firms in a neoclassical framework.

In this paper, we focus on micro data of firms and investigate the effects of tax rate cuts on the value of firms by utilizing the accounting residual income valuation model devised by Ohlson (1995), and identify conditions under which effects of tax rate changes are neutral, favorable, or rather detrimental. In order to conduct these analyses we use the simulation method proposed by Graham (1996) and apply it to our Japanese firm sample.[2] Furthermore, in doing so, we take into consideration both the tax loss carry-forward allowances and changes in net deferred tax assets and liabilities.

Section 2 discusses the motivation of our study, previous studies, and our research objectives. Section 3 formulates the valuation model. Section 4 explains our data and reports on basic observations. Section 5 explains the simulation method we employ. Section 6 reports the simulation results and Section 7 concludes.

2. Taxation and Firm Value

2.1. Motivation of the Study

Corporate tax-shield benefits or tax burdens arise from two sources: from debt or from non-debt. In this paper we focus on the latter. When Japanese firms incur losses, they can extend their tax-loss shield against future income, like in many other countries. Note that in the U.S., it can be charged to future and past income.[3] Hence, allowances from non-debt sources help firms decrease their future tax burden and possibly reduce the cost of capital.

Moreover, the firm may choose to pay a higher or lower tax today, hoping that in the future the firm can re-collect earlier payments by charging against future income to reduce future tax burden. These timing differences between the tax payable reported in income statements and the actual tax payable to the tax authority, are charged either to deferred tax assets or deferred tax liabilities on balance sheets. Note also that these tax timing differences can occur both inside the

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2 Kubota and Takehara (2007) use a similar method to compute the cost of capital for Japanese firms.

3 In Japan, the Corporation Tax Act (Article 57 Paragraph 3) allows for firms with reported losses to deduct these against future profits up to a maximum of seven years. Also, the provision of the tax loss carry-back allowance is provided, although it has not been implemented since 1992, except for firm liquidations.

parent company and between the parent firms and their subsidiaries. These balances are recorded by charging the differences which were either accrued or deferred during the accounting period whose amount is multiplied by current statutory tax rates.

The Japanese financial and tax reporting systems follow the so called uniform reporting system like continental European countries.[4] However, from fiscal year 1999, the tax deferral accounts in balance sheets were recorded in consolidated financial statements on the condition that such an accrued amount had a high probability to be reversed within five years. In spite of this new tax timing difference allowance, the Japanese system can still be classified as a uniform reporting system in the sense that depreciation methods, inventory costing, and other major accounting choices have to follow uniform reporting both for tax and financial accounting purposes.

2.2. Previous Studies

The effects of corporate taxation on corporate income and fundamental value of the nonfinancial corporate sector were analyzed by Downs and Tehranian (1988). They focus on the Economic Recovery Act of 1981 and find that this act favored new capital, and the fundamental value of corporations suffered with an average 6.1 percent windfall loss. Collins and Kemsley (2000) extended Ohlson's residual income model on an after tax basis, accounting for dividend taxes and capital gains, and found that dividend taxes were largely capitalized into share prices, and investors incurred additional taxes on capital gains in addition to dividend taxes. With accounting and capital structure decisions, Calegari (2000) investigated the effect of changes in tax accounting provisions on firm debt policy and on the magnitude of accounting accruals, and found that there were significant effects on both. From the viewpoint of investors, the effects of tax changes on investors' portfolio decisions were investigated by Poterba (2001).

As to analyses on Japanese firms and the economy, Kubota, Saitou, and Takehara (2009) found a general equilibrium solution with corporate taxation and derived Tobin's q on an after tax basis. However, even though their model was multi-period, it was within a neo-classical framework, and firms and capital resolved every period. In another macroeconomic approach,

4 See Cummins et al. (1994) for these classifications.

Tajika and Yui (2000) analyzed the effects of corporate taxation by focusing on the optimal allocations of capital with tax neutrality in their infinite horizon model. However, their model was a certainty model.

Our paper utilizes the firm valuation model which can accommodate future uncertainty of after tax income with parameter estimates from all individual firm data. The use of both the residual valuation model and the simulation method by Graham (1996) to analyze the effects of corporate taxation on firm values has never been conducted for Japanese data, and this is a contribution to the literature.

2.3. Research Objectives

In this paper we try to assess the importance of the aforementioned provisions when the corporate tax rate is changed, which could affect firm values. The effects of tax rate changes on firm valuation becomes a very complex computational procedure and is rather entangled for the multi-period case, as shown in the Appendices. Note the tax loss carry-forward allowances are valid only up to a maximum of seven years by the Corporation Tax Act in Japan and the book entry of deferred tax assets is also expected to be reversed within five years in order to be certified by CPAs, while all future income possesses infinite lives. Every year the new entry of tax allowances when the firm incurs losses and when deferred tax assets or liabilities are recorded, will generate accumulated processes with finite lives.

With that reason we choose to use the simulation method, and in particular we focus on the tax rate cut case. As we proceed with the analysis, we demonstrate that these effects can be neutral, favorable, or unfavorable. We find that different results depend both on past profitability and variability of firms, whose interactions we compute by using the simulation method of Graham (1996). The fundamental value of firms is derived utilizing the Edwards-Bell-Ohlson residual income valuation model (Ohlson, 1995).

Finally, we emphasize that our analysis is important from the viewpoint of both regulators and corporate managers. Regulators would want to assess the directions of new investment behavior by firms triggered by the statutory tax rate cut for the purpose of implementing better economic policies. At the same time, investment decisions chosen by corporate managers may change through a rational response to corporate tax rate changes (MacKie-Mason, 1990). Such changes in firm behavior will change the allocation of scarce resources, in both industry and in the economy.

With these considerations, we try to empirically identify firms which undergo favorable changes, neutral effects, or unfavorable changes triggered by the enactment of corporate tax rate cuts.

3. Firm Valuation Equation

We compute fundamental value of firms using the Edwards-Bell-Ohlson formula (Ohlson, 1995). Into this formula we plug in the inputs from simulated future income series readjusted for an after tax basis. The fundamental value is defined in equation (1). In equation (1) B_t is the owner's equity value measured at its historical cost at the end of the previous period t-1, x_t^a is the "residual income" as defined by Ohlson (1995), and R_f is the risk free rate. The left hand side variable, V_t^*, thus denotes the computed fundamental value.

$$V_t^* = B_t + \sum_{j=1}^{\infty} \frac{E_t(x_{t+j}^a)}{(1+R_f)^j} \tag{1}$$

Ohlson (1995) originally formulates equation (1) assuming risk-neutral valuation for simplicity. However, by allowing for risk premium, Lehman (1993) demonstrates that the formula can be extended into the risk discounting model as follows.

$$V_t^* = B_t + \sum_{j=1}^{\infty} \frac{E_t(\widetilde{NI}_{t+j} - r_{e,t}\widetilde{B}_{t+j-1}) | \Phi_{t-1})}{(1+r_{e,t})^j} \tag{2}$$

In this equation, $\widetilde{NI}_{t+j}$ is the future net income stream, $r_{e,t}$ is the discount rate which is also the cost of equity, and Φ_{t-1} is the publicly available information set at the end of time t-1, Note the cost of equity, $r_{e,t}$, shows up both in the numerator to compute the residual income and in the denominator to discount the residual income.

In an original formulation of the Ohlson model which satisfies a clean surplus relationship, it is implicitly assumed that the future net income stream $\widetilde{NI}_{t+j}$ is on an after tax basis. Because we focus on the effects of taxation in this paper, we define $\widetilde{NI}_{t+j}$ on a before tax basis. We use the following equation (3) in which $\tau^{*}_{c,t+j}$ is the effective corporate tax rate for period *t+j*. When uniform reporting is imposed for financial and tax purposes, it coincides with the statutory tax rate τ_c as long as the firm does not incur losses in the past seven years. As we demonstrate in the Appendices, computations of taxable income and thus the computation of effective corporate tax rates are much more complex. We track this by the use of numerical simulations with the parameter values estimated from the actual data of Japanese firms in Section 6.[5] The valuation equation we use is based on effective tax rates, $\tau^{*}_{c,t}$, taking into consideration both the tax loss carry-forward and deferred tax assets and liabilities. It can thus be written as follows.

$$V_t^{*} = B_t + \sum_{j=1}^{\infty} \frac{E_t(\widetilde{NI}_{t+j} \times (1-\tau^{*}_{c,t+j}) - r_{e,t}\widetilde{B}_{t+j-1}) | \Phi_{t-1})}{(1+r_{e,t})^{j}} \tag{3}$$

In the following, we assume that the cost of equity, $r_{e,t}$, is the rate of return before personal tax, which can vary over time, and we estimate the cost of equity based on publicly available information with the Fama and French model.[6] In order to estimate $r_{e,t}$ we use the unconditional version of the three-factor model (Fama and French, 1993) and we roll forward

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5 Collins and Kimsley (2000) formulate the Ohlson valuation equation by incorporating dividend taxes and capital gains taxes. The use of this form of equation and the accompanied simulation studies are subjects for future research.

6 See Brennan (1970) for CAPM specifications where personal tax parameters are included. However, in this paper we do not consider that Miller (1977) equilibrium holds equivocally in an economy, and we discount after tax residual income by the rate of return on stock before the corporate tax basis. In Section 6.3 we extend the Ohlson valuation model for a future study on an after tax basis for both dividend and capital gains taxes.

every year with 60 months of the rate of return data. Fama and French's model comprises three factors: value-weight excess market returns, the size factor spread portfolio (often referred to as the SMB factor), and the book-to-price ratio factor spread portfolio (also known as the HML factor). The empirical version of the Fama and French (1993) three-factor model can be written as follows, where $r_{j,t}$ is the return of the security j in month t, $r_{M,t}$ is the return of the market portfolio, $r_{f,t}$ is the risk-free rate, and *SMB* and *HML* are the Fama-French (1993) Small-Minus-Big and High-Minus-Low factors, and $\varepsilon_{j,t}$ is the residuals, respectively.

$$r_{j,t} - r_{f,t} = \beta_i^M (r_{M,t} - r_{f,t}) + \beta_i^{SMB} SMB_t + \beta_i^{HML} HML_t + \varepsilon_{j,t} \quad (4)$$

Every year we compute the fundamental value of firms on June 30th after all financial statements from the March 31st fiscal year end become publicly available and are approved at shareholder meetings. Note we use only the sample of firms whose fiscal year ends March 31st, which amounts to more than 90 percent of all the listed firms on the Tokyo Stock Exchange.

Note valuation equation (2) includes the summation of the infinite time horizon. However, in the Monte Carlo simulation framework, we compute the intrinsic value of the firm by assuming that residual income becomes zero after the year t=21. Consequently, after generating the sample paths of residual income from taxable income, we sum up the present value of the residual income for the years t=1,...,20.

4. Data and Basic Observations

Our financial data is based on consolidated financial statements of all Japanese firms starting from calendar year 2000 (fiscal year 1999) through 2009 (2008), excluding financial firms. We exclude sample firms with negative book values in equity and also firms with less than 5% and higher than 95 % of estimated drift parameters and variance parameters estimated by the equation (5). Thus, the numbers of firm observations are a maximum of 1,101 firms for calendar year 2006, and a minimum of 805 firms for calendar year 2000.[7] The data source for financial variables is the Nikkei NEEDS Database, and for stock returns, the Nikkei Portfolio Master Database.

TABLE 1 ABOUT HERE

Table 1 shows the frequency distributions of the ratio of each year's tax loss carry-forward balance (shown as LCF in the table) to the book value of equity for Japanese firms for our entire sampling period, 2000 through 2009. These allowances can be charged against future income as up to either five or seven years after the fiscal year they are reported.[8] Numbers reported in the table are in percent, which we label LCF, and we find in the second row from the top that more than 30.58% of the firms did not incur losses in taxable income between 2000 and 2009. The peak boom year is 2000 when 44.72% of firms incurred positive income and the lowest year is 2009 when only 30.58% of firms had positive income.

When you add percentages within the LCF range between 0 and 2 percent, one finds that in both 2000 and 2001 and in 2006 and 2007, these percentages are higher, which means the majority of firms were generating profits or losing very little. For example, in 2001, the number is 68%, and in 2006 it is 73%. However, after the Lehman shock of September 2008, one finds that this number drastically decreased in 2009. The comparable number is 58%, which was 71% in 2008. Also, in the bottom row of the table for 2009 we find that more than 3.62 percent of firms have a LCF percentage exceeding 20%, which is a large loss. We also find that these numbers are large at 2.87% in 2002, and 3.60% in 2003. 2002 corresponds to the year after the information technology bubble crashed.

For the purpose of referring to business cycles in Japan, in Figure 2 we plot the expansion and contraction periods as well as the time trend of the total value of net income before tax for all sample firms.

FIGURE 2 ABOUT HERE

[7] The Japanese financial reporting system changed from individual to consolidated filings in fiscal year 1999. This is why we start the sample observations in 2000.

[8] Up to fiscal year 2004, the maximum number that tax loss can be carried forward is five years, and then it changed to seven years.

The years after 2001 and 2008 are conspicuous in terms of the sudden drop in net income numbers, which may have resulted because of larger tax loss allowances. Also, one can reconfirm that from 2002 through 2007, Japan experienced a slow but sustainable expansion period.

Next, Table 2 shows the balance of net deferred assets, which are defined as deferred tax assets minus deferred tax liabilities, divided by the book value of equity for all years of our sample period, from 2000 through 2009. We call this variable DTA.

TABLE 2 ABOUT HERE

The seventh row from the top shows the ratio, DTA, of the cases where there is no outstanding balance. These are firms for which the timing of the tax payment and financial reporting coincide. The percentage is a minimum with 0.091% in 2006 and a maximum of 1.491% in 2000. As one reads through these numbers for DTA from the top to the bottom row, one finds that the majority of firms in Japan have balances on the debit side, whose balance appears on the Deferred Tax Assets account. [9] Also, we find the majority of firms belong to ranges of DTA from zero to 10. On the other hand, the largest number of negative DTA cases, whose balance appears in the Deferred Tax Liabilities account, lies within the range of DTA between -5 and 0 for all years. So, unlike financial statements in the U.S., where tax accounting and financial accounting are separated, and the balance on the deferred tax liabilities side is more common by deferring the tax payment while expensing for financial reporting purposes in earlier years, financial statements in Japan seem to have more balance on the debit side. When the corporate tax rate is reduced according to Japanese Accounting Standards, this deferred tax asset balance has to be downwardly readjusted for the balance amount of assets to account for the lower tax rate. Also, in the case of firms with a debit (credit) balance, future income after tax payments may increase (decrease), and thus the value of these firms may appreciate (depreciate).

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9 US firms have their balances more frequently in deferred tax liabilities accounts. For example, a U.S. firm chooses the Modified Accelerated Cost Recovery System of the Tax Reform Act of 1986 for depreciation, and can use the straight-line depreciation method for financial reporting..

We will investigate in Section 6 with the calibration method.

5. Simulating the Future Net Income Path

We compute the present value of the future net income stream after tax, using a simulation method proposed by Graham (1996). First, we estimate a simple time series model of taxable income for each firm. The definition of income before tax for our study is the sum of earnings before tax plus the net deferred tax balance, divided by statutory tax rates. Japanese accounting standards require firms to report the deferred tax balance on an after tax basis. [10] [11]

The change in taxable income is defined as the change in earnings plus tax deferrals, and we assume that it follows a stochastic process (6), in which ΔTI_{it} is the first difference of taxable income for firm i between time period t and t+1, μ_i the mean drift parameter for firm i, and η_{it} an identically and independent normal random variable for all t for each i with finite and constant variance σ_t which are also estimated and used for generating simulation paths.

$$\Delta TI_{it} = \mu_i + \eta_{it} \tag{5}$$

The parameters for the stochastic process of taxable income are estimated using the past five years of data for the mean trend and the volatility of the error term for each firm.[12] Based on these parameter values, we compute the expected present value of future tax payable, and consequently, future residual income on an after tax basis, defined in equation (4). In this computation, we take into account both outstanding tax carry-forward balances and future tax loss possible allowances in cases where a firm happens to incur losses on any one of the 10,000 simulation paths in future 20 years.[13] We use expected statutory tax rates to readjust the future

[10] We use the earnings data from consolidated financial statements because individual tax returns are not observable in Japan.

[11] Note that Japanese financial and tax reporting follow the uniform reporting system. However, from fiscal year 1999 on, the tax deferral account in balance sheets was recorded in financial statements on the condition that such a deferred amount had a high probability of being reversed.

[12] The status of past income flow is used as a reference for CPAs to judge whether temporary tax differences are highly likely to be reversed the asset balance recorded on the deferred tax asset account can be certified. We followed Kubota and Takehara (2007) in using five years of data, but extended it to 8 years to accommodate the business cycles of Japanese firms. We thank Kazumi Asako for pointing this out.

[13] For firms which have experienced losses less than 7 years ago, the tax loss carry-forward benefits will

tax deferral balance by using Japanese accounting standards.[14] In the simulation, we assume that the remaining balance on deferred tax assets is resolved in the first next period when firms incur enough profit, and if not, in consequent next periods. We also assume that firms follow the same dividend payment as the average amount of the past five years.

6. Simulated Results from Hypothetical Corporate Tax Cuts

In Table 3 we report the year-by-year results of our simulations. We compare V_0, the valuation based on the current effective tax rate of 40.87%, to V_1, the hypothetical valuation under the effective tax rate of 35%, which is equivalent to an approximately 5 percent cut in corporate tax rate from equation (2). We report the ratio V_1/V_0, called VR in the table, which is a hypothetical value under the tax rate cut to the value when the current tax rate is continued. All our calibrated valuations are done each year for June 30th. For example, for calendar year 2000, balance sheet data from March 2000 is used, which is from financial statements of firms for fiscal year 1999. With this ratio we can contrast firms which are expected to increase values by a tax cut (lower half of table) with firms which are expected to decrease values (upper half of table).

TABLE 3 ABOUT HERE

In Table 3 we find that for a majority of firms, the ranges of VR values are within 1.00 to 1.15. The modal value seems to lie between 1.05 and 1.10. Thus, with an effective 5.87% tax rate cut, the value increases from 5% to 10% for a majority of firms. Note that this is purely from tax effects. With possible additional productivity increases, we may expect higher changes in firm values.[15]

Noteworthy is the fact that the slight value decrease can be observed in 2002 and 2000. For

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accrue. We decided to extend our simulations for the period of 20 consecutive years to fully account for future cumulative effects.

14 The recommendation to include tax deferral accounts in Japanese accounting standards, Accounting Standards for Tax Effect Accounting, was released on October 30, 1998 and was enacted in April 1999. Some firms began their voluntary disclosure in April 1998.

15 We are not taking into consideration firms' potential productivity improvements caused by corporate tax rate cuts. Kubota and Takehara (2010) do this.

the range of VR within 0.95 and 1.00, 22.25 % of the sample firms fall into this category in 2002 and the corresponding number is 27.38% for 2009. In other years these numbers are smaller. The reason why this happened might be due to the downturn of the economy (see Figure 2), when future profits were expected to decline, and corporate tax reduction effects became smaller. In other words, the decrease in effective tax rates for particular firms might have turned out to be smaller than the decrease in statutory tax rates and it canceled (added to) any gain (loss) from deferred tax liabilities (assets).

More importantly, from fiscal year 2008 to 2009, the percentage of firms for which VR values stayed between 1.00 and 1.10 suddenly decreased from 73.56% (=7.19+66.37) to 42.36% (=13.33+29.03). This means that the percentage of firms for which positive effects can be expected drastically decreased in 2009, which would have attenuated policy effects of the corporate tax rate, if the tax cut policy been enacted in that year. These results demonstrate very important implications for policy makers on the right timing of policy implementation. Thus, in Japan, if the government ever wanted a tax rate cut, the corporate tax cut should have been enacted in 2007 when 79.29% (=5.53+73.76) belonged to this category,

Next, Table 4 reports industry-wide distribution of VR ratios as of June 2009. Industry classification is based on 33 classifications by the Tokyo Stock Exchange. We imposed the condition that there are at least 15 firms in an industry.

TABLE 4 ABOUT HERE

We find possible positive effects of corporate tax cuts in the food industry, pharmaceuticals, land transportation, and warehousing by counting the percentage of firms whose VR values are larger than 1.00 up to 1.15. Slight negative effects from counting VR values between 0.99 to 0.90 are observed for chemicals, iron and steel, machinery, electric appliances, precision instruments and other products. Note the latter group is heavily equipped. Hence, even if the corporate tax cut is not as effective as an alternative corporate tax cut policy, the policy maker could devise an accelerated depreciation or shortened estimated life of equipment to augment policy effects like the case of the U.S. Tax Reform Act of 1986.[16]

Table 5 summarizes the characteristics of firms by classifying them by the magnitude of VR values to further interpret our previous results.

TABLE 5 ABOUT HERE

The first column DTA is the balance of net tax deferred assets as reported in Table 2, and the second column LCF is the tax loss carry-forward as reported in Table 1. We find overall that DTA is larger for the group with favorable effects of a tax cut, which means that the tax cut causes favorable effects for firms via the net tax deferred asset account.

As to LCF values, the tendency is not so clear cut. It seems the distribution is similar above and below the value of VR 1.00. We also find that LCF values are the largest in extreme points where VR is less than or equal to 0.8 and larger than 1.2. Accordingly, we claim that there are extreme losing firms with large tax loss carry-forward amounts, but that the tax cut may have either positive or negative effects. We infer that these effects are caused by joint effects of both DTA and LCF, of which element is more decisive we cannot at this time analytically identify. However, as a simple illustration, we formulate each mechanism in the Appendices with the three-period model, for which multiple integrals have to be evaluated.[17] We do not find differences in firm size as measured by the natural logarithm of the total market value of equity for 10 separate rows. As to the "value" factor, the book-to-market ratio used in financial economics, we find that firms with positive tax cut effects have higher book-to-market ratios, which means the stock price is low relative to the book value. Therefore, the tax cut effect works stronger in the so called value firm group, a group of distressed firms as judged by capital market participants (Fama and French, 1993).

16 Note Samuelson (1964) is the first study which theoretically analyzed the effects of tax depreciation methods on firm value as well as social equity between large and small firms. Note that the higher accelerated depreciation rates and smaller salvage values were permitted for tax purposes in Japan since 2007.

17 This is subject to future research. One method is to construct purely hypothetical balance sheets and income statements and extrapolate firm investment and consequent future cash flow in a calibrated model with a corporate tax rate cut. This experiment is conducted in Kubota and Takehara (2010).

The final two columns are the mean growth rates of net income before tax and their standard deviations. Among firms for which the tax effect is unfavorable (VR$\leq$1), the mean growth rate is all negative. For the favorable tax cut effect group, even though some numbers are negative, they are uniformly larger than the negative group. For standard deviations, larger values on the two extreme ends seem to have significant roles to make VR much larger or much smaller than one.

In sum, we have demonstrated with a calibration method that the estimated stochastic process of net income, after taking into consideration the outstanding net balance of both DTA and LCA, can reveal the final effect of corporate tax cuts on firm values. It is a new finding which has never been explored with very recent data for countries with uniform tax reporting systems like Japan, and this is a new contribution to the literature.

7. Conclusion

This paper addressed a fundamental query in changes in firm valuation triggered by hypothetical corporate tax rate changes. The study is based on micro foundations of simulations of all firms listed in Japan with a calibration method. We utilized the fundamental Ohlson's residual income valuation model. In entangling effects on firm value with corporate tax rate changes, we paid particular attention to net changes on deferred tax liabilities in equity and contra accounts of deferred tax assets. Future paths of taxable net income for all individual firms were micro-simulated using the method of Graham (1996) based on the estimated stochastic process of this income. By discounting future income with the equity cost of capital computed with the Fama and French three factor asset pricing model, we obtained the valuation model for all firms after corporate tax effects are fully subtracted.

We measured effects that these tax rate changes imposed on firms' valuation using simulated future paths of taxable income and the assumed alternative hypothetical statutory tax rates. Our results demonstrated that corporate tax rate changes can enhance the stock price most of the time, while there were cases in which the effects were neutral or even detrimental. These different results were caused by mixed effects of current provisions that allowed firms to carry their tax losses forward and the net balance on firms' tax deferred accounts on either the debit or credit side.

In conclusion, we find that firms' past and future profitability and variability are crucial in identifying the exact threshold points at which firms experience value fluctuations from the corporate tax rate change.

Extensions to incorporate parametric changes of firms' profitability by corporate tax rate cuts (Auerbach, 2002) as well as to introduce individual income taxes for investors (Collins and Kemsley, 2000) are our future work. For example, Kubota and Takehara (2010) address the former theme by introducing firm investment functions for Japanese data.

Appendix A: Impact of Tax Loss Carry Forward on Valuation

In this appendix we show, for expository purpose, the value of the firm as value of discounted future net income after-tax for the case of simple two period model and demonstrate how the tax loss carry-forward allowances come into play in valuation process.

For simplicity we denote the net income before tax at time *t* as NI_t instead of EBT_t as used in the main text. Also, for expository purposes we assume the following simple random walk stochastic process of net income before tax. We omit the index *j* of the firm for simplicity. Note we also assume away the depreciation expenses and the end of the second period firm liquidation value in this example.

$$\Delta TI_t = NI_t - NI_{t+1} = \mu + \eta_t,$$
$$\text{where} E(\eta_t) = 0, Var(\eta_t) = \sigma^2, \eta_t \text{and} \eta_{t+l} (l \neq 0) \text{independent.} \tag{A-1}$$

Then, when the previous period net income before tax NI_t is realized, the followings hold; $E(NI_{t+1}) = NI_t + \mu$, $VAR(NI_{t+2}) = \sigma^2$, $E(NI_{t+2}) = E(NI_{t+1}) + \mu$, and again $VAR(NI_{t+1}) = \sigma^2$. However, we make use of the probability density function of NI_t and NI_{t+1} as $f(\bullet)$ to simplify following expressions.

First, the discounted value from the expected first period income is the following, in which r_e is the appropriate discount rate and τ_c is the statutory corporate tax rate.

$$\varphi_1 = \frac{1}{1+r_e}\int_0^{\infty} NI_{t+1} \times (1-\tau_c) f(NI_{t+1}) dNI_{t+1} \frac{1}{1+r_e}\int_{-\infty}^{0} 0 \times f(NI_{t+1}) dNI_{t+1}$$

(A-2)

Second, the value from the expected second period income on an after-tax basis is the followings. The first expression (A-3) corresponds to the case when there was no tax loss carry-forward recorded in the first period $t+1$. The second expression (A-4) is when the tax loss carry-forward $-(NI_t \times \tau_c)$ was recorded for the period $t+1$.

$$\varphi_2^{(a)} = \frac{1}{(1+r_e)^2}\int_0^{\infty}\int_0^{\infty} NI_{t+2} \times (1-\tau_c) f(NI_{t+1}) f(NI_{t+2}) dNI_{t+1} dNI_{t+2}$$
$$+\frac{1}{(1+r_e)^2}\int_{-\infty}^{0}\int_0^{\infty} 0 \times f(NI_{t+1}) f(NI_{t+2}) dNI_{t+1} dNI_{t+2} \tag{A-3}$$

$$\varphi_2^{(b)} = \frac{1}{(1+r_e)^2}\int_0^{\infty}\int_{-\infty}^{0} (NI_{t+2} \times (1-\tau_c) - NI_{t+1} \times \tau_c) f(NI_{t+1}) f(NI_{t+2}) dNI_{t+1} dNI_{t+2}$$
$$+\frac{1}{(1+r_e)^2}\int_{-\infty}^{0}\int_{-\infty}^{0} 0 \times f(NI_{t+1}) f(NI_{t+2}) dNI_{t+1} dNI_{t+2} \tag{A-4}$$

Thus, the tax loss carry-forward affects the valuation of the firm depending on the realization of the taxable income before tax in a rather complicated way, even for this simple example of two period model case and these processes accumulate up to the maximum of seven years to produce multiple integrals of future after tax income stream.

Finally, the value of the equity becomes the followings.

$$V_t = \phi_1 + \varphi_2^{(a)} + \varphi_2^{(b)} \tag{A-5}$$

Appendix B: Impact of Deferred Tax Assets and Liabilities on Valuation

In this appendix we demonstrate how the deferred tax assets or liabilities change the future tax payment amount used in the valuation equation.

Let us define as TTD_t, temporary tax differences to generate deferred tax assets or liabilities , as the amount that cannot be expensed for tax purposes when $TTD_t > 0$ and the amount that can be deferred for future deferred tax payment when $TTD_t < 0$. In this appendix for simplicity we denote the net income at time t as NI_t instead of EBT_t as used in the main text.

Then, for the first period the corporate tax is the following (B-1) when the realization of the net income satisfies $NI_{t+1} - TTD_t \geq 0$ and when $TTD_t > 0$ so that the corporation can prepay the tax from the net income. This is the case when the corporation does early pre-payment for tax purposes and the deferred tax assets balance are carried on debit side of its balance sheet. On the other hand, if $NI_{t+1} - TTD_t < 0$ occurs, there will be no tax payment.

$$\text{CorprateTax} = (NI_{t+1} - TTD_{t+1}) \times \tau_c \qquad \text{(B-1)}$$

On the other hand, when $TTD_t < 0$, instead, again the same equation for tax payable holds for tax payable as in (B-2) when the inequality $NT_{t+1} \geq TTD_{t+1}$ holds, whose pre-tax income is higher, and if $NT_{t+1} < TTD_{t+1}$, the tax is zero.

$$\text{CorprateTax} = (NI_{t+1} - TTD_{t+1}) \times \tau_c \qquad \text{(B-2)}$$

Next, in the second period, depending on whether $TTD_t > 0$ or $TTD_t < 0$ the corporate tax becomes either one of the following three cases.

1) When $TTD_t > 0$ and assuming that the tax authority admits to expense this deferred tax assets amount for tax purposes during this period (which may be still uncertain), we get the following tax payable when the second period income before tax is positive and the inequality $NI_{t+2} > |TTD_{t+1}|$ holds. Otherwise, the second period tax becomes zero.

$$\text{CorprateTax} = (NI_{t+2} - TTD_{t+1}) \times \tau_c \quad \text{(B-3)}$$

2) When $TTD_t < 0$ and the pre-tax was paid during the first period, the amount carried on deferred tax liabilities will be expensed for tax purposes for sure in this second period, and the corporation would have to pay the following amount (B-3) as deferred tax.

$$\text{CorprateTax} = (NI_{t+2} - TTD_{t+1}) \times \tau_c \quad \text{(B-4)}$$

However, if the net income is negative and inequality $|NI_{t+2}| < TTD_{t+1}$ hold, then the second period tax becomes zero.

3) In the case of deferred or accrued tax payment, there exists additional uncertainty for the latter case in the sense that the tax authority may not finally admit expensing of this pre-payment for tax purposes. This uncertainty adds to the uncertain realizations of random variables of future net income stream before tax as shown in this appendix. This additional uncertainty would have to be also incorporated in evaluating the multiple integrals of the future income stream.

Finally, when there is additional tax loss carry-forward as shown in Appendix A, it will further affect the final tax payable in the second period and the effective tax rates for corporations, and consequently the firm values are dependent upon the complicated mixture of these two factors. Accordingly, even when the statutory corporate tax rate changes, the effects on firm valuation will not be necessary geared towards the uniform directions, which we demonstrate in our simulations in the main text of the paper.

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Table 1. Year by Year Frequency Distribution of Tax Loss Carry-Forward to Book value of Equity

LCF is defined as (Tax Loss Carry Forward subject to tax effect accounting) /(Book Value of Equity) in percent.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
LCF=0	44.72	42.00	34.75	32.06	33.44	34.77	36.60	36.07	35.53	30.58
0<LCF≦2	23.85	27.26	28.78	27.37	31.67	35.33	37.42	37.31	35.73	27.79
2<LCF≦4	9.81	11.14	10.55	11.45	12.05	10.03	9.72	10.11	11.88	17.56
4<LCF≦6	5.96	5.68	7.45	8.29	6.33	5.81	5.09	4.77	5.29	7.33
6<LCF≦8	4.60	3.25	5.05	5.02	4.15	3.84	2.72	3.53	3.09	4.03
8<LCF≦10	2.86	1.97	3.44	3.71	2.49	1.97	1.73	1.43	1.70	2.79
10<LCF≦12	1.99	1.74	2.52	2.62	2.49	1.97	1.45	0.95	1.30	2.69
12<LCF≦14	0.50	1.39	1.26	1.85	1.87	1.50	0.54	1.05	1.30	1.34
14<LCF≦18	1.61	1.39	1.61	2.29	0.52	1.12	0.73	0.67	0.50	0.93
16<LCF≦18	0.75	0.93	0.92	0.76	1.14	0.56	0.91	0.67	0.50	0.83
18<LCF≦20	0.75	0.46	0.80	0.98	0.83	0.56	0.54	0.19	0.40	0.52
20<LCF	2.61	2.78	2.87	3.60	3.01	2.53	2.54	3.24	2.79	3.62