

Replacing Income Taxation with Consumption Taxation in Japan

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Abstract

Over the past two decades, Japan has suffered from low economic growth and a large and growing debt to output ratio. Furthermore, this ratio is expected to continue to rise as Japan anticipates significant increases in future government expenditures due to an aging population. As a consequence of these problems, Japan has proposed and implemented decreases in the corporate income tax rate as well as increases in the consumption tax rate. In this paper we focus on the output and welfare effects of a reduction in income taxation in Japan along with increases in consumption taxation to stabilize the debt to output ratio. We consider various tax reforms using the model described in Hansen and İmrohoroglu (2016). Reducing or eliminating labor or capital income taxation, and replacing the lost revenues with higher consumption taxation, produces sizable increases in labor supply, investment and output. For example, while output is projected to be roughly constant between 2015 and 2020 in the benchmark equilibrium representing the status quo, under alternative policies considered it would be 7% to 14% higher by 2020.

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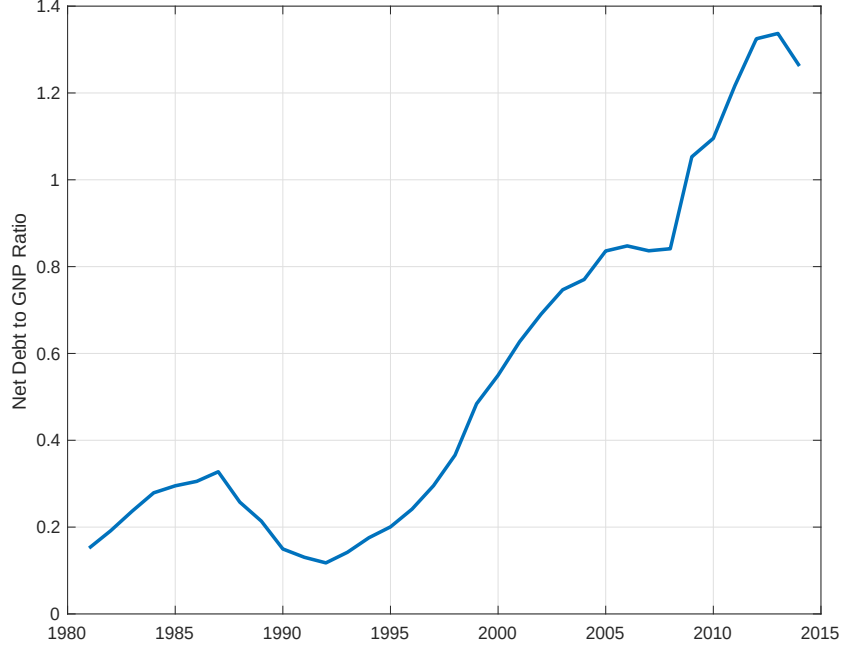


Figure 1: Net Debt to GNP Ratio

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 as shown in Figure 1.²

¹As 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, Hoshi, and Kashyap (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, Narita, and Narita (2015) use plant level data and find that resource misallocation, labor in particular, contributed negatively to aggregate productivity growth. Guner, Ventura, and Yi (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, Moll, and Shin (2013) develop a theory in which well-intended policies may have a sizable negative long-run effect on aggregate output and productivity.

²Net debt is defined as the difference between financial liabilities and assets of the general government in Japanese national accounts. The measure of GNP used for constructing the debt to output series reflects adjustments to the national accounts to be described in Section 3.

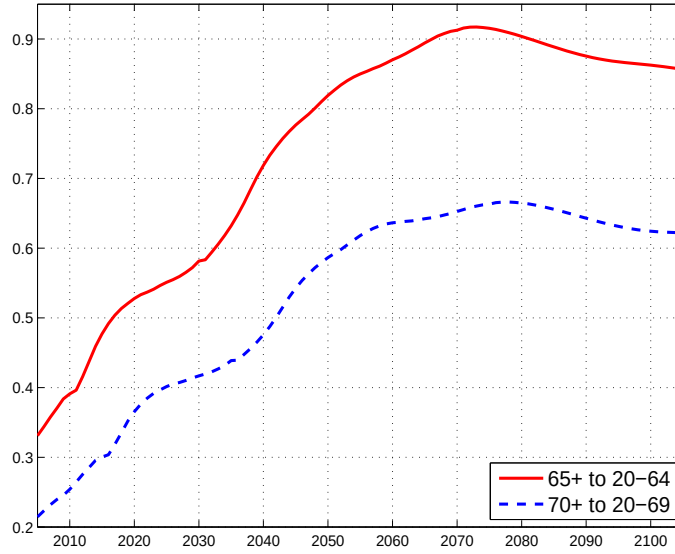


Figure 2: Projected Japanese Dependency Ratios (Population Statistics of Japan 2012)

Going forward, the debt is expected to accelerate due to the aging of the Japanese society. As shown in Figure 2, the dependency ratio in Japan is expected to increase dramatically over the next fifty years.³

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. Figure 3 displays the predicted time paths of the government purchases and transfer payments relative to GNP.⁴ Both series exhibit a clear positive trend over the next couple of decades.

To achieve the two policy goals, 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 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 2013.⁵ 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

³The figure displays two kinds of dependency ratios. The first is the number of 65 and older individuals to the number of 20 to 64 year old individuals and the second is the ratio of 70 and older individuals to the number of people between 20 and 69. The actual population data and the projections of future population are taken from the Population Statistics of Japan 2012 and the National Institute of Population and Social Security Research, respectively.

⁴These 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.

⁵The “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.

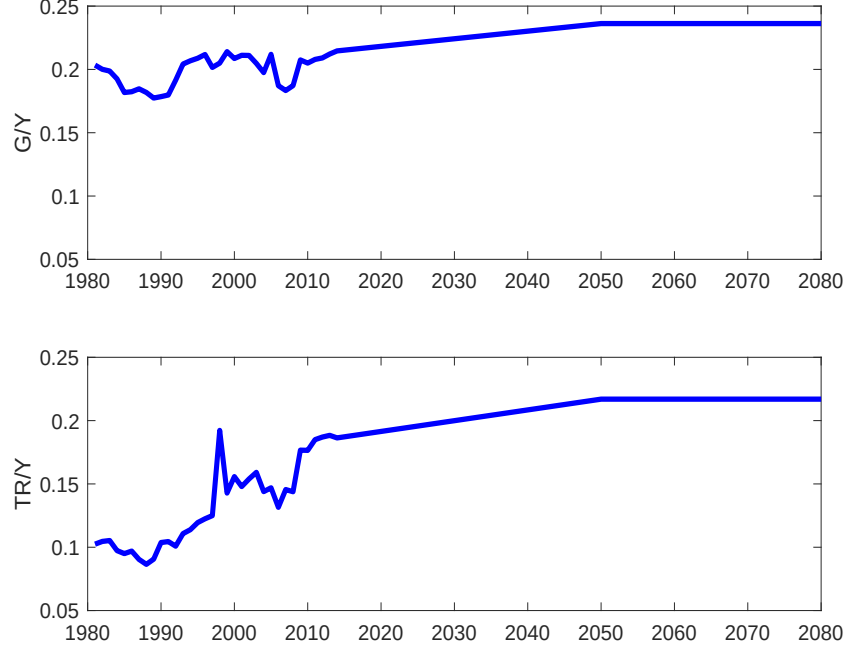


Figure 3: Government Expenditures to GNP: Data 1981-2014, projections 2015-2050

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.

In this paper, we study the impact of changes in the tax structure on Japan’s economy. We do this by simulating a neoclassical growth model built upon Hayashi and Prescott (2002), Chen, İmrohoroglu, and İmrohoroglu (2006), and Hansen and İmrohoroglu (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.⁶ The second is a debt stabilization policy rule followed by the government. As in Hansen and İmrohoroglu (2016), once the debt to output ratio reaches a critical level, the Japanese government automatically increases the consumption tax rate to stabilize the debt.⁷

Simulations are conducted in two steps. First, we compute the equilibrium future

⁶Sakuragawa and Hosono (2010) employ an alternative approach that incorporates intermediation costs to obtain low equilibrium interest rates on government debt.

⁷In 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.

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.⁸ 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 reduction in corporate tax rates 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 reform is introduced. This result is obtained by introducing a tax reform that is broadly consistent with actual tax reforms being 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% 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 1% 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 less than 2% 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 12% increase in consumption taxes to replace the lost revenue. In the long run steady state, the consumption tax rate would still be 12% 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, Milesi-Ferretti, and Asea (1997), examines growth implications of tax structure.⁹ 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, Bleaney, and Gemmell (1999) and Arnold (2008) document using the data of

⁸Following Hansen and İmrohoroglu (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.

⁹There are also a number of theoretical papers including Judd (1985), Chamley (1986) that study the relationship between the level of output and tax rates.

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 İmrohoroglu (2016), explores how tax structure matters for fiscal sustainability. Among them, our paper is closest to Hansen and İmrohoroglu (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 İmrohoroglu (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 1981-2014. 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 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, $b_{\max}$, 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 $\bar{\tau}_c$ and $\bar{b}$. Given this, the actual values for $\tau_{c,t}$ and TR_t are determined as follows:

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

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

According to equation (2), once the upper bound on debt is reached, the consumption tax is set equal to its steady state value, $\bar{\tau}_c$, 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 $\bar{b}$, the consumption tax rate is set equal to its steady state value.

In addition, as shown in equation (3), at date T_1 transfers are reduced by 8% of output reflecting our assumption that “tax base broadening” will be implemented at the time debt-reducing reform is required.¹⁰ At date T_2 , the point at which the debt to output ratio is at or below its steady state value, transfers are adjusted to retire (or augment) the stock of government debt [determined by equation (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.

¹⁰As in Hansen and İmrohoroglu (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.

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:

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

subject to

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

$$+ [1 - (1 - q_{t-1})\tau_{b,t}]B_t + TR_t, \quad (6)$$

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 [equation (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 $\phi > 0$.¹¹

Finally, μ_t 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.¹² 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, $\mu_t = \mu A_t^{1/(1-\theta)}$.

¹¹For 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 $c_t + k_{t+1} + q_t b_{t+1} = w_t + r_{k,t} k_t + (1 - \delta) k_t$. 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 $1/q$.

¹²This parameter helps us to match the volatility of bond prices.

2.3 Firm's Problem

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

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

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 $\{G_t, TR_t, D_t, B_t, \tau_{h,t}, \tau_{k,t}, \tau_{c,t}, \tau_{b,t}\}_{t=0}^\infty$, 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 [equations (4) and (5)],
- the government budget constraint, given by equations (1) - (3), is satisfied each period,
- the market for bonds clears,
- and the goods market clears: $C_t + [\eta_t K_{t+1} - (1 - \delta) K_t] + G_t = Y_t$,
- the labor market and capital rental markets clear, which implies that $W_t = (1 - \theta) A_t K_t^\theta h_t^{-\theta}$ and $r_t = \theta A_t K_t^{\theta-1} h_t^{1-\theta}$.

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.

$$\frac{(1 + \tau_{c,t+1})\gamma_t^{1/(1-\theta)}c_{t+1}}{(1 + \tau_{c,t})c_t} = \beta[1 + (1 - \tau_{k,t+1})(r_{t+1} - \delta)], \quad (7)$$

$$\frac{\phi}{\mu + b_{t+1}} + \frac{\beta\eta_t[1 - (1 - q_t)\tau_{b,t+1}]}{(1 + \tau_{c,t+1})c_{t+1}} = \frac{q_t\eta_t\gamma_t^{1/(1-\theta)}}{(1 + \tau_{c,t})c_t}, \quad (8)$$

$$\alpha h_t^{1/\psi} = \frac{(1 - \tau_{h,t})w_t}{(1 + \tau_{c,t})c_t}, \quad (9)$$

$$y_t = k_t^\theta h_t^{1-\theta}, \quad (10)$$

$$\eta_t\gamma_t^{1/(1-\theta)}k_{t+1} = (1 - \delta)k_t + x_t. \quad (11)$$

Equation (7) is the typical Euler equation arising from the choice of capital stock at time t . The bond Euler equation is given by (8). The first order condition for hours worked is shown in equation (9). The production function and the law of motion for capital are given in equations (10) and (11), respectively. The budget constraint for the household is given below in equation (12)

$$\begin{aligned} (1 + \tau_{c,t})c_t + \eta_t\gamma_t^{1/(1-\theta)}k_{t+1} + q_t\eta_t\gamma_t^{1/(1-\theta)}b_{t+1} \\ = (1 - \tau_{h,t})w_th_t + [1 - (1 - q_{t-1})\tau_{b,t}]b_t + tr_t - d_t + [1 + (1 - \tau_{k,t})(r_t - \delta)]k_t. \end{aligned} \quad (12)$$

The government budget equation is given by equation (13)

$$\begin{aligned} g_t + tr_t + b_t &= q_t\eta_t\gamma_t^{1/(1-\theta)}b_{t+1} + \tau_{c,t}c_t + \tau_{h,t}w_th_t \\ &\quad + \tau_{k,t}(r_t - \delta)k_t + \tau_{b,t}(1 - q_{t-1})b_t + d_t. \end{aligned} \quad (13)$$

Equation (14) is the detrended debt sustainability rule

$$d_t = \begin{cases} \kappa(b_t - \bar{b}_t \bar{y}) & \text{if } b_s/y_s \geq b_{\max} \text{ for some } s \leq t, \\ 0 & \text{otherwise.} \end{cases} \quad (14)$$

where $\bar{y}$ is the value of y_t along the balanced growth path and $\bar{b}$ is the targeted debt to output ratio along the balanced growth path.

Finally, the market clearing conditions are given below in equations (15), (16) and (17)

$$r_t = \theta k_t^{\theta-1} h_t^{1-\theta}, \quad (15)$$

$$w_t = (1 - \theta)k_t^\theta h_t^{-\theta}, \quad (16)$$

$$c_t + x_t + g_t = y_t. \quad (17)$$

Hence we have 10 equations, (7) through (16), in 10 unknowns $\{c_t, x_t, h_t, y_t, k_{t+1}, b_{t+1}, d_t, q_t, w_t, r_t\}$ at each time period t .

2.6 Solution Procedure

We take as given a value for k_{1981} and a sequence $\{\tau_{c,t}, \tau_{h,t}, \tau_{b,t}, \tau_{k,t}, \eta_t, \gamma_t, g_t, tr_t\}_{t=1981}^{\infty}$, where the elements of this sequence are constant beyond some date. These constant values determine the steady state to which the economy ultimately converges. We use a shooting algorithm, similar to that in Hayashi and Prescott (2002), Chen, İmrohoroglu, and İmrohoroglu (2006) and Hansen and İmrohoroglu (2016), to determine the value of c_{1981} (or, equivalently, k_{1982}) such that the sequence of endogenous variables $\{c_t, x_t, h_t, y_t, k_{t+1}, b_{t+1}, d_t, q_t, w_t, r_t\}$ determined by equations (7) through (16) converges to the steady state. That is, the shooting algorithm guarantees that the capital stock sequence satisfies the transversality condition. Note that our fiscal sustainability rule guarantees that the bond to output ratio is equal to $\bar{b}$ in the steady state achieved in the limit.

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 equations 7 to 17). 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 below:

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
$Y =$	$C + I + G$

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 Figure 3), 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.¹³ These estimates are very similar to those calculated independently by İmrohoroglu, Kitao, and Yamada (2016).¹⁴

¹³The 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%.

¹⁴İmrohoroglu, Kitao, and Yamada (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 calibration of the projected increase in government purchases and transfer payments combined 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 last values of the observed ratios for 2014 to the 2050 ratios projected by Fukawa and Sato (2009). This leads to increases of 2.06 and 3.06 percentage points in G/Y and TR/Y , respectively, from 2015 to 2050.

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 baseline 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 2017. 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 semiannual interest income from coupon-bearing bonds and is withheld (15% income tax plus 5% local tax) at the time the interest is paid.

Figure 4 below 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 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

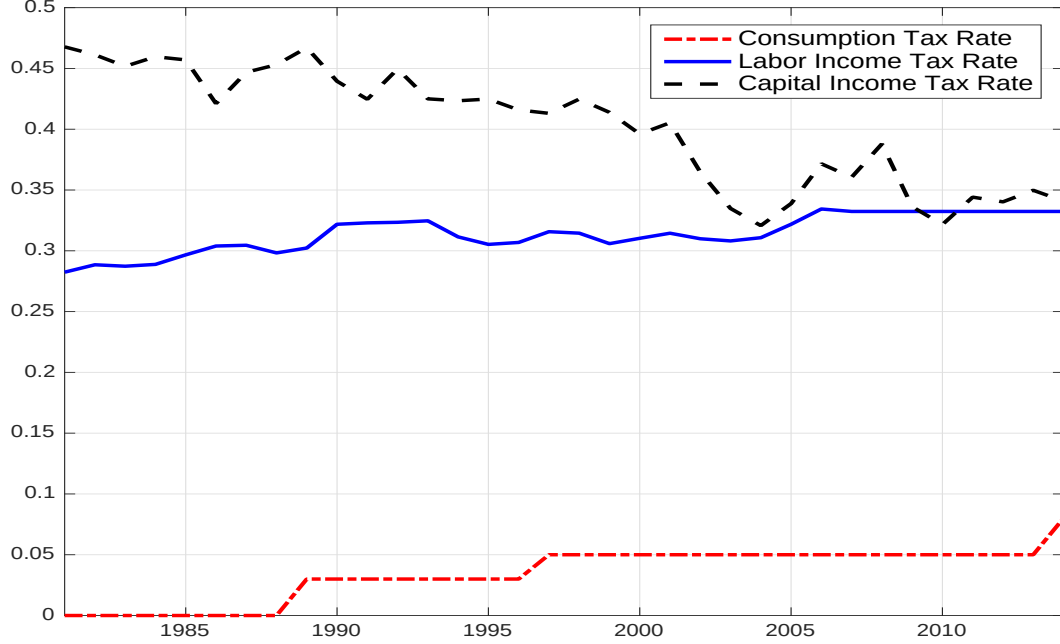


Figure 4: Tax Rates

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, $\beta, \alpha, \psi, \phi$, and μ , in the utility function given by equation (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, Guren, Manoli, and Broda (2012).

For the three preference parameters β, α , and ϕ , we use the equilibrium conditions given in equations (18), (19), and (20) for the sample period to obtain values for each year and, from that, averages over the sample.

$$\beta_t = \frac{(1 + \tau_{c,t+1})\gamma_t^{1/(1-\theta)}c_{t+1}}{(1 + \tau_{c,t})c_t \left[1 + (1 - \tau_{k,t+1}) \left(\theta \frac{y_{t+1}}{k_{t+1}} - \delta \right) \right]} \quad (18)$$

$$\alpha_t = \frac{h_t^{-1/\psi} (1 - \tau_{h,t})(1 - \theta)y_t}{(1 + \tau_{c,t})c_t h_t} \quad (19)$$

$$\phi_t = \eta_t(\mu + b_{t+1}) \left[\frac{q_t \gamma_t^{1/(1-\theta)}}{(1 + \tau_{c,t})c_t} - \frac{\beta_t [1 - (1 - q_t)\tau_{b,t+1}]}{(1 + \tau_{c,t+1})c_{t+1}} \right]. \quad (20)$$

Note, however, that the equilibrium condition in equation (20) contains the equilibrium price of government bonds, q_t . The empirical counterpart to q_t that we compute reflects

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	Equation (18), Sample Average
α	22.03	Equation (19), Sample Average
ψ	0.5	Chetty et al (2012)
ϕ	0.12	Equation (20), Sample Average
μ	1.1	Fit q_t for 1981-2014

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:

$$q_t = \frac{B_{t+1}/F_t}{(B_{t+1} + P_{t+1})/F_{t+1}}. \quad (21)$$

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.

4 Quantitative Experiments

4.1 Steady State Tradeoffs

Figure 5 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.¹⁵ 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 vertical line in figure) means that it is possible to reduce the capital tax rate without raising the consumption tax by much.

¹⁵Note 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.

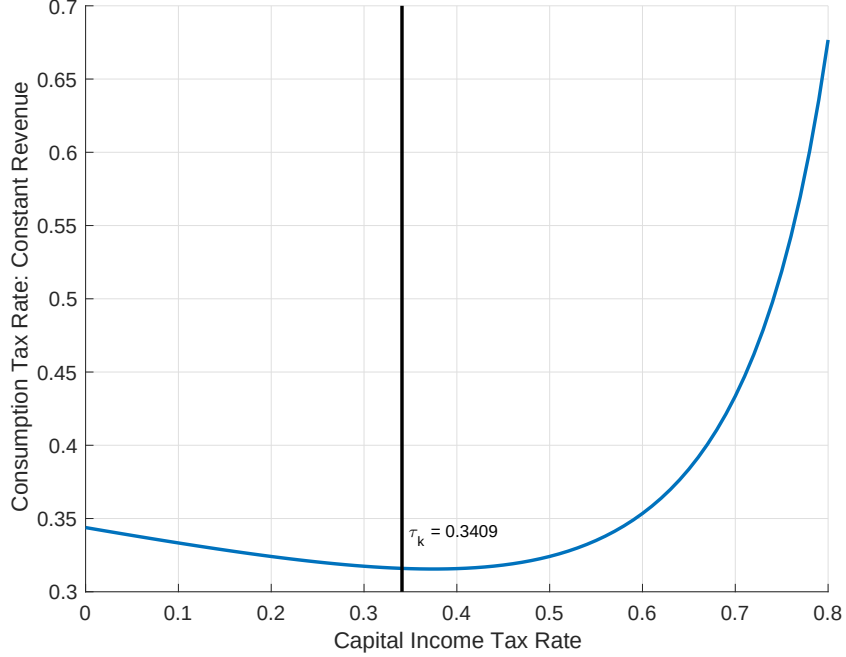


Figure 5: Steady State Iso-Revenue Curve ($\tau_h = 0.3324$)

Similarly, Figure 6 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 alternative ways of implementing a policy that reduces income taxes beginning in 2015. In the first set of experiments, the consumption tax rate is raised 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 equation (??) is reached. In the second set of experiments, no increase in the consumption tax is implemented in 2015. Instead, the government is assumed to delay this increase 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 calibration, it does so by increasing τ_c .

For each approach, 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} .

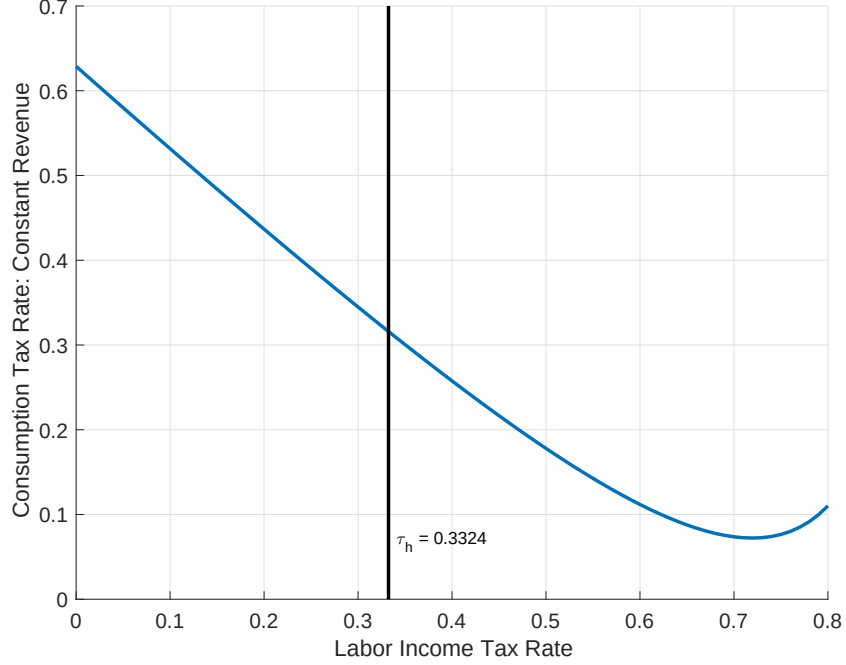


Figure 6: Steady State Iso-Revenue Curve ($\tau_k = 0.3409$)

The other experiments are ones where τ_k and/or τ_h are reduced in 2015. The following table summarizes these experiments:

4.2.1 How the Model's Rule for Fiscal Sustainability Works

In this subsection, we demonstrate how our rule works to achieve fiscal sustainability in the baseline case. 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.

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%. Figure 7 indicates that the first trigger, T_1 occurs in the year 2012 in this baseline 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 the following figures illustrate what

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

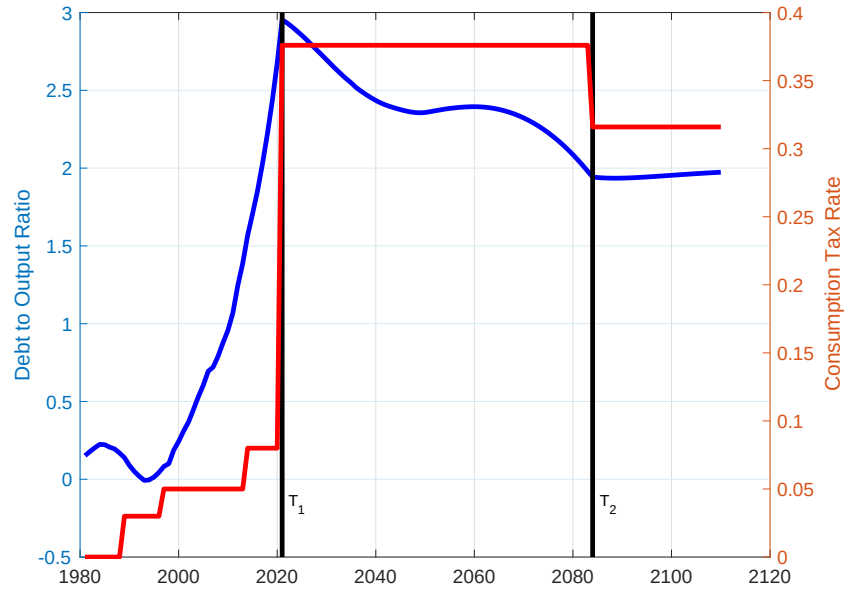


Figure 7: Debt to Output Ratio and the Consumption Tax Rate

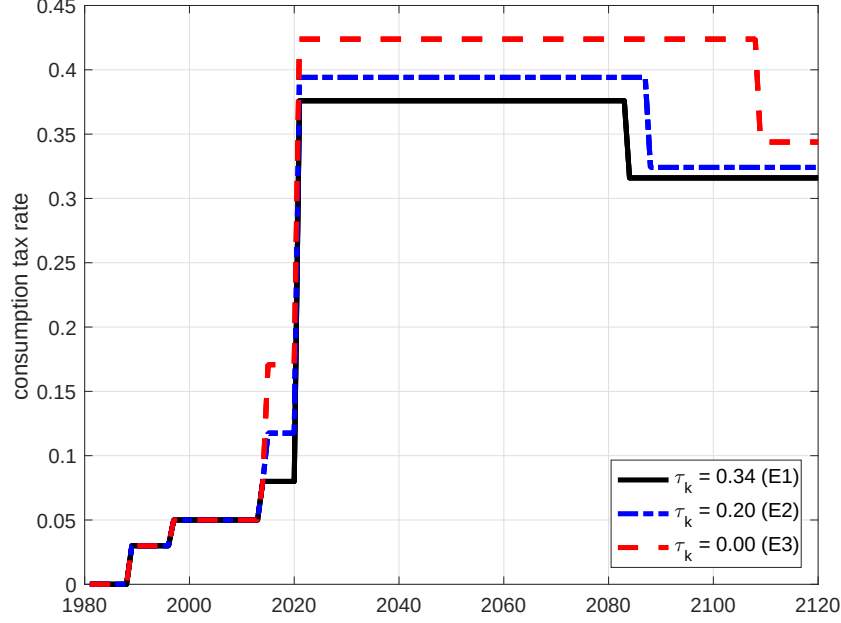


Figure 8: Consumption Tax Rate

happens to the consumption tax rate, as well as the effective tax rate, in each of these experiments.

Figures 8 and 9, the changes in τ_c and the resulting changes in the effective tax rate are shown for the experiments in which the capital income tax rate is lowered, but the labor income tax rate is held constant. In particular, these tax rates are shown for the benchmark calibration (E1) and experiments E2 and E3. While it is a bit difficult to see in Figure 8, there is an increase in τ_c in 2015 in E2 and E3 but not in E1. This is because, in the benchmark case, the consumption tax rate remains equal to its 2014 value of 0.08 in 2015. The next increase in τ_c is at date T_1 , the first date at which the debt to output ratio reaches b_{max} [see equation (??)]. This happens in 2021 in all three scenarios depicted in this figure. 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 in equation (??), the consumption tax rate is decreased to its steady state value. This happens in 2084 in the benchmark path case, 2088 in E2 and 2109 in E3.

The next two figures shows the time path of the consumption tax rate and the effective tax rate in the experiments where only τ_h is decreased (E2 and E3), as well as in the benchmark case (E1). One thing to note in Figure 10 is that a larger increase in the consumption tax is required in 2015 in order to compensate for the revenue lost from reducing τ_h then 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, Figures 12 and 13 show the same time series for the benchmark (E1) and experiments where both τ_k and τ_h are lowered in 2015 (E6 and E7). 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,

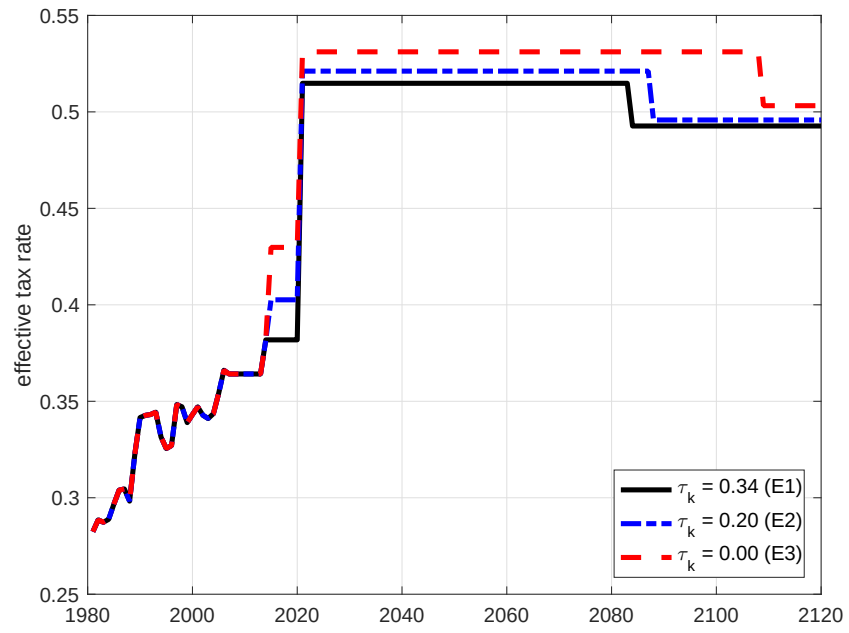


Figure 9: Effective Tax Rate

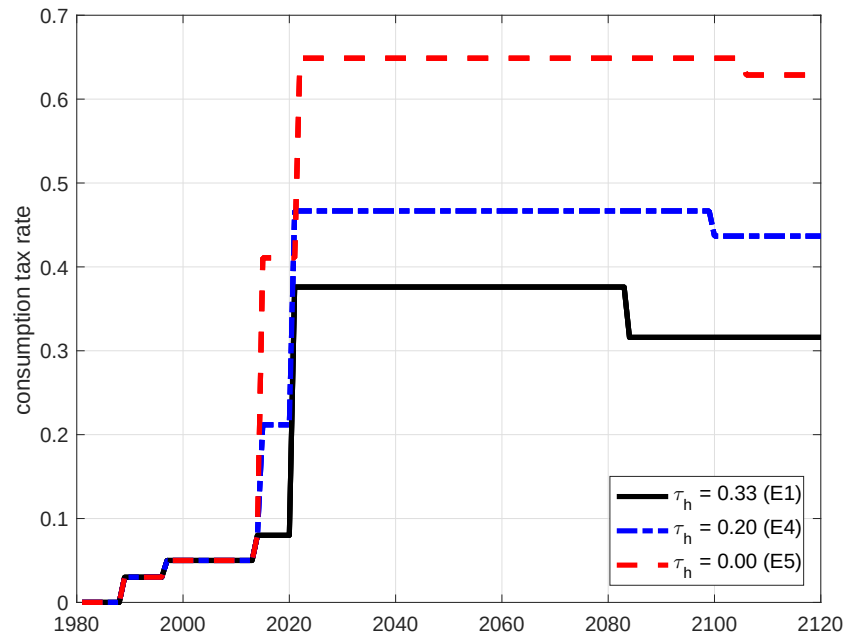


Figure 10: Consumption Tax Rate

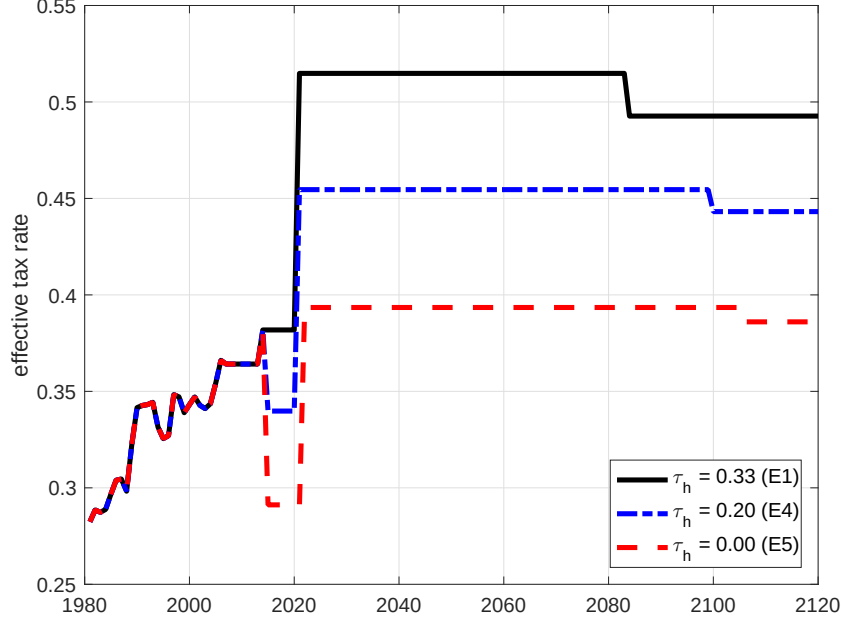


Figure 11: Effective Tax Rate

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 following table summarizes the tax rate changes shown in Figures 8 through 13, as well as the dates ($T1$ and $T2$) when tax rates change after 2015.

The transition paths for the capital stock, hours worked, output, consumption and investment are shown in Figures 14 through 18. 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.

Figure 14 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 Figure 15, but is increased substantially when τ_h is set to zero in E5 and E7.

The paths for output, shown in Figure 16, 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. Figures 17 and 18 show how this breaks down in consumption and investment. The same ordering as for output applies to investment, which means that lowering τ_k to zero has the largest effect. The ordering is slightly different for consumption, but lowering both tax rates to zero still provides the largest gains.

To get a sense for how these policy changes would affect living standards, we show output per person in Figure 19. In all cases where income taxation is substituted for con-

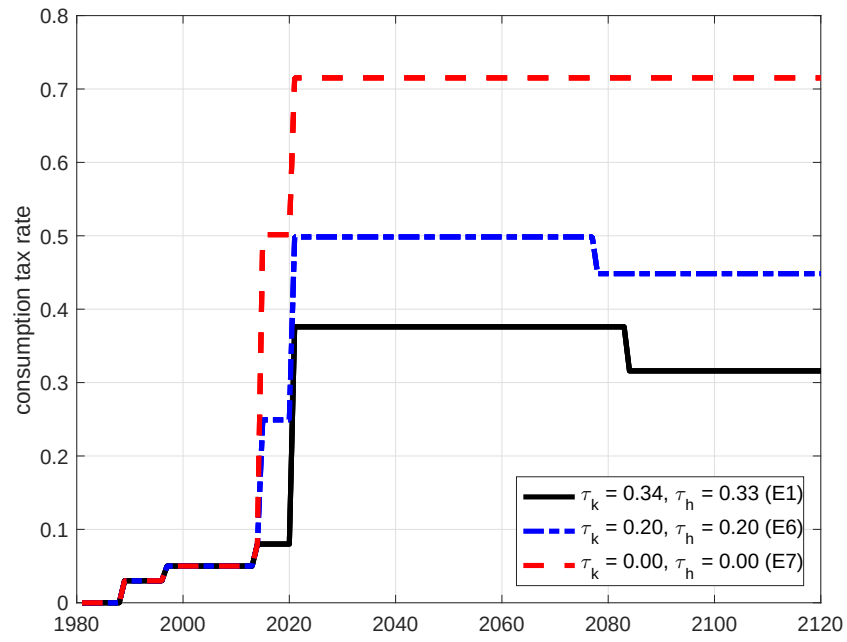


Figure 12: Consumption Tax Rate

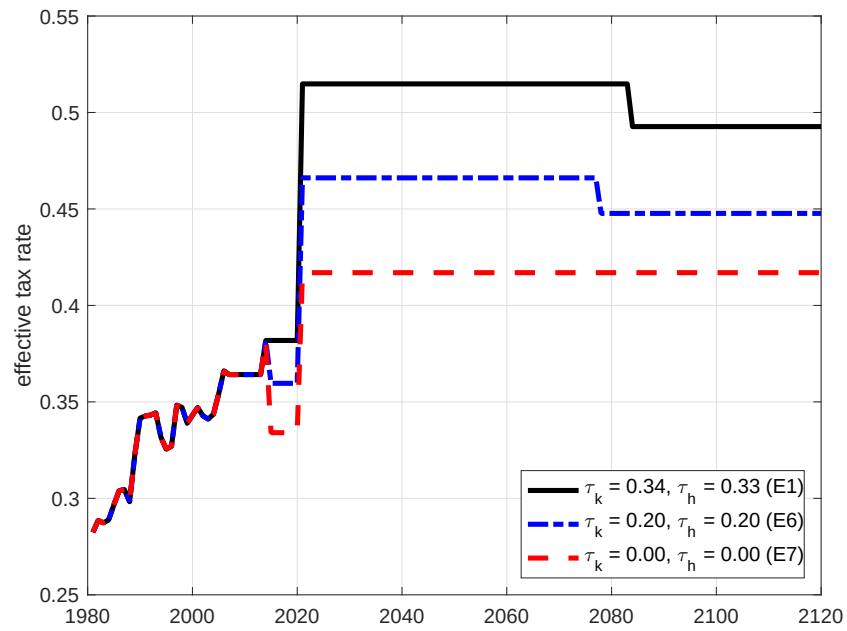


Figure 13: Effective Tax Rate

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 .

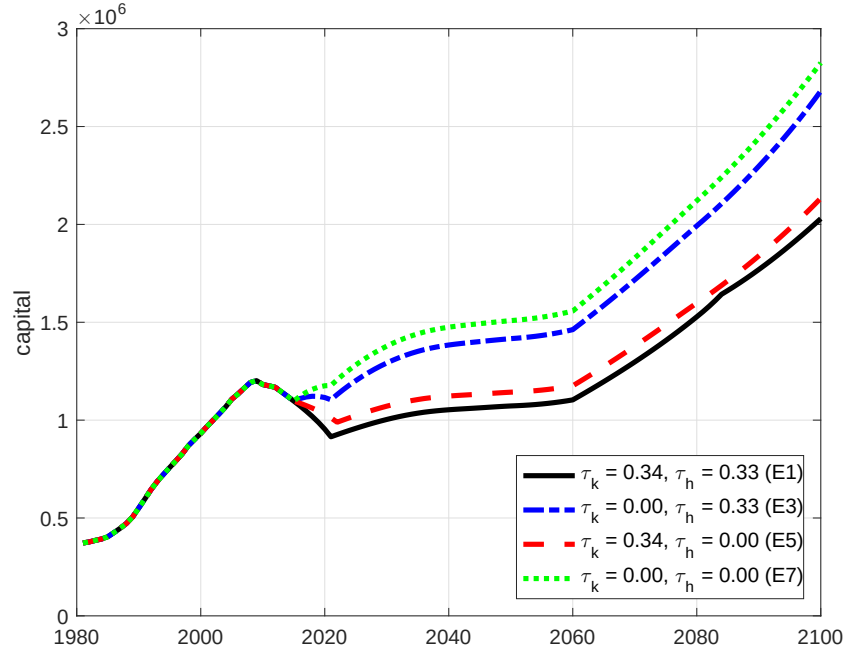


Figure 14: Capital Stock

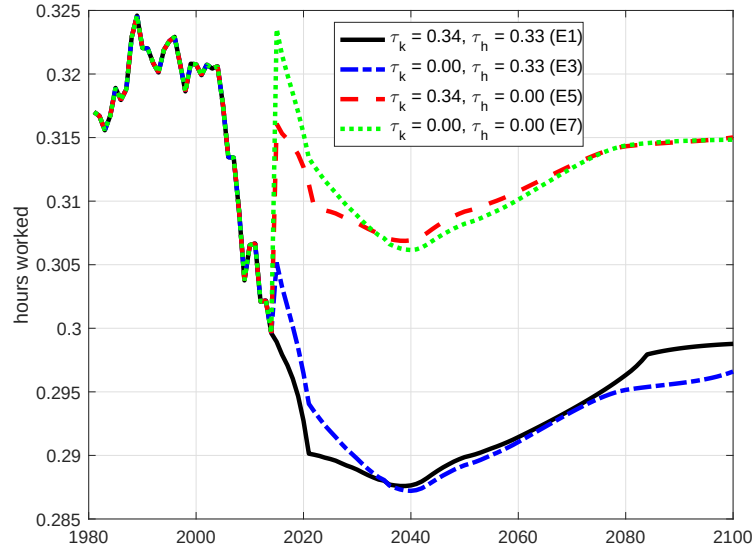


Figure 15: Hours Worked

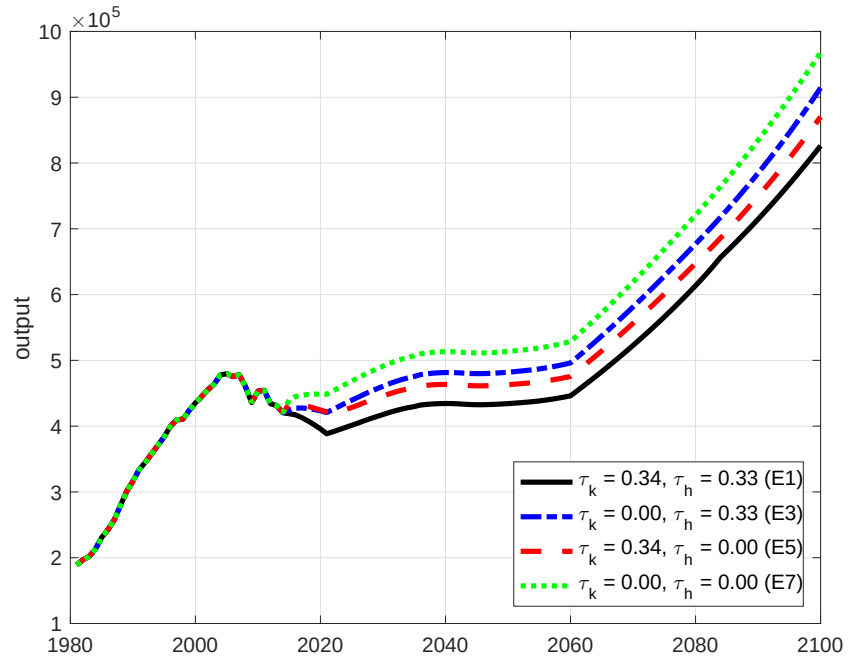


Figure 16: Output

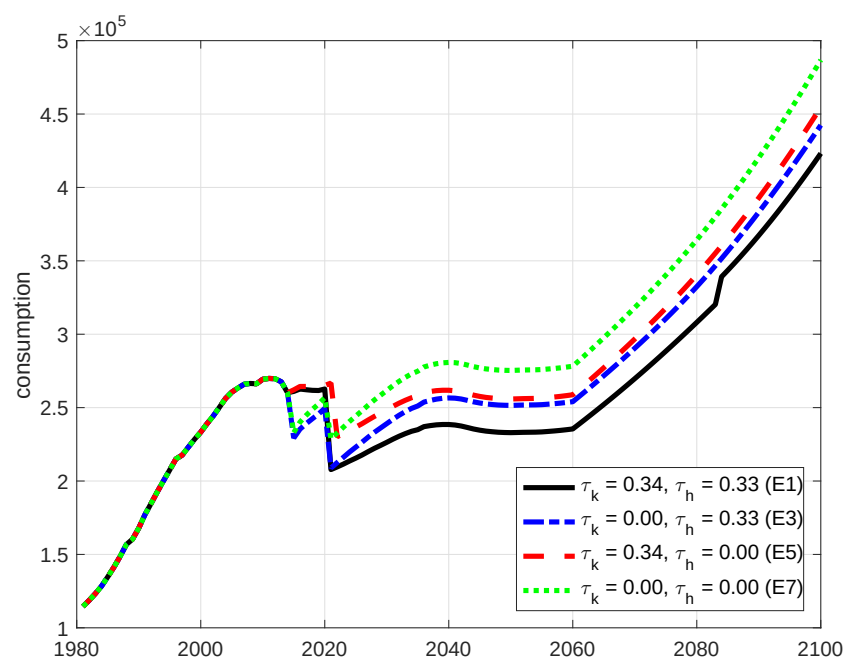


Figure 17: Consumption

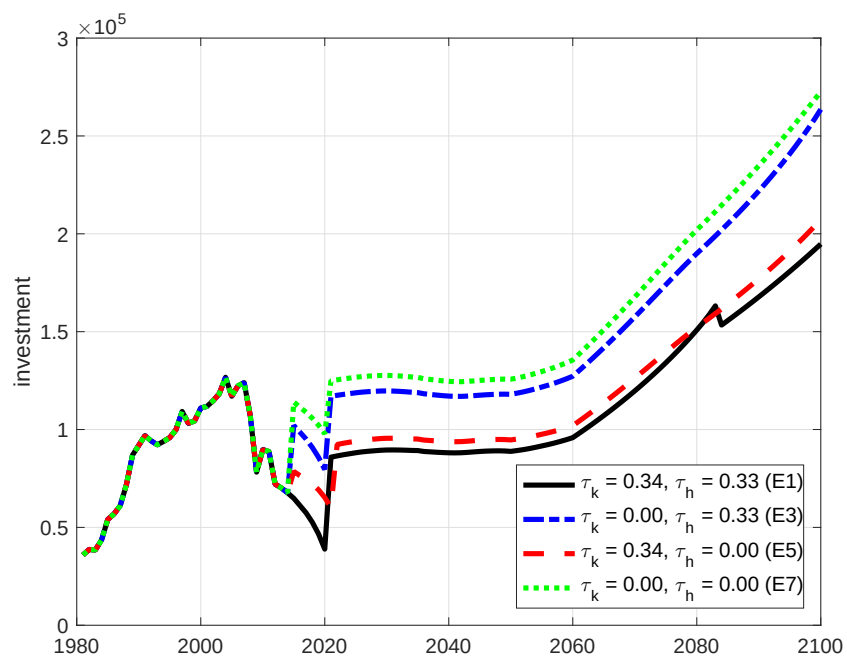


Figure 18: Investment

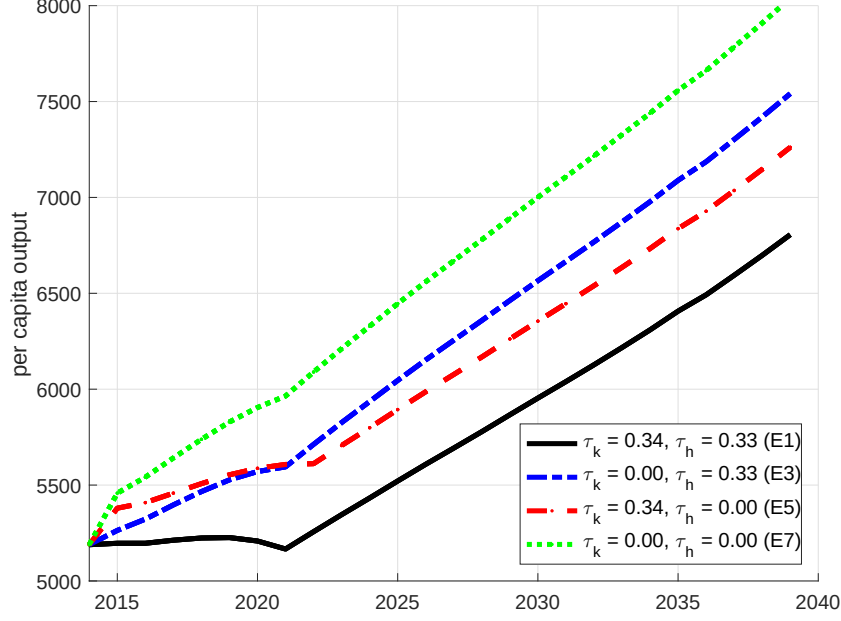


Figure 19: Output per Person

Table 5: Average Annual Growth Rate of Output per Working Age Population

	<i>E1</i>	<i>E3</i>	<i>E5</i>	<i>E7</i>
2015 – 2021	0.17%	1.18%	0.61%	1.58%
2025 – 2060	1.58%	1.62%	1.58%	1.62%

sumption 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 7 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 ultimate 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.

¹⁶The value of T_1 in E5 is 2022.

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 .

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 according to equation (??). Table 6 provides results from the same set of experiments report 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 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.

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%

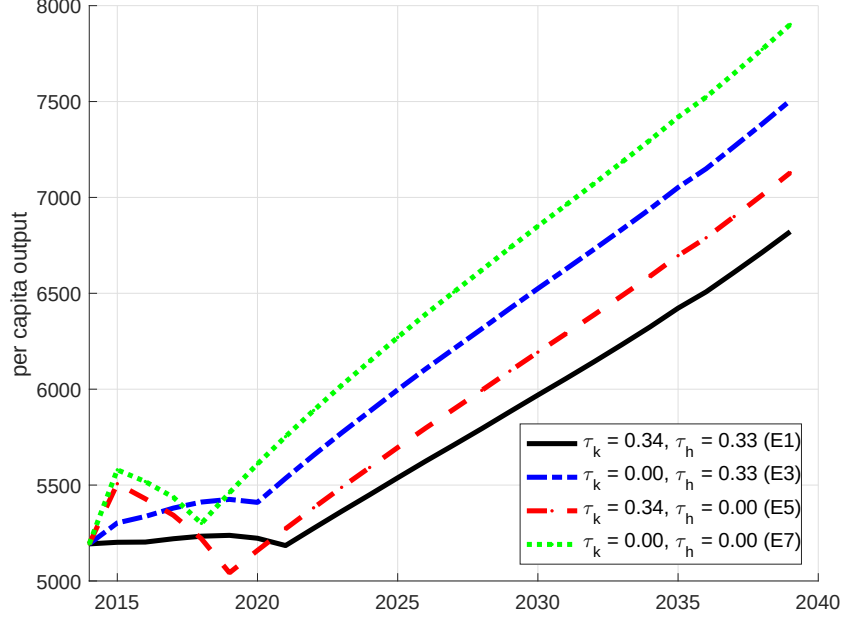


Figure 20: Output per Person

4.3 Welfare Analysis

In this section we compute welfare differences across experiments E1-E7. For each experiment 2-7, we calculate the consumption equivalent variation relative to Experiment 1, by calculating the percent change in consumption that would be required each period in Experiment 1 to make the present discounted utility the same as in the alternative experiment.

To be more specific, let the realized discounted 1981 value of utility in Experiment 1 be denoted by $\widehat{W}$. This can be calculated using the sequence of consumption, hours and bond holdings that are realized in Experiment 1, as follows:

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

Let W be the corresponding realized utility for one of our alternative experiments. The consumption equivalent variation, λ , is the percentage change in consumption required in each period in Experiment 1 that would equate W to $\widehat{W}$. That is, λ solves the following equation:

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

Table 8: Welfare Analysis: Consumption Equivalent Variation (λ) Relative to Experiment 1

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

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. Three patterns from this table are 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 larger than those from reducing τ_h . For example, 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).

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, İmrohoroğlu, and İmrohoroğlu (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

We 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.

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. In addition, there are significant welfare gains from this tax reform.

References

- Arnold, J. (2008). Do tax structures affect aggregate economic growth? empirical evidence from a panel of oecd countries. Working Paper.
- Barro, Robert, J. (1990). Government spending in a simple model of endogeneous growth. *Journal of Political Economy* 98(5), 103–125.
- Buera, F., B. Moll, and Y. Shin (2013). Well-intended policies. *Review of Economic Dynamics* 16(1), 216–230.
- Caballero, R., T. Hoshi, and A. Kashyap (2008). Zombie lending and depressed restructuring in japan. *American Economic Review* 98(5), 1943–1977.
- Chamley, C. (1986). Optimal taxation of capital income in general equilibrium with infinite lives. *Econometrica* 54(3), 607–622.
- Chen, K., A. İmrohoroglu, and S. İmrohoroglu (2006). The Japanese saving rate. *American Economic Review* 96(5), 1850–1858.
- Chetty, R., A. Guren, D. Manoli, and A. W. Broda (2012). Does indivisible labor explain the the difference between micro and macro elasticities? a meta-analysis of extensive margin elasticities. In D. Acemoglu, J. Parker, and M. Woodford (Eds.), *NBER Macroeconomics Annual*, pp. 1–56. Massachusetts: The University of Chicago Press.
- Easterly, W. and S. Rebelo (1993). Fiscal policy and economic growth: An empirical investigation. *Journal of Monetary Economics* 32(3), 417–458.
- Fukawa, T. and I. Sato (2009). Projection of pension, health and long-term care expenditures in japan through macro simulation. *The Japanese Journal of Social Security Policy* 8(1), 33–42.
- Guner, N., G. Ventura, and X. Yi (2008). Macroeconomic implications of size-dependent policies. *Review of Economic Dynamics* 11(4), 721–744.
- Gunji, H. and K. Miyazaki (2011). Estimates of average marginal tax rates on factor incomes in japan. *Journal of the Japanese and International Economies* 25(2), 81–106.
- Hansen, G. and S. İmrohoroglu (2016). Fiscal reform and government debt in japan: A neoclassical perspective. *Review of Economic Dynamics* 21(July), 201–224.
- Hayashi, F. and E. C. Prescott (2002). The 1990s in japan: A lost decade. *Review of Economic Dynamics* 5(1), 206–235.
- İmrohoroglu, S., S. Kitao, and T. Yamada (2016). Achieving fiscal balance in Japan. *International Economic Review* 57(1), 117154.
- Judd, K. L. (1985). On the performance of patents. *Econometrica* 53(3), 567–586.
- Kneller, R., M. F. Bleaney, and N. Gemmell (1999). Fiscal policy and growth: evidence from oecd countries. *Journal of Public Economics* 74(2), 171–190.
- Kwon, H. U., F. Narita, and M. Narita (2015). Resource reallocation and zombie lending in japan in the 1990s. *Review of Economic Dynamics* 18(4), 709–732.

- Mendoza, E. G., G. M. Milesi-Ferretti, and P. Asea (1997). On the ineffectiveness of tax policy in altering long-run growth: Harberger's superneutrality conjecture. *Journal of Public Economics* 66(1), 99–126.
- Nutahara, K. (2015). Laffer curves in japan. *Journal of the Japanese and International Economics* 36(C), 56–72.
- Sakuragawa, M. and K. Hosono (2010). Fiscal sustainability of japan: A dynamic stochastic general equilibrium approach. *The Japanese Economic Review* 61(4), 517–537.
- Trabandt, M. and H. Uhlig (2011). The laffer curve revisited. *Journal of Monetary Economics* 58(4), 305–327.