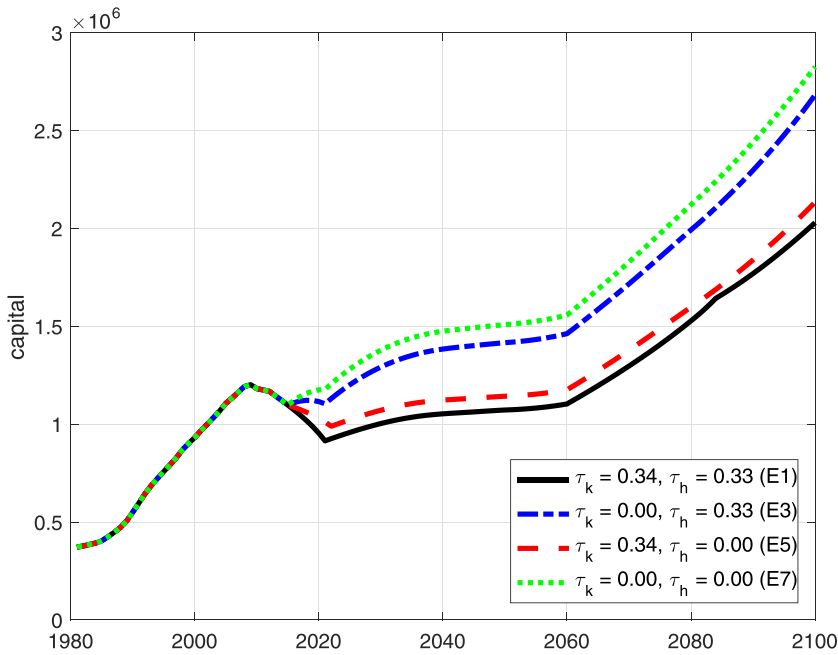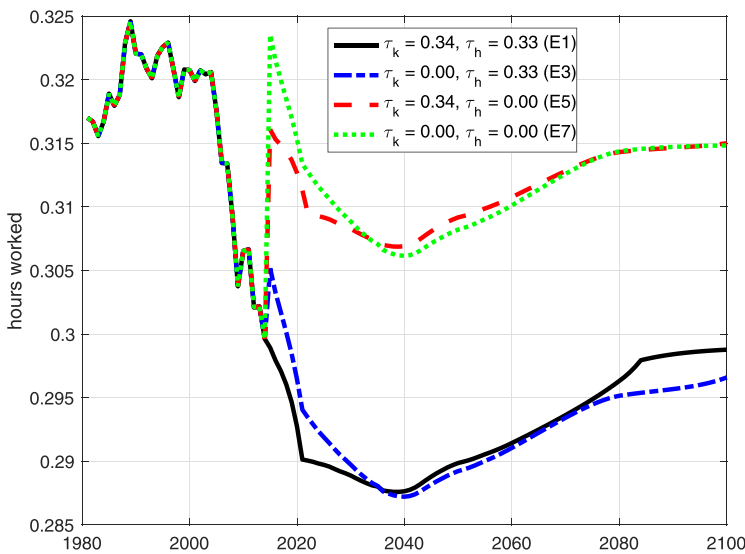
Fig. 6. Capital stock.

Fig. 7. Hours worked.

Fig. 6 shows that capital stock is slightly above the benchmark path when only τ_h is set to zero, but is significantly higher when τ_k is set to zero in experiments E3 and E7. Conversely, hours worked is not much affected by only setting τ_k equal to zero, as shown in Fig. 7, but is increased substantially when τ_h is set to zero in E5 and E7.

The paths for output, shown in Fig. 8, incorporates changes in both inputs to production. All policy changes shown increase output relative to the benchmark. Setting both tax rates to zero (E7) increases output the most while only setting τ_h to zero (E5) increases it the least.

To get a sense for how these policy changes would affect living standards, we show output per person in Fig. 9. In all cases where income taxation is substituted for consumption taxation, the Japanese economy is predicted to enjoy considerable growth in income per capita relative to the benchmark starting in 2015 until date $T_1 = 2021$.[16] After 2021, all cases grow at a similar rate, although living standards are permanently higher in the cases with higher growth beginning in 2015.

The average growth rates for per capita income is shown in Table 5

for the initial years after the policy change (2015–2021) and for the years 2025–2060. In all cases, this growth rate is equal to 1.5% in the balanced growth path to which the model economy ultimately converges. The conclusion to be drawn from this table is that, according to this model, Japan could enjoy considerable growth in the short run by replacing income taxation with consumption taxation. In fact, the level of output in 2021 is 8.3% higher in experiment E3 than in the baseline E1. Similarly, output would be 8.5% higher in E5 and 14.8% higher in E7 when all income taxation is replaced with consumption taxation.

4.2.3. Unanticipated reform with a delayed increase in τ_c

In this subsection we consider how our results would change if Japan were to reduce income tax rates in 2015 without increasing τ_c. Instead, any increase in the consumption tax is delayed until date T_1 and is set according to Eq. (2). Table 6 provides results from the same set of experiments reported on in Table 4. As the first line of this table shows, τ_c does not change from the benchmark in 2015. As a result, T_1, the date when the maximum debt to output ratio is reached, is a year or

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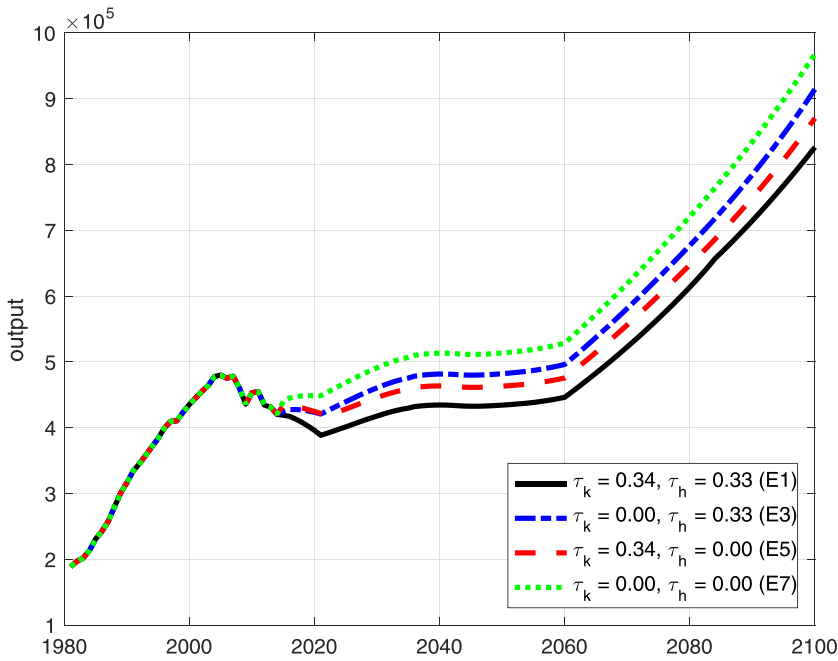
[16] The value of T_1 in E5 is 2022.

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Fig. 8. Output.

Table 5
Average annual growth rate of output per working age population.

	E1	E3	E5	E7
2015 − 2021	0.17%	1.18%	0.61%	1.58%
2025 − 2060	1.58%	1.62%	1.58%	1.62%

Table 7 and Fig. 10, the growth rate of output per capita is negative in several of the years between 2015 and 2021. If all income taxes are eliminated, output would be 11.3% higher than in the baseline. These growth rates are lower here relative to the revenue neutral case because lower income taxes with knowledge that the consumption tax will be raised in the future leads to a temporary consumption boom that dampens the investment boom that these tax reforms
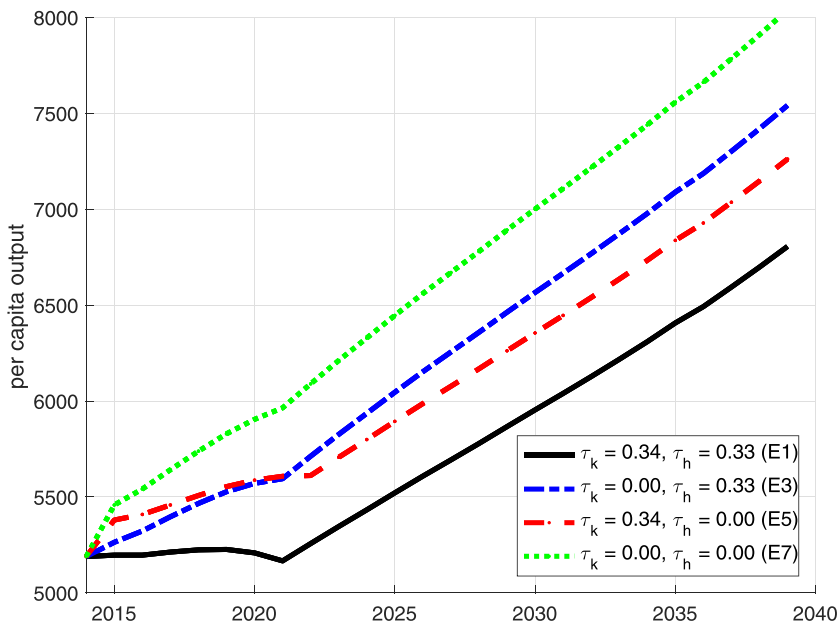
Fig. 9. Output per person.

two earlier than the dates reported in Table 4. The main finding is that the tax increases required at T_1 are generally higher than in the previous case.

As can be seen from Table 7 and Fig. 10, the growth benefits from tax reform are lower than in the case where the consumption tax rate is increased simultaneously with the reduction in income tax rates. In particular, output in 2021 in experiment E3 is 7.1% higher than in the baseline (E1). In experiment E5, where only the labor tax is eliminated, output would be only 2% higher in 2021. In fact, as can be seen in both

otherwise trigger.

4.3. Welfare analysis

In this section we compute welfare differences across experiments E1-E7. For each experiment E2-E7, we calculate the consumption equivalent variation (CEV) relative to our baseline experiment by calculating the percent change in consumption that would be required each period in experiment E1 to make the present discounted utility the
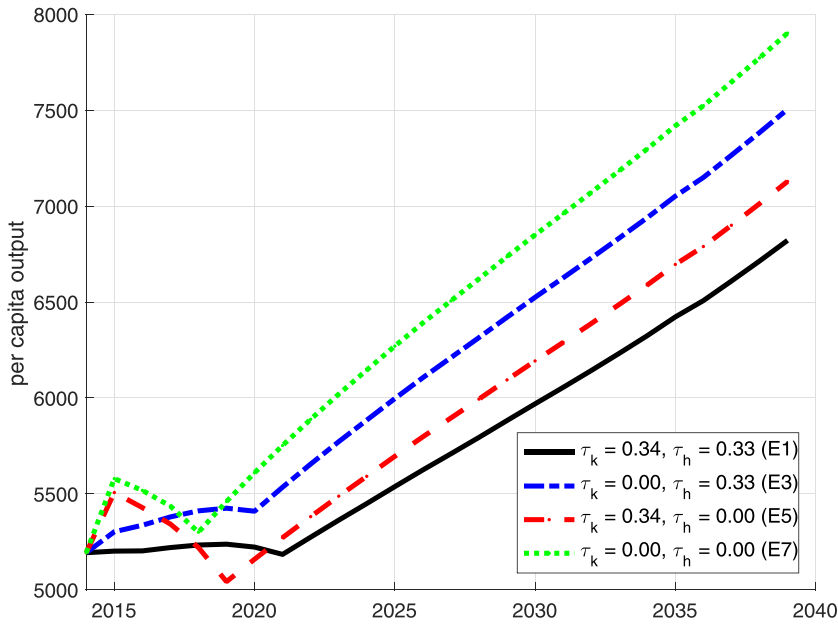
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Table 6
Unanticipated reform with a delay in τ_c.

	E1	E2	E3	E4	E5	E6	E7
$\tau_{c,\,2015}$	0.08	0.08	0.08	0.08	0.08	0.08	0.08
τ_{2015}	0.3818	0.3819	0.3819	0.2593	0.0741	0.2593	0.0741
T_1	2021	2020	2020	2020	2019	2019	2018
τ_{c,T_1}	0.3760	0.3841	0.4438	0.5067	0.7287	0.5285	0.8052
τ_{T_1}	0.5148	0.5177	0.5376	0.4690	0.4215	0.4766	0.4460
T_2	2084	2103	2122	2112	2084	2070	2073
τ_{c,T_2}	0.3160	0.3241	0.3438	0.4367	0.6287	0.4485	0.6752
τ_{T_2}	0.4927	0.4958	0.5032	0.4432	0.3860	0.4477	0.4031

E1: Benchmark, $\tau_{k,t} = 0.3409$ and $\tau_{h,t} = 0.3324$ for all $t \geq 2015$; E2: $\tau_{k,t} = 0.2$ and $\tau_{h,t} = 0.3324$ for all $t \geq 2015$; E3: $\tau_{k,t} = 0$ and $\tau_{h,t} = 0.3324$ for all $t \geq 2015$; E4: $\tau_{k,t} = 0.3409$ and $\tau_{h,t} = 0.2$ for all $t \geq 2015$; E5: $\tau_{k,t} = 0.3409$ and $\tau_{h,t} = 0$ for all $t \geq 2015$; E6: $\tau_{k,t} = 0.2$ and $\tau_{h,t} = 0.2$ for all $t \geq 2015$; E7: $\tau_{k,t} = 0$ and $\tau_{h,t} = 0$ for all $t \geq 2015$; T_1: Date when B/Y reaches 250%.; T_2: Date when B/Y is less than or equal to steady state value.; $\tau_{c,\,t}$: Consumption tax rate at date t.; $\tau_t = (\tau_{c,t} + \tau_{h,t})/(1 + \tau_{c,t})$ Effective tax rate at date t. π in equation (2) equals $\tau_{c,T_1} - \tau_{c,T_2}$.

Table 7
Average annual growth rate of output per working age population.

	E1	E3	E5	E7
$2015 - 2021$	0.17%	0.93%	-0.30%	0.80%
$2025 - 2060$	1.58%	1.64%	1.64%	1.67%

Table 8
Welfare analysis: CEV (λ) relative to experiment 1.

	For $t \geq 2015$		λ	λ
	$\tau_{k,\,t}$	$\tau_{h,\,t}$	(R-neutral)	(delay)
E1	0.3409	0.3324	-	-
E2	0.20	0.3324	0.0090	0.0099
E3	0.0	0.3324	0.0196	0.0257
E4	0.3409	0.20	0.0047	0.0138
E5	0.3409	0.0	0.0111	0.0212
E6	0.20	0.20	0.0120	0.0144
E7	0.0	0.0	0.0309	0.0362

$$W = \sum_{t=1981}^{\infty} \beta^t N_t \left[\log[(1+\lambda)\widehat{C}_t] - \alpha \frac{\widehat{h}_t^{1+1/\psi}}{1+1/\psi} + \phi \log(\mu_t + \widehat{B}_{t+1}) \right].$$

Solving for λ yields

$$\lambda = \exp\left(\frac{W - \widehat{W}}{\sum_{t=1981}^{\infty} \beta^t N_t} \right) - 1.$$

In Table 8 we report the welfare gains associated with the transition paths for each experiment relative to our benchmark, E1. In particular, the fourth and fifth columns of the table provide the value of λ for each of experiments we have considered. Three patterns from this table are

Fig. 10. Output per person.

same as in the alternative experiment.

To be more specific, let the realized discounted 1981 value of utility in experiment E1 be denoted by $\widehat{W}$. This can be calculated using the sequence of consumption, hours and bond holdings that are realized in experiment E1:

$$\widehat{W} = \sum_{t=1981}^{\infty} \beta^t N_t \left[\log \widehat{C}_t - \alpha \frac{\widehat{h}_t^{1+1/\psi}}{1+1/\psi} + \phi \log(\mu_t + \widehat{B}_{t+1}) \right].$$

Let W be the corresponding realized utility for one of our alternative experiments. The CEV, λ, is the percentage change in consumption required in each period so that the augmented sequence realized in the benchmark transition E1 provides discounted utility equal to W. That is, λ solves the following equation:

worth noting. First, the welfare gains are strictly higher in each experiment if the consumption tax increase is delayed until the fiscal trigger is activated (date T1). This reflects the role of discounting and may also reflect that, if the increase in τ_c is delayed, it is anticipated when the unanticipated tax reform is introduced in 2015. An implication of this may be that to delay planned consumption tax increases in spite of reducing tax rates on capital income, as Japan has done twice, is not problematic from the perspective of our model.

The second pattern is that the welfare gains from reducing τ_k are generally larger than those from reducing τ_h. For example, in the revenue neutral case, the welfare gains from reducing τ_k to 0.2 and leaving τ_h unchanged (experiment E2) are about twice as large as the gains from leaving τ_k unchanged and reducing τ_h to 0.2 (experiment E4). Finally, significant welfare gains–more than 3%–are possible by eliminating all income taxation in favor of consumption taxation (experiment E7).
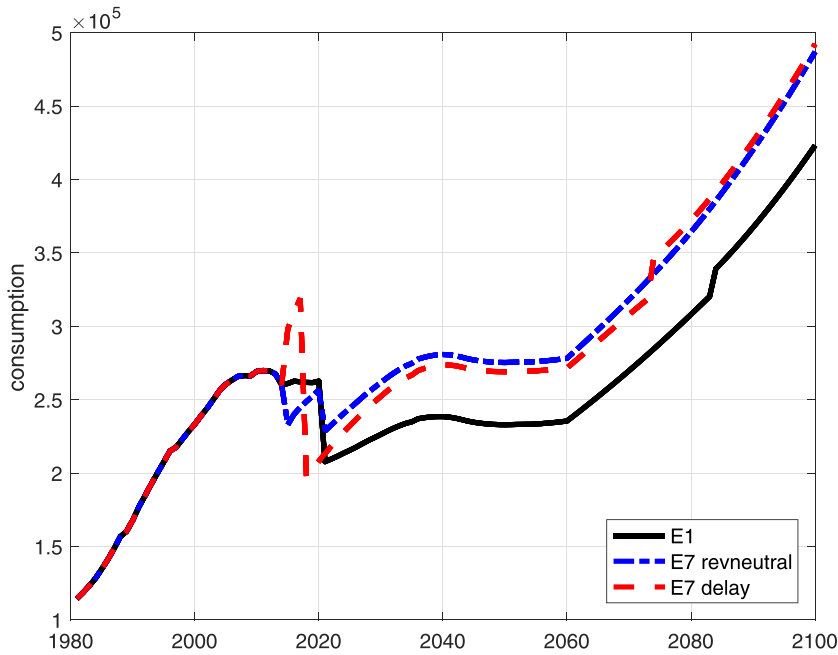
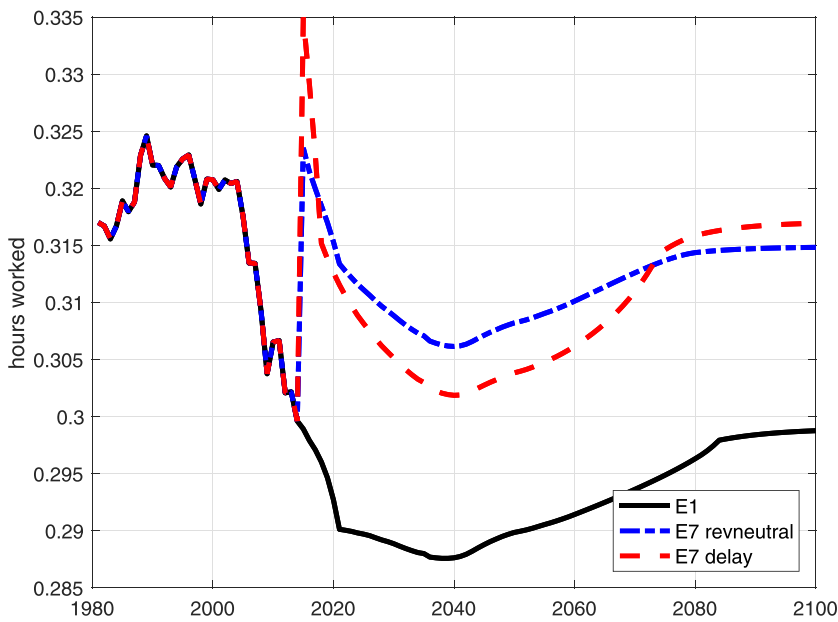G. Hansen, S. İmrohoroğlu

Fig. 11. Consumption.

Fig. 12. Hours worked.

5. Conclusion

Japan's policymakers have recently reduced the effective corporate income tax rate in an effort to generate higher investment and output. In this paper we use a neoclassical growth model that builds on Hayashi and Prescott (2002), Chen et al. (2006), and Hansen and İmrohoroğlu (2016) to measure the effects of replacing income taxation with consumption taxation on Japan's economy. Our model is a one sector deterministic growth model in which the private sector has perfect foresight about population growth rates, government policy and factor prices. Both the quantity and the price of bonds are endogenously determined in our model; government purchases of goods and services and transfer payments are exogenous. The government raises revenue by taxing factor incomes, interest income and consumption. The representative household values consumption, leisure, and government bonds and markets are complete. By including bonds in the utility function, the model is made consistent with the very strong domestic

demand for government bonds in Japan.

Our focus on this paper is an unanticipated tax reform that takes place in 2015. That is, from the beginning (1981), agents in our model anticipate the tax changes that will happen when the debt to output ratio reaches the critical level. They do not, however, anticipate the movement away from income taxation that we implement in 2015. We then compare the welfare and growth consequences of these unanticipated changes relative to what would happen without such a reform.

We consider two different ways of implementing a policy that reduces income taxes in 2015. First, we assume that the consumption tax rate rises at the beginning of 2015 in order to replace the lost revenue associated with the income tax rate reduction; we label these experiments 'revenue-neutral'. In the second set of experiments, no increase in the consumption tax is implemented in 2015, which we call 'delayed increase' because the government is assumed to delay any increase in the consumption tax until the debt to output trigger is reached. Our 'delayed increase' experiments seem closer to actual Japanese

government's tax reform policy compared to the 'revenue-neutral' experiments.[17]

After calibrating the model to the Japanese economy, we compute transition paths from observed initial conditions in Japan in 1981 to a steady-state in the distant future. Relative to maintaining income tax rates at the 2014 levels, reductions in either the labor or capital income tax (with a higher consumption tax rate to replace lost revenues) produce significant gains in labor supply or investment in the short run, with the gains higher when both income taxes are reduced. These growth effects are larger in the 'revenue-neutral' experiments.

Our welfare analysis indicates that there are significant gains from reducing income taxation, more than 3% if all income taxation is eliminated. These welfare gains are generally larger from reducing the tax on capital income than those from reducing the labor income tax rate.

Finally, the welfare gains are strictly higher in each experiment if the consumption tax increase is delayed until the fiscal trigger is activated. In other words, our growth effects favor the revenue-neutral experiments that call for an immediate rise in the consumption tax rate when income taxation is reduced, but our welfare findings suggest that delaying this increase in the consumption tax may be better from the point of view of welfare analysis. This reflects the role of discounting and the fact that even when the consumption tax increase is delayed it is still fully anticipated to take place in the near future when the unanticipated tax reform is introduced in 2015.

Acknowledgments

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[17] As of September 2017, the actual government policy is close to our 'delayed increase' policy in the following two aspects: (i) The increase in the consumption tax rate and the decrease in corporate tax rate have not gone hand in hand so far. The consumption tax rate was not raised to 10% as scheduled, and the timing of the rise was postponed, while the corporate tax rate was reduced as scheduled. (ii) The rise of the consumption tax rate and fiscal consolidation going forward explicitly are both committed to by the government. Note also, however, that the actual government policy is different from the 'delayed increase' policy as it is not explicit in details as to when and how the consolidation is going to be attained.