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Impact of Corporate Tax Reform on Firm Dynamics: An empirical study of the shift from income-based to pro forma standard taxation in Japan[1]

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Abstract

Many countries have reduced their statutory tax rates (STRs) on corporate income while broadening their tax bases. Japan presents an intriguing case study in this context. It has reduced its STR while expanding its pro forma standard tax primarily based on companies' value-added.

This study analyzes the impact of Japan's corporate tax reforms since the mid-2010s on firm dynamics using forward-looking effective tax rates (ETRs) that incorporate pro forma standard taxation. Our observations indicate that these corporate tax reforms lowered the ETR and narrowed the disparities between companies. Although the reduction in ETRs stimulated increased investment and employment, the positive impacts were partially offset for large firms owing to the expansion of pro forma standard taxation, which effectively increased the labor costs.

Keywords: Corporate Tax, Forward-looking Effective Tax Rates, Pro Forma Standard Tax, Firm Dynamics

JEL classification: H25

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1 Introduction

Corporate tax issues have been at the center of public debate over the past few decades. Many countries have reduced their statutory tax rates (STRs) on corporate income while broadening the tax base through less generous depreciation allowances and reduced tax exemptions (Devereux et al. 2002). It is vital to examine the impact of such a corporate tax reform.

However, STRs do not necessarily indicate the real tax burden on companies. This is because companies' tax burdens differ depending on their composition of fixed assets and debt structures. There are two methods of measuring corporate effective tax rates (ETRs): backward-looking and forward-looking. Backward-looking ETRs are calculated by dividing the tax amount by corporate profits (Kemsley 1998; Desai et al. 2004; Mutti and Grubert 2004; Kobayashi et al. 2020). This method is intuitive and effective for depicting corporate tax burdens. However, backward-looking ETRs reflect companies' tax planning, thereby causing endogeneity problems (Devereux and Griffith 2003). Meanwhile, the forward-looking ETRs constructed by Devereux and Griffith (2003) and Devereux (2007) are calculated based on the profits generated by hypothetical future investment projects. These help us comprehend the impact of tax reform, which is not affected by corporate tax planning and can be regarded as an exogenous variable in the empirical analysis. Devereux and Griffith (2003) derived two types of forward-looking ETRs: effective marginal tax rate (EMTRs) and effective average tax rate (EATRs). EMTRs are tax rates imposed when a company makes a marginal investment that results in a zero after-tax net present value (NPV) and represent the tax rate on normal profits alone. EATR refers to the tax rate on all corporate profits including normal and excess profits. Devereux and Griffith (2003) stated that the selection of the corporate location depends on the EATRs.

Owing to their preferable features, forward-looking ETRs have generally been used to examine the impact of corporate tax reforms worldwide. Devereux and Griffith (2003) calculated the ETRs for the UK, France, Germany, and the US from 1979 to 1999. They showed that the UK had transitioned significantly. Based on the framework of Devereux

and Griffith (1999), Spengel et al. (2020) calculated the effective tax rates on investments in EU member countries, the Republic of North Macedonia, Turkey, the UK, Switzerland, Canada, Japan, and the US using data from 1998 to 2020.

Numerous studies have calculated ETRs and investigated their impacts. Egger et al. (2009) calculated forward-looking EMTRs and EATRs using microdata from 650,000 companies worldwide. They revealed that calculating the ETRs at the company level is more relevant than that at the country level with regard to tax burdens. Their empirical analysis established that a reduction in ETRs increases corporate investment, as anticipated by the economic theory. Steinmüller et al. (2019) calculated ETRs worldwide from the late 1990s to the early 2010s and examined how variations in ETRs affect corporate investment behaviors. They revealed that the elasticity of EMTRs is -0.33. Federici et al. (2020) investigated the effect of corporate taxes on firms' export behavior in Italy. They determined that higher tax rates increase the likelihood of new firms entering foreign markets.

Japan provides an intriguing case study of the impact of ETRs. By the early 2010s, Japan had begun implementing a comprehensive corporate tax reform that reduced STRs and broadened the tax base. The Japanese government confronted a strained budget owing to an aging population, which limited its capability to broaden the tax base further. To align with the international trend of decreasing STRs, the government decided to lower the corporate tax rate below 30% (the average level of STRs in developed countries) while expanding the pro forma standard tax (whose tax base consists primarily of value-added components). This reform is aimed at reducing STRs and equalizing tax burdens. It has been termed the "growth-oriented corporate tax reform" by the Japanese government.

Another intriguing aspect of Japan's reforms enables us to examine the impact of corporate tax reforms under different philosophies. During the implementation, the Japanese government introduced pro forma standard taxation exclusively for large companies. This left small- and medium-sized enterprises under the conventional taxation system without pro forma standard. This differentiation enables us to investigate how different tax schemes affect corporate behavior.

However, to date, the impact of Japan's reforms has not been investigated sufficiently. To

our knowledge, Uemura (2022) evaluated Japan's corporate tax reform in the 2010s by estimating the EATR and EMTR and concluded that it reduced both the ETRs. However, Uemura (2022) did not empirically examine the behavioral effects of corporate tax reform. It did not incorporate pro forma standards into forward-looking ETR formulas.

This study evaluates corporate-level financial data from 2014 to 2018 to calculate forward-looking ETRs by incorporating pro forma standard taxation into the formula and investigating how the reform affected corporate behavior. As mentioned, the corporate tax reforms in Japan since the mid-2010s have lowered the STR while expanding pro forma standard taxation.

This paper is structured as follows: Section 2 provides an overview of the corporate tax reform that is the subject of this paper's analysis. Section 3 introduces the model for forward-looking ETRs, which incorporates pro forma standards into the formulas. Section 4 explains the data used in the analysis, descriptive statistics, and the analytical methodology. Section 5 presents the estimation results. Section 6 concludes the paper.

2 Institutional Background

2.1 Corporate Taxation in Japan

In Japan, three major taxes are levied on corporate income and the value added by corporations: the national corporate tax, local corporate inhabitant tax (encompassing both prefectural and municipal taxes), and local enterprise tax (a prefectural tax). The national corporate tax is imposed on corporate income. The local corporate inhabitant tax mandates that corporations, as members of local communities, contribute to community expenses similar to individuals. This tax comprises prefectural and municipal components. It includes a fixed levy based on capital and other factors, and a surcharge on corporate tax payable. Local corporate enterprise taxes are levied on business activities. Similar to the local inhabitant tax, corporations that gain from various administrative services provided by local governments in conducting their business should share the costs of these services. In addition to the income levy based on corporate income, corporations with capital exceeding JPY 100 million are subject to a value-added levy and capital levy (called pro forma standard taxes). The value-added levy is calculated by adding wages, net interest, and net rent paid to income (before carrying forward losses), as defined by the tax law. The capital levy is based on a corporation's capital and reserves.

These pro forma standard taxes are essential for ensuring equity in the distribution of tax burdens, elucidating the characteristic of enterprise taxes as benefit-based taxes, stabilizing local tax revenues, and stimulating economic activity[1]. This system requires corporations to endure a broad proportional burden based on the scale of their businesses. Corporations with paid-in capital of at most JPY 100 million are subject only to income tax. However, the tax rate is higher than that for corporations with capital exceeding JPY 100 million. Additionally, specific industries such as electricity suppliers are taxed on revenue rather than income (revenue-based taxation). With regard to the consideration of tax expenses for accounting purposes, corporate tax and corporate inhabitant tax cannot be deducted. However, corporate enterprise tax can be deducted.

[1] Government Tax Commission (2000) "Materials Related to the Pro forma Standard Taxation"(in Japanese) tiho18.pdf p.12.

The Japanese government uses the statutory ETR for corporate income as an index to measure the corporate tax burden. We should note that the tax on value added is not included in this statutory ETR. It is calculated as follows:

$$\frac{National\ Corporate\ Tax\ Rate\ +\ National\ Corporate\ Tax\ Rate\ \times\ Local\ Corporate\ Inhabitant\ Tax\ Rate\ +\ Corporate\ Business\ Tax\ Rate\ (Income\ levy)}{1\ +Corporate\ Business\ Tax\ Rate\ (Income\ levy\ )}$$

The business tax rate appears in the denominator because the corporate enterprise tax can be included as a deductible expense. Using this formula, the statutory ETR for companies with paid-in capital of over JPY 100 million (hereafter "large companies" in terms of the tax code) and companies with paid-in capital of at most JPY 100 million (hereafter "SME") were 34.62% and 36.05% in FY2014, respectively.

2.2 Growth-Oriented Corporate Tax Reform

This study scrutinizes the "growth-oriented corporate tax reforms" initiated in FY2014. The reform aimed to reduce the statutory effective corporate tax rate to below 30% from the approximately 35% in FY2014. The objectives were to (1) increase Japan's competitiveness as a business hub and (2) restructure the corporate tax burden framework. The reform addressed the need for a broader tax base and lower tax rate. The distinctive feature of this reform is expanding the tax base by broadening pro forma standard taxation concomitant with a reduction in the corporate income tax rate. Specifically, the income levy rates for corporate enterprise taxes decreased, whereas the tax rates for added value and capital levies increased.

As mentioned in the introduction, the Japanese government has termed the reform "growth-oriented corporate tax reform" because it aims to reduce STRs and equalize tax burdens. Additionally, the Japanese government introduced pro forma standard taxation exclusively for large companies. This left small- and medium-sized enterprises under the conventional taxation system without a pro forma standard.

Table 1 illustrates these tax rates and their variations since FY2014. The national corporate

tax rate was 25.5% in FY2014. However, it reduced to 23.9% in FY2015, 23.4% in FY2016–FY2017, and 23.2% in FY2018. As the local corporate inhabitant tax is surcharged on the national corporate rate, the local corporate tax burden reduced. The corporate enterprise tax rate did not vary for companies with a paid-in capital of at most JPY 100 million. For companies with paid-in capital exceeding JPY 100 million, the income levy rate decreased gradually from 7.2% in FY2014 to 3.6% in FY2018. The corporate enterprise tax (value-added levy) rate was 0.48% in FY2014, 0.72% in FY2015, and 1.20% from FY2016 to FY2018. The capital levy rate of the corporate enterprise tax increased from 0.2% in FY2014 to 0.5% in FY2016.

Overall, the statutory ETR of large companies was 34.62% in FY2014, 32.11% in FY2015, 29.97% in FY2016–FY2017, and 29.74% in FY2018. For companies with paid-in capital exceeding JPY 100 million, the rates were 36.05% in FY2014, 34.34% in FY2015, 33.80% in FY2016–FY2017, and 33.59% in FY2018.

As observed previously, the statutory effective corporate tax rate does not account for the pro forma standard tax burden. This study also considers the burden of pro forma taxation. We calculate the statutory corporate effective tax rate of the pro forma standard using the following formula proposed by Doi (2016):

$$\frac{(1-(National\ Corporate\ Tax\ Rate\ +\ National\ Corporate\ Tax\ Rate\ \times\ Local\ Corporate\ Inhabitant\ Tax\ Rate))\ \times\ Local\ Enterprise\ Tax\ Rate\ (Added\ Valed\ levy)}{1\ +Local\ Enterprise\ Tax\ Rate\ (Income\ levy\ )+Local\ Enterprise\ Tax\ Rate\ (Added\ Valed\ levy)}$$

Based on this formula, the statutory corporate ETR of the pro forma standard for large companies was 0.31% in FY2014, 0.49% in FY2015, and 0.83% from FY2016 to FY2018.

Based on this formula, the statutory corporate ETR of the pro forma standard was 0.31% for large companies in FY2014, 0.49% in FY2015, and 0.83% between FY2016 and FY2018.

To compensate for the revenue losses incurred by reducing STRs, the Japanese government has limited the carryforward of losses. Under the Japanese tax system, companies are permitted to use their net operating losses to offset future taxable income. By FY 2014, large companies could offset up to 80% of their taxable income with losses

carried forward, whereas SMEs could offset 100% of their taxable income. However, this limit reduced gradually to 50% for large companies between FY 2015 and FY 2017 and remained at 100% for SMEs. Additionally, the statute of limitations for losses generated after FY 2017 was extended from 9 to 10 years.

Finally, the depreciation methods for buildings (straight-line method) and machinery and equipment (200% declining-balance method) remain unaltered. This indicates that these do not affect the ETRs.

Table 1 Changes in corporate taxation

Company Category	Tax base/ category	Tax item	Fiscal Year				
			2014	2015	2016	2017	2018
Large	Income	National Corporate Income Tax Rate	25.5	23.9	23.4	23.4	23.2
		Local Corporate Inhabitant Tax Rate	17.3	17.3	17.3	17.3	17.3
		Local Enterprise Tax Rate	7.2	6.0	3.6	3.6	3.6
		Statutory Effective Corporate Tax Rate	34.62	32.11	29.97	29.97	29.74
	Value Added	Local Enterprise Tax Rate	0.48	0.72	1.2	1.2	1.2
		Statutory Effective Corporate Tax Rate	0.31	0.49	0.83	0.83	0.83
	Loss Carryforward	Maximum Deduction Ratio of Taxable Income	80%	65%	60%	55%	50%
		Statute of Limitations	9 years	9 years	9 years	10 years	10 years
SME	Income	National Corporate Income Tax Rate	25.5	23.9	23.4	23.4	23.2
		Local Corporate Inhabitant Tax Rate	17.3	17.3	17.3	17.3	17.3
		Local Enterprise Tax Rate	9.6	9.6	9.6	9.6	9.6
		Statutory Effective Corporate Tax Rate	36.05	34.34	33.80	33.80	33.59
	Loss Carryforward	Maximum Deduction Ratio of Taxable Income	100%	100%	100%	100%	100%
		Statute of Limitations	9 years	9 years	9 years	10 years	10 years
Large/SME	Depreciation	Building	Straight-line Method				
		Machinery and Equipment	200% Declining-balance Method				

(Note) "Large" means companies whose paid-in capital is over 100M JPY and SME means companies whose paid-in capital is 100M JPY or less.

3 Theoretical Model

In this section, we extend forward-looking effective tax by incorporating pro forma standard taxation. Many empirical studies utilized the forward-looking ETRs constructed by Devereux and Griffith (2003). However, these considered only corporate tax based on income and did not consider pro forma standards. We consider the pro forma standard for the ETRs. The detailed setup and derivation of the formulas are provided in the Appendix.

3.1 Ordinary Effective Tax Rates

Before considering pro forma standard taxation, we introduce the ordinary ETRs. As mentioned earlier, the forward-looking effective tax rate used in many empirical studies is based on Devereux and Griffith (2003). Abstracting personal income taxation, the value of the firm at the end of period t, V_t is expressed as follows:

$$V_t = \sum_{s=0}^{\infty} \left\{ \frac{D_{t+s} - N_{t+s}}{(1+\rho)^s} \right\} \tag{3.1}$$

where D_t is the dividend at the end of period t, N_t is the issuance of new shares in period t, ρ is the shareholder discount rate.

Following Devereux and Griffith (2003), we assume that an investment is made in period t, the capital stock increases, and the capital stock returns to its original level in period t + 1. Then the after-tax NPV (net present value) of an investment, R_t, can be expressed as follows:

$$R_t = (1+i)^{t-1} dV = -(1-z)(1-\tau_c A) + \frac{1}{1+r}[(1-\tau_c)F_K^0 + (1-z)(1-\tau_c A)(1-\delta)] + \tau_b \left(\frac{i}{(1+r)(1+\pi)} \right) dB_t \tag{3.2}$$

where i is the nominal interest rate, V_t denotes the value of the firm at the end of the period, z is the investment tax reduction or subsidy, τ_c is the corporate tax rate (effective ETR), A is the present value of depreciation, r refers to the real interest rate, F_K^0 is the gross profit margin on capital when neither tax is not imposed on wages or tax, δ is the economic depreciation rate, τ_b is the deduction rate for interest payments, π is an inflation rate, and B_t is the debt.On the other hand, without tax, the NPV, R_t^0, becomes

$$R_t^0 = -1 + \frac{1}{1+r}[F_k^0 + (1-\delta)] = \frac{1}{1+r}[(F_k^0 - \delta) - r]. \tag{3.3}$$

As mentioned in the introduction, the ETR can be average or marginal. EATRs are levied on all corporate profits including normal and excess profits, whereas EMTRs apply to a marginal investment yielding a zero after-tax NPV and represent the tax rate on normal profits alone.

EATR is defined as the difference between the after-tax and pre-tax NPV divided by the pre-tax rate of profit:

$$\text{EATR} = \frac{R_t^0 - R_t}{F_K^0 - \delta/(1+r)} \tag{3.4}$$

The EMTR is defined as the tax rate on an investment with an after-tax NPV of zero (3.2).

$$(1-z)(1-\tau_c A) = \frac{1}{1+r}\left[(1-\tau_c)\hat{F}_K + (1-z)(1-\tau_c A)(1-\delta)\right] + \tau_b\left(\frac{i}{(1+r)(1+\pi)}\right)dB_t$$

Solving the above for $\hat{F}_K$ the marginal gross profit margin on capital establishes:

$$\hat{F}_K = \frac{1}{1-\tau_c}\left\{(r+\delta)(1-z)(1-\tau_c A) - \tau_b \frac{i}{(1+\pi)} dB_t\right\} \tag{3.5}$$

Therefore, EMTR is derived as follows

$$\text{EMTR} = \frac{\hat{F}_K - (r+\delta)}{\hat{F}_K - \delta} \tag{3.6}$$

3.2 Incorporating Pro Forma Standard Taxation

Devereux and Griffith (2003) assumed that labor input is constant and that firm production is determined by the capital stock at the end of the previous period, K_{t-1}. We now consider labor inputs. Suppose that firms generate output using $K_{t-1}$and labor input L_t. We assume that production technology has diminishing returns to scale and that economic rent (excess profits) is generated. We also assume that the labor input is optimized for each period. We use the following CES production functions:

$$F(K,L) = \left[\beta_K K^{1-1/\theta} + \beta_L L^{1-1/\theta} + \beta_E E^{1-1/\theta}\right]^{\theta/(\theta-1)} \quad (3.7)$$

where $\beta_K + \beta_L + \beta_E = 1$, $\beta_j$is the distribution rate of production factors, E is the constant factor that generates excess profits, and θ is the elasticity of substitution among production factors. F'^0_K is the gross profit margin on capital when tax is imposed on wages but not on profits, and $\widehat{F'}_K$ is the marginal gross profit margin on capital when tax is imposed on wages and profits. In calculating the effective tax rates we let $\theta = 1$.

The labor input is optimized for each period. We define labor productivity without tax F_L^0. Then, the labor input is determined at the level where the labor productivity is equal to the wages and the capital productivity is equal to the marginal revenue and the NPV of investment. That is, the following equations hold:

$$F_L^0 = \frac{W_t}{q_t} = w \quad (3.8)$$

$$L_{t+1}^0 = L(w, K_t) \quad (3.9)$$

We incorporate firms' selection of labor input in response to pro forma standard taxation.

$$(1-\tau_c) q_t \hat{F}_L(K_t, L_{t+1}) = (1-\tau_c+\sigma) W_{t+1} \; or \; \hat{F}_L = \left(1 + \frac{\sigma}{1-\tau_c}\right) w \quad (3.10)$$

$$\hat{L}_{t+1} = L\left(\left(1 + \frac{\sigma}{1-\tau_c}\right) w, K_t\right) \quad (3.11)$$

A tax on wages affects a company's labor input and alters its marginal productivity.

We define R_t^0 as the NPV of investment when there are no taxes on wages or profits, R'_t as the NPV of investment when taxes are imposed on both wages and profits, F_K^0 as the gross profit rate when there are no taxes on wages or profits, and F'^0_K as the gross profit rate on capital when there are taxes on wages but none on profits. The EATR is then calculated as follows:

$$\text{EATR} = \frac{R_t^0 - R'_t}{(F_K^0 - \delta)/(1+r)} \quad (3.12)$$

where F'^0_K is

$$F'^0_K \approx \left[1 + \frac{\Delta F_L}{\hat{F}_L} \frac{d \ln F_K}{d \ln \hat{F}_L}\right]^{-1} F_K^0 = \left[1 + \frac{\sigma}{(1-\tau_1+\sigma)} \gamma_{KL} \varepsilon_L\right]^{-1} F_K^0 \quad (3.13)$$

R'_t can be expressed using F'^0_K as follows:

$$R'_t = \left\{-(1-z)(1-\tau_c A) + \frac{1}{1+r}[(1-\tau_c)F'^0_K + (1-z)(1-\tau_c A)(1-\delta)]\right\} + \tau_b\left(\frac{i}{(1+r)(1+\pi)}\right)dB_t \quad (3.14)$$

We calculate the EMTR when there is an impact on the labor input owing to the external standard taxation on labor:

$$\widehat{F'}_K = \frac{1}{1-\tau_c}\left\{(r+\delta)(1-z)(1-\tau_c A) - \tau_b \frac{i}{(1+\pi)}dB_t\right\}\left(1 + \frac{\sigma}{(1-\tau_1+\sigma)}\gamma_{KL}\varepsilon_L\right) \quad (3.15)$$

where γ_{KL} denotes the rate of the variation in marginal productivity of capital with respect to an increase in labor and ε_L is the elasticity of labor input to labor costs when the capital stock is fixed. We then determine EMTR as follows:

$$\text{EMTR} = \frac{\widehat{F'}_K - (r+\delta)}{\widehat{F'}_K - \delta} \quad (3.15)$$

3.3 Decomposition of Forward-looking Effective Tax Rate into Income Taxation and Wage Taxation

In analyzing forward-looking ETRs, we also analyse the forward-looking ETR on profits (ETR before pro forma standard) and the impact of wage taxation on the forward-looking ETR (ETR after pro forma standard). However, for companies with capital of at most JPY 100 million, the corporate enterprise tax (value-added levy) is not imposed. This results in a forward-looking ETR owing to a wage taxation of zero.

Let EATR_{before} and EMTR_{before} represent the forward-looking EATR and forward-looking EMTR before the pro forma standard, respectively. Let EATR_{after} and EMTR_{after} represent the forward-looking EATR and forward-looking EMTR after pro forma taxation, respectively. We can then define $\text{EATR}_{after} - \text{EATR}_{before}$ as the EATR on the pro forma standard and $\text{EMTR}_{after} - \text{EMTR}_{before}$ as the EMTR on the pro forma standard. We utilize these ETRs when decomposing ETRs in the following sections.

4 Data and Empirical Method

4.1 Data

To measure the firm-specific forward-looking ETR, we use the TSR Corporate Information File (2007–2022), TSR Financial Information File (2007–2022), and TSR Corporate Correlation File (2007–2022). These datasets were compiled by Tokyo Shoko Research Inc. through extensive surveys of millions of companies in Japan. These encompass a wide range of data including basic company information such as capital and industry, as well as detailed financial information. We focus on companies whose capital categories were stable between FY2014 and FY2018.

4.2 Calculating Forward-looking Effective Tax Rate

The firm-specific forward-looking ETR is calculated using the aforementioned model by employing firm-specific parameters for the following variables: the before-tax gross profit rate of capital F_K^0, labor distribution ratio β_L, economic depreciation rate δ, tax depreciation rate φ, debt ratio b_f, and present value of tax depreciation multiplied by the tax rate on profits A.

δ, φ, and A are calculated as follows:

$$\delta_f = \delta^b \Theta_f^b + \delta^m \Theta_f^m$$
$$\varphi_f = \varphi^b \Theta_f^b + \varphi^m \Theta_f^m$$
$$A_f = A^b \Theta_f^b + A^m \Theta_f^m$$

Θ_f^b is the proportion of buildings in companies' new investment, Θ_f^m is the proportion of machinery and equipment in companies' new investment, and $\Theta_f^b + \Theta_f^m = 1$. δ^b and $\delta^m$are the capital depreciation rates of buildings and machinery, respectively. φ^b and φ^m are the tax depreciation rates of buildings and machinery, respectively. $A^b$and A^m represent the present value of tax depreciation multiplied by the tax rate on profits for buildings and machinery/equipment, respectively. δ^b, δ^m, φ^b, φ^m, A^b, and A^m are not firm-specific parameters. Based on these parameters, we calculated the firm-specific EATR and EMTR.

The parameters are listed in Table 2. The STR on profits encompasses corporate tax, local corporate tax, corporate inhabitant tax on corporate income, corporate enterprise tax (income tax), local special corporate tax, and corporate enterprise tax (value-added tax). It does not account for excess tax rates. The STR apart from that imposed on income includes a corporate enterprise tax (value-added tax) and does not consider excess tax rates. Corporate inhabitant taxes (per capita) and corporate enterprise taxes (capital levy) are excluded.

The relationship between the STR on income, STR on other than income, and STR for each tax item is described in the previous section. The inflation rate is calculated as the average variation in the consumer price index from 2006 to 2018.

Using the TSR Financial Information File, the net profit margins are calculated by dividing operating profits by tangible fixed assets. We use the average from 2006 to 2011 for each company. However, when calculating the forward-looking ETR, we assume that investments are made in new projects. Therefore, regardless of the net profit margin calculated from the financial information, we assume that investments would not be made if the profit margin is not likely to exceed a certain threshold. Consequently, the profit margin is obtained by adding the real interest rate (assumed to be 3%) to the inflation rate, and a certain profit margin (2%) is set as the lower limit of the net profit margin. That is, if "operating profit / tangible fixed assets" exceeds the lower limit calculated using the real interest rate and inflation rate, "operating profit / tangible fixed assets" is used as the net profit margin. If it does not exceed the lower limit, the lower limit calculated from the real interest rate and inflation rate is used.

The increase in added value (salaries, wages, and net rent paid) with an increase in assets by one unit in the previous period is considered differently for salaries and net rent. For salaries, the Ministry of Health, Labour and Welfare's Basic Survey on Wage Structure was used to calculate the annual salary per employee for each industry, which was multiplied by the number of employees to determine the salary for each company. Salaries were divided by tangible fixed assets in the balance sheet of the TSR Financial Information File to determine the increase in salaries with an increase in assets. For the net rent, the rent in

the income statement of the TSR Financial Information File is divided by the tangible fixed assets in the balance sheet of the same file to calculate the increase in net rent corresponding to the increase in assets. The sum of "salaries and wages / tangible fixed assets" and "net rent / tangible fixed assets" represents the increase in added value other than profit when assets increase by one unit. However, when this figure exceeds the increase in sales when assets increase by one unit, the second quantity is used. Based on this, the average value from fiscal years 2006–2011 is used to represent the increase in added value other than profits for an increase in assets in the previous period by one unit.

In calculating the building ratio and machinery ratio, the balance sheet in the TSR Financial Information File is used to estimate the amount of buildings and attached equipment acquired and the amount of machinery acquired per year. For corporate accounting depreciation, the useful life of buildings and attached equipment is set at 27 years and depreciated using the straight-line method. Meanwhile, the useful life of machinery and equipment is set at eight years and depreciated using the 200% declining balance method. It is assumed that an equal amount is acquired each year. In this case, the number of buildings and attached equipment acquired per year is 0.0714 times the amount on the balance sheet, and the amount of machinery and equipment acquired per year is 0.2837 times the amount on the balance sheet.

The building ratio is calculated for each company as "building and attached equipment acquisition cost per fiscal year / (building and attached equipment acquisition cost per fiscal year + machinery and equipment acquisition cost per fiscal year)." The building ratio for each company is calculated as the average value for each fiscal year. The machinery and equipment ratio is calculated as 1 - building ratio.

The debt ratio is calculated for each company using balance sheets in the TSR Financial Information File as follows: "(short-term borrowings + long-term borrowings to be repaid within one year + bonds to be redeemed within one year + bonds + long-term borrowings) / total assets." The average value for 2006–2011 is used to determine the debt ratio for each company.

Note that the data regarding the net profit ratio, increase in added value other than profit

for an increase in assets in the previous period by one unit, building ratio, machinery and equipment ratio, and debt ratio for certain companies are missing from the TSR Financial Information File. In such cases, the average values are calculated after excluding the years with missing data.

We assume that the elasticity of substitution, θ, is one. This implies that we consider the Cobb–Douglas production function rather than the CES function.

Table 3 presents the descriptive statistics of the factors used to calculate forward-looking ETRs.

Table 2 Parameterization for Calculating Forward-looking Tax Rates

Parameters	Calculations	Firm-specific
Nominal interest rate ρ	(1+r)×(1+ π)-1	
Real interest rate r	0.05	
Inflation rate π	0.02	
Corporate effective tax rate τ_c	Calculate based on actual institutions	
the present value of tax depreciation multiplied by the tax rate on profits A	Calculate based on actual institutions	
deduction rate for interest payments τ_b	Same as τ_c	
investment tax reduction or subsidy z	0	
Labor subsidy or tax σ	Calculate based on the pro forma standard	
Economic depreciation δ	Weighted average of building (3.61%) and machinery/equipment (12.25%) for each firm	✓
proportion of buildings in companies' new investment Θ_f^b	Acquisition of buildings and attached equipment/ (acquisition of buildings and attached equipment + acquisition of machinery and equipment)	✓
Pre-tax return on capital F_K^0	Operating profit/Tangible fixed assets + Rate of economic depreciation	✓
Borrowing ratio for investment dB_t	(Short-term loans + Long-term loans due within one year + Corporate bonds due within one year + Corporate bonds + Long-term loans)/ Total assets	✓
elasticity of substitution between production factors θ	1	
Labor share β_L	Labor cost / Value added	Industry-specific

Table 3 Descriptive Statistics of Variables Used in Calculating Forward-looking Effective Tax Rates.

		Operating Profit/Tangible Fixed Assets	Labor Share	Building Ratio	Debt Ratio
SME	Sample Size	348,668	348,668	348,668	348,668
	Mean	0.154	0.795	0.452	0.453
	Median	0.101	0.819	0.373	0.428
	SD	0.079	0.088	0.397	0.332
Large	Sample Size	11,567	11,567	11,567	11,567
	Mean	0.162	0.648	0.680	0.197
	Median	0.144	0.698	0.823	0.122
	SD	0.078	0.214	0.340	0.218
Total	Sample Size	360,235	360,235	360,235	360,235
	Mean	0.154	0.790	0.459	0.445
	Median	0.102	0.819	0.387	0.416
	SD	0.079	0.098	0.398	0.332

(Note) Averages from FY2012 to FY2014

4.3 Empirical Method

We analyze the impact of Japan's corporate tax reforms from the mid-2010s (specifically the "growth-oriented corporate tax reform" spanning from FY2014 to FY2018 (Table 1)) on firm dynamics using forward-looking ETRs. Drawing on the methodologies of Egger et al. (2009) and Steinmüller et al. (2019), we estimate the following equations:

$$\ln y_{i2018} - \ln y_{i2014} = \beta_0 + \beta_1(ETR_{i2018} - ETR_{i2014}) + \beta_2 \ln y_{i2014} + \boldsymbol{X'_{i2014}\beta_3} + \epsilon_i$$

Here, y_{it} represents the outcome for company i in period t. We use tangible assets, number of full-time employees, and labor costs (comprising the compensation of executive members, compensation of employees, and employee benefits). ETR_{it} refers to the forward-looking EATR and EMTR. Therefore, β_1 is the coefficient of primary interest in the analysis. It indicates the effect of corporate tax reform on firm dynamics. $\ln y_{i2014}$ is the initial value of the outcome variable, which captures the initial condition of each firm. $\boldsymbol{X'_{i2014}}$ indicates other baseline variable vector such as industry dummies. ϵ_i is the error term.

As mentioned in Section 1, the forward-looking ETR is calculated based on standard assumptions regarding companies' investment and financing behaviors. Its strength lies in its capability to be considered as an exogenous variable in empirical analysis.

In addition to the standard specifications, three supplementary analyses were conducted. First, as observed previously, Japan's corporate tax reform reduced STRs while expanding pro forma taxation standards for large companies. We decompose the ETRs into income tax and value-added tax for large companies using the method described in Section 3.3. Second, we investigate how liquidity constraints and loss carryforward alter the impact of corporate tax reform. In the context of corporate behavior, liquidity constraints can play a decisive role. This is because companies confronting such constraints may not be capable of responding effectively even if ETRs vary significantly. The calculation of ETRs assumes that any incurred losses can be offset at a certain point in the future. However, as mentioned earlier, there is a limit to the amount of carried-forward losses that can be deducted, and certain losses cannot be offset fully. In addition, since 2015, corporate tax reforms have

imposed more stringent limitations on the deduction of carried-forward losses. Our equation adds an interaction term between ETRs and the liquidity constraint dummy, and another between ETRs and the carries forward dummy. We define companies whose average cash flow (after-tax profit + depreciation expense) is negative from FY2014 to FY2018 as those confronting liquidity constraints, and identify companies that had carried-forward losses as of FY 2014 by defining these as those whose sum of pre-tax profits for FY 2014 and after-tax net profits for the previous four years are negative. Third, as indicated by its name, the corporate tax reform aims to enhance economic growth. To achieve this, it is crucial to promote the creation of startups and facilitate the exit of inactive firms. We examine whether the Japanese corporate tax reform enhanced economic vibrancy by incorporating an interaction term that includes a dummy variable for newly established firms and zombie companies. We define newly established firms as those founded after 2014 and categorize zombie companies as those with operating profit margins below 2% and debt-to-total asset ratios exceeding 70%.

5 Descriptive and Preliminary Analysis

5.1 Distributions

Next, we consider the effects of corporate tax reforms on firm dynamics. We first conduct preliminary descriptive and distributional analyses. Figure 1 presents the kernel density estimates of the ETRs for SMEs and large companies before and after the reform. All the distributions shifted to the left in the post-reform stage and appeared to be more concentrated. This result reflects a reduction in the effective statutory corporate tax rate on profits. Although the tax burden on companies with high profit margins reduced significantly, the reduction in tax burden was marginal for companies with low profit margins. These observations are corroborated by the box plots shown in Figure 2. The figure illustrates the median of each distribution represented by the horizontal lines within the boxes. The median ETR for large companies decreased more substantially than that for SMEs because the income tax rate of local enterprises decreased for large companies (Table 1). Consequently, the STR of income for large companies decreased more than that for SMEs.

The boxes in Figure 2 indicate the interquartile range (IQR) spanning the 25th–75th percentile. It measures the dispersion of the distribution. Each box has become more centered post-reform. These figures demonstrate that Japan's corporate tax reform has equalized its corporate tax burden.

Table 4 provides the descriptive statistics for the forward-looking EATR and EMTR by company size and fiscal year. This table decomposes the ETRs into the income tax rate (before the pro forma standard) and the tax rate including value-added tax (after the pro forma standard). SMEs did not experience pro forma standard taxation. Therefore, the ETRs after pro forma standards are identical to those before. This table also verifies the observations from Figure 1 and Figure 2. The corporate tax reform reduced the EATR. This made the reduction more significant for large companies than for SMEs. However, the expansion of pro forma taxation at least partially offsets the reduction induced by decreasing income tax rates.

Figure 3 displays the scatter plots of the EATR and EMTR for FY2014 and FY2018. The solid navy lines indicate 45° lines. The dots below the lines represent firms whose tax rates decreased from FY2014 to FY2018, and vice versa. With regard to the EATR, most companies experienced tax rate reductions. The more significant the tax burdens in FY2014, the higher were the tax rate reductions in FY2018. For the EMTR, although firms with positive tax rates in FY2014 tended to experience tax rate reductions, those with negative rates in FY2014 tended to experience tax rate increases. This indicates that the dispersion of EMTR narrowed significantly.

Figure 1 Distributions of ETRs for SMEs and Large Companies before and after the Reform

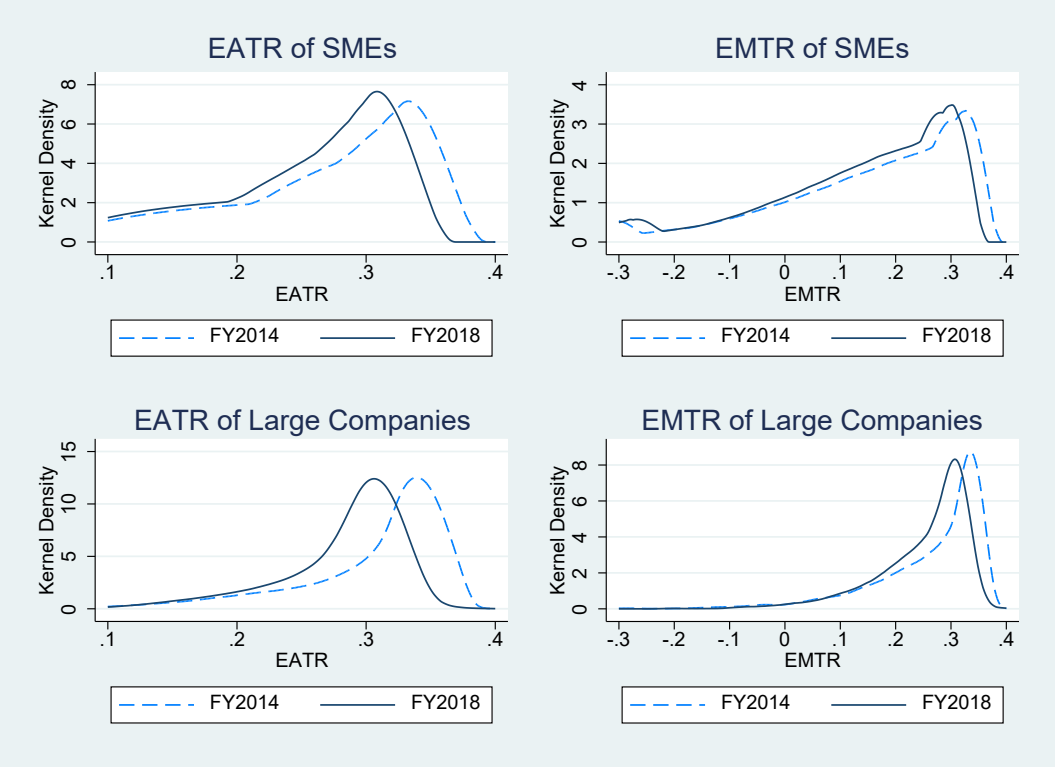


Figure 2 Box Plots of ETRs for SMEs and Large Companies before and after the Reform

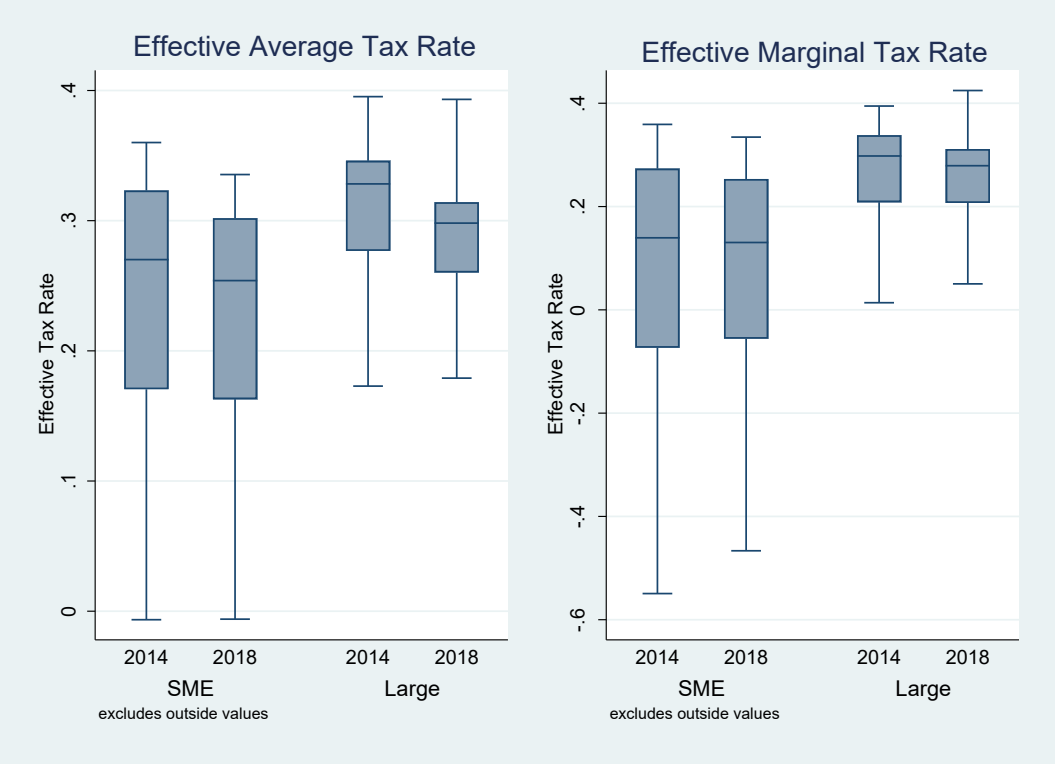
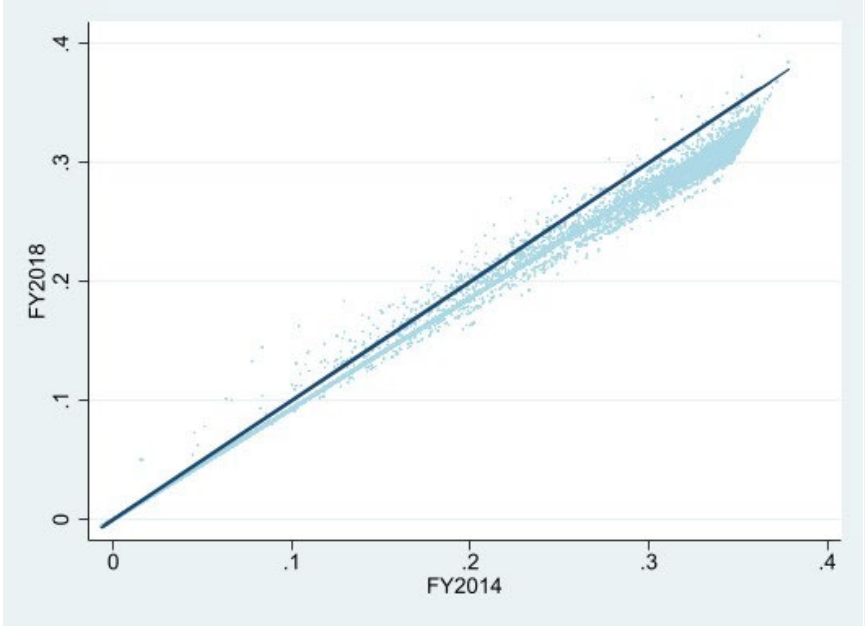


Table 4 Descriptive Statistics of Forward-looking Effective Tax Rates

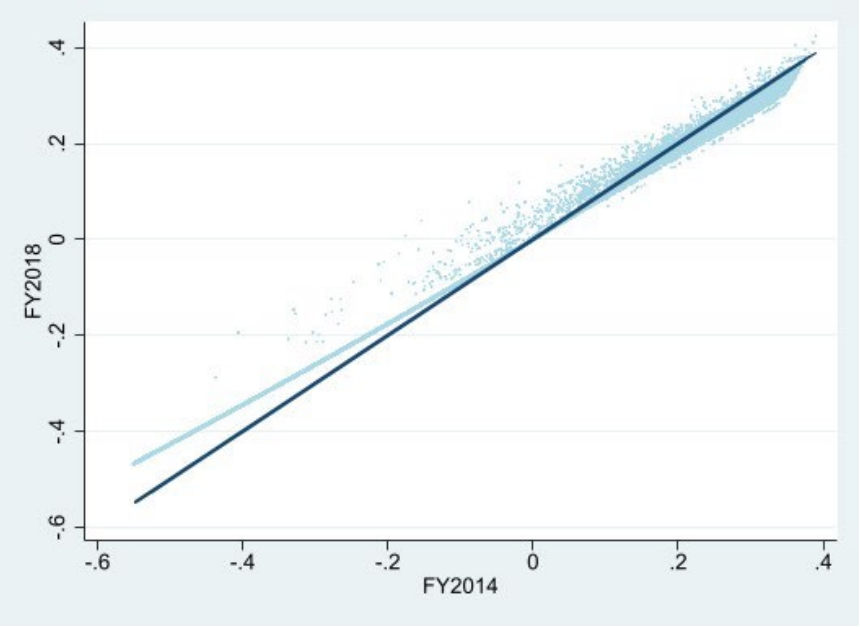
			SME			Large			Total		
			FY2014	FY2018	Diffirence	FY2014	FY2018	Diffirence	FY2014	FY2018	Diffirence
EATR	Before pro	Mean	23.8%	22.4%	-1.4%	28.9%	25.1%	-3.8%	24.0%	22.5%	-1.5%
	forma	SD	10.4%	9.6%	-0.8%	6.6%	5.3%	-1.2%	10.3%	9.5%	-0.9%
	standard	Median	27.0%	25.4%	-1.6%	31.8%	27.4%	-4.4%	27.2%	25.5%	-1.7%
		IQR	15.3%	13.9%	-1.4%	7.2%	5.8%	-1.4%	15.0%	13.5%	-1.5%
	After pro	Mean	23.8%	22.4%	-1.4%	30.1%	28.0%	-2.1%	24.0%	22.6%	-1.5%
	forma	SD	10.4%	9.6%	-0.8%	6.4%	5.2%	-1.2%	10.4%	9.5%	-0.8%
	standard	Median	27.0%	25.4%	-1.6%	32.8%	29.8%	-3.0%	27.3%	25.6%	-1.7%
		IQR	15.3%	13.9%	-1.4%	6.9%	5.4%	-1.5%	15.1%	13.7%	-1.4%
EMTR	Before pro	Mean	6.3%	6.7%	0.4%	23.7%	20.6%	-3.1%	6.9%	7.2%	0.3%
	forma	SD	25.8%	22.6%	-3.2%	12.2%	9.7%	-2.5%	25.7%	22.4%	-3.2%
	standard	Median	13.9%	13.0%	-0.9%	28.2%	24.1%	-4.1%	14.7%	13.6%	-1.0%
		IQR	34.7%	30.9%	-3.8%	13.9%	11.9%	-2.0%	34.1%	30.4%	-3.7%
	After pro	Mean	6.3%	6.7%	0.4%	25.5%	24.7%	-0.8%	7.0%	7.3%	0.3%
	forma	SD	25.8%	22.6%	-3.2%	11.6%	9.1%	-2.6%	25.7%	22.5%	-3.2%
	standard	Median	13.9%	13.0%	-0.9%	29.8%	27.9%	-1.9%	14.8%	13.8%	-1.0%
		IQR	34.7%	30.9%	-3.8%	13.0%	10.4%	-2.5%	34.2%	30.6%	-3.6%

Figure 3 Scatter Plot of ETR for FY2014 and FY2018:

Effective Average Tax Rate



Effective Marginal Tax Rate



5.2 Variance Function Regression

In this subsection, we employ variance function regression (VFR) to investigate the distributional shifts of ETRs. Conventional regression methods focus primarily on how explanatory variables affect the mean of dependent variables. Meanwhile, VFR addresses how explanatory variables influence the variance of dependent variables by incorporating a variance function into the regression model[2].

Table 5 presents the estimation results of the variance function regression. We use the large company dummy, log of value-added, log of labor productivity, debt ratio, labor share, new company dummy, and zombie dummy as explanatory variables (all from FY2014). The interaction terms of these variables with the FY2018 dummy (which captures the impact of corporate tax reform on the ETR distribution) are also included. Column (1) shows the results of the EATR using only the large company dummy and FY2018 dummy as covariates. The coefficient of the large company dummy is significantly positive for the mean and negative for the variance. This indicates that large companies' EATR was higher and less dispersed than that of SMEs as of FY2014. The coefficient of the FY2018 dummy is statistically negative for both mean and variance. This indicates that corporate tax reform contributed to decreasing both average and variance of the EATR. The coefficient of the interaction term between the FY2018 dummy and large company dummy is significantly negative for both mean and variance. This indicates that the impact of the corporate tax reform was higher for large companies in terms of reducing and equalizing the tax burden.

Column (2) contains additional explanatory variables. Before the reform, large and productive firms tended to experience higher tax burdens, whereas companies with high debt ratios and labor share experienced lower tax burdens. After the reform, converse trends emerged. This indicates that large and productive firms experienced a reduction in their tax burden and that this burden was equalized. The newly established company dummy, defined as a company founded in 2014, encountered higher EATRs before the

[2] Specifically, we estimate the following two equations simultaneously using the two-step GLS estimator:

$$\ln ETR_{it} = \boldsymbol{X'_{i2014}\beta_1} + \boldsymbol{X'_{i2014}} \times FY2018Dummy \times \boldsymbol{\beta_2} + \epsilon_{it}$$
$$\mathrm{VAR}(\epsilon_{it}) = \boldsymbol{X'_{i2014}\gamma_1} + \boldsymbol{X'_{i2014}} \times FY2018Dummy \times \boldsymbol{\gamma_2}$$

reform. This trend did not vary significantly even after the reform. Zombie companies tended to gain from low EATRs in FY2014. However, their EATR increased by 4.5% in FY2018. This indicates that the reform likely induced zombie companies to exit the market and reduce their business activities (if EATRs influence corporate behavior).

Columns (3) and (4) present the EMTR results. The coefficients are generally similar to those for the EATRs. However, the coefficient of the FY2018 dummy in column (3) for the mean, -0.0023, is significantly smaller in absolute terms than that in column (1), -0.017. This indicates that the reduction in the tax burden in terms of EMTRs is less than that for EATRs. Conversely, the coefficient of the interaction terms of the FY2018 dummy and large company dummy in column (3) for variance, -0.2114, is larger in absolute terms than that in column (1), -0.141. This indicates that the distribution of EMTRs is more centralized than that of EATRs.

Column (4) presents the estimation results when additional covariates are incorporated. In terms of marginal rates, the debt ratio plays a critical role. Although companies with high debt gained from low marginal rates, the reforms significantly increased these rates. Unlike EATRs, EMTRs tended to be lower for newly established companies even before the reform. Zombie companies gained from low EMTRs in FY2014. However, their EMTR increased by 0.65% in FY2018. This indicates that the reform likely induced zombie companies to exit the market and reduce their business activities (assuming that EMTRs influence corporate behavior).

Table 5 Estimation Results of Variance Function Regressions

	Effective Average Tax Rate				Effective Marginal Tax Rate			
	(1)		(2)		(3)		(4)	
	Mean	log(variance)	Mean	log(variance)	Mean	log(variance)	Mean	log(variance)
Large Company Dummy	0.0557***	-1.0899***	0.0039***	-0.6256***	0.1764***	-1.7278***	-0.0075***	-0.0059
	(0.0007)	(0.0289)	(0.0007)	(0.0325)	(0.0014)	(0.0289)	(0.0009)	(0.0325)
ln(value added)			0.0017***	-0.0434***			0.0147***	-0.3729***
			(0.0001)	(0.0046)			(0.0002)	(0.0046)
ln(labor productivity)			0.0028***	-0.0635***			-0.0033***	0.1205***
			(0.0002)	(0.0073)			(0.0003)	(0.0073)
Debt Ratio			-0.1093***	0.2658***			-0.4025***	0.397***
			(0.0004)	(0.0069)			(0.0007)	(0.0069)
Labor Share			-0.0267***	0.1822***			0.0485***	-1.2873***
			(0.0005)	(0.0181)			(0.0007)	(0.0181)
New Company Dummy			0.0031***	-0.038***			-0.0087***	-0.1581***
			(0.0004)	(0.0148)			(0.0006)	(0.0148)
Zombie Dummy			-0.068***	0.3139***			-0.1025***	0.0218
			(0.0006)	(0.0173)			(0.0009)	(0.0173)
FY2018 Dummy	-0.017***	-1.0899***	-0.0144***	-0.2209**	-0.0023***	-1.7278***	-0.0079**	-0.5554***
	(0.0003)	(0.0289)	(0.0024)	(0.0893)	(0.0007)	(0.0289)	(0.0037)	(0.0893)
× Large Company Dummy	-0.0064***	-0.1415***	-0.0037***	-0.3349***	-0.0086***	-0.2114***	0.0094***	-0.212***
	(0.0010)	(0.0071)	(0.0009)	(0.0464)	(0.0018)	(0.0071)	(0.0012)	(0.0464)
× ln(value added)			-0.0004**	0.001			-0.0015***	0.0372***
			(0.0002)	(0.0066)			(0.0002)	(0.0066)
× ln(labor productivity)			-0.0006**	0.0088			-0.0001	-0.0082
			(0.0003)	(0.0104)			(0.0004)	(0.0104)
× Debt Ratio			0.007***	0.0022			0.0493***	0.0022
			(0.0005)	(0.0097)			(0.0009)	(0.0097)
× Labor Share			0.0025***	-0.0034			-0.0044***	0.1012***
			(0.0007)	(0.0257)			(0.0010)	(0.0257)
× New Company Dummy			-0.0003	0.0052			-0.0001	0.0045
			(0.0006)	(0.0209)			(0.0008)	(0.0209)
× Zombie Dummy			0.0045***	0.0015			0.0065***	-0.1627***
			(0.0009)	(0.0245)			(0.0012)	(0.0245)
Constant	0.2491***	-4.555***	0.2907***	-4.426***	0.0826***	-2.7816***	0.1306***	-0.1828***
	(0.0002)	(0.0050)	(0.0018)	(0.0632)	(0.0005)	(0.0050)	(0.0027)	(0.0632)
Sample Size	406,063		406,063		406,063		406,063	

Standard Errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

6 Estimation Results

6.1 Baseline Estimations

In this section, we investigate how Japan's corporate tax reform affected firm dynamics by estimating the equations presented in Section 4.3. Before examining this, we assess the validity of the newly constructed forward-looking tax rate, which incorporates the pro forma standard. We evaluate this by examining how well newly constructed forward-looking tax rates explain corporate behavior. Table 7 and Table 9 display the estimation results of regressing the variations in outcomes on the variations in EATR and EMTR for large companies. The first column for each outcome in Table 7 and Table 9 shows the results including only EATR as an explanatory variable. The second column for each outcome indicates the addition of each baseline outcome and industry dummies. The third and fourth columns for each outcome use the conventional EATR, which considers only income tax, rather than incorporating pro forma standard taxation. These comparisons enable us to assess the validity of the newly constructed forward-looking tax rate model. Comparing the first and third columns, the standard errors of the new rates are generally significantly smaller than those of the conventional rates. For example, the standard errors are 0.583 for the first column and 0.917 for the third in Table 7. The R-squared values are 0.014 and 0.008 for the same columns. Even after controlling for the baseline outcome and industry dummies, the standard errors are 0.670 and 1.026 for the second and fourth columns, respectively, and the R-squared values are 0.052 and 0.045, respectively. The R-squared values obtained from the regressions using the new tax rates are consistently higher than those obtained from the conventional rates. These results affirm that the new rates have higher explanatory power with regard to corporate behavior than conventional rates. This implies that our newly constructed rates display empirical validation in addition to theoretical effectiveness.

Let us return to our original motivation. Table 6 and Table 7 display the estimation results after regressing the variations in outcomes on variations in the EATR for SMEs and large companies, respectively. Overall, most coefficients of $\Delta EATR$ $(= EATR_{i2018} - EATR_{i2014})$ for each outcome are negative and statistically significant. Because the EATR reduced from

FY2014 to FY2018 in terms of the average and median, corporate tax reform induced an increase in outcomes. However, these coefficients for large companies are small in absolute terms. This implies that the impact of the reform on large companies' behavior was limited.

Table 8 and Table 9 show the estimation results of regressing the variations in outcomes on the variations in EMTR rather than EATR. Although the coefficients are smaller than the EATR in absolute terms, the overall results are similar to those of the EATR. The coefficients of EMTR for SMEs are larger than those for large companies in absolute terms. This corresponds with the results obtained using EATR.

The fifth column for each outcome in Table 7 and Table 9 provides further insights by dividing the ETR into income tax and value-added tax (pro forma standards). Although most coefficients for the EATR of income tax are small in absolute terms and statistically insignificant in Table 7, the magnitudes of the EATR of value-added tax are statistically significant and consistently larger than those of income tax. Although the variations in the EATR induced by expanding pro forma standard taxation are smaller than those induced by reducing income tax, enhancing pro forma tax monotonically increases the EATR, and the coefficients are larger. Similar results are obtained in Table 9, which utilizes EMTR rather than EATR. Therefore, expanding the pro forma tax partially offset the impact of the corporate tax reform. This may explain the differences in the coefficients between SMEs and large companies.

Table 6 Estimation Results (EATR): SMEs

	Δln(tangible asset)		Δln(employees)		Δln(labor cost)	
	(1)	(2)	(3)	(4)	(5)	(6)
ΔEATR	-11.65***	-11.55***	-2.056***	-3.026***	-4.487***	-6.692***
	(0.402)	(0.401)	(0.144)	(0.148)	(0.210)	(0.220)
Baseline Outcome	No	Yes	No	Yes	No	Yes
Industry Dummies	No	Yes	No	Yes	No	Yes
Sample Size	106,001	106,001	106,001	106,001	106,001	106,001
R-squared	0.008	0.038	0.002	0.012	0.005	0.031

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7 Estimation Results (EATR): Large Companies

	Δln(tangible asset)					Δln(employees)					Δln(labor cost)				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
ΔEATR	-4.983***	-5.260***				-2.037***	-2.373***				-1.650***	-2.802***			
	(0.583)	(0.670)				(0.284)	(0.341)				(0.339)	(0.432)			
ΔEATR (Income Tax)			-6.442***	-5.781***	-3.045***			-1.784***	-1.987***	-0.658			-1.470**	-2.147***	-0.517
			(0.917)	(1.026)	(1.181)			(0.458)	(0.513)	(0.532)			(0.611)	(0.673)	(0.688)
ΔEATR (Value Added Tax)					-7.556***					-4.210***					-5.298***
					(1.425)					(0.620)					(0.717)
Baseline Outcome	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Industry Dummies	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Sample Size	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172
R-squared	0.014	0.052	0.008	0.045	0.053	0.013	0.044	0.004	0.034	0.048	0.005	0.044	0.001	0.036	0.048

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8 Estimation Results (EMTR): SMEs

	Δln(tangible asset)		Δln(employees)		Δln(labor cost)	
	(1)	(2)	(3)	(4)	(5)	(6)
ΔEMTR	-1.058***	-2.646***	-0.371***	-0.718***	-0.0442	-0.902***
	(0.129)	(0.128)	(0.0375)	(0.0394)	(0.0598)	(0.0628)
Baseline Outcome	No	Yes	No	Yes	No	Yes
Industry Dummies	No	Yes	No	Yes	No	Yes
Sample Size	106,001	106,001	106,001	106,001	106,001	106,001
R-squared	0.001	0.037	0.001	0.012	0.000	0.023

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9 Estimation Results (EMTR): Large Companies

	Δln(tangible asset)					Δln(employees)					Δln(labor cost)				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
ΔEMTR	-1.451***	-1.652***				-0.520***	-0.572***				-0.253	-0.702***			
	(0.406)	(0.473)				(0.167)	(0.191)				(0.201)	(0.235)			
ΔEMTR (Income Tax)			-0.963	-1.151	0.303			0.149	-0.0328	0.743**			0.247	-0.123	0.762**
			(0.691)	(0.764)	(0.867)			(0.249)	(0.269)	(0.290)			(0.309)	(0.328)	(0.349)
ΔEMTR (Value Added Tax)					-4.735***					-2.669***					-3.084***
					(1.065)					(0.439)					(0.534)
Baseline Outcome	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Industry Dummies	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Sample Size	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172
R-squared	0.003	0.043	0.001	0.040	0.047	0.002	0.033	0.000	0.030	0.041	0.000	0.035	0.000	0.033	0.041

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6.2 Heterogeneous Effects of Liquidity Constraints and Loss-Carryforward

In this subsection, we investigate the heterogeneity owing to liquidity constraints and loss carryforward. Table 10 presents the results of incorporating the interaction terms with the liquidity constraint dummy for the EATR for SMEs. Most coefficients of the interaction terms with liquidity constraints and loss carryforward are positive. This indicates that SMEs confronting these conditions tend to be inelastic to variations in EATRs. Table 11 presents the results for large companies. For tangible assets, liquidity constraints mitigate the impact of the corporate tax reform but do not affect the number of employees. Investing in tangible assets requires upfront cash. This implies that companies attempting to invest in such assets should secure funding. Conversely, for the number of employees, the interaction terms with the carryforward dummy have statistically positive coefficients for SMEs in Table 10 and for large companies in Table 11. Limiting the amount of carried-forward losses reduces the value of the accumulated loss carryforward, thereby decreasing cash holdings.

Table 12 and Table 13 present similar estimation results using EMTR for SMEs and large companies, respectively. The results show patterns moderately different but overall similar to those shown in Table 10 and Table 11. Although both liquidity constraints and carryforward affect the elasticity of the EMTR for tangible assets, only the coefficient of the interaction dummy with carryforward is statistically significant. This is revealed by Table 12. For large companies, most coefficients of the interaction terms are not statistically significant.

Table 10 Estimation Results including Interaction Terms with Liquidity Constraint and Carry Forward (EATR): SMEs

	Δln(tangible asset)			Δln(employees)			Δln(labor cost)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ΔEATR	-10.81***	-9.282***	-9.893***	-2.900***	-2.322***	-2.451***	-5.717***	-3.940***	-3.952***
	(0.418)	(0.522)	(0.540)	(0.158)	(0.198)	(0.210)	(0.233)	(0.286)	(0.304)
× Liquidity Constraint Dummy	6.229***		4.522**	1.701***		0.838	0.292		-0.380
	(1.362)		(1.825)	(0.442)		(0.608)	(0.626)		(0.814)
× Carry Forward Dummy		2.506***	2.294***		1.996***	1.950***		2.511***	2.461***
		(0.523)	(0.525)		(0.178)	(0.178)		(0.246)	(0.247)
Liquidity Constraint Dummy	-0.160***		-0.0889***	-0.0444***		-0.0254**	-0.192***		-0.102***
	(0.0227)		(0.0322)	(0.00765)		(0.0113)	(0.0108)		(0.0149)
Carry Forward Dummy		-0.192***	-0.0986***		-0.0628***	-0.0403***		-0.171***	-0.114***
		(0.00986)	(0.0130)		(0.00352)	(0.00489)		(0.00473)	(0.00649)
Baseline Outcome	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample Size	106,001	58,732	58,732	106,001	58,732	58,732	106,001	58,732	58,732
R-squared	0.047	0.044	0.046	0.018	0.018	0.019	0.051	0.052	0.055

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 11 Estimation Results including Interaction Terms with Liquidity Constraint and Carry Forward (EATR): Large Companies

	Δln(tangible asset)			Δln(employees)			Δln(labor cost)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ΔEATR	-4.755***	-3.137***	-3.927***	-2.181***	-1.529***	-1.459***	-2.471***	-1.780***	-1.581***
	(0.646)	(0.652)	(0.613)	(0.347)	(0.346)	(0.345)	(0.451)	(0.470)	(0.461)
× Liquidity Constraint Dummy	7.277**		8.332***	0.626		-0.952	-0.773		-2.318*
	(2.829)		(2.998)	(1.258)		(1.287)	(1.266)		(1.399)
× Carry Forward Dummy		0.879	-0.465		1.366**	1.476**		0.531	0.843
		(1.721)	(1.759)		(0.572)	(0.615)		(0.707)	(0.776)
Liquidity Constraint Dummy	-0.287***		-0.116	-0.0903***		-0.0615*	-0.117***		-0.0651
	(0.0631)		(0.0788)	(0.0282)		(0.0352)	(0.0285)		(0.0433)
Carry Forward Dummy		-0.319***	-0.132**		-0.102***	-0.0708***		-0.0949***	-0.0786**
		(0.0454)	(0.0545)		(0.0194)	(0.0267)		(0.0255)	(0.0356)
Baseline Outcome	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample Size	4,172	3,795	3,795	4,172	3,795	3,795	4,172	3,795	3,795
R-squared	0.081	0.064	0.071	0.053	0.058	0.059	0.049	0.048	0.049

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 12 Estimation Results including Interaction Terms with Liquidity Constraint and Carry Forward (EMTR): SMEs

	Δln(tangible asset)			Δln(employees)			Δln(labor cost)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ΔEMTR	-2.589***	-2.207***	-2.214***	-0.741***	-0.656***	-0.686***	-0.732***	-0.107	-0.0827
	(0.137)	(0.226)	(0.230)	(0.0424)	(0.0708)	(0.0724)	(0.0670)	(0.101)	(0.104)
× Liquidity Constraint Dummy	1.061***		0.198	0.531***		0.346**	-0.0563		-0.106
	(0.377)		(0.526)	(0.107)		(0.158)	(0.163)		(0.213)
× Carry Forward Dummy		0.761**	0.741**		0.197*	0.158		-0.785***	-0.769***
		(0.369)	(0.375)		(0.112)	(0.113)		(0.169)	(0.172)
Liquidity Constraint Dummy	-0.272***		-0.156***	-0.0737***		-0.0373***	-0.206***		-0.0946***
	(0.00936)		(0.0165)	(0.00310)		(0.00587)	(0.00423)		(0.00783)
Carry Forward Dummy		-0.220***	-0.129***		-0.0734***	-0.0513***		-0.190***	-0.135***
		(0.00954)	(0.0128)		(0.00343)	(0.00482)		(0.00459)	(0.00639)
Baseline Outcome	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample Size	106,001	58,732	58,732	106,001	58,732	58,732	106,001	58,732	58,732
R-squared	0.046	0.041	0.043	0.018	0.016	0.017	0.046	0.048	0.051

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 13 Estimation Results including Interaction Terms with Liquidity Constraint and Carry Forward (EMTR): Large Companies

	Δln(tangible asset)			Δln(employees)			Δln(labor cost)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ΔEMTR	-1.425***	-0.788	-0.924*	-0.470**	-0.292	-0.247	-0.453*	-0.381	-0.270
	(0.491)	(0.484)	(0.480)	(0.205)	(0.231)	(0.229)	(0.247)	(0.295)	(0.288)
× Liquidity Constraint Dummy	2.542		2.377	0.173		-0.821	-0.947		-1.972**
	(1.584)		(1.767)	(0.522)		(0.612)	(0.615)		(0.771)
× Carry Forward Dummy		1.569	0.765		0.696*	0.980**		0.320	0.996
		(1.097)	(1.097)		(0.386)	(0.448)		(0.523)	(0.606)
Liquidity Constraint Dummy	-0.432***		-0.252***	-0.112***		-0.0454	-0.120***		-0.0251
	(0.0532)		(0.0744)	(0.0221)		(0.0321)	(0.0276)		(0.0432)
Carry Forward Dummy		-0.346***	-0.160***		-0.119***	-0.0912***		-0.109***	-0.1000***
		(0.0442)	(0.0541)		(0.0190)	(0.0264)		(0.0249)	(0.0357)
Baseline Outcome	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample Size	4,172	3,795	3,795	4,172	3,795	3,795	4,172	3,795	3,795
R-squared	0.074	0.060	0.065	0.043	0.052	0.054	0.042	0.044	0.046

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6.3 Heterogeneous Effects of New and Zombie Companies

This subsection examines the heterogeneous effects among newly founded zombie companies. As Table 14 shows, for EATR among SMEs, the interaction term coefficient with the new company dummy is statistically significant and negative for tangible assets. This indicates that newly founded companies tend to be affected by variations in tax rates. Conversely, zombie companies are less susceptible to tangible assets. These results imply that corporate tax reform is effective in promoting newly founded companies but ineffective in inducing zombie companies to exit the market. For large companies, as Table 15 shows, the interaction term with the new company dummy is significantly negative for the number of employees. This implies that such companies respond to variations in the EATR. The interaction term with the zombie company dummy is significantly positive for labor costs. This indicates that these companies are not susceptible to variations in tax rates. Overall, corporate tax reforms are regarded as an effective policy tool for promoting new companies. However, these are ineffective in facilitating the exit of zombie companies. Nevertheless, zombie companies tend to confront an abrupt increase in EATR, as shown in Table 5. Therefore, Japanese corporate tax reforms could have contributed to the exit of these companies.

Table 16 presents the EMTR results for SMEs. Unlike Table 14, the coefficient of the interaction term with the zombie company dummy is negative and statistically significant. This indicates that zombie companies respond to the EMTR. Column 6 indicates that the coefficient of the interaction term with the new company dummy is negative and statistically significant. This implies that corporate tax reform significantly affected the employment of these companies. For large companies, as shown in Table 17, most coefficients of the interaction terms are not statistically significant, except for the interaction terms with the new company dummy for the number of employees.

Table 14 Estimation Results including Interaction Terms with New and Zombie Company (EATR): SMEs

	Δln(tangible asset)			Δln(employees)			Δln(labor cost)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ΔEATR	-11.21***	-10.35***	-10.17***	-2.885***	-2.617***	-2.471***	-6.671***	-3.552***	-3.546***
	(0.405)	(0.464)	(0.464)	(0.152)	(0.181)	(0.182)	(0.230)	(0.266)	(0.275)
× New Company Dummy	-4.270***		-4.078***	-0.269		-0.198	0.546		1.026
	(1.538)		(1.539)	(0.525)		(0.526)	(0.794)		(0.787)
× Zombie Company Dummy		2.701	3.802**		-0.0499	0.122		-3.959***	-3.746***
		(1.677)	(1.674)		(0.525)	(0.525)		(0.770)	(0.769)
New Company Dummy	0.174***		0.178***	0.0674***		0.0689***	0.0974***		0.108***
	(0.0276)		(0.0276)	(0.00982)		(0.00983)	(0.0149)		(0.0148)
Zombie Company Dummy		-0.0377**	-0.0279		-0.0172***	-0.0172***		-0.144***	-0.144***
		(0.0172)	(0.0172)		(0.00598)	(0.00600)		(0.00887)	(0.00886)
Baseline Outcome	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample Size	105,805	105,988	105,792	105,805	105,988	105,792	105,805	105,988	105,792
R-squared	0.048	0.039	0.048	0.019	0.013	0.019	0.036	0.035	0.041

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 15 Estimation Results including Interaction Terms with New and Zombie Company (EATR): Large Companies

	Δln(tangible asset)			Δln(employees)			Δln(labor cost)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ΔEATR	-4.859***	-5.148***	-4.752***	-2.024***	-2.491***	-2.138***	-2.522***	-2.933***	-2.646***
	(0.675)	(0.659)	(0.661)	(0.339)	(0.356)	(0.355)	(0.431)	(0.450)	(0.448)
× New Company Dummy	-5.864		-5.836	-4.154**		-4.171**	-2.380		-2.392
	(3.600)		(3.588)	(1.962)		(1.935)	(2.207)		(2.202)
× Zombie Company Dummy		0.0470	-0.224		2.207*	1.934		3.894**	3.586**
		(6.079)	(6.058)		(1.215)	(1.250)		(1.537)	(1.550)
New Company Dummy	-0.0137		-0.0132	-0.0160		-0.0169	0.0579		0.0568
	(0.107)		(0.106)	(0.0637)		(0.0629)	(0.0706)		(0.0705)
Zombie Company Dummy		-0.0822	-0.0723		0.0286	0.0329		-0.00730	-0.00437
		(0.137)	(0.137)		(0.0382)	(0.0396)		(0.0429)	(0.0432)
Baseline Outcome	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample Size	4,163	4,172	4,163	4,163	4,172	4,163	4,163	4,172	4,163
R-squared	0.057	0.052	0.057	0.057	0.045	0.058	0.053	0.045	0.054

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 16 Estimation Results including Interaction Terms with New and Zombie Company (EMTR): SMEs

	Δln(tangible asset)			Δln(employees)			Δln(labor cost)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ΔEMTR	-2.533***	-1.922***	-1.826***	-0.648***	-0.580***	-0.518***	-0.892***	0.367***	0.361***
	(0.133)	(0.162)	(0.165)	(0.0409)	(0.0488)	(0.0497)	(0.0663)	(0.0789)	(0.0812)
× New Company Dummy	0.0469		0.165	-0.300**		-0.276**	0.194		0.372*
	(0.461)		(0.460)	(0.138)		(0.138)	(0.229)		(0.222)
× Zombie Company Dummy		-1.208***	-0.786**		-0.0770	0.0151		-2.117***	-2.002***
		(0.389)	(0.389)		(0.121)	(0.121)		(0.183)	(0.183)
New Company Dummy	0.240***		0.241***	0.0706***		0.0711***	0.0895***		0.0922***
	(0.0104)		(0.0104)	(0.00341)		(0.00341)	(0.00481)		(0.00476)
Zombie Company Dummy		-0.0577***	-0.0786***		-0.0189***	-0.0230***		-0.0957***	-0.102***
		(0.0122)	(0.0122)		(0.00478)	(0.00477)		(0.00688)	(0.00687)
Baseline Outcome	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample Size	105,805	105,988	105,792	105,805	105,988	105,792	105,805	105,988	105,792
R-squared	0.045	0.038	0.046	0.018	0.012	0.019	0.028	0.034	0.039

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 17 Estimation Results including Interaction Terms with New and Zombie Company (EMTR): Large Companies

	Δln(tangible asset)			Δln(employees)			Δln(labor cost)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ΔEMTR	-1.547***	-1.339***	-1.216***	-0.457**	-0.636***	-0.516**	-0.668***	-0.715***	-0.686***
	(0.479)	(0.458)	(0.456)	(0.192)	(0.224)	(0.227)	(0.234)	(0.266)	(0.265)
× New Company Dummy	-1.381		-1.632	-1.744**		-1.708*	-0.605		-0.592
	(2.084)		(2.062)	(0.881)		(0.882)	(1.155)		(1.155)
× Zombie Company Dummy		-2.998	-3.095		0.424	0.289		0.188	0.151
		(2.845)	(2.834)		(0.533)	(0.539)		(0.775)	(0.778)
New Company Dummy	0.150**		0.145**	0.0880***		0.0886***	0.128***		0.128***
	(0.0635)		(0.0632)	(0.0266)		(0.0266)	(0.0337)		(0.0337)
Zombie Company Dummy		0.135	0.146		-0.00556	0.00515		-0.0138	-0.00633
		(0.231)	(0.232)		(0.0614)	(0.0625)		(0.0608)	(0.0609)
Baseline Outcome	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample Size	4,163	4,172	4,163	4,163	4,172	4,163	4,163	4,172	4,163
R-squared	0.048	0.044	0.049	0.046	0.033	0.046	0.045	0.035	0.045

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

7 Conclusion

We used firm-level financial data from 2014 to 2018 to analyze the impact of corporate tax reforms in Japan in the mid-2010s using forward-looking effective corporate tax rates. The Japanese experience provides an effective opportunity to examine the effectiveness of corporate tax reform because it expands the tax base while lowering the statutory tax rate. Although only the statutory tax rate was lowered for companies with capital of at most JPY 100 million, the statutory tax rate was lowered, and pro forma standard taxation was expanded for companies with capital of over JPY 100 million.

Our observations can be summarized as follows: First, corporate tax reforms lowered the effective tax rate and reduced the disparities between companies. Although large and productive companies gained from the reform, high-debt zombie companies confronted increases in their effective tax rates. Second, although the reduction in ETRs generated increased investment and employment, the positive impacts were offset partially for large firms owing to the expansion of pro forma standard taxation, which effectively increases labor costs. Third, companies confronting liquidity constraints and holding accumulated loss carryforwards tend to be unresponsive to variations in their ETRs. Liquidity constraints tend to mitigate the impact of tax rate variations on investment, whereas holding a loss carryforward tends to mitigate the impact of corporate tax reforms on employment. Finally, newly founded companies were responsive to variations in effective tax rates, whereas zombie companies were not. This implies that corporate tax reforms are an effective policy tool for promoting new companies but ineffective in facilitating the exit of zombie companies. However, because zombie companies tend to confront an abrupt increase in the EATR, Japanese corporate tax reforms could contribute to the exit of these companies.

Nonetheless, several analytical issues remained unresolved. First, although we constructed a theoretical model that incorporates the pro forma basis into calculating forward-looking effective tax rates by considering the elasticity of substitution, in the empirical analysis, we assumed that the elasticity of substitution is one (equivalent to assuming a Cobb–Douglas function). We may be successful in estimating the effect of effective tax rate variations on corporate behavior and the elasticity of substitution at the

firm or industry level. Second, when examining the impact of corporate tax reforms on firm dynamics, it is important to consider entry and exit dynamics as outcomes. Owing to the low data availability, we excluded these outcomes from our regression analysis. Incorporating these factors is a challenge for future research. Third, we considered only the investments in buildings and machinery. Given the variations in the current economic and social structures, the importance of intangible assets has grown significantly. Owing to data constraints, intangible assets were excluded from this study. However, addressing this issue would be a challenge for future research. Finally, we analyzed only companies with stable capital categories. Expanding pro forma standard taxation may incentivize companies, particularly labor-intensive ones, to modify their capital categories. Incorporating such corporate behavior into our analysis are the remaining challenges.

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Appendix

In the following, we describe the method for calculating firm-specific EATR and EMTR. Herein, we consider the tax on wages (pro forma standard taxation, etc.). As mentioned earlier, the forward-looking effective tax rate used in many empirical studies is based on Devereux and Griffith (2003). Abstracting personal income taxation, the value of the firm at the end of period t, V_t is expressed as follows:

$$V_t = \sum_{s=0}^{\infty} \left\{ \frac{D_{t+s} - N_{t+s}}{(1+\rho)^s} \right\} \tag{1}$$

where D_t is the dividend at the end of period t, N_t is the issuance of new shares in period t, ρ is the shareholder discount rate.

A firm's net dividends are constrained by its income and expenditures. We define the dividend constraint equation following Devereux and Griffith (2003). In Devereux and Griffith (2003), corporate tax was limited to the amount based on profits, and the amount of corporate tax based on added value was not considered. We calculate the effective tax rate by considering the variations in corporate value owing to the variations in the marginal profitability of capital through variations in labor input. This is owing to the impact of taxes based on added value (including wages) on the tax base.

Therefore, we revise the dividend constraint equation as follows:

$$D_t = q_t F(K_{t-1}, L_t) - W_t L_t - q_t I_t + B_t - (1+i)B_{t-1} - T_t + N_t \tag{2}$$

$$T_t = \tau_c [q_t F(K_{t-1}, L_t) - W_t L_t - \varphi K_{t-1}^T] + \sigma W_t L_t - z q_t I_t - \tau_b i B_{t-1} \tag{3}$$

$$K_t = (1-\delta)K_{t-1} + I_t \tag{4}$$

$$\begin{aligned} D_t = {} & [q_t F(K_{t-1}, L_t) - W_t L_t](1-\tau_c) - q_t I_t + B_t - [1 + i(1-\tau_b)]B_{t-1} \\ & + \tau_c \varphi K_{t-1}^T - \sigma W_t L_t + z q_t I_t + N_t \end{aligned} \tag{5}$$

where $F(K_{t-1}, L_t)$ is the production, K_t is the capital stock, L_t is the labor input, $I_t$is the investment, $B_t$is the debt, $T_t$is the corporate tax, W_t is the wage rate, q_t is the goods price, I_t is the investment, i is the nominal interest rate, B_t is the debt, τ_c is the corporate tax rate (effective statutory tax rate), $\varphi$is the tax depreciation rate, K_{t-1}^T is the value of capital stock

for tax purposes, σ is the tax on wages (pro forma standard taxation, etc.) or subsidy, z is the investment tax reduction or subsidy, τ_b is the deduction rate for interest payments, and δ is the economic depreciation rate. If there are no constraints on the deductibility of interest payments, $\tau_c = \tau_b$.

In Devereux and Griffith (2003), the labor input was assumed to be specified, and production was defined as a function of the capital at the end of the previous period, K_{t-1}. In this study, to consider the variations in labor input, we assume that firms produce using both capital at the end of the previous period $K_{t-1}$and labor for the current period L_t as production factors. The production volume is assumed to have diminishing returns to scale, and economic rent (excess profit) is assumed to be generated. Additionally, the labor input (employment) is assumed to be optimized for each period. We use the CES production function as the production function:

$$F(K,L) = \left[\beta_K K^{1-1/\theta} + \beta_L L^{1-1/\theta} + \beta_E E^{1-1/\theta}\right]^{\theta/(\theta-1)} \quad (6)$$

where $\beta_K + \beta_L + \beta_E = 1$, $\beta_j$is the distribution rate of production factors, E is the fixed factor that is the source of excess profits, and θ is the elasticity of substitution between production factors.

In the following, F_K^0 is the gross profit margin on capital when tax is not imposed on wages or profits, $\hat{F}_K$ is the marginal gross profit margin on capital when tax is imposed on profits but not on wages, F'^0_K is the gross profit margin on capital when tax is imposed on wages but not on profits, and $\widehat{F'}_K$ is the marginal gross profit margin on capital when tax is imposed on wages and profits.

Figure 1 Variables of Profit Margin, Labor Productivity, Labor Input, and NPV of an investment

variable	Variable contents	Tax on wages	Tax on profits
F_K^0	Gross profit margin on capital	none	none

$\hat{F}_K$	Marginal gross profit margin on capital	none	imposed
F'^0_K	Gross profit margin on capital	imposed	none
$\widehat{F'}_K$	Marginal gross profit margin on capital	imposed	imposed
F_L^0	Labor Productivity	none	none
$\hat{F'}_L$	Labor Productivity	imposed	imposed
L^0	Labor Input	none	none
$\hat{L}$	Labor Input	imposed	imposed

variable	Variable contents	Tax on wages	Tax on profits
R^0	NPV of an investment	none	none
R	NPV of an investment	none	imposed
R'	NPV of an investment	imposed	imposed

The net present value (NPV) of an investment equals the variation in the firm's value. The NPV of investment is expressed as follows:

$$R_t = (1+i)^{t-1} dV_t = (1+i)^{t-1} \sum_{s=0}^{\infty} \left\{ \frac{\gamma dD_{t+s} - dN_{t+s}}{(1+i)^s} \right\} \tag{7}$$

where R_t is the NPV of investment.

Following Devereux and Griffith (2003), we assume that an investment is made in period t, the capital stock increases, and the capital stock returns to its original level in period t + 1.

The relevant equation is as follows:

$$dD_t = [-q_t dI_t + dB_t + dN_t] - dT_t \tag{8}$$

$$dD_{t+1} = [q_{t+1} F_K^0(K_t, L_{t+1}) dI_t - q_{t+1} dI_{t+1} - (1+i) dB_t] - dT_{t+1} \tag{9}$$

$$dT_t = -z q_t dI_t \tag{10}$$

$$dT_{t+1} = \tau_c [q_{t+1} F_K^0(K_t, L_{t+1}) dI_t - \varphi dK_t^T] - z dI_{t+1} - \tau_b i dB_t \tag{11}$$

$$dT_{t+s} = -\tau_c \varphi dK_{t+s}^T \qquad s \geq 2 \tag{12}$$

$$dI_{t+1} = -(1-\delta) dI_t \qquad \Leftrightarrow\ dK_{t+s} = 0 \quad s \geq 1 \tag{13}$$

Based on these assumptions, the following equation holds:

$$R_t = (1+i)^{t-1} dV = dD_t - dN_t + \frac{1}{1+i} dD_{t+1} - \frac{1}{1+i} dN_{t+1} \tag{14}$$

That is,

$$R_t = (1+i)^{t-1} dV_t = -q_t(1-z)dI_t + dB_t$$
$$+\frac{1}{1+i}\left[q_{t+1}(1-\tau_c)F_K^0 dI_t + q_{t+1}(1-z)(1-\delta)dI_t - \left(1+i(1-\tau_b)\right)dB_t\right]$$
$$+\tau_c \varphi \sum_{s=1}^{\infty} \frac{1}{((1+i)^s} dK_{t+s}^T \tag{15}$$

The following equation holds:

$$q_{t+1} = (1+\pi) q_t \tag{16}$$

where the price of money increases at an inflation rate, π.

Depreciation is applied to the remaining capital (= $1-z$) after deducting the subsidy per unit of investment:

$$\sum_{s=1}^{\infty} \frac{1}{((1+i)^s} \varphi dK_{t+s}^T = (1-z)A\left(q_t dI_t + \frac{1}{1+i} q_{t+1} dI_{t+1}\right) \tag{17}$$

where A is the present value of depreciation.

If the depreciation method is the declining-balance method,

$$\mathrm{A} = \frac{\varphi}{i+\varphi} \tag{18}$$

It is equal to a cash flow tax where $\varphi = \infty \quad \Rightarrow A = 1$ (immediate deduction).

From the above,

$$R_t = (1+i)^{t-1} dV_t = -q_t(1-z)(1-\tau_c A)dI_t$$
$$+\frac{1+\pi}{1+i} q_t[(1-\tau_C)F_K^0 dI_t + (1-z)(1-\tau_c A)(1-\delta)dI_t] + \tau_b\left(\frac{i}{1+i}\right)dB_t \tag{19}$$

●The after-tax NPV (tax on wages is not considered)

The price and new investment for this term are set to one: q_t=1, dI_t=1. No new shares are issued: $dN_t = 0$. The following equation holds for the real interest rate r: $(1+\rho) = (1+r)(1+\pi)$.

The after-tax NPV of an investment (R_t) can be expressed as follows based on (19):

$$R_t = (1+i)^{t-1}dV = -(1-z)(1-\tau_c A) + \frac{1}{1+r}[(1-\tau_c)F_K^0 + (1-z)(1-\tau_c A)(1-\delta)] + \tau_b\left(\frac{i}{(1+r)(1+\pi)}\right)dB_t \quad (20)$$

●The effective average tax rate (EATR; tax on wages is not considered)

The before-tax NPV (R_t^0) is

$$R_t^0 = -1 + \frac{1}{1+r}[F_k^0 + (1-\delta)] = \frac{1}{1+r}[(F_k^0 - \delta) - r] \quad (21)$$

EATR is defined as the difference between the after-tax and pre-tax NPV divided by the before-tax rate of return:

$$\text{EATR} = \frac{R_t^0 - R_t}{F_K^0 - \delta/(1+r)} \quad (22)$$

●The effective marginal tax rate (EMTR; tax on wages is not considered)

The effective marginal tax rate (EMTR) is the tax rate on an investment with an after-tax NPV of zero.

From (20),

$$(1-z)(1-\tau_c A) = \frac{1}{1+r}\left[(1-\tau_c)\hat{F}_K + (1-z)(1-\tau_c A)(1-\delta)\right] + \tau_b\left(\frac{i}{(1+r)(1+\pi)}\right)dB_t$$

$\Rightarrow$

$$(1+r)(1-z)(1-\tau_c A) = \left[(1-\tau_c)\hat{F}_K + (1-z)(1-\tau_c A)(1-\delta)\right] + \tau_b\frac{i}{(1+\pi)}dB_t$$

$\Rightarrow$

$$\hat{F}_K = \frac{1}{1-\tau_c}\left\{(r+\delta)(1-z)(1-\tau_c A) - \tau_b\frac{i}{(1+\pi)}dB_t\right\} \quad (23)$$

The definition of the EMTR is in line with Devereux and Griffith (2003):

$$\text{EMTR}=\frac{\hat{F}_K-(r+\delta)}{\hat{F}_K-\delta} \tag{24}$$

● Labor inputs

It is assumed that labor input is optimized in each period.

In the absence of tax on wages, the labor productivity and wages are equal, and the labor input is determined at a level where the capital productivity, marginal revenue, and NPV of investment are also equal.

That is,

$$F_L^0=\frac{W_t}{q_t}=w \tag{25}$$

$$L_{t+1}^0=L(w,K_t) \tag{26}$$

where F_L^0 is the labor productivity in the absence of tax on wages.

This study incorporates the effects of corporate taxation on wages, such as pro forma standard taxation, on firms' selection of labor input.

$$(1-\tau_c)q_t\hat{F}_L(K_t,L_{t+1})=(1-\tau_c+\sigma)W_{t+1}\ \rightarrow \hat{F}_L=\left(1+\frac{\sigma}{1-\tau_c}\right)w \tag{27}$$

$$\hat{L}_{t+1}=L\left(\left(1+\frac{\sigma}{1-\tau_c}\right)w,K_t\right) \tag{28}$$

Tax on wages affects the amount of labor input by firms. This, in turn, alters the marginal productivity of capital. The variation in capital productivity resulting from variations in labor input can be approximated as follows:

$$\begin{aligned}\widehat{F'}_K(K_t,\hat{L}'_{t+1})-\hat{F}_K(K_t,\hat{L}_{t+1}) &\approx \hat{F}_{Kl}*(\hat{L}'_{t+1}-\hat{L}_{t+1})=\hat{F}_{Kl}\hat{L}_{t+1}*\frac{\Delta L_{t+1}}{\hat{L}_{t+1}}\\ &=\hat{F}_K\frac{\hat{F}_{Kl}\hat{L}_{t+1}}{\hat{F}_K}\frac{\Delta F_L}{\hat{F}_L}*\frac{\hat{F}_L}{\Delta F_L}\frac{\Delta L_{t+1}}{\hat{L}_{t+1}}=\hat{F}_K\left(\frac{\hat{F}_{Kl}\hat{L}_{t+1}}{\hat{F}_K}\right)\left(\frac{\Delta F_L}{\hat{F}_L}\right)\varepsilon_L\\ &=\hat{F}_K\cdot\gamma_{KL}\cdot\frac{\sigma}{(1-\tau_1+\sigma)}\varepsilon_L\end{aligned} \tag{29}$$

$$\Delta F_L=\hat{F}_L-F_L^0=\frac{\sigma}{1-\tau_c}w$$

$$\varepsilon_L=-\frac{\hat{F}_L}{\Delta F_L}\frac{(-\Delta L_{t+1})}{\hat{L}_{t+1}}=-\frac{d\ln L_{t+1}}{d\ln\hat{F}_L}$$

$$\frac{\hat{F}_{Kl}\hat{L}_{t+1}}{\hat{F}_K} = \frac{d\ln F_K}{d\ln L_{t+1}} = \gamma_{KL}$$

$$\Delta L_{t+1} = \hat{L}'_{t+1} - \hat{L}_{t+1} = -\left(\hat{L}_{t+1} - \hat{L}'_{t+1}\right)$$

$$\frac{\Delta F_L}{\hat{F}_L} = \left(\frac{\sigma}{1-\tau_c}\right)\cdot\left(1+\frac{\sigma}{1-\tau_c}\right)^{-1} = \frac{\sigma}{(1-\tau_C+\sigma)} \tag{30}$$

We use this approximation formula to calculate the effective tax rate, considering the variation in labor input resulting from taxes on wages:

We use the CES production function as the production function:

$$F(K,L) = \left[\beta_K K^{1-1/\theta} + \beta_L L^{1-1/\theta} + \beta_E E^{1-1/\theta}\right]^{\theta/(\theta-1)} \qquad (6)(restated)$$

where Ω is defined as follows:

$$\Omega = \left[\beta_K K^{1-1/\theta} + \beta_L L^{1-1/\theta} + \beta_E E^{1-1/\theta}\right] \tag{31}$$

The firm's selection of labor can be expressed by the following equation:

$$F_L = \left[\beta_K K^{1-1/\theta} + \beta_L L^{1-1/\theta} + \beta_E E^{1-1/\theta}\right]^{1/(\theta-1)}\beta_L L^{-1/\theta} = \hat{w} \tag{32}$$

$$\Omega = \left[\beta_K K^{1-1/\theta} + \beta_L L^{1-1/\theta} + \beta_E E^{1-1/\theta}\right] = \left(\frac{\hat{w}}{\beta_L}\right)^{\theta-1} L^{1-1/\theta} \tag{33}$$

$$ln\left[\beta_K K^{1-1/\theta} + \beta_L L^{1-1/\theta} + \beta_E E^{1-1/\theta}\right] = (\theta-1)\,ln\,\hat{w} + \left(1-\frac{1}{\theta}\right)ln\,L + const \tag{34}$$

where F_L is the labor productivity and $\hat{w}$ is the wage.

By differentiating the above equation and holding the capital stock constant, we calculate the elasticity of labor demand.

$$(\theta-1)\,dln\,\hat{w} + \left(\frac{\theta-1}{\theta}\right)d\,ln\,L = \frac{1}{\Omega}\left(\frac{\theta-1}{\theta}\right)\beta_L L^{-\frac{1}{\theta}}dL$$

$$= \left(\frac{\theta-1}{\theta}\right)\frac{1}{\Omega}L^{1-1/\theta}\beta_L d\,ln\,L = \left(\frac{\theta-1}{\theta}\right)\left(\frac{\beta_L}{\hat{w}}\right)^{\theta-1}\beta_L d\,ln\,L \tag{35}$$

$$\left(1-\beta_L\left(\frac{\beta_L}{\hat{w}}\right)^{\theta-1}\right)d\,ln\,L = -\theta\,dln\,\hat{w} \tag{36}$$

The following equation (37) is derived from (34). Here, ε_L is the elasticity of labor input to labor costs when the capital stock is fixed:

$$\varepsilon_L = -\frac{d\,ln\,L}{dln\,\hat{w}} = \theta\left(1-\beta_L\left(\frac{\beta_L}{\hat{w}}\right)^{\theta-1}\right)^{-1} \tag{37}$$

where the wage after tax $\widehat{w}$ is defined as follows:

$$\widehat{w} = \left(1 + \frac{\sigma}{1-\tau_c}\right) w \tag{38}$$

The marginal productivity of capital is given by the following formula based on (9):

$$F_K = \left[\beta_K K^{1-\frac{1}{\theta}} + \beta_L L^{1-\frac{1}{\theta}} + \beta_E E^{1-\frac{1}{\theta}}\right]^{\frac{1}{\theta-1}} \beta_K K^{-\frac{1}{\theta}} \tag{39}$$

$$ln\, F_K = \frac{1}{\theta-1} ln\left[\beta_K K^{1-\frac{1}{\theta}} + \beta_L L^{1-\frac{1}{\theta}} + \beta_E E^{1-\frac{1}{\theta}}\right] - \frac{1}{\theta} ln\, K + const \tag{40}$$

By differentiating the above equation, we calculate the rate of variation in the marginal productivity of capital with respect to an increase in labor:

$$dln\, F_K = \frac{1}{\theta}\frac{\beta_L L^{-\frac{1}{\theta}}}{\Omega} dL = \frac{1}{\theta}\frac{\beta_L L^{1-\frac{1}{\theta}}}{\Omega} dln\, L = \frac{\beta_L}{\theta}\left(\frac{\beta_L}{\widehat{w}}\right)^{\theta-1} dln\, L \tag{41}$$

$$\gamma_{KL} = \frac{dln\, F_K}{dln\, L} = \frac{\beta_L}{\theta}\left(\frac{\beta_L}{\widehat{w}}\right)^{\theta-1} \tag{42}$$

where γ_{KL} is the rate of the variation in marginal productivity of capital with respect to an increase in labor.

Therefore,γ_{KL} ε_L is given as follows:

$$\gamma_{KL} \cdot \varepsilon_L = -\frac{d \ln \hat{F}_K}{d \ln \widehat{w}} = \beta_L \left(\frac{\beta_L}{\widehat{w}}\right)^{\theta-1} \cdot \left(1 - \beta_L \left(\frac{\beta_L}{\widehat{w}}\right)^{\theta-1}\right)^{-1} \tag{43}$$

●EATR (tax on wages is considered)

When calculating the after-tax EATR, the before-tax profit is assumed to be the profit without taxes on profits or wages.

Refer to Figure 1 for the variables represented by R_t^0, R'_t F_K^0, and F'^0_K.

$$\text{EATR} = \frac{R_t^0 - R'_t}{(F_K^0 - \delta)/(1+r)} \tag{44}$$

$$R_t^0 = \frac{1}{1+r}[(F_k^0 - \delta) - r] \qquad (21)\text{(restated)}$$

where F'^0_K is

$$F'^{0}_{K} \approx \left[1 + \frac{\Delta F_L}{\hat{F}_L} \frac{d \ln F_K}{d \ln \hat{F}_L}\right]^{-1} F^{0}_{K}$$

$$F'^{0}_{K} \approx \left[1 + \frac{\sigma}{(1 - \tau_1 + \sigma)} \gamma_{KL} \varepsilon_L\right]^{-1} F^{0}_{K} \tag{45}$$

R'_t can be expressed using F'^{0}_{K} as follows:

$$R'_t = \left\{-(1-z)(1-\tau_c A) + \frac{1}{1+r}\left[(1-\tau_c)F'^{0}_{K} + (1-z)(1-\tau_c A)(1-\delta)\right]\right\} + \tau_b \left(\frac{i}{(1+r)(1+\pi)}\right) dB_t \tag{46}$$

●EMTR (tax on wages is considered)

The EMTR is calculated as follows in cases where the tax on wages (such as pro forma standard taxation) affects the labor input:

From(26),

$$\widehat{F'}_K = \left(\hat{F'}_K - \hat{F}_K\right) + \frac{1}{1-\tau_c}\left\{(r+\delta)(1-z)(1-\tau_c A) - \tau_b \frac{i}{(1+\pi)} dB_t\right\} \tag{47}$$

From (29),

$$\hat{F'}_K - \hat{F}_K \approx \hat{F}_K \cdot \gamma_{KL} \cdot \frac{\sigma}{(1 - \tau_1 + \sigma)} \varepsilon_L \tag{48}$$

From (48), (47) is transformed as follows:

$$\widehat{F'}_K = \frac{1}{1-\tau_c}\left\{(r+\delta)(1-z)(1-\tau_c A) - \tau_b \frac{i}{(1+\pi)} dB_t\right\}\left(1 + \frac{\sigma}{(1 - \tau_1 + \sigma)} \gamma_{KL} \varepsilon_L\right) \tag{49}$$

where $\left(\hat{F'}_K - \hat{F}_K\right)$ is the variation in the productivity of capital.

If the investment is financed by issuing new shares or retained earnings, $dB_t = 0$. If the investment is financed through debt financing, $dB_t = 1$. Then the EMTR is defined as follows:

$$\text{EMTR} = \frac{\widehat{F'}_K - (r+\delta)}{\widehat{F'}_K - \delta} \tag{50}$$