Incidence of Corporate Income Tax and Optimal Capital Structure: A Dynamic Analysis

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Abstract

In this paper, we analyze the incidence of corporate income tax using a dynamic general equilibrium model. By building a dynamic macroeconomic model, it is able to analyze not only the instantaneous incidence of corporate income tax but also consider the intertemporal incidence. The dynamic model in this paper includes capital structure, that is, choice of equity, debt, and retained earnings to implement investment. It also includes agency cost on debt: per unit of agency cost on debt is progressively-increasing. We implement a simulation based on the dynamic model, and measure the incidence of corporate income tax on labor income. We found that a percentage of the incidence on labor income is about 50-80% in the short run (for one year), and a percentage of the incidence on capital income is about 20-50%. In the long run, about 95% of the incidence is on labor income. Almost all of the incidence is shifted to labor income, but not all of the incidence is. In contrast, in a neo-classical growth model, the entire incidence is shifted to labor income in the long run. The result of this paper seems to be caused by the agency cost on debt.

Keywords: incidence of corporate income tax, capital structure, debt-financing, cost of capital, dynamic analysis

JEL classification codes: H22, H25
1. Introduction

Incidence of corporate income tax is an old and new problem in public economics. In Japan, under discussion on the tax reform, raising consumption tax (VAT) will be needed and the burden of corporate income tax is heavier than other countries. Against the argument, there is an objection that the policy package of consumption tax increase and corporate income tax cut is politically unacceptable. In the background, it is intuitively thought that consumption tax is mainly beard by consumers and corporate income tax is mainly beard by corporations. Such asserters ignore the previous studies of the shifting and incidence of corporate income tax.

In such present situation, it is necessary to examine analysis of the incidence of corporate income tax to discuss the hereafter tax reform, especially consumption tax increase and corporate income tax reduction. In this paper, we build a theoretical model to investigate tax incidence, and implement numerical analysis.

Static analysis of incidence of tax started from the pioneering study by Harberger (1962) had been developed into dynamic analysis to consider the intertemporal resource allocation. On the other hand, about the analyses of the tax reform in Japan, the simulation analyses prospered in the late 1980s when consumption tax (VAT) was not be introduced, and some analysis were done in the mid 1990s when the tax system was revised. But such analyses are scarcely made in recent years. In addition, the previous simulation analyses of tax reform mainly focus on the loss and gain of each agent with tax reform. These analyses do not prove the incidence of the burden of corporate income tax clearly.

Recently, in the US, Gravelle and Smetters (2006), Randolph (2006) and others implement numerical analyses of the incidence of corporate income tax. However, they employ a static model without corporate finance. Unfortunately, there is no empirical study on it in Japan over a few decades.

In this paper, while considering the tide of this precedent study, we focus on the incidence of the burden of corporate income tax and analyze it on the basis of Japanese tax system and macroeconomic data. Especially, it is necessary to consider in the dynamic macroeconomic model that can analyze it to explain the intertemporal incidence. By building a dynamic macroeconomic model, it is able to analyze not only the instantaneous incidence of corporate income tax but also consider the intertemporal
incidence.

2. The Framework

2.1 Behavior of Each Agent

In section 2, we explain a theoretical model in this paper. For the following numerical analysis, we adopt the discrete time model. Turnovsky (1995) provides a continuous time model, which is similar to our model. The representative household lives indefinitely, and gets some utility from consumption of private goods and leisure in each period. The representative household decides consumption and leisure to maximize lifetime utility. In addition, every household in this economy is homogeneous and the population of household is one and fixed in every period.

The price of private goods is 1 as the numeraire goods, and this household is assumed to be a price taker. We presume this economy is a closed economy for simplification.

Lifetime utility function of the representative household is

$$\sum_{t=1}^{\infty} \rho^t U(c_t, l_t)$$

where $U_c > 0$, $U_{cc} < 0$, $U_l < 0$, $U_{ll} \leq 0$, $U_{cl} \leq 0$

c: private consumption: numeraire,
l: labor supply,
$\rho$: discount factor of the household (constant over time)

Budget constraint of the representative household is as follows

$$b_{t+1}^G - b_t^G + b_{t+1}^B - b_t^B + s_{t+1}(E_{t+1} - E_t) + (1 + \tau_c)c_t$$

$$= (1 - \tau_w)w_t l_t + (1 - \tau_G)(r_t^G b_t^G + r_t^B b_t^B) + (1 - \tau_R)D_t - \tau_G (s_t + s_{t+1})E_t + T_t$$

where

$b^G_t$: outstanding of government bonds (at the beginning of period $t$),
$b^B_t$: outstanding of corporate bonds (at the beginning of period $t$),
$D_t$: dividends,
$E_t$: number of shares outstanding (at the beginning of period $t$),
$s_t$: (relative) price of equities,
$w_t$: wage rate,
$r^G_t$: interest rate on government bonds,
$r^B_t$: interest rate on corporate bonds,
$\tau_c$: consumption tax rate, $\tau_w$: labor income tax rate,
\( \tau_R \): interest income tax rate, \( \tau_D \): dividend income tax rate, 
\( \tau_G \): capital gain tax rate, \( T_t \): lump-sum transfer from the government  
\[ \chi_t = \frac{D_t}{sE_t} \]: dividend payout ratio

Initial conditions of bonds and shares denotes 
\[ b^G_0 = \overline{b^G}, b^P_0 = \overline{b^P}, E_0 = \overline{E} \]

The representative household maximizes lifetime utility under perfect foresight: \( \{c_t, l_t, b^G_t, b^P_t, E_t\} \)

\[
\max \sum_{t=1}^{\infty} \rho^t U(c_t, l_t)
\]

s.t. \[
b_{t+1}^G - b_t^G + b_{t+1}^P - b_t^P + s_{t+1} (E_{t+1} - E_t) + (1 + \tau_c) c_t
\]
\[
= (1 - \tau_w) w_t l_t + (1 - \tau_R) (r_t^G b_t^G + r_t^P b_t^P) + (1 - \tau_D) D_t - \tau_G (s_{t+1} - s_t) E_t + T_t
\]

\( w_t, r_t^G, r_t^P, s_t, \tau_w, \tau_R, \tau_C, \tau_D, \tau_G, T_t \): given

In this optimization problem, we obtain first order conditions for the representative household as follows (\( \mu_t \): Lagrangian multiplier of this optimization problem)

\[
U_{ct} \leq (1 + \tau c) \mu_t
\]

\[ c_t \{U_{ct} - (1 + \tau c) \mu_t\} = 0 \]  \hspace{1cm} (2)

\[
U_{lt} \leq - w_t (1 - \tau w) \mu_t
\]

\[ l_t \{U_{lt} + w_t (1 - \tau w) \mu_t\} = 0 \]  \hspace{1cm} (3)

\[
r_t^G (1 - \tau_R) \leq \frac{\mu_{t-1}}{\rho \mu_t} - 1
\]

\[ b_t^G \{r_t^G (1 - \tau_R) - \frac{\mu_{t-1}}{\rho \mu_t} + 1\} = 0 \]  \hspace{1cm} (4)

\[
r_t^P (1 - \tau_R) \leq \frac{\mu_{t-1}}{\rho \mu_t} - 1
\]

\[ b_t^P \{r_t^P (1 - \tau_R) - \frac{\mu_{t-1}}{\rho \mu_t} + 1\} = 0 \]  \hspace{1cm} (5)

\[
(1 - \tau_D) \frac{D_t}{s_tE_t} + (1 - \tau_G) \frac{s_{t+1} - s_t}{s_t} \leq \frac{\mu_{t-1}}{\rho \mu_t} - 1
\]

\[ E_t \{(1 - \tau_D) \frac{D_t}{s_tE_t} + (1 - \tau_G) \frac{s_{t+1} - s_t}{s_t} - \frac{\mu_{t-1}}{\rho \mu_t} + 1\} = 0 \]  \hspace{1cm} (6)

The rate of return on consumption denotes
\[
\theta_t \equiv \frac{\mu_{t-1}}{\rho \mu_t} - 1
\]

Also transversality conditions are given by
\[
\lim_{t \to \infty} \mu_t b^G_t \rho^t = 0
\]
\[
\lim_{t \to \infty} \mu_t b^P_t \rho^t = 0
\]
\[
\lim_{t \to \infty} \mu_t \mu_t E_t \rho^t = 0
\]

Next, the firm decides the amount of labor demand, capital (investment), and finance by equity or debt to maximize the intertemporal corporate value. We set the following production function of the representative firm,
\[
y_t = F(k_t, l_t)
\]
where \(F_l > 0, F_{l l} < 0, F_k > 0, F_{k k} < 0\)

\(y_t\): output, \(l_t\): labor input, \(k_t\): capital input

We assume homogeneity of degree one in the production function. Then
\[
F(k_t, l_t) = F(\frac{k_l}{l_t}, 1)l_t \equiv f(\frac{k_l}{l_t})l_t
\]
\[
f'(\frac{k_l}{l_t}) > 0, f''(\frac{k_l}{l_t}) < 0
\]

Therefore we can express
\[
F_k(k_t, l_t) = f'(\frac{k_l}{l_t})
\]
\[
F_l(k_t, l_t) = f(\frac{k_l}{l_t}) - \frac{k_l}{l_t}f'(\frac{k_l}{l_t})
\]

The production function is assumed to satisfy the Inada condition. We also describe the dynamics of capital as follows
\[
k_{t+1} = I_t + (1-\delta)k_t
\]  \((7)\)

where \(I_t\): (gross) investment

There is assumed to be adjustment cost in private investment. We set an adjustment cost function of capital
\[
C(I_t, k_t)
\]
The adjustment cost function is assumed to be homogenous of degree one:
\[
C(I_t, k_t) = C(I_t, k_t)I_t + C_0(I_t, k_t)k_t
\]
and
\[
C(I_t, k_t) \geq 0, C(0, k_t) = 0, C_0(0, k_t) = 0,
\]

Now, debt-equity ratio is expressed as
\[
\lambda_t = \frac{b^P_t}{sE_t}, 0 \leq \lambda_t
\]
(capital adequacy ratio: \( \frac{s_i E_i}{b_i^p + s_i E_i} = \frac{1}{1 + \lambda_i} \))

As proposed by Osterberg (1989), we suppose that there is agency cost on debt. \( a(\lambda) \) denotes per unit of agency cost on debt, where \( a(0) > 0, a_\lambda > 0, a_{\lambda\lambda} \geq 0 \). Hence, effective interest payment of the firm in period \( t \) is expressed as \( \{r^p_t + a(\lambda_t)\} b^p_t \).

After-tax profit of the representative firm in period \( t \) is represented as
\[
y_t - w_d t - \{r^p_t + a(\lambda_t)\} b^p_t - \delta k_t - C(I_t, k_t)
- \tau_t [y_t - w_d t - \{r^p_t + a(\lambda_t)\} b^p_t - \delta k_t] + \sigma I_t = D_t + RE_t
\]

where
\( \tau_t \): corporate income tax rate,
\( RE_t \): retained earnings,
\( \sigma \): rate of investment tax credit
\( \delta \): depreciation rate (0\( \leq \delta \leq 1 \): constant over time)

We can describe corporate finance for investment as follows
\[
I_t = RE_t + s_{t+1}(E_{t+1} - E_t) + b^p_{t+1} - b^p_t
\]

From (8) and (9), we obtain
\[
s_{t+1}(E_{t+1} - E_t) + b^p_{t+1} - b^p_t
= D_t - (1 - \tau_t)[y_t - w_d t - \{r^p_t + a(\lambda_t)\} b^p_t - \delta k_t] + (1 - \sigma)I_t + C(I_t, k_t)
\]

We define corporate value of the representative firm in period \( t \): \( V_t \) by
\[
V_t = s_i E_i + b^p_i
\]

We suppose that the representative firm maximize the initial market value of the firm \( V_0 \), given as these initial conditions
\[
k_0 = k_0, b^p_0 = b^p_0, E_0 = E_0
\]

The equation of motion of \( V_t \) is described as
\[
V_{t+1} - V_t = s_{t+1}E_{t+1} + b^p_{t+1} - s_t E_t - b^p_t
= (s_{t+1} - s_t)E_t + s_{t+1}(E_{t+1} - E_t) + b^p_{t+1} - b^p_t
\]

From (6), we obtain
\[
(s_{t+1} - s_t) E_t = \frac{\theta s_i E_i}{1 - \tau_G} - \frac{(1 - \tau_D)D_t}{1 - \tau_G}
\]

Substituting these into (10),
\[
V_{t+1} - V_t = \frac{\theta s_i E_i}{1 - \tau_G} - \frac{(1 - \tau_D)D_t}{1 - \tau_G} + D_t
- (1 - \tau_t)[y_t - w_d t - \{r^p_t + a(\lambda_t)\} b^p_t - \delta k_t] + (1 - \sigma)I_t + C(I_t, k_t)
\]
\[ \Gamma_t \equiv (1 - \tau_F)[y_t - w_t h - \delta k_t] - (1 - \sigma)I_t - C(I_t, k_t) \]  

then (10)' becomes

\[ V_{t+1} = \left[ 1 + (1 - \tau_F)\{r^P_t + a(\lambda_t)\} \frac{\lambda_t}{1 + \lambda_t} + \frac{\theta}{1 - \tau_G} \frac{1}{1 + \lambda_t} \right] V_t + \frac{(\tau_D - \tau_G)D_t}{1 - \tau_G} \Gamma_t, \]  

In this situation, dividend policy or financing instrument for investment does matter. Hence, we adapt tax capitalization view ("new view") of dividend policy, proposed by King (1974) and Auerbach (1979, 1981) (see Auerbach (2002)). The new view implies that

\[ I_t = RE_t \]

It means \( s_{t+1}(E_{t+1} - E_t) + b_{t+1}^p - b_t^p = 0 \).

From equation (10),

\[ D_t = (1 - \tau_F)[y_t - w_t l_t - \{r^P_t + a(\lambda_t)\} b_t^p - \delta k_t] - (1 - \sigma)I_t - C(I_t, k_t) \]  

From these equations, equation (12) is rewritten as

\[ V_{t+1} = \left[ 1 - \frac{1 - \tau_D}{1 - \tau_G} (1 - \tau_F)\{r^P_t + a(\lambda_t)\} \frac{\lambda_t}{1 + \lambda_t} + \frac{\theta}{1 - \tau_G} \frac{1}{1 + \lambda_t} \right] V_t - \frac{1 - \tau_D}{1 - \tau_G} \Gamma_t \]

In this equation, we define

\[ \gamma_t \equiv \frac{1 - \tau_D}{1 - \tau_G} \left( \frac{1}{1 - \tau_F} \{\theta + (1 - \tau_R)a(\lambda_t)\} \right) \frac{\lambda_t}{1 + \lambda_t} + \frac{\theta}{1 - \tau_G} \frac{1}{1 + \lambda_t} \]  

by using \( r^P_t = \frac{\theta}{1 - \tau_R} \)  

(5)' \gamma_t is the weighted average of the cost of debt capital and equity capital. It means the (instantaneous) cost of capital in period t. Equation (12) becomes

\[ V_{t+1} = (1 + \gamma_t) V_t - \frac{1 - \tau_D}{1 - \tau_G} \Gamma_t \]  

(12)'

Solving the difference equation (12)',

\[ V_0 = \sum_{t=0}^{\infty} \frac{1 - \tau_D}{1 - \tau_G} \Gamma_t \left\{ \prod_{i=0}^{t} (1 + \gamma_i) \right\}^{-1} \]

The representative firm maximizes its corporate value by choosing \{k_t, I_t, l_t, b^p_t, E_t, \lambda_t\}

\[ \max \ V_0 = \sum_{t=0}^{\infty} \frac{1 - \tau_D}{1 - \tau_G} \Gamma_t \left\{ \prod_{i=0}^{t} (1 + \gamma_i) \right\}^{-1} \]  

(14)

s.t. \( i_{t+1} = I_t + (1 - \delta)k_t \)  

(7)

\[ w_t, r^P_t, \theta, s_t, \tau_R, \tau_W, \tau_G, \tau_D, \tau_F, \sigma; \] given

The firm chooses real cash flow or the instantaneous cost of capital (the rate of discount) to maximize the corporate value. From equations (12) and (13), it is obvious that instantaneous cost of capital \( \gamma_t \) (the rate of discount)
depends on only debt-equity ratio \( \lambda \) as variables that the firm can operate. So, in order to maximize the corporate value, the firm should decide the value of \( \lambda \) to minimize the instantaneous cost of capital in period \( t \).

In this problem, the firm firstly minimizes the instantaneous cost of capital \( \gamma_i \) by choosing \( \lambda_i \) with taking \( \theta_i, \tau_R, \tau_G, \tau_D, \) and \( \tau_F \) as given.

\[
\frac{\partial \gamma_i}{\partial \lambda_i} = 0
\]

It implies

\[
\frac{(1-\tau_D)(1-\tau_F)}{1-\tau_R}\{\theta_i + (1-\tau_R)\alpha(\lambda_i) + (1-\tau_R)a'(\lambda_i)(1+\lambda_i)\lambda_i\} - \theta_i = 0
\]

(9)

\( \lambda^*_i \) denotes \( \lambda_i \) such that equality holds in equation (9). Minimized (instantaneous) cost of capital \( \gamma^*_i \) is defined as

\[
\gamma^*_i = \frac{\theta_i}{1-\tau_G} - \frac{a'\left(\lambda^*_i\right)}{1-\tau_G}\frac{(1-\tau_D)(1-\tau_F)}{(1-\tau_G)}(\lambda^*_i)^2
\]

Secondly, the representative firm maximizes its corporate value by choosing \( \{k, I, l\} \) under \( \gamma^*_i \)

\[
\max_v V_0 = \sum_{i=0}^{\infty} \frac{1-\tau_D}{1-\tau_G} \Gamma_i \left\{ \prod_{i=0}^{t} (1+\gamma^*_i) \right\}^{-1}
\]

(14)

s.t. \( k_{i+1} = I_i + (1-\delta)k_i \)

(7)

\( w, r^p, \theta, s, \tau_R, \tau_W, \tau_G, \tau_D, \tau_F, \sigma : \) given

Optimality conditions of this optimization problem are expressed as follows (\( q_i \): the Lagrangian multiplier for (7)).

\[
\frac{1-\tau_D}{1-\tau_G} (1-\tau_F)(F_{lt} - w_i) = 0
\]

\[
- \frac{1-\tau_D}{1-\tau_G} \{(1-\sigma) + C_{lt}\} + q_i = 0
\]

\[
q_i - q_{i-1} - \gamma^*_i q_{i-1} = - \frac{1-\tau_D}{1-\tau_G} \{(1-\tau_F)(F_{lt} - \delta) - C_{lt}\} + \delta q_i
\]

Transversality condition of this problem is given by

\[
\lim_{i\to\infty} q_i k_i \left\{ \prod_{i=0}^{t} (1+\gamma^*_i) \right\}^{-1} = 0
\]

Therefore, we obtain the following conditions of the representative firm

\[
F_{lt} = w_l
\]

(15)

\[
q_i = \frac{1-\tau_D}{1-\tau_G} \{(1-\sigma) + C_{lt}\}
\]

(16)
Finally, we describe the behaviour of the government. The government operates in accordance with its flow budget constraint

\[
\begin{align*}
(1 - \delta)q_i &= (1 + \gamma^*)q_{t-1} - \frac{1 - \tau_D}{1 - \tau_G} \{(1 - \tau_F)(F_{kt} - \delta) - C_{kt}\} \\
\end{align*}
\]  

(17)

where \(g_i\): government expenditure

2-2. Perfect Foresight Equilibrium

In this system, there are five endogenous variables \(\{c_t, l_t, k_t, q_t, \lambda_t\}\) with exogenous variables \(\{g_t, T_t, b_t, \tau_r, \tau_w, \tau_c, \tau_D, \tau_G, \tau_F, \sigma\}\). In the private goods market, the following equilibrium condition is satisfied

\[
y_t = c_t + g_t + I_t + C(I_t, k_t) \\
\]

(19)

The perfect foresight equilibrium includes the following conditions

\[
\begin{align*}
U(c_t, l_t) &= -\frac{1 - \tau_w}{1 + \tau_c} F_t(k_t, l_t) \\
\frac{a(\lambda^*_t) + a'(\lambda^*_t)(1 + \lambda^*_t)}{1} &= \theta_t \left\{ \frac{1}{(1 - \tau_F)(1 - \tau_F)} - \frac{1}{1 - \tau_G} \right\} \\
\end{align*}
\]

(9)'

where \(\theta_t = \frac{U_t(c_{t-1}, l_{t-1})}{\rho U_c(c_{t-1}, l_{t-1})} - 1\)

(21)

\[
\begin{align*}
q_t &= \frac{1 - \tau_D}{1 - \tau_G} \{(1 - \sigma) + C_t(k_{t+1} - (1 - \delta)k_t, k_t)\} \\
(1 - \delta)q_t &= (1 + \gamma^*)q_{t-1} \\
- \frac{1 - \tau_D}{1 - \tau_G} \{(1 - \tau_F)\{F_t(k_t, l_t) - \delta\} - C_t(k_{t+1} - (1 - \delta)k_t, k_t)\} \\
\end{align*}
\]

(17)'

where \(\gamma^*_t = \frac{\theta_t}{1 - \tau_G} - a'(\lambda^*_t) \left( \frac{1 - \tau_D}{1 - \tau_F} \right) \left( \frac{1}{1 - \tau_G} \right)\)

(22)

\[
F_t(k_t, l_t) = c_t + g_t + k_{t+1} - (1 - \delta)k_t + \delta k_t + C_t(k_{t+1} - (1 - \delta)k_t, k_t) \\
\]

(19)'

2-3. Steady state equilibrium

In the steady state, \(c_{t+1} = c_t = c, k_{t+1} = k_t = k, l_{t+1} = l_t = l, g_{t+1} = g_t = q, \lambda_{t+1} = \lambda_t = \lambda, b^p_{t+1} = b^p_t = b^p, E_{t+1} = E_t = E\). In the steady state, the following conditions are held.

\[
(1 + \tau_c)U_t(c, l) + F_t(k, l)(1 - \tau_w)U_c(c, l) = 0 \\
\]

(23)
\[ a(\lambda^*) + a'(\lambda^*)(1+\lambda^*)\lambda^* = \theta \left\{ \frac{1}{(1-\tau_D)(1-\tau_F)} - \frac{1}{1-\tau_R} \right\} \]  
(9)^

where \( \theta = \frac{1}{\rho} - 1 \)

\[ q = \frac{1-\tau_D}{1-\tau_G} \{1-\sigma + C_f(\delta k, k)\} \]  
(24)

\[ (\delta + \gamma^*)q = \frac{1-\tau_D}{1-\tau_G} \{(1-\tau_F)(F_k(k, l) - \delta) - C_k(\delta k, k)\} \]  
(25)

where \( \gamma^* = \frac{\theta}{1-\tau_G} - a'(\lambda^*)\frac{(1-\tau_D)(1-\tau_F)(\lambda^*)^2}{1-\tau_G} \)  
(22)^

\[ F(k, l) = c + g + \delta k + C(\delta k, k) \]  
(26)

2.4. Specification of functions

The above dynamic macroeconomic model is so complicated. Then we implement a numerical analysis to investigate the incidence of the corporate income tax using this model. For a numerical analysis, we specify the functions described above. In order to explore the incidence in the Japanese economy, we adopt functional forms based on Hayashi and Prescott (2002), which examines the recent Japanese economy by using a dynamic macroeconomic model.

The instantaneous utility function is specified as

\[ U(c_t, l_t) = \ln c_t - \alpha l_t \]

The production function is defined as

\[ y_t = A k_t^{1-\zeta} \]

Adjustment cost of investment denotes

\[ C(I_t, k_t) = \psi \left( \frac{I_t^{1-\zeta}}{k_t} \right) \]  
where \( \psi \) is a positive constant.

Based on Pratap (2003), which is not used in Hayashi and Prescott (2002). Function of agency cost on debt is

\[ a(\lambda_t) = a \lambda_t^2 \]  
where \( a \) is a positive constant.

Substituting these specified functions into equations (9)', (23) ~ (26)

\[ c_t = \frac{(1-\tau_w)A(1-\zeta)}{\alpha(1+\tau_c)} \left( \frac{k_t}{l_t} \right)^{\zeta} \]  
(27)

\[ \theta_t = \frac{c_t - \rho c_{t-1}}{\rho c_{t-1}} \]  
(28)
Now, we suppose that government expenditure $\bar{g}$ is exogenously given.

Cubic equation (29) has two imaginary roots and one real root. The only real root is

$$\lambda_i = \frac{1}{2} \left[ \left\{ 2Z_i - 1 + 2\sqrt{Z_i(Z_i - 1)} \right\}^{-1/3} + \left\{ 2Z_i - 1 + 2\sqrt{Z_i(Z_i - 1)} \right\}^{-1/3} - 1 \right]$$

where $Z_i = \frac{\theta_i}{\alpha} \left\{ \frac{1}{(1 - \tau_D)(1 - \tau_F)} - \frac{1}{1 - \tau_R} \right\}$

We assume the equation (33) is held in this system.

The system of equations (27), (28), and (33) implies that $c_t$ is expressed as a function of $k_t/l_t$. Also we find that $\theta_t$ is expressed as a function of $c_t$ and $c_{t-1}$, thus a function of $k_t/l_t$ and $k_{t-1}/l_{t-1}$. Moreover, $\lambda_t$ is expressed as a function of $\theta_t$, thus a function of $k_t/l_t$ and $k_{t-1}/l_{t-1}$.

From equation (30),

$$I_t = \frac{1}{2\psi} \left( \frac{1 - \tau_D}{1 - \tau_G} q_t - 1 + \sigma \right)$$

or

$$I_t = \frac{1}{2\psi} \left( \frac{1 - \tau_D}{1 - \tau_G} q_t - 1 + \sigma \right) k_t$$

Substituting equation (34) into equation (30), we obtain

$$k_{t+1} = \left\{ 1 - \delta + \frac{1}{2\psi} \left( \frac{1 - \tau_D}{1 - \tau_G} q_t - 1 + \sigma \right) \right\} k_t$$

Substituting equations (34) and (34)' into equation (32),
In sum up, this system is consolidated into equations (32)', (35), and (31) into which equations (27), (28), (33) and (34) are substituted, with three endogenous variables \( \{k_i, \frac{k'}{l_i}, q_i\} \).

In this consolidated system, the steady-state solutions for three endogenous variables are

\[
q = \frac{1 - \tau_D}{1 - \tau_G} \{1 - \sigma + 2 \psi \delta \} \quad (36)
\]

\[
k = \frac{1}{l} \left[ \frac{(\delta + \gamma')(1 - \sigma + 2 \psi \delta) + \psi \delta}{A(1 - \tau_f)} + \frac{1 - \tau_D}{A} \right]^{\frac{1}{\zeta - 1}} \quad (37)
\]

\[
k = \frac{(1 - \tau_D) A(1 - \zeta) \left(\frac{k}{l}\right)^{\zeta} + \bar{g}}{A \left(\frac{k}{l}\right)^{-\delta - \psi \delta^2}} \quad (38)
\]

From these equations, steady state values are expressed as

\[
c = \frac{(1 - \tau_D) A(1 - \zeta)}{\alpha(1 + \tau_c)} \left(\frac{k}{l}\right)^{\zeta} \quad (27)'
\]

\[
\theta = \frac{1}{\rho} - 1 \quad (28)'
\]

\[
\lambda = \frac{1}{2} \left[ \left\{ Z - 1 + 2 \sqrt{Z(Z - 1)} \right\}^{1/3} + \left\{ Z - 1 + 2 \sqrt{Z(Z - 1)} \right\}^{1/3} - 1 \right] \quad (33)'
\]

where \( Z = \frac{1 - \rho}{a \rho} \left\{ \frac{1}{(1 - \tau_D)(1 - \tau_f)} - \frac{1}{1 - \tau_x} \right\} \)

\[
\gamma' = \frac{1 - \rho \gamma}{\rho(1 - \tau_G)} \left(1 - \frac{(1 - \tau_D)(1 - \tau_f)}{1 - \tau_G} \right) 2 \alpha \lambda^3 \quad (22)''
\]

\[
I = \delta k \quad (7)'
\]

\[
q = \frac{1 - \tau_D}{1 - \tau_G} \{1 - \sigma + 2 \psi \delta \} \quad (31)'
\]

\[
(\delta + \gamma')q = \frac{1 - \tau_D}{1 - \tau_f} \left[ A \frac{k}{l} \left(\frac{k}{l}\right)^{\zeta - 1} - \delta \right] - \psi \delta \quad (31)'
\]
2-5. Simulation

We make the numerical analysis based on the above theoretical model. Now, we set the values of the parameters that is in the specific functions and the policy variables. The values of variables are shown in Table 1. In this paper, the analysis is based on quarter and one period means one quarter. Then, we set \( \zeta = 0.362,\rho = 0.993945231\) (= (0.976)\(^{1/4}\)), \( \alpha = 0.34325\) (= 1.373/40), \( \delta = 0.021543747\) (= (1+0.089)\(^{1/4}\)-1), which are used by Hayashi and Prescott (2002). These values are set close to the present condition of the Japanese economy. The value of \( a \) is set to be \( 0 \leq \lambda \leq 1 \) in equation (33). The parameters in the production function and the adjustment cost function are set as their steady-state values, which are close to the present condition of the Japanese economy. The tax rates that is used in this paper are almost the same rates in Japan.

Then we clarify the equilibrium in steady state from equations (35)-(38). Solution of each variable in the steady state when the value of the parameter is set above are shown in Table 1. We find that those values are fairly practical.

Here we can establish the basis to analyze economic effects in a dynamic macroeconomic model when we use this parameter and simultaneous equations (31), (32)', and (35).

2-6. Incidence of Corporate Income Tax

In this section, we implement quantitative analysis on incidence of corporate income tax. We employ a definition of tax incidence proposed by Feldstein (1974):

The incidence of an increase in a tax on labor income is defined as

\[
\frac{\lambda d[(1-\tau_w)F_i]}{\lambda d[(1-\tau_w)F_i] + kd[(1-\tau_k)F_i]}
\]

where \( \tau_k \): (effective) tax rate on capital income

Equation (39) can be rewritten as

\[
J = \frac{d[(1-\tau_w)(f-\kappa f')]}{d[(1-\tau_w)(f-\kappa f')] + \kappa d[(1-\tau_k)f']}
\]

where \( \kappa \equiv \frac{k}{l}, f \equiv \frac{F(k,l)}{l} \)
Hence, the incidence of an increase in corporate income tax rate ($\tau_F$) on labor income is expressed as

$$\frac{dJ}{d\tau_F} = \frac{(1-\tau_W)(-\kappa f^*)}{(1-\tau_W)(-\kappa f^*)} \frac{d\kappa}{d\tau_F} + \kappa \left( \frac{(1-\tau_D)(1-\tau_F)}{1-\tau_G} f^* \frac{d\kappa}{d\tau_F} - \frac{1-\tau_D}{1-\tau_G} f' \right)$$

We assume changed tax revenue with an increase in corporate income tax rate is appropriated for a change in lump-sum transfer to household ($T_t$).

In the system of equations (31), (32)', and (35) with three endogenous variables $\{k_t, l_t, q_t\}$ and a policy variable $\tau_F$,

Linearizing this system about steady-state equilibrium

$$M \begin{bmatrix} q_{t+1} \\ \kappa_{t+1} \\ k_{t+1} \end{bmatrix} = N \begin{bmatrix} q_t \\ \kappa_t \\ k_t \end{bmatrix} + \Lambda \tau_{Ft+1}$$

... Finally, we can express this system as

$$Q_A \begin{bmatrix} q_t \\ \kappa_t \end{bmatrix} + Q_b k_t = 0 \quad \Leftrightarrow \quad \begin{bmatrix} q_t \\ \kappa_t \end{bmatrix} = Q_A^{-1} Q_B k_t \quad (40)$$

$$k_{t+1} = (Q_D - Q_C Q_A^{-1} Q_B)^{-1} q_{t+1} + (Q_D - Q_C Q_A^{-1} Q_B)^{-1} q_{t+1} + (Q_D - Q_C Q_A^{-1} Q_B)^{-1} q_{t+1} + (Q_D - Q_C Q_A^{-1} Q_B)^{-1} q_{t+1} + (Q_D - Q_C Q_A^{-1} Q_B)^{-1} q_{t+1} + (Q_D - Q_C Q_A^{-1} Q_B)^{-1} q_{t+1} + (Q_D - Q_C Q_A^{-1} Q_B)^{-1} q_{t+1} \quad (41)$$

According to Figure 1, under the value of the parameter that is adopted in this paper, the burden of corporate income tax, about 50% of the burden results in labor income and another 50% results in capital income in the short run (for the first quarter).

During one year (in the fourth quarter), about 80% of the burden results in labor income and about 20% of that results in capital income. As time passes, the ratio of the burden that results in labor income rises and it is proved that about 95% of the burden results in labor income in the long run.

Turnovsky (1995) points out that all burden of corporate income tax results in labor income in the long run. In this paper, however, analysis proves that about 5% of the burden results in capital income in the long run. It seems that this is because the agency cost on debt effects on incidence.

In Turnovsky (1995), it is analyzed by the theoretical model that supposed there was no agency cost on debt. So if the tax rate of corporate
income tax changes, instantaneous cost of capital in steady state around that time is represented as \( \gamma^* = \frac{\theta}{1 - \tau_G} \), if there is no agency cost on debt.

Because the rate of return on consumption in the steady state is fixed regardless of corporate income tax, if there is no agency cost on debt, even though the rate of corporate income tax changes, the instantaneous cost of capital converges to the same value in the previous steady-states. Even if the rate of corporate income tax changes, therefore, it is affected in the short run, but in the long run it converges to the same rate of return on capital after taxation (that is, equals the rate of return on consumption in steady state, and also equals subjective discount rate). So in the long run the burden of corporate income tax does not result in capital income at all, but it results in labor income completely.

In this paper, however, it is analyzed by the theoretical model that supposed there is some agency cost on debt. For that reason, as represented in equation (22)', with the variation of the tax rate of corporate income tax, instantaneous cost of capital in steady state fluctuates by the effect of the agency cost on debt. If the tax rate of corporate income tax is raised, some incentive to raise the debt-equity ratio \( \lambda_t \) occurs because the effect of tax avoidance on debt in finance rises. But the higher the debt-equity ratio \( \lambda_t \) is raised, the more the agency cost on debt increase. Therefore, it is thought that the burden of corporate income tax resulted in capital income also in the long run because of the influence of additional increase of the agency cost on debt that caused by the raise of the tax rate of corporate income tax.

3. Concluding Remarks

In this paper, we analyze the incidence of corporate income tax using a dynamic general equilibrium model. We implement a simulation with parameters based on the Japanese economy, and measure the incidence of corporate income tax on labor income.

In the short run (for one year), a percentage of the incidence on labor income is about 50 ~ 80%, and a percentage of the incidence on capital income is about 20 ~ 50%. In the long run, about 95% of the incidence is on labor income. Almost all of the incidence is shifted to labor income, but not all of the incidence is.

Turnovsky (1995) points out that the entire incidence is shifted to
labor income in the long run. It seems to be caused by the agency cost on debt. The instantaneous cost of capital in the steady state is expressed as

$$\gamma^* = \frac{\theta}{1 - \tau_G} - \alpha'(\gamma^*) \frac{(1 - \tau_D)(1 - \tau_F)}{1 - \tau_G} (\gamma^*)^2$$

(22)'

in this paper. On the other hand, without the agency cost on debt (like Turnovsky (1995)), it becomes

$$\gamma^* = \frac{\theta}{1 - \tau_G}$$

A policy implication of this analysis is that considerably large share of the incidence of corporate income tax is on labor income in Japan. Moreover a percentage of the incidence on labor income rises in the long run. From this analysis, we can conclude that the advantage of tax reduction reaches more labor income (in more concrete words, the labor income after taxation increases) when the rate of corporate income tax is cut.

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Table 1
Parameter Values and Steady State Values of Variables

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Steady state</th>
<th>(unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>0.34325</td>
<td>0.006091</td>
<td>Steady state (unit)</td>
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<tr>
<td>$\zeta$</td>
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<td>0.620304</td>
<td>$g/y$</td>
</tr>
<tr>
<td>$\psi$</td>
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<td>$c/y$</td>
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<td>$I/y$</td>
</tr>
<tr>
<td>$\rho$</td>
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<td>$g/y$</td>
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<tr>
<td>$\delta$</td>
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<td>$y/k$</td>
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<tr>
<td>$\sigma$</td>
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<td>$l$</td>
</tr>
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<td>$A$</td>
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<td>tri yen</td>
</tr>
<tr>
<td>$\tau_C$</td>
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<td>$\tau_D$</td>
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<td>$\tau_W$</td>
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<tr>
<td>$G$</td>
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</table>
Figure 1
The incidence on labor income with an 1% (0.3% point) increase in corporate income tax rate