TCER Working Paper Series

DOES THE JAPANESE CONSOLIDATED TAXATION SYSTEM HELP ENCOURAGE HIGH-RISK INVESTMENT?

Masanori Orihara
Hideshi Itoh

July 2012

Working Paper E-49
http://tcer.or.jp/wp/pdf/e49.pdf

TOKYO CENTER FOR ECONOMIC RESEARCH
1-7-10-703 Iidabashi, Chiyoda-ku, Tokyo 102-0072, Japan

Abstract

This paper examines the effects of the Japanese Consolidated Taxation System (CTS) on business groups' investment behavior. Our simple model predicts that the introduction of the CTS encourages business groups to make high-risk investments more aggressively. This incentive comes from the tax-loss offset effects of the CTS, in line with Domar and Musgrave (1944) and subsequent studies about the asymmetry of tax-loss treatment.

Our unique and comprehensive datasets enable us to test whether the CTS has greater impacts on R&D investment, which entails high-risk, than capital expenditure at each level of parents, subsidiaries, and business groups. Our empirical results show that: (i) the introduction of the CTS increases both capital expenditure and R&D investment; (ii) this effect is larger for R&D investment than capital expenditure; (iii) firms become more sensitive to their own or their parents' market to book ratio by the CTS introduction; (iv) this change in sensitivity is more significant for R&D investment than capital expenditure; and (v) the CTS business groups utilize their internal capital markets to transfer resources from their partly owned subsidiaries, which cannot obtain tax benefits. We deal with endogeneity associated with the voluntary nature of the CTS in several ways, and we demonstrate that the changes in investment behavior are caused by the CTS itself. Our results support that the CTS meets the Japanese government's expectations to facilitate efficient coordination and development of investment activities in business groups.

Masanori Orihara
University of Illinois at Urbana-Champaign
Department of Economics
214 David Kinley Hall, 1407 W. Gregory,
Urbana, Illinois 61801 US
orihara1@illinois.edu

Hideshi Itoh
TCER
and
Hitotsubashi University
Graduate School of Commerce and Management
2-1 Naka, Kunitachi, Tokyo
hideshi.itoh@r.hit-u.ac.jp

Does the Japanese Consolidated Taxation System Help Encourage High-Risk Investment?*

Masanori Orihara† Hideshi Itoh‡

July 1, 2012

Abstract

This paper examines the effects of the Japanese *Consolidated Taxation System* (CTS) on business groups' investment behavior. Our simple model predicts that the introduction of the CTS encourages business groups to make high-risk investments more aggressively. This incentive comes from the tax-loss offset effects of the CTS, in line with Domar and Musgrave (1944) and subsequent studies about the asymmetry of tax-loss treatment. Our unique and comprehensive datasets enable us to test whether the CTS has greater impacts on R&D investment, which entails high-risk, than capital expenditure at each level of parents, subsidiaries, and business groups.

Our empirical results show that: (i) the introduction of the CTS increases both capital expenditure and R&D investment; (ii) this effect is larger for R&D investment than capital expenditure; (iii) firms become more sensitive to their own or their parents' market to book ratio by the CTS introduction; (iv) this change in sensitivity is more significant for R&D investment than capital expenditure; and (v) the CTS business groups utilize their internal capital markets to transfer resources from their partly owned subsidiaries, which cannot obtain tax benefits. We deal with endogeneity associated with the voluntary nature of the CTS in several ways, and we demonstrate that the changes in investment behavior are caused by the CTS itself. Our results support that the CTS meets the Japanese government's expectations to facilitate efficient coordination and development of investment activities in business groups.

Keywords: Business Group, Corporate Tax, Loss Treatment, Corporate Investment, R&D Activity, Internal Capital Market.

JEL Classification: G31, G32, H25, O32.

*We are grateful to Dhammika Dharmapala for valuable insights and guidance, and Heitor Almeida for constructive comments. It is gratefully acknowledged that the Ministry of Economy, Trade, and Industry (METI) allows us to use the Basic Survey of Business Structure and Activities, and that the Global Centers of Excellence (GCOE) program "Innovation in the Japanese Corporation" provides financial support. We thank Yuki Abe, Itaru Koyamazaki, and Yasunori Toda for excellent research assistance. We benefited from comments by the discussant Daisuke Miyakawa and participants at TCER Conference "Organizational Reform and Performance of Japanese Firms: Analysis of Panel Dataset" held at Hitotsubashi University on March 9, 2012.

†Department of Economics, University of Illinois at Urbana-Champaign

‡Graduate School of Commerce and Management, Hitotsubashi University

1 Introduction

Business groups have been contributing to the economy in many countries (Almeida et al., 2011), and have recently become a topic of widespread consideration in corporate finance. Given that there are not many domestic business groups in the U.S., researchers are taking advantage of international data. For example, Almeida et al. (2011) use Korea's data and Gopalan et al. (2007) use India's. Japanese business groups have not been thoroughly studied since Hoshi et al. (1991) investigated cash flow sensitivity of investment by using *keiretsu* that is a traditional form of Japanese business groups. Japanese business groups have experienced a series of institutional reforms since the middle of the 1990s, such as the amendment of the Japanese Antitrust Law in 1997 to enable the establishment of pure holding companies. This paper deals with the *Consolidated Taxation System* (CTS) introduced in 2002. This is an elective system for parent companies of the business groups. When a parent introduces this system, gains and losses are aggregated across the parent and its wholly owned subsidiaries (i.e., those subsidiaries whose stakes are 100% owned by their parents).

The industries had been demanding the Japanese government to introduce the CTS before 2002. Yoshiki Yagi, who served as Executive Vice President of Hitachi, stated in 2002 that the industries had requested the realization of the CTS for the past five years (*Nihon Keizai Shimbun*, 3/14/2002). This system is expected to have considerable effects on tax payments of companies, as the following numbers taken from the *Nihon Keizai Shimbun* show: Fujitsu that introduced the CTS in 2002 said it had reduced tax payments by 16 billion yen in the previous fiscal year (1/14/2004); Sumitomo Corporation that introduced the CTS in 2004 expected that it would reduce tax payments by 4 billion yen (1/14/2004); Yokogawa Electric Corporation that introduced the CTS in 2012 expected that it would reduce tax payments by 1 billion yen (3/10/2010).

What are implications of this system on the Japanese economy? It clearly reduces tax revenues at least for a short run. The Japanese Ministry of Finance estimated that the reduction of revenues due to the CTS could amount up to 800 billion yen (*Weekly Toyo Keizai*, 2/23/2002). On the other hand, this system is expected to stimulate firms' investments and boost the economy as a result. The essence of the CTS is that business groups can utilize losses of different legal entities in the business groups in the same tax year. This system helps mitigate investment distortions caused by the asymmetry of tax-loss treatments, in which firms that incur losses cannot receive refunds immediately (Auerbach, 1986). This change in loss treatment also leads to a different attitude toward risks entailed in investments. Domar and Musgrave (1944) claim that agents can choose higher-risk behavior if their losses are partly recouped through a reduction of tax burden. To sum up, the CTS is expected to mitigate disincentives on investments, in particular higher-risk activities such as R&D investment, which are caused by the asymmetric treatment of tax-losses.

We will pursue four purposes in this paper. First, we build a simple model to apply Domar and Musgrave (1944)'s logic to business groups. The model will help us clearly explain our empirical predictions. Second, we test the model's predictions with unique and comprehensive panel data. This is our main part. We provide evidence that the CTS has considerable effects on investment behavior. Third, we also examine the effects of the CTS on business groups' internal capital markets. The fact that the CTS does not have direct effects on partly owned subsidiaries enables us to identify the roles of internal capital markets in a different way from previous studies. Fourth, we discuss policy implications of the CTS. This discussion will have broad implications across counties. For example, Korea introduced a similar group taxation system in 2010 according to the KPMG's *Taxation of Cross-Border Mergers & Acquisitions 2010: South Korea*. This paper will have contributions to both corporate finance and taxation literature by discussing issues that are interconnected each other.

An advantage of our study is that we have access to datasets that contain detailed information with many observations. This enables us to investigate empirical implications at three units of analysis by using two kinds of investments. The units of analysis are subsidiaries, parents, and business groups. A subsidiary is a company whose majority of shares are held by another firm (i.e., held by a parent company). A business group is a collection of firms consisting of a parent and their subsidiaries. We consider two kinds of investment: capital expenditure and R&D investment. We emphasize two differences between them. First, R&D investment is expected to entail higher-risk than capital expenditure. This would be plausible and we will confirm this result in our data. Second, individual firms need their own capital expenditure to conduct their businesses. On the other hand, R&D investment can be centralized, and parents can allocate outcomes of their R&D activities among the business group members. In reality, capital expenditure ratio (i.e., capital expenditure divided by lagged fixed tangible assets) is about 11% at both parents' and subsidiaries' level, while R&D investment ratio (i.e., R&D investment divided by lagged fixed tangible assets) is about 8% at parents' level and 3% at subsidiaries' level, as we will discuss in Table 3 later.

We present a simple model in Section 2.2. The empirical predictions are summarized in Section 2.4. Our basic prediction is that the introduction of the CTS has positive effects on the level of both kinds of investment at each level of parents, subsidiaries, and business groups (Predictions 1P, 1S, and 1G in Section 2.4). This is exactly because of the CTS's tax-loss offset effects. The model also shows that R&D investment is affected more strongly by the CTS than capital expenditure, because of the higher-risk the former entails (Predictions 2). Since R&D investment is more likely to fail, the CTS is more likely to be utilized for R&D activities. Therefore, the CTS is expected to have stronger effects when considering R&D investment than capital expenditure. The model implies that the CTS alone does not affect subsidiaries' investments (Prediction 3). We will use this result to mitigate a potential endogeneity issue in Section 6.1.3. We expect to see the established positive correlation between firm's investment opportunities measured by its market to book ratio (MTB ratio) and investment level (Predictions 4P and 4G). We also examine the effects of the CTS on sensitivity of investments to a change in MTB ratio. Higher sensitivity implies higher ex-ante investment efficiency. We show that CTS firms are more sensitive to MTB ratio than non-CTS firms (Predictions 5P and 5G). Furthermore, we show that investments of partly owned subsidiaries decrease when the parent has introduced the CTS (Predictions 6). This result implies that business groups utilize their internal capital markets to obtain tax benefits from the CTS.

To test these predictions, we use unique and comprehensive datasets. Our main dataset is the *Basic Survey of Japanese Business Structure and Activities* (BS data) collected annually by the Japanese Ministry of Economy, Trade and Industry since 1991. This dataset contains various financial/economic information of 25000–30000 firms every year. This number of observations is considerably larger than that of widely used datasets in corporate finance, such as *Compustat* whose number of observations is around 10000 each year. The CTS was introduced in 2002, and we use the data between 2001 and 2008. After applying certain data filtration, the total number of observation is 14672 every year on average as we will show in Table 2. The number of parents and subsidiaries is 837 and 2065 every year on average, respectively. These numbers are relatively stable over the time periods. On the other hand, the number of CTS firms has monotonically increased. The number of CTS parents is 19 in 2002 and 77 in 2008. The number of their subsidiaries is 144 in 2002 and 527 in 2008. These numbers demonstrate that the CTS is taking on increased importance among business groups. The ratio of wholly owned subsidiaries to subsidiaries is about 60% every year. It is interesting to see that this ratio is not very different between CTS groups and non-CTS groups. This suggests that the ownership structures are not affected much by the CTS introduction.

Regression results support our main predictions and provide several additional insights. The introduction of the CTS increases both capital expenditure and R&D investment significantly (Predictions 1P, 1S, and 1G). The effects are stronger for R&D investment than capital expenditure (Prediction 2). The increment of capital expenditure is 3% at both parents' and business groups' levels, and 7% at subsidiaries' level. The increase in R&D investment is 6% at parents' level and 4% at business groups' level. Since the median value of investment ratio is smaller for R%D investment than capital expenditure as we will show in 3, R&D investment is affected more strongly by the CTS in both absolute and relative senses at parents' and business groups' levels. MTB ratio has positive and significant effects on capital expenditure at parents' and groups' levels (Predictions 4P and 4G). The change in sensitivity to MTB ratio by the CTS introduction has positive and significant effects at subsidiaries' level for both types of investment. If the parents' and subsidiaries' investment opportunities are positively correlated, this result is supported by our model. At parents' and business groups' levels, a change in sensitivity to MTB ratio on capital expenditure is positive but insignificant, while that on R&D investment is positive and significant (Predictions 5P and 5G). In short, these results support our theoretical predictions and show significant effects of the CTS on investments.

The endogeneity associated with parent's voluntary decision on the CTS introduction is the central cause of concern. For example, the parent might want to introduce the CTS because it anticipates unobservable and time-varying investment opportunities. We will take four approaches to this potential issue. First, we have already dealt with the endogeneity in a way, by showing stronger sensitivity to MTB ratio by the introduction of the CTS. Even if unobservable investment opportunities might have caused high level of investments, it is less likely that they are the reason of stronger sensitivity to MTB ratio. Second, we include current and/or future capital expenditures as one of the independent variables of the R&D investment equation. They are expected to capture both observable and unobservable investment opportunities of R&D activities. In other words, we can estimate "residual" effects of the CTS after controlling investment opportunities. We show that the CTS still has positive effects on R&D investment.

Third, we use the IV method when the unit of analysis is subsidiaries. The CTS has the effects at subsidiaries' level when the parent has introduced the CTS and the subsidiaries are wholly owned. This implies that the CTS itself does not affect subsidiaries' investments as confirmed by Proposition 3. In addition, CTS dummy variable and CTS wholly owned dummy variable are highly correlated, because 60% of subsidiaries are wholly owned. Therefore, the CTS dummy variable is adequate as an instrument. The results are similar with those in the non-IV case. Fourth, we discuss institutional details of the CTS. Since the CTS is a permanent system with considerable entry and fixed costs, it is less likely that relatively short-run investment opportunities are primary reasons for the introduction of the CTS. In addition, we present descriptive evidence to show that past performance might affect more on the CTS introduction than future investment opportunities, because of some special treatments about loss carryforwards.

We will present three extensions. In the first and second extensions, we restrict our observations to CTS subsidiaries or wholly owned subsidiaries. The results in both cases are similar with those in the base analysis. Third, we look at the effects of the CTS on partly owned subsidiaries. This aspect is interesting to examine because having partly owned subsidiaries, which cannot obtain tax benefits, make high-risk investment is costly for their parents' tax management. Our results show that CTS partly owned subsidiaries invest less than other subsidiaries (Prediction 6). This suggests that CTS groups transfer resources from their partly owned subsidiaries to either wholly owned subsidiaries or parents through their internal capital markets. It is plausible that the resources especially those for R&D investment are transferred to parents, because CTS parents increase R&D investment considerably. This would be the first paper to show that business groups use internal capital markets to obtain tax benefits.

Most of the previous studies have investigated business groups and the effects of tax on investment risks separately, while our study examines interactions of them. The only exception dealing with this interaction is Dreßler and Overesch (2010). They study the effects of tax-loss treatment on investment behavior among German multinationals' foreign subsidiaries. One of their focuses is group taxation, and they show that group loss provisions increase the level of subsidiaries' investments. Three differences with our paper are worth emphasizing. First, they use only capital expenditure. Therefore, they cannot investigate different effects of group taxation on investments with differentiated level of risks. Second, the subsidiaries in their paper are located in overseas territories. Compared with domestic business groups, it would be difficult to predict the effects of parents' investment opportunities on foreign subsidiaries and discuss internal capital markets, because of too many differences in the economic environment between domestic parents and their foreign subsidiaries. Third, the unit of analysis in their paper is only subsidiaries, while our units include parents and business groups as well. Thus, we can investigate the different effects of tax on different units of analysis. We will actually show that the CTS has different effects on subsidiaries and parents, especially with respect to R&D activities.

A growing number of studies have been discussing business groups recently. Almeida and Kim (2012) lay out that one of the benefits of using business groups over conglomerates is that researchers observe reliable data in individual units. This is because firms in business groups are independent legal entities, different from segments in conglomerates. In addition, we need individual firms' financial data since tax is imposed on individual legal entities. Efficiency of internal capital markets has been an important topic in studies on conglomerates and business groups. For example, Stein (1997) argues their positive aspects of winner picking, while Rajan et al. (2000) shows their negative aspects due to agency costs. Almeida and Kim (2012) show that internal capital markets of Korean business groups *chaebol* worked efficiently, in the aftermath of the 1997 Asian Financial Crisis. Our paper also shows that Japanese business groups utilize the CTS and their internal capital markets efficiently. Our study is unique from a methodological perspective, since we use a change in tax to identify transfers across internal capital markets that are not generally observed. Our results show a sharp contrast to Seru (forthcoming)'s results that show internal capital markets are inefficient for R&D activities by using conglomerates' data.

Our results have policy implications as well. The Japanese government expects that the introduction of the CTS enables business groups to coordinate and structure their investment plans efficiently. This is the first paper to show that the CTS has the expected effects on business groups' investment behavior, by showing the CTS groups are more sensitive to MTB ratio than non-CTS groups. This will ease the concern that the CTS could harm the economy with a short term reduction in corporate tax revenues. Business group taxation system has also been introduced in different countries. Dreßler and Overesch (2010) show that 22 out of the 41 countries in their data introduced group taxation in 1996, and the number increased to 27 countries in 2007. As we have mentioned, Korea introduced the group taxation system in 2010. Korea's system is very similar with the Japanese CTS: for example, revenues of parents and only wholly owned subsidiaries are aggregated. Hence, this study has broader implications on policy discussion about business group taxation.

The remaining sections are organized as follows. We provide background information about the CTS, and present a simple model to show empirical predictions in Section 2. We describe data and summary statistics in Section 3. Estimation procedures are explained in Section 4. We show empirical results in Section 5, which is the main part of this paper. We make robustness checks and some extensions in Section 6. We state concluding remarks in Section 7.

2 Hypotheses

2.1 Consolidated Taxation System

The Japanese *Consolidated Taxation System* (CTS) was introduced in 2002. The adoption of this system is not mandatory but elective for parents. We will show the number of firms that have adopted this system in Table 2 later. If parents choose to introduce this system, the parents must aggregate their losses and gains with their 100% (i.e., wholly owned) subsidiaries'. If parents want to introduce this system, they must submit their application to the government six months before the start of the coming fiscal year. This period was shortened by three months in 2010, which is after the last year of our data of 2008. Note that most Japanese firms' fiscal year starts in April and ends in the next year's March. A potential difficulty arises because parents have two endogenous variables to put this system into effect: the parent's introduction of the CTS and the parent's choice as to the ownership structure. Theoretically, parents can adjust their ownership structures to enjoy tax benefits. For example, if the parent anticipates large consecutive losses in one subsidiary that is currently owned less than 100% by the parent, the parent can change the subsidiary into a wholly owned one to reduce the group's tax burden.

Whether this kind of ownership stake adjustments has actually happened is an empirical issue. The following numbers suggest that such phenomena are not widely observed. Consider a subsidiary whose parent introduces the CTS in year t. The data show that over 95% of the wholly owned subsidiaries in year t are also wholly owned in year $t-1$ and $t+1$, respectively. In addition, over 95% of the wholly owned subsidiaries in year $t-1$ are also wholly owned in year t. Thus, the ownership structures are not affected much by the CTS introduction. The ownership would be determined by economic, legal, historical, or other factors. Determinants of ownership structures are an interesting research topic but beyond the scope of this paper. This unresponsiveness of the ownership structures to the CTS is beneficial for our analysis, since we can focus more on endogeneity issues related to the CTS introduction.

2.2 Model

2.2.1 Setup

We will present a theoretical model to derive main empirical implications. Suppose that there are a parent (P) and its subsidiary (S). Each of them has an investment project. P's project succeeds with probability q and fails with probability $1-q$. S's project succeeds with probability r and fails with probability $1-r$. We allow a correlation in the distribution and the probability that both of the projects succeed is $qr+\alpha$. The term α measures the strength of the correlation and must satisfy inequalities (1) and (2) in order to make joint probabilities nonnegative.

$$\alpha < \overline{\alpha} \equiv \min\{(1-q)r, q(1-r)\} \tag{1}$$

$$\alpha > \underline{\alpha} \equiv -\min\{qr, (1-q)(1-r)\} \tag{2}$$

Table 1: Probability distribution

		S: success	S: failure
P	success	$qr+\alpha$	$q(1-r)-\alpha$
	failure	$(1-q)r-\alpha$	$(1-q)(1-r)+\alpha$

Table 1 describes the entire distribution. P chooses a pair of investments (p, s) where $p \geq 0$ is the investment level for P's project and $s \geq 0$ is that for S's project. Assume that the cost structure is linear, and p and s are the investment costs. Since P has controlling stakes over S, we assume that P chooses S's investment level. We assume that investment does not affect the success probabilities but affects the gross profits from successful projects. One interpretation is that the investment only increases the size of the project. The gross profit from the P's successful project depends on investment level p in the project and a parameter u that affects P's investment opportunities, and is denoted by $x(p, u)$. We assume $x(p, u)$ is greater than or equal to p for all p. The gross profit from the S's successful project is similarly denoted by $y(s, v) \geq s$ where v is a parameter that affects S's investment opportunities. The gross profit is zero when the project fails for each case.

We assume each of the gross profit is strictly increasing and concave in the own investment level: $x_p(p, u) > 0, x_{pp}(p, u) < 0, y_s(s, v) > 0$, and $y_{ss}(s, v) < 0$. Furthermore, we assume both the gross profit and the marginal gross profit from a successful project are increasing in its own investment opportunities: $x_u(p, u) \geq 0$, $x_{pu}(p, y) \geq 0$, $y_v(s, v) \geq 0$, and $y_{sv}(s, v) \geq 0$. We denote corporate tax rate by $\tau \in (0, 1)$ and P's ownership share of S by $\theta \in (0.5, 1]$.

2.2.2 Benchmark: No-tax Case

Let us first consider an economic environment without tax as a benchmark case. P's problem is

$$\max_{p,s} \{qx(p, u) - p + \theta(ry(s, v) - s)\}.$$

The benchmark solutions p^{nt} and s^{nt} satisfy[1]

$$x_p(p^{nt}, u) = \frac{1}{q}, \tag{3}$$

$$y_s(s^{nt}, v) = \frac{1}{r}. \tag{4}$$

The parameters q and r measure risk that each investment entails. When these parameters are close to one, as in the case of capital expenditure, the investments carry low risk. On the other hand, R&D investments are expected to have high risk, in the sense of low q and r. Equations (3) and (4), along with our assumptions on $x(\cdot)$ and $y(\cdot)$, show each firm's investment increases in its own investment opportunities (u for P and v for S) and decreases in its own riskiness (measured by $1/q$ and $1/r$).

[1] From now on we always assume interior solutions exist. Sufficient conditions can be easily specified.

2.2.3 Non-CTS Case

Let us now introduce corporate tax with the rate of τ. Suppose that P has not introduced the CTS. P's problem is

$$\max_{p,s} \{qx(p,u) - p + \theta(ry(s,v) - s) - \tau q(x(p,u) - p) - \theta\tau r(y(s,v) - s)\}.$$

The solutions p^{nc} and s^{nc} satisfy

$$x_p(p^{nc}, u) = \frac{1-\tau q}{(1-\tau)q}, \tag{5}$$

$$y_s(s^{nc}, v) = \frac{1-\tau r}{(1-\tau)r}. \tag{6}$$

It is easy to show that $p^{nc} < p^{nt}$ and $s^{nc} < s^{nt}$ hold by comparing equations (3) and (4) with equations (5) and (6), respectively. This implies that the introduction of tax decreases the investment levels. Both p^{nc} and s^{nc} are also decreasing in tax rate τ. In addition, p^{nc} and s^{nc} are increasing in (q, u) and (r, v), respectively: the firm invests more when the investment entails lower own risk or when the firm anticipates better own investment opportunities.

In our specification, these effects are independent in the sense that only the firm's own investment risks and opportunities affect the own investments. Our specification, however, allows P's investment opportunities to influence S's investment level positively by interpreting u as one component of v, which could be a vector of elements that affect S's investment. We actually observe this positive relationship between the parent's investment opportunities measured by its MTB ratio and the subsidiaries' investment level, as we will show in Table 7, for example.

2.2.4 CTS Case

Next, suppose that P has introduced the CTS and $\theta = 1$. P's problem is

$$\max_{p,s}\{qx(p,u) - p + ry(s,v) - s - \tau(qr+\alpha)(x(p,u) - p + y(s,v) - s)$$
$$- \tau(q(1-r)-\alpha)\max[x(p,u) - p - s, 0] - \tau((1-q)r-\alpha)\max[y(s,v) - p - s, 0]\}.$$

The first order conditions with respect to p and s are equations (7) and (8), respectively,

$$0 = qx_p(p,u) - 1 \begin{cases} -\tau(qr+\alpha)(x_p(p,u) - 1) & \text{if } s \geq x(p,u) - p, p \geq y(s,v) - s \\ -\tau q(x_p(p,u) - 1) & \text{if } s \leq x(p,u) - p, p \geq y(s,v) - s \\ -\tau(qr+\alpha)(x_p(p,u) - 1) + \tau((1-q)r-\alpha) & \text{if } s \geq x(p,u) - p, p \leq y(s,v) - s \\ -\tau q(x_p(p,u) - 1) + \tau((1-q)r-\alpha) & \text{if } s \leq x(p,u) - p, p \leq y(s,v) - s \end{cases} \tag{7}$$

$$0 = ry_s(s,v) - 1 \begin{cases} -\tau(qr+\alpha)(y_s(s,v) - 1) & \text{if } s \geq x(p,u) - p, p \geq y(s,v) - s \\ -\tau(qr+\alpha)(y_s(s,v) - 1) + \tau(q(1-r)-\alpha) & \text{if } s \leq x(p,u) - p, p \geq y(s,v) - s \\ -\tau r(y_s(s,v) - 1) & \text{if } s \geq x(p,u) - p, p \leq y(s,v) - s \\ -\tau r(y_s(s,v) - 1) + \tau(q(1-r)-\alpha) & \text{if } s \leq x(p,u) - p, p \leq y(s,v) - s \end{cases} \tag{8}$$

From now on, we suppose that $s \geq x(p,u) - p$ and $p \geq y(s,v) - s$ hold for relevant values of $(p, s; u, v)$.[2] In this case, corporate tax is imposed only when both projects succeed. In other words, this is the case where business groups can enjoy the highest tax benefits from the CTS. From

[2] More detailed analysis including the cases in which these inequalities do not hold is relegated to Appendix.

equations (7) and (8), the solutions p^{c1} and s^{c1} satisfy[3]

$$x_p(p^{c1}, u) = \frac{1 - \tau qr - \tau\alpha}{(1 - \tau r)q - \tau\alpha}, \tag{9}$$

$$y_s(s^{c1}, v) = \frac{1 - \tau qr - \tau\alpha}{(1 - \tau q)r - \tau\alpha}. \tag{10}$$

From these two equations, we can show the following results. First, p^{c1} increases in (u, q) and s^{c1} increases in (v, r). These positive own effects of investment opportunities and negative own effects of investment risk are the same as in the case without the CTS introduction. Second, different from the non-CTS case, we observe cross effects here: p^{c1} decreases in r and s^{c1} decreases in q. The intuition behind these cross effects is as follows. Suppose that market anticipates that P is planning a lower-risk project and q goes up. P's project is more likely to succeed, which implies that profits from S's investments are more likely to be taxed. As a result, P has less incentive to have S invest more. On the other hand, P might increase S's investment if the investment opportunities of both firms are positively correlated. Therefore, it is difficult to provide general predictions about the cross effects.

2.3 Comparison

Let us now compare the investment levels in the CTS case with the non-CTS case. We fist discuss the case where P has only one subsidiary as we have assumed. We will extend the model and discuss the case where there are two subsidiaries in Subsection 2.3.2.

2.3.1 One Subsidiary Case

Proposition 1 (i) below states that both P's and S's investments are higher with the CTS than without it. This is because profits of the CTS firms will be taxed only if both projects succeed.[4] Furthermore, this comparison will show that the CTS has different effects on investment depending on the level of

[3] Numerators and denominators in both equations are positive under assumptions (1) and (2).

[4] On the other hand, when profits are taxed if and only if P's project succeeds (corresponding to case that $s \leq x(p, u) - p$ and $p \geq y(s, v) - s$ hold), P's investment level is not affected by the introduction of the CTS. However, S's investment level increases because its profits will be taxed if and only if both projects are successful. See Appendix.

its risks. Proposition 1 (ii) states that if P's and S's investment opportunities are not too positively correlated, there are larger differences in investment levels between the non-CTS and the with-CTS case as q and r become lower. That is, the CTS has larger effects on investment when the risks are high. Since R&D investment involves higher-risk (i.e., lower q and r) than capital expenditure as we will show empirically later, we anticipate that the former is affected more by the CTS. [5]

Proposition 1 (i) $p^{c1} > p^{nc}$ and $s^{c1} > s^{nc}$ hold. (ii) There exists $\alpha_0 \in (0, \overline{\alpha}]$ such that $p^{c1} - p^{nc}$ is decreasing in q and $s^{c1} - s^{nc}$ is decreasing in r if $\alpha \leq \alpha_0$ holds.

Proof See Appendix.

The next proposition concerns how the sensitivity to investment opportunities changes with the introduction of the CTS. We make the following additional assumptions:

$$\frac{x_{pu}(p,u)}{-x_{pp}(p,u)} \quad \text{is increasing in } p; \tag{11}$$

$$\frac{y_{sv}(s,v)}{-y_{ss}(s,v)} \quad \text{is increasing in } s. \tag{12}$$

Sufficient conditions for these assumptions to hold are as follows:

$$x_{ppu}(p,u) \geq 0 \quad \text{and} \quad y_{ssv}(s,v) \geq 0, \tag{13}$$

$$x_{ppp}(p,u) \geq 0 \quad \text{and} \quad y_{sss}(s,v) \geq 0. \tag{14}$$

Remember that we have assumed $x(p,u)$ and $y(s,v)$ are strictly increasing in p and s, and increasing in u and v, respectively; and $x_p(p,u)$ and $y_s(s,v)$ are decreasing in p and s, and increasing in u and v, respectively. Assumption (13) means that the marginal gross profits are decreasing in investment at a slower rate as investment opportunities are getting better. Assumption (14) is of a technical nature. For example, this assumption holds if x_{pp} and y_{ss} are constants. This assumption is not necessary:

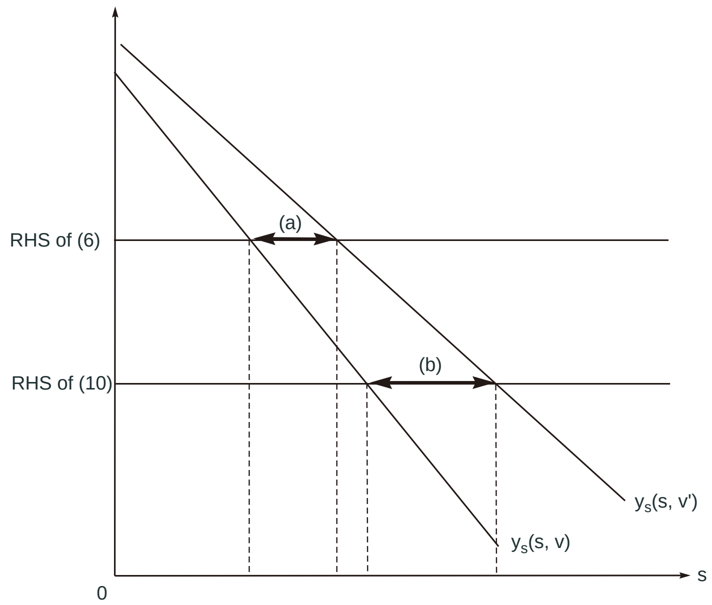
[5]We are assuming that the marginal gross profit from a successful project is not different between the two kinds of investments. Our claim is reinforced and continues to hold if the gross profit from a successful R&D investment is higher than that from capital expenditure, which seems to be a realistic case.

(11) and (12) continue to hold if x_{ppp} and y_{sss} are not too negative. Under these assumptions, we can show the following results.

Proposition 2 Suppose $u' > u$ and $v' > v$. Under assumptions (11) and (12), $p^{c1}(u') - p^{c1}(u) \geq p^{nc}(u') - p^{nc}(u)$ and $s^{c1}(v') - s^{c1}(v) \geq s^{nc}(v') - s^{nc}(v)$ hold.

Proof The first-order conditions (5) and (9) yield $dp^{nc}/du = x_{pu}(p^{nc}, u)/(-x_{pp}(p^{nc}, u))$ and $dp^{c1}/du = x_{pu}(p^{c1}, u)/(-x_{pp}(p^{c1}, u))$. The conclusion $p^{c1}(u') - p^{c1}(u) \geq p^{nc}(u') - p^{nc}(u)$ then follows immediately from $p^{c1} > p^{nc}$ and assumption (11). The proof for $s^{c1}(v') - s^{c1}(v) \geq s^{nc}(v') - s^{nc}(v)$ is similar. Q.E.D.

Figure 1: Sensitivity to S's investment opportunities



Proposition 2 shows that the sensitivity to a change in own investment opportunities is stronger for CTS firms than non-CTS firms. Figure 1 illustrates the result in terms of S's investment, in which we assume $v' > v$. By assumption of $y_{sv}(s, v) \geq 0$, the marginal gross profit curve under investment opportunity v' is above the curve under investment opportunity v. Furthermore, in the figure the marginal gross profit curves are linear ($y_{sss} \equiv 0$) and the curve under v' is less steep than that under v ($y_{ss}(s, v') \geq y_{ss}(s, v)$). These two observations imply that (13) and (14) hold for $y(s, v)$. Distance (a) in the figure corresponds to $s^{nc}(v') - s^{nc}(v)$, sensitivity of investments to the change in the investment opportunities under the non-CTS case. Distance (b) corresponds to $s^{c1}(v') - s^{c1}(v)$, sensitivity of investments to the change in the investment opportunities under the CTS case. As the figure shows, distance (b) is larger than (a), which implies that inequality $s^{c1}(v') - s^{c1}(v) \geq s^{nc}(v') - s^{nc}(v)$ holds. We can show that inequality $p^{c1}(u') - p^{c1}(u) \geq p^{nc}(u') - p^{nc}(u)$ also holds in the same way. Note that although we have interpreted v in $y(s, v)$ as a parameter measuring only S's own investment opportunities, it could be plausible that v is a vector and u is one of its components. This would be true when the businesses of P and S are related. Under this circumstance, Proposition 2 implies that the sensitivity to the parent's investment opportunities is higher for CTS wholly owned subsidiaries.

2.3.2 Two Subsidiaries Case: Internal Capital Markets

The model can be extended to the situation in which P has two subsidiaries and allocates funds between them so that we can provide implications of the CTS on internal capital markets. Suppose P owns two subsidiaries. As in the model, one of them denoted by S has a project with success probability r and gross profit $y(s, v)$. This subsidiary is wholly owned by P. The other subsidiary denoted by T has a project with success probability k and gross profit $z(t, w) \geq t$, where $t \geq 0$ is T's investment level and w is a parameter that represents T's investment opportunities. P's ownership stake of T is $\lambda \in (0.5, 1)$, which implies that T is not wholly owned by P. To simplify the analysis, we fix P's investment p and focus on the investment levels of S and T. We assume that P's funds are so limited that the total investments for the subsidiaries cannot exceed $I > 0$: $s + t \leq I$. Furthermore, we assume this constraint is binding for relevant values of (s, t).

Suppose first that P has not introduced the CTS. P's problem is

$$\max_{s,t} \{(ry(s, v) - s) + \lambda(kz(t, w) - t) - \tau r(y(s, v) - s) - \lambda\tau k(z(t, w) - t)\},$$

subject to $s + t = I$. The solutions s^{nc} and $t^{nc} = I - s^{nc}$ satisfy

$$(1-\tau)ry_s(s^{nc}, v) - (1-\tau r) = \lambda\left[(1-\tau)kz_t(t^{nc}, w) - (1-\tau k)\right]. \tag{15}$$

Next, suppose that P has introduced the CTS. P's problem is

$$\max_{s,t}\{(ry(s,v) - s) + \lambda(kz(t,w) - t) - \lambda\tau k(z(t,w) - t)$$
$$- \tau(qr + \alpha)(x(p,u) - p + y(s,v) - s)\},$$

subject to $s + t = I$. We assume $s \geq x(p,u) - p$ and $p \geq y(s,v) - s$, and hence P and S are taxed only when both projects succeed. Note that since T is not a wholly owned subsidiary, tax is still imposed on T when its project succeeds. The solutions s^{c1} and $t^{c1} = I - s^{c1}$ satisfy

$$[(1-\tau q)r - \tau\alpha]y_s(s^{c1}, v) - (1 - \tau qr - \tau\alpha) = \lambda\left[(1-\tau)kz_t(t^{c1}, w) - (1-\tau k)\right]. \tag{16}$$

Comparing the left-hand sides of (15) and (16) yields $s^{c1} > s^{nc}$, which in turn implies $t^{c1} < t^{nc}$. The adoption of the CTS increases the investment of the wholly owned subsidiary while it decreases that of the partly owned subsidiary.

2.4 Summary of Empirical Predictions

Our model provides several empirical predictions as we summarize below. Since we will mostly use fixed effects model, we make both cross sectional and time series comparisons.

Prediction 1P When the parent has introduced the CTS, the parent invests more.

Prediction 1G When the parent has introduced the CTS, the business group invests more.

Prediction 1S When the parent has introduced the CTS, its wholly owned subsidiaries invest more.

Prediction 2 R&D investment is affected more strongly by the CTS than capital expenditure.

Prediction 3 The introduction of the CTS alone does not affect subsidiaries' investment.

Prediction 4P The parent increases its investment level as its investment opportunities become better.

Prediction 4G The business group increases its investment level as its parent's investment opportunities become better.

Prediction 5P When the parent has introduced the CTS, sensitivity of its investment to a change in its own investment opportunities is higher.

Prediction 5G When the parent has introduced the CTS, the sensitivity of the business group's investment to a change in the parent's investment opportunities is higher.

Prediction 6 When the parent has introduced the CTS, its partly owned subsidiaries invest less.

Predictions 1S, 1P, and 1G are main hypotheses about positive effects of the CTS on the individual unit's investments. Prediction 2 derived from Proposition 1 (ii) compares two different types of investment with respect to risk. The BS data that contain sufficient information about R&D activities enable us to directly test the Domar and Musgrave (1944)'s implication that previous studies could not. Prediction 3 states subsidiaries' investments are affected only when their parents have introduced the CTS and the subsidiaries are wholly owned. This result is useful to mitigate potential endogeneity issues. Predictions 4P and 4G are common in the investment equation literature (Fazzari et al., 1988), and it is worth testing if they hold in business groups. Predictions 5P and 5G relate the CTS with sensitivity to a change in investment opportunities. They claim that we should expect the sensitivity is stronger when each unit can obtain tax benefits from the CTS as shown in Proposition 2. Prediction 6 shows differentiated effects of the CTS on subsidiaries. Since partly owned subsidiaries cannot obtain tax benefits, it is not efficient to have them make large investments, in particular higher-risk ones.

3 Data

We will test these theoretical predictions with three datasets: (i) *Basic Survey of Japanese Business Structure and Activities* (BS dataset); (ii) *Financial Quest* (FQ dataset); and (iii) hand-collected data about the CTS. These datasets in particular the first source have not been used in corporate finance even though it contains valuable information. We will hence describe the datasets at length.

3.1 Description of the Datasets

Our primary data source, the BS dataset, has been collected by the Japanese Ministry of Economy, Trade and Industry since the fiscal year of 1991. The data are collected every year after 1994. We have data up to the fiscal year of 2008. The target of this survey is firms with over 50 employees and 30 million Japanese yen of capital in most industries. The main target of this survey has been manufacturing firms and provides ideal resources to estimate the investment equation starting from Fazzari et al. (1988). The number of firms covered in the BS dataset is between 25000 and 30000 every year. One of the most widely used datasets in corporate finance, *Compustat*, contains information about 10000 firms every year during the similar periods of our datasets for comparison.

The BS dataset lacks some financial information. A different dataset, the FQ data, provides financial information about stock price and stock outstanding. The FQ dataset also provides information about whether the parent has introduced the CTS as of 2011: the number is 238. However, it does not tell in which year the parent adopted the CTS. We look into individual firms' financial statements to find the year of the CTS introduction. We drop the following parent companies: (a) the parents whose year of the CTS introduction is not found from their financial statements, (b) the year of the CTS introduction is after 2008, or (c) the parents whose stock codes are not defined. Large firms usually state in which year they have introduced the CTS in their financial statements, and thus condition (a) is likely to exclude small parents. Since we are investigating the investment equation, this exclusion of small firms would not be important. The BS dataset covers financial information up to 2008 and condition (b) is necessary. We need stock code to merge the FQ data with the BS data. Also, we will use the market to book ratio of parents. Thus, we will not use the information of parents without stock codes, and condition (c) does not affect our analysis. As a result, 150 parents remain in the CTS dataset, before merging CTS data with the BS data and FQ data.

A potential problem is whether the CTS data are representative. The Japan's National Tax Agency tells that 795 parents introduced the CTS and there were 6546 wholly owned CTS subsidiaries as of June 2008. The number of parents that introduced the CTS at the end of the fiscal year of 2008 is 150 in our data that cover about 19% of the total number of the CTS parents. The number of wholly owned subsidiaries in the same year that appears in our dataset is 863 that cover about 13% of the total number of the CTS wholly owned subsidiaries in the year. The FQ dataset seems to cover all listed firms, and those firms that do not appear in this dataset are likely to be unlisted. We need parents' market to book ratio and thus the parents we actually use are listed ones. Note that the BS dataset includes information about unlisted subsidiaries of listed CTS parents. In addition, unlisted firms tend to be smaller and their subsidiaries would be even smaller. Because we estimate the investment equation and previous studies have eliminated smaller firms, the lack of data about smaller firms would not be a problem. Thus, the CTS data we are using are sufficient for our purposes.

3.2 Summary Statistics

We now formally define several terms used in this paper. We will then describe data filtration process and summary statistics in the following subsections. A subsidiary is a firm that has a firm (i.e., a parent) owning over 50% of its shares. A parent is a firm that owns at least one subsidiary. A wholly owned subsidiary is a subsidiary whose parent's ownership is 100%. A subsidiary is a CTS subsidiary when its parent has adopted the CTS. A wholly owned CTS subsidiary is both a CTS subsidiary and a wholly owned subsidiary. A standalone is a firm that is neither a parent nor a subsidiary.

3.2.1 The Number of Each Form of Firms

We look at the number of each form of firms to understand the basic structure of Japanese business groups. We report the number of parents that are listed, because we will use market value of stocks in the main analysis. Note that firms report the number of all of their subsidiaries in the BS data, but financial information about these subsidiaries need not be included in the data. I will also report the number of listed parents whose subsidiaries exist in the BS data. This is the number of business groups in the BS data. Notice that the number of business groups can be larger than that of parents.

This is because subsidiaries report the stock code of their parents in the BS data, but the financial information about the parents might not appear in the BS data. This implies that some of the business groups in our analysis consist only of their subsidiaries.

As is common in the literature, we eliminate firms in financial industries since their investment behavior is thought to be largely different from non-financial firms'. We eliminate those observations before the year of 2001 since the CTS was introduced in 2002. We will deflate investment level by each firm's lagged fixed tangible asset to take account of firm size, and drop those firms whose lagged fixed tangible asset value is less than 500 million yen or missing. Eliminating small firms is common for investment equation literature (for example, see Almeida and Campello, 2007). We also drop firms both of whose capital expenditure and R&D investment are missing. We will use the parents' MTB ratio when the unit of analysis is subsidiaries. Therefore, we drop subsidiaries whose parents' MTB ratio cannot be calculated due to lack of necessary information, when subsidiaries are the units of analysis. Similarly, we drop parents whose MTB ratio cannot be calculated, and business groups whose parents' MTB ratio cannot be calculated, when they are the units of analysis, respectively. The resulting number of total observations is 117378. We summarize the number of each form of firms in Table 2.

Table 2: The number of each form of firms

The first row represents years between 2001 and 2008. In the first column of the table: "P" refers to a listed parent; "BG" refers to a business group; "S" refers to a subsidiary; "WS" refers to a wholly owned subsidiary; and "Obs." refers to total observations. We include only subsidiaries whose parents' market to book ratio can be calculated. We include parents whose own market to book ratio can be calculated. We include business groups whose parents' market to book ratio can be calculated.

	2001	2002	2003	2004	2005	2006	2007	2008	Total
P	829	831	839	847	848	826	830	842	6692
BG	846	844	855	862	864	847	854	862	6834
S	2094	2084	1964	1774	2127	2117	2156	2205	16521
WS	1184	1231	1169	1072	1327	1314	1351	1359	10007
CTS P	-	19	28	44	65	70	76	77	379
CTS S	-	144	185	250	416	442	492	527	2456
CTS WS	-	85	105	145	247	260	296	317	1455
Obs.	15223	15172	14538	14361	14625	14414	14518	14527	117378

Table 2 gives several insights about Japanese business groups as well as the CTS. First, the number of CTS parents and subsidiaries has increased monotonically over time, while the number of parents and subsidiaries is relatively stable. The number of CTS parents (subsidiaries) is 19 (144) in 2002 and 77 (527) in 2008, respectively. Second, the ratio of CTS parents (subsidiaries) to non-CTS parents (subsidiaries) also increases monotonically. The ratio of CTS parents (subsidiaries) is 2.3% (7.0%) in 2002 and 9.1% (23.9%) in 2008, respectively. Third, the ratio of the number of wholly owned subsidiaries to that of subsidiaries is around 60% every year. The ratio of the number of CTS wholly owned subsidiaries to that of CTS subsidiaries is similar every year as well. One could have expected to see an increase in the ratio of wholly owned subsidiaries among CTS groups, because the CTS applies only to parents and their wholly owned subsidiaries. On the other hand, this was expected given the previous discussion showing that business groups' ownership structures are not affected much by the CTS.

Fourth, an individual parent owns 2.5 subsidiaries in the data while an individual CTS parent owns 6.5 subsidiaries on average, which suggests that CTS groups tend to be larger than non-CTS groups. Fifth, we observe a relatively rapid increase in the numbers of CTS parents and subsidiaries in 2004 and 2005. This might be due to the elimination of additional 2% tax that CTS firms had to pay only in 2002 and 2003. Sixth, there exist variations in the year of the CTS introduction. This creates potential endogeneity problems relating to unobservable and time-variant investment opportunities. For example, those firms that anticipate profitable but high-risk investment opportunities might want to introduce the CTS. If this is the case, a positive correlation between the CTS introduction and the level of investment ratio is just caused by third factors. We will later discuss how we deal with the endogeneity.

3.2.2 Summary Statistics of Each Variable

We will report summary statistics of each variable that we will use in our main regressions. The dependent variables are capital expenditure and R&D investment divided by the lagged fixed tangible asset respectively. The number is interpreted as investment ratio. In a business group, every variable is aggregated across the parent and its subsidiaries and then we calculate the investment ratio. Table 3 shows median values and standard deviation of each variable.

Table 3: Summary statistics

In the first row of the table: "P" refers to a listed parent; "BG" refers to a business group; "S" refers to a subsidiary; and "WS" refers to a wholly owned subsidiary. In the first column: "Capex" refers to capital expenditure; "L.asset" refers to lagged fixed tangible assets; "R&D" refers to R&D investment; "MTB" refers to its own market to book ratio for P, and refers to the parent's market to book ratio for BG and S; "CF" refers to cash flow that is defined as income before extraordinary items and taxes plus depreciation; "ownership" refers to the parent's ownership stake of the subsidiary; "leverage" refers to the sum of short-term and long-term debts divided by assets; "ln(asset)" refers to log of assets; and "age" refers to the firm's age for P and S, and refers to the parent's age for BG. We report median values of each variable. We report standard deviation of each variable in parentheses.

	P	BG	S	WS	CTS P	CTS BG	CTS S	CTS WS
Capx/L.asset	0.107	0.111	0.105	0.112	0.130	0.134	0.132	0.149
	(0.268)	(0.250)	(0.329)	(0.353)	(0.233)	(0.214)	(0.349)	(0.377)
R&D/L.asset	0.077	0.045	0.033	0.032	0.126	0.069	0.054	0.047
	(0.227)	(0.178)	(0.338)	(0.390)	(0.434)	(0.306)	(0.618)	(0.711)
MTB	1.054	1.055	1.207	1.235	1.197	1.198	1.316	1.314
	(0.596)	(0.617)	(0.556)	(0.563)	(0.624)	(0.623)	(0.602)	(0.587)
CF/L.asset	0.249	0.247	0.218	0.220	0.257	0.265	0.300	0.313
	(0.935)	(0.808)	(0.944)	(1.064)	(0.776)	(0.631)	(1.183)	(1.201)
ownership	–	–	100	–	–	–	100	–
	–	–	(16.172)	–	–	–	(17.322)	–
leverage	0.521	0.537	0.725	0.750	0.677	0.690	0.720	0.742
	(0.202)	(0.197)	(0.316)	(0.339)	(0.181)	0.170	(0.399)	(0.476)
ln(asset)	11.142	11.208	8.849	8.756	12.354	12.656	9.3215	9.171
	(1.444)	(1.501)	(1.179)	(1.142)	(1.650)	(1.720)	(1.302)	(1.199)
age	60	60	37	34	65	65	37	32
	(18.031)	(18.218)	(18.177)	(16.990)	(19.284)	(19.271)	(18.194)	(16.894)

Several observations are worth emphasizing. First, the capital expenditure ratio is higher than the R&D investment ratio for every form of firms. Therefore, smaller magnitude of R&D coefficients in the regression compared with capital expenditure coefficients does not necessarily mean that the effect of the CTS introduction is smaller for R&D investment than capital expenditure. Second, the capital expenditure ratio is not largely different between each form (i.e., CTS or non-CTS) of parents and subsidiaries. On the other hand, R&D investment ratio is higher for each form of parents than each form of subsidiaries. These observations would suggest that capital expenditure is decentralized, while R&D investment is relatively centralized. Third, there is not a large difference between subsidiaries and wholly owned subsidiaries for both kinds of investment.

3.3 Does R&D Investment Carry Higher-Risk Than Capital Expenditure?

In this paper, the distinction between capital expenditure and R&D investment are important, because we are arguing that the latter entails higher-risk than the former. This claim sounds plausible. We will actually show that R&D investment carries higher-risk by using our data. We construct a risk measure based on Acharya et al. (2011). They first take the difference between the firm's ROA, which is some profitability measure divided by assets, and industry median ROA, which is calculated year by year. Then, they obtain the standard deviation of the values across the entire year periods for the firm. This reflects fluctuation of the outcome across time, and will be an adequate risk measure. In addition, this measure reflects time and industry effects as well. We use profit after tax as the profitability measure. The results are qualitatively similar if we use different measures. The control variables are log of assets and leverage. We use between estimation, and the results are similar when we use pooled regression.

Table 4 shows the results. R&D investment has significant and positive effects on the risk in model (1), while capital expenditure has insignificant effects in model (2). Both of the investments have significant and positive effects on the risk in model (3), but the effects are larger for R&D investment. Therefore, we conclude that R&D investment carries higher-risk than capital expenditure.

4 Estimation Procedure

The dependent variables are two kinds of investment expenditures deflated by lagged fixed tangible assets: capital expenditure ratio and R&D investment ratio. The independent variables of our interest are dummy variables that indicate if the parent has introduced the CTS. When the unit of analysis is subsidiaries, we use a CTS wholly owned subsidiary dummy variable. This is an interaction variable of a CTS subsidiary dummy with a wholly owned subsidiary dummy variable. The CTS subsidiary dummy variable takes one when the firm is a CTS subsidiary and takes zero otherwise. We define other dummy variables in the same way. When the unit of analysis is parents or business groups, we include the CTS parent dummy variable.

Table 4: Effects of investments on risk measure

The dependent variable is the risk measure that is standard deviation of industry adjusted profit after tax. See the construction process of this variable in the main text. The independent variables are defined as follows. "R&D" is R&D investment. "Capex" is capital expenditure. L.asset is lagged fixed tangible assets. "ln(asset)" is log of assets. "leverage" is the sum of short-term and long-term debts divided by assets. We use between estimation. T-statistics are reported in parenthesis.

	(1)	(2)	(3)
R&D/L.asset	0.0294***		0.0272***
	(7.686)		(7.076)
Capex/L.asset		0.00201	0.00765***
		(1.487)	(3.240)
ln(asset)	0.00132**	0.00115**	0.00129**
	(2.295)	(2.196)	(2.204)
leverage	0.0841***	0.0815***	0.0846***
	(29.28)	(35.16)	(28.93)
Constant	-0.0329***	-0.0322***	-0.0338***
	(-5.634)	(-6.269)	(-5.679)
Observations	49,030	110,417	46,238
Firms	11,127	20,072	10,840

*** p<0.01, ** p<0.05, * p<0.1

Control variables are taken from two streams of the literature: studies on the investment equation and R&D activities. The investment equation literature started from Fazzari et al. (1988) has demonstrated that cash flow and market to book (MTB) ratio are important factors that affect investment behavior. Cash flow is defined by income before extraordinary items and taxes plus depreciation. The literature has shown the positive sensitivity of cash flow. MTB ratio is defined as the sum of the firm's market value of stocks and debts divided by the firm's asset value. This variable is expected to measure investment opportunities observed by markets. The own effect, the effect of the MTB ratio on its own investment, is expected to be positive (Predictions 4P and 4G). A concern is that the market value of stock is unobservable for unlisted firms. This could be especially problematic because wholly owned subsidiaries cannot be listed in Japan. Instead of the firm's own MTB ratio, we use the parent's MTB ratio to control the investment opportunities for its subsidiaries. Our model helps us to provide a prediction about cross effect, the effect of the parent's MTB ratio on its subsidiaries' investment. The effect would be positive when u is one component of v, which could be interpreted as a vector whose elements affect subsidiaries' investment, and u has positive effects on subsidiaries' investment through a change in v. This argument is plausible especially when parents and their subsidiaries engage in similar businesses.

We create variables to measure the sensitivity to a change in investment opportunities caused by the CTS introduction. This is an interaction variable of each of the CTS dummies with the MTB ratio. At parents' and groups' levels, we expect to see the change in sensitivity is positive (Predictions 5P and 5G). When u and v are positively correlated, we expect to see this positive effect at subsidiaries' level as well. This paper is related with the literature on R&D activities. We include similar control variables with Seru (forthcoming)'s. The variables are leverage, firm age, squared firm age, and log of assets. While Seru uses log of sales instead of log of assets, our results are not affected if we use log of sales. We include ownership ratio of parents and a CTS subsidiary dummy variable in some specifications when the unit of analysis is subsidiaries. In each of the specification, we include year dummies to control macroeconomic shocks. We also include firm fixed effects in most cases, and we explain the reason when we do not. We use robust standard errors clustered by firm-level.

5 Results for Investment Equation

We will present main results in this section. We will show results of the investment equation when the unit of analysis is parents, subsidiaries, and business groups in turn.

5.1 Parents

The unit of analysis in this subsection is parents. The independent variable of interest is a CTS parent dummy variable. Table 5 shows results when the dependent variable is capital expenditure. Models (1) – (2) show that the effect of the CTS on investment ratio is positive and significant, which is consistent with Prediction 1P. The increment is around 3%. The effect of parent's MTB ratio is also positive and significant, which is consistent with Prediction 4P. The change in sensitivity to MTB ratio by the CTS introduction is positive but insignificant.

Table 6 shows results when the dependent variable is R&D investment. Models (1) – (2) show that the introduction of CTS significantly increases parent's R&D investment by 6%, which is consistent with Prediction 1P. This increment is economically significant as well given that the median R&D investment ratio for parent companies is 7.7%. It is worth emphasizing that the median capital expenditure ratio for parents is 10.7% and the increment due to the introduction is 3%. Thus, the results suggest that R&D investment is affected more strongly than capital expenditure in both absolute and relative (i.e., compared with the median values of each investment) senses. This result is consistent with Prediction 2. The MTB ratio does not have significant effects, while cash flow sensitivity is positive. These insignificant coefficients on MTB ratio appear to be inconsistent with Prediction 4P. However, the positive and significant cash flow sensitivity might capture investment opportunities for parents' R&D activities. The change in sensitivity to MTB ratio by the CTS introduction is positive and significant at 1% level, which is consistent with Prediction 5P. Recall that a change in the sensitivity is positive but insignificant when the dependent variable is capital expenditure. The positive and significant change in the sensitivity to MTB ratio suggests that the CTS enhances efficiency in investments, especially with respect to R&D activities.

5.2 Subsidiaries

We will present results when the unit of analysis is subsidiaries. Table 7 presents results when the dependent variable is capital expenditure. Model (1) shows that CTS wholly owned subsidiaries invest by 6.5% more than the comparison groups. This result supports Prediction 1S. Models (2) and (3) show that the CTS itself does not affect subsidiaries' investment behavior and only CTSS$*$WS has positive and significant effects. This confirms Prediction 3 as well as Prediction 1S. Models (1) – (3) show that the increase in parent's MTB ratio has positive and significant effects on their subsidiaries' investment level. This is plausible because parents' investment opportunities would be positively correlated with their subsidiaries' in many business groups. Models (4) – (6) show that a change in sensitivity to parent's MTB ratio caused by the introduction of the CTS is positive and significant at 1% level. This is also possible under the same circumstance about the relationship between parents' and subsidiaries' investment opportunities.

Table 8 shows results when the dependent variable is R&D investment ratio. CTS wholly owned subsidiaries invest more at 10% level according to model (1). However, models (2) – (3) show that the sum of the coefficients on CTSS$*$WS and CTS is positive but not statistically significant. Therefore, the effects of the CTS on subsidiaries' R&D investment appear to be positive but the results are not robust, suggesting that Predictions 1S and 2 might not be supported at subsidiaries' level. Models (1) – (3) show parent's MTB ratio does not have significant effects on subsidiaries' R&D investment. Models (4) – (6) show that a change in sensitivity to MTB ratio by the CTS introduction is positive and significant at 10% level. This result will be derived from our model if parents' investment opportunities have impacts on subsidiaries' investment thorough a change in the subsidiaries' investment opportunities.

5.3 Business Groups

The unit of analysis in this subsection is business groups. The independent variable of interest is a CTS parent dummy variable. We aggregate each variable across parents and their subsidiaries in the business groups. Table 9 shows results when the dependent variable is capital expenditure. The results are very similar with the case when the unit of analysis is parents shown in Table 5. Models (1) – (2) show that the effect of the CTS introduction on investment ratio is positive and significant, which is consistent with Prediction 1G. The increment is about 3%. Parents' MTB ratio has positive effects on investment ratio, while the change in sensitivity to parent's MTB ratio by the CTS introduction is positive but insignificant.

Table 10 shows results when the dependent variable is R&D investment. The results are also qualitatively similar with the case when the unit of analysis is parents shown in Table 6, which is consistent with Prediction 1G. However, the results are quantitatively different from the parents' case. The CTS introduction significantly increases parent's R&D investment, but the effect is less than 4%. This could be due to our results that R&D investment is not robustly affected by the CTS at subsidiaries' level. Still, R&D investment is affected more by the CTS introduction than capital expenditure in both absolute and relative senses at business groups' level as well: the absolute increment is larger for R&D investment (4% vs. 3%), and the median R&D investment ratio among business groups is lower than capital expenditure ratio (4.5% vs. 11.1%). This result is consistent with Prediction 2. The MTB ratio does not have significant effects, while cash flow sensitivity is positive. The change is sensitivity to MTB ratio by the CTS introduction is positive and significant in both models (3) and (4). This result supports Prediction 5G.

5.4 Intermediate Summary

We have shown that the CTS increases both capital expenditure and R&D investment significantly in most of the cases. This is consistent with Predictions 1S, 1P, and 1G. The only exception is the case where the unit of analysis is subsidiaries and the dependent variable is R&D investment. The effects are positive but insignificant. R&D investment is affected strongly at parents' and business groups' levels, and therefore the insignificant results at subsidiaries' level do not mean that our prediction is incorrect. This result would suggest that subsidiaries react differently to the CTS when it comes to R&D investment. We will discuss the implications later. Our results at parents' and business groups' levels are consistent with Prediction 2 as well as Domar and Musgrave (1944). Our research contributes to the literature of the effects of tax on investment risk by comparing the CTS's effects on R&D investment with capital expenditure.

MTB ratio has positive and significant effects on capital expenditure, which is consistent with Predictions 4P and 4G. On the other hand, it has insignificant effects on R&D investment in most specifications. A change in sensitivity to MTB ratio by the CTS has positive and significant effects at subsidiaries' level for both investments. At parents' and business groups' levels, a change of sensitivity of MTB ratio on capital expenditure is positive but insignificant, and that on R&D investment is positive and significant, which is consistent with Predictions 5P and 5G. These results suggest that the change in sensitivity is clearer when the dependent variable is R&D investment, and that the CTS especially enhances efficiency of R&D investment at parents' and groups' levels.

6 Robustness

We have investigated the investment equation at each level of subsidiaries, parents, and business groups with two kinds of investment. The central concern is an endogeneity problem. If the parents introduce the CTS because they anticipate unobservable investment opportunities, higher level of investments are simply caused by third factors. Since we have included fixed effects, we are taking account of time-invariant investment opportunities in the specific firms or industries. However, we have not dealt with time-varying unobserved investment opportunities. We will deal with this potential problem in four ways. We also conduct three extensions in the following section.

6.1 Endogeneity

We will deal with the endogeneity in four ways: investigating a change in sensitivity to MTB ratio by the CTS introduction; including current and/or future capital expenditures as an independent variable of the R&D investment equation; using the IV method; discussing institutional details.

6.1.1 Sensitivity to MTB Ratio

Tables 5 – 10 show that sensitivity to MTB ratio by the CTS introduction is positive and significant for R&D investment. We have interpreted that these are evidence for efficiency in higher-risk investments among CTS groups. At the same time, we can interpret them as evidence to show that the CTS effects on investments are not caused by unobservable investment opportunities. MTB ratio depends on evaluation of the firms by markets, which is difficult for firms to predict precisely. Even though a part of higher level of investments could be caused by third factors, it is plausible that higher sensitivity to MTB ratio is purely caused by the CTS. Therefore, the results in Tables 5 – 10 suggest that the CTS itself enhances efficiency in investments.

6.1.2 Capital Expenditure in the R&D Investment Equation

We will take advantage of our framework that we have two investment variables. That is, we can add current and/or future capital expenditure to the R&D investment equation. This additional control variable is expected to reflect every investment opportunity – both observable and unobservable ones. If we find the effects of the CTS after using them as one of the control variables, we can more convincingly conclude that the CTS increases R&D investment. In other words, we can estimate "residual" effects of the CTS on R&D investment by including capital expenditure as an independent variable. Since R&D activities are mostly affected at parents' and business groups' levels, we report results when the unit of analysis is parents or business groups.

We show results in Table 11 when the unit of analysis is parents, and in Table 12 when the unit of analysis is business groups. Models (1) – (3) in Table 11 confirm that the CTS increases the level of R&D investment by about 4%. The coefficients are smaller than those in Table 6, and significant only at 10% level in models (1) and (3). It is natural to see that current and/or capital expenditure have positive effects on R&D investment. Models (4) – (6) in Table 11 show that the sensitivity to MTB ratio by the CTS is positive and significant. The coefficients are again smaller than those in Table 6. On the other hand, Table 12 shows that the CTS has almost the same effects on R&D investment as in Table 6, even after controlling investments. The main coefficients are mostly significant at 5% level. We have two conclusions from these results. First and most important, the CTS has significant impacts on R&D investment after controlling investment opportunities by including current and/or future investments. Second, the decline of the CTS's effects at parents' level after including the investment variables could suggest that at least some parts of the increase in investments might have been caused by third factors. Nevertheless, we emphasize that we found the direct effects of the CTS at parents' level as well as business groups' level: the positive and significant coefficients of CTS and CTS$*$MTB in Tables 11 and 12.

6.1.3 IV Regression

In this subsection, we will deal with the endogeneity by using the IV method at subsidiaries' level. When the unit of analysis is subsidiaries, the dummy variable of interest is the interaction term of the CTS subsidiary dummy and the wholly owned subsidiary dummy (CTSS$*$WS). The problem is that this variable is endogenous because the CTS is an elective system for parents. We use the

CTS subsidiary dummy (CTSS) as an instrument. The correlation between CTSS∗WS and CTSS is 0.76, and they are highly correlated. This high correlation is natural because 60% of subsidiaries are wholly owned in our data. The introduction of the CTS itself does not enable firms to aggregate gains and losses, and therefore does not affect subsidiaries' investment behavior (Prediction 3). Therefore, the use of the CTS dummy variable as an instrument is appropriate.

Table 13 reports results of the IV regression when the dependent variable is capital expenditure. The results are consistent with Prediction 1S, and similar with the previous OLS case shown in Table 7. The CTS increases wholly owned subsidiaries' investment ratio by about 7%. The coefficients on the parent's MTB ratio are positive and significant. Table 14 shows IV regression results when the dependent variable is R&D investment. The coefficients on the CTS∗WS dummy variable is positive but insignificant.

6.1.4 Endogeneity and Institutional Details

We have dealt with the endogeneity with econometric methodologies in the previous three subsections. In this subsection, we will ease the endogeneity concern through discussion of the institutional details of the CTS. Since our primary concern is that the parents introduce the CTS because they anticipate unobservable investment opportunities, we will focus on this specific aspect of the endogeneity. Before beginning the main argument, we will set out the basic trade-off that parents face when they introduce the CTS. The benefit of the CTS is clear: business groups can utilize losses of other group members. On the other hand, costs associated with the CTS are less clear. One obvious cost is that the CTS business groups must carry out more cumbersome procedures for tax payments than before. The *Nihon Keizai Shimbun* (1/14/2004) reports that CTS related businesses such as selling information technology system that enables business groups to calculate their consolidated tax payments more easily were growing rapidly. This would suggest that CTS groups need to bear additional fixed costs every year as well as the entry cost associated with the CTS introduction. In addition, some special treatment about loss carryforwards would increase the costs, as we will explain below.

First, the CTS is a permanent system. If the parents introduce the CTS, they can abolish the CTS only under very rare circumstances. In fact, no firms in our data have abolished the CTS during 2002 – 2008. Even if the parents anticipate investment opportunities, they would not be able to see opportunities in the distant future. On the other hand, entry and fixed costs associated with the CTS would be relatively easy to calculate. If firms are not myopic, the discounted value of fixed costs will be significant. Therefore, it would be reasonable that costs associated with the CTS could be more important than short-run benefits from unobservable investment opportunities. Since such costs are unlikely to be correlated with investment opportunities, we would not have to worry much about the endogeneity.

Second, the CTS has special treatments on loss carryforwards that are different between parents and subsidiaries. When the parent incurred losses in the past, it can carry forward these losses into the CTS group. This will work as an incentive for parents to introduce the CTS. In reality, the *Nihon Keizai Shimbun* (3/10/2011) reports that Yokogawa Electric Corporation decided to introduce the CTS because the company had ten billion yen of carryforwards, and it has some subsidiaries including Yokogawa Meters & Instruments Corporation that are expected to generate positive profits. Kiyoaki Shimagami, who served as Senior Executive Vice President of Toshiba Corporation, told that they would utilize their losses to reduce their subsidiaries' tax payments (*Nihon Keizai Shimbun*, 1/8/2003). The carryforwards of Toshiba Corporation seemed to be over 350 billion yen according to this article.

Contrary to the parents' loss treatment, subsidiaries' past losses cannot be carried forward into the CTS business groups. There were legal reforms about this treatment, but they were implemented in 2010. If the business groups have subsidiaries that have large past losses, they would be less likely to introduce the CTS. In reality, the *Nihon Keizai Shimbun* (3/14/2002) reports that Matsushita Electric Industrial Co., Ltd. (currently Panasonic Corporation) seemed not to introduce the CTS because one of its subsidiaries, Matsushita-Kotobuki Electronics Co., Ltd. (currently Panasonic Healthcare Co., Ltd.), held carryforwards of 15 billion yen. The *Weekly Toyo Keizai* (2/23/2002) reports that 8 out of 101 companies in their survey answered that they might not want to introduce the CTS because of the treatment of subsidiaries' carryforwards. These two aspects about the carryforwards suggest that past performances rather than future investment opportunities could matter for the decision of the CTS introduction. There could be a correlation between past performance and future investments, but it would be difficult to see a significant relationship there. Thus, our discussion about the institutional details suggests that the endogeneity associated with unobservable investment opportunities would not be a serious concern for our study.

6.2 Extension

We will present three extensions in this section. The first two are intended for robustness checks at subsidiaries' level: we restrict observations to CTS subsidiaries or wholly owned subsidiaries. We will then investigate additional implications of the CTS in the third extension. We examine the effects of the CTS on partly owned subsidiaries' investment behavior as the third extension, in order to seek implications of the CTS on internal capital markets. Partly owned subsidiaries are the only firms that cannot obtain tax benefits among firms in the CTS business groups. Therefore, business groups have incentives not to have them invest (Prediction 6), and transfer resources to either parents or wholly owned subsidiaries to obtain tax benefits.

6.2.1 Only CTS Subsidiaries

We only include subsidiaries whose parents have introduced the CTS in this subsection. The variable of interest is a wholly owned subsidiary dummy variable. This specification is attractive because the composition of wholly owned subsidiaries in business groups is not affected much by the CTS introduction, as we have seen before. In other words, the wholly owned subsidiary dummy variable would works as an exogenous variation in this specification. The Hausman test suggests that we should use the random effect model only when the dependent variable is capital expenditure. Table 15 shows results when the dependent variable is capital expenditure. The results are similar with those in Table 7, in which we include all subsidiaries, and they support Prediction 1S. Models (4) – (6) present the positive effects on a change in sensitivity to the parent's MTB ratio by the CTS introduction. One difference from Table 7 is that we observe positive and significant sensitivity of cash flow. Table 16 shows results when the dependent variable is R&D investment ratio. Main results are similar with those in Table 8, in which we include all subsidiaries: the wholly owned subsidiary dummy has no effects on R&D investment.

6.2.2 Only Wholly Owned Subsidiaries

We restrict our observations to wholly owned subsidiaries. When the unit of analysis is subsidiaries, those firms affected directly by the CTS introduction are wholly owned subsidiaries and looking at this case will be important. The variable of interest is a CTS subsidiary dummy variable. Table 17 shows results when the dependent variable is capital expenditure. The results are similar as the case when we include both wholly and partly owned subsidiaries shown in Table 7. The CTS subsidiary dummy has positive and significant effects on investment ratio, which supports Prediction 1S. Parents' MTB ratio has positive and significant effects only in model (1) at 10% level. The change in sensitivity to parent's MTB ratio by the CTS introduction is positive and significant. Table 18 shows results when the dependent variable is R&D investment. The results are similar with those shown in Table 8. The introduction of the CTS has positive but insignificant effects on R&D investment. The sensitivity to parent's MTB ratio of the CTS introduction also has positive but insignificant effects. Overall, the results in these two subsections are similar with the case when we use all the subsidiaries.

6.2.3 Internal Capital Market: CTS Partly Owned Subsidiaries

The CTS applies only to parents and their wholly owned subsidiaries. Nevertheless, the CTS has interesting implications on partly own subsidiaries' investment behavior. That is, parents has less incentive to have them make higher-risk investments, since they cannot obtain tax benefits. Therefore, it is more efficient to transfer resources from partly owned subsidiaries to parents or wholly owned subsidiaries through the internal capital markets. This is the first paper to identify internal capital markets by using a change in tax system. In addition, the effects of the CTS on partly owned subsidiaries could be different between capital expenditure and R&D investment. We have been interested in the differences in risks of each investment. Another difference is the degree of centralization of each investment. Firms need capital investment such as machines and factories at individual firms' level to conduct their business activities. On the other hand, R&D activities can be centralized and parents can allocate the outcomes across their subsidiaries. Thus, we could expect that the negative effects on CTS partly owned subsidiaries' investment will be stronger for R&D investment. If this is the case, we can conclude that internal capital markets work efficiently especially for R&D activities. This prediction is in contrast with Seru (forthcoming)'s that shows inefficiency of internal capital markets on R&D activities by using data about conglomerates.

Table 19 presents results when the dependent variable is capital expenditure. Models (2) – (3) show negative and significant effects of the CTS on CTS partly owned subsidiaries' investment, which is consistent with Prediction 6. The size of coefficient is about -7% The change in sensitivity to MTB ratio by the CTS introduction is negative but insignificant. Table 20 shows results when the dependent variable is R&D investment. Models (2) – (3) show that the effects of the CTS on R&D investment are negative and significant, which is consistent with Prediction 6. The size of the coefficients is about -10%. This effect is larger than the previous case when the dependent variable is capital expenditure. Models (4) - (6) show that a change in sensitivity to parent's MTB ratio is negative and significant. This result suggests that parents use the internal capital markets actively when they anticipate high investment opportunities about R&D activities contrary to Seru (forthcoming). It is plausible that CTS parents transfer resources from their partly owned subsidiaries to parents, given the large increase in CTS parents' R&D investment.

7 Conclusion

We have investigated the relationship between the Japanese *Consolidated Taxation System* (CTS) and business groups' investment behavior. The majority of Japanese large firms are parents of their business groups, and they have considerable influence over their subsidiaries' business activities. This economic circumstance is common in some other countries as well. Therefore, it is important to study how tax system affects business groups' activities. The CTS and the Japanese business environment provide a suitable situation to study this issue. Our unique and comprehensive datasets enable us to investigate the effects of the CTS at parents', subsidiaries', and business groups' levels. In addition, two kinds of investment are available in our data: capital expenditure and R&D investment. These two investments have important differences in terms of risks as well as the degree of centralization. Our resources make it possible for us to investigate a number of research and policy questions that previous studies could not.

Our most important conclusion is that the introduction of the CTS increases investment level, especially that of R&D investment. This is because of the loss offset effects widely discussed since Domar and Musgrave (1944). We also show that the CTS makes firms more sensitive to investment opportunities measure by market to book ratio (MTB ratio). This higher sensitivity to MTB ratio implies that the CTS enhances efficiency in investments. The CTS also has interesting implications on internal capital markets. We show that investment level of partly owned subsidiaries, which cannot obtain tax benefits from the CTS, decreases especially with respect to R&D activities. Since parents' R&D investment level increases considerably, it is plausible that the resources are transferred from CTS partly owned subsidiaries to their parents. This is the first paper to demonstrate that the business groups utilize their internal capital markets to obtain tax benefits.

A potential concern is the endogeneity of the CTS, and we deal with this issue in several ways. The most convincing results to show that the CTS itself has caused the effects on investments would be that the CTS has positive and significant effects on R&D investment even after including current and/or future capital expenditure. This variable captures any kinds of investment opportunities, and therefore the result supports that unobservable investment opportunities are not the reason of the high level of investment. In addition, stronger sensitivity to MTB ratio by the CTS introduction supports that the CTS itself has enhanced efficient investments, since it is unlikely that firms predict their MTB ratio precisely when they introduce the CTS. Furthermore, the fact that it is difficult for business groups to abolish the CTS once they introduce this system would suggest that firms care more about entry and fixed costs associated with the CTS rather than short-run unobservable investment opportunities. We also show descriptive evidence that firms could concern more about their past performance than future investment opportunities, because of the special treatments on loss carryforwards when they introduce the CTS. Our results confirm that the CTS meets the Japanese government's expectations to encourage business groups to make investments efficiently. In addition, more and more countries have introduced group taxation system and our results have broad policy implications on them as well.

References

[1] Acharya, Viral V., Amihuda, Yakov, and Litov, Lubomir. (2011). Creditor rights and corporate risk-taking. *Journal of Financial Economics*, 102(1): 150-166.

[2] Almeida, Heitor and Campello, Murillo. (2007). Financing constraints, asset tangibility, and corporate investment. *Review of Financial Studies*, 20(5): 1429-1460.

[3] Almeida, Heitor and Kim, Chang Soo. (2012). The effect of internal capital markets on corporate investment: Evidence from the Asian Financial Crisis. mimeo.

[4] Almeida, Heitor, Park, Sang Yong, Subrahmanyam, Marti G., and Wolfenzon, Daniel. (2011). The structure and formation of business groups: Evidence from Korean chaebols. *Journal of Financial Economics*, 99(2): 447-475.

[5] Altshuler, Rosanne and Auerbach, Alan J. (1990). The significance of tax law asymmetries: An empirical investigation. *Quarterly Journal of Economics*, 105(1): 61-86.

[6] Auerbach, Alan J. (1986). The dynamic effects of tax law asymmetries. *Review of Economic Studies*, 53(2): 205-225.

[7] Domar, Evsey D. and Musgrave, Richard A. (1944). Proportional income taxation and risk-taking. *Quarterly Journal of Economics*, 58(3): 388-422.

[8] Dreßler, Daniel and Overesch, Michael. (2010). Investment impact of tax loss treatment - Empirical insights from a panel of multinationals. *ZEW Discussion Paper*, 10-097.

[9] Fazzari, Steven M., Hubbard, R. Glenn, Petersen, Bruce C., Blinder, Alan S., and Poterba, James M. (1988). Financing constraints and corporate investment. *Brookings Papers on Economic Activity*, 1: 141-206.

[10] Gopalan, Radhakrishnan, Nanda, Vikram, and Seru, Amit. (2007). Affiliated firms and financial support: Evidence from Indian business groups. *Journal of Financial Economics*, 86(3): 759-795.

[11] Hoshi, Takeo, Kashyap, Anil, and Scharfstein, David. (1991). Corporate structure, liquidity, and investment: Evidence from Japanese industrial groups. *Quarterly Journal of Economics*, 106(1): 33-60.

[12] Seru, Amit. (forthcoming). Firm boundaries matter: Evidence from conglomerates and R&D activity. *Journal of Financial Economics*.

[13] Stein, Jeremy C. (1997). Internal capital markets and the competition for corporate resources. *Journal of Finance*, 52(1): 111-133.

[14] Rajan, Raghuram, Servaes, Henri, and Zingales, Luigi. (2000). The cost of diversity: The diversification discount and inefficient investment. *Journal of Finance*, 55(1): 35-80.

Appendix

Optimal Investments under CTS

In the main text, we have assumed that the solution (p^{c1}, s^{c1}) to the first-order conditions (9) and (10) satisfies $s^{c1} \geq x(p^{c1}, u) - p^{c1}$ and $p^{c1} \geq y(s^{c1}, v) - s^{c1}$. Then (p^{c1}, s^{c1}) is in fact the optimal investments under CTS that maximize P's objective function. If either condition is violated, we must analyze the other cases to obtain the optimal investments.

In contrast with the main text, we here assume that $s^{c1} < x(p^{c1}, u) - p^{c1}$: joint profit is positive if P's project succeeds and S's project fails. We maintain the reasonable assumption $p \geq y(s, u) - s$

for relevant values as in the main text: if P's projects fails, joint profit becomes negative even if S's project succeeds. (7) and (8) yield the first-order conditions under $s < x(p,u) - p$ and $p \geq y(s,v) - s$ as follows:

$$x_p(p,u) = \frac{1-\tau q}{(1-\tau)q}$$
$$y_s(s,v) = \frac{1-\tau q}{(1-\tau q)r - \tau\alpha}$$

Denote the solution by (p^{c2}, s^{c2}). From the first-order conditions we find $p^{c2} = p^{nc} < p^{c1}$ and $s^{c2} > s^{c1}$. P's investment does not change with the adoption of CTS, because $s < x(p,u) - p$ and $p \geq y(s,v) - s$ imply that the result of P's project is decisive for tax as is the case under no CTS. On the other hand, S's investment is higher under CTS because of no tax on S's successful project if P's project fails. It is also easy to see s^{c2} is increasing in (v, r) and decreasing in (q, α).

Since we are assuming $p \geq y(s,u) - s$ for (p^{nc}, s^{c2}) and (p^{c1}, s^{c1}), as well as $s^{c1} < x(p^{c1}, u) - p^{c1}$, we need to analyze two cases separately in order to find the optimal investments: (a) $s^{c2} \leq x(p^{nc}) - p^{nc}$ and (b) $s^{c2} > x(p^{nc}) - p^{nc}$. First assume $s^{c2} \leq x(p^{nc}) - p^{nc}$. Then (p^{nc}, s^{c2}) is the optimal investments under CTS. In this case, while P's investment is not affected by the introduction of the CTS, the adoption of CTS increases S's investment as in the case analyzed in the main text. Next, assume $s^{c2} > x(p^{nc}) - p^{nc}$. In this case, the optimal investments under CTS is some (p, s) satisfying $s = x(p) - p$. Since $s^{c1} < x(p^{c1}) - p^{c1}$ holds, such a (p, s) exists and satisfies $p^{c1} > p > p^{nc}$ and $s^{c2} > s > s^{c1}$. Hence, the introduction of the CTS increases both P's and S's investments in this case, as in the case analyzed in the main text.

Proof of Proposition 1

(i) Comparing the right-hand sides of (5) and (9) yields

$$\text{sign}\left\{\frac{1-\tau q}{(1-\tau)q} - \frac{1-\tau qr - \tau\alpha}{(1-\tau r)q - \tau\alpha}\right\} = \text{sign}\left\{t(1-q)[(1-r)q - \alpha]\right\},$$

which is positive under assumption (1). Similarly, Comparing the right-hand sides of (6) and (10) yields

$$\text{sign}\left\{\frac{1-\tau r}{(1-\tau)r} - \frac{1-\tau qr-\tau\alpha}{(1-\tau q)r-\tau\alpha}\right\} = \text{sign}\left\{t(1-r)[(1-q)r-\alpha]\right\},$$

which is positive under assumption (1).

(ii) Differentiating the right-hand sides of (5) and (9) with regard to q yields, respectively,

$$\frac{\partial}{\partial q}\left(\frac{1-\tau q}{(1-\tau)q}\right) = -\frac{1}{(1-\tau)q^2}$$
$$\frac{\partial}{\partial q}\left(\frac{1-\tau qr-\tau\alpha}{(1-\tau r)q-\tau\alpha}\right) = -\frac{1-\tau qr-\tau\alpha}{[(1-\tau r)q-\tau\alpha]^2}$$

Then

$$\begin{aligned}\text{sign}\left\{\frac{\partial}{\partial q}\left(p^{c1}-p^{nc}\right)\right\} &= -\text{sign}\left\{\frac{\partial}{\partial q}\left(\frac{1-\tau q}{(1-\tau)q} - \frac{1-\tau qr-\tau\alpha}{(1-\tau r)q-\tau\alpha}\right)\right\}\\ &= -\text{sign}\left\{\tau\alpha^2 - [1-\tau r+1-q+\tau(1-r)]q\alpha + (1-\tau r)(1-r)q^2\right\}\end{aligned}$$

The right-hand side is strictly negative for $\alpha \le 0$. In particular, it is strictly negative at $\alpha = 0$, and hence there exists $\alpha_0 > 0$, which may be equal to the maximum possible level $\overline{\alpha}$ defined in assumption (1), such that the right-hand side is negative for $\alpha \le \alpha_0$. The proof that $s^{c1} - s^{nc}$ is decreasing in r for $\alpha \le \alpha_0$ is similar.

Table 5: Capital expenditure: Parents

The dependent variable is capital expenditure divided by lagged fixed tangible assets. The independent variables are defined as follows. "CTS" is a dummy variable that takes one when the company has introduced the CTS. "MTB" is the market to book ratio defined by the sum of market value of stocks and debts divided by assets. "CTS∗MTB" is an interaction term of CTS and MTB dummy variables. "L.asset" is lagged fixed tangible assets. "CF" is the cash flow that is defined as income before extraordinary items and taxes plus depreciation. "leverage" is the sum of short-term and long-term debts divided by assets. "ln(asset)" is log of assets. "age" is the firm's age and "age^2" is its squared value. T-statistics are reported in parenthesis. We include year dummy and firm fixed effects. We use robust standard errors clustered by firm-level.

	(1)	(2)	(3)	(4)
CTS	0.0263*	0.0362**		
	(1.769)	(2.340)		
CTS∗MTB			0.0122	0.0133
			(0.958)	(0.981)
MTB	0.0884***	0.0872***	0.0881***	0.0870***
	(2.771)	(2.749)	(2.754)	(2.734)
CF/L.asset	0.0406	0.0368	0.0405	0.0367
	(1.434)	(1.388)	(1.433)	(1.386)
leverage		0.134***		0.133***
		(2.642)		(2.617)
ln(asset)		0.124***		0.122***
		(3.706)		(3.652)
age		0.000415		0.000340
		(0.268)		(0.218)
age^2		5.08e-07		1.16e-06
		(0.0364)		(0.0825)
Constant	0.0458	-1.449***	0.0462	-1.423***
	(1.411)	(-4.200)	(1.419)	(-4.137)
Observations	6,504	6,497	6,504	6,497
Parents	1,017	1,017	1,017	1,017

*** p<0.01, ** p<0.05, * p<0.1

Table 6: R&D investment: Parents

The dependent variable is R&D investment divided by lagged fixed tangible assets. The independent variables are defined as follows. "CTS" is a dummy variable that takes one when the company has introduced the CTS. "MTB" is the market to book ratio defined by the sum of market value of stocks and debts divided by assets. "CTS∗MTB" is an interaction term of CTS and MTB dummy variables. "L.asset" is lagged fixed tangible assets. "CF" is the cash flow that is defined as income before extraordinary items and taxes plus depreciation. "leverage" is the sum of short-term and long-term debts divided by assets. "ln(asset)" is log of assets. "age" is the firm's age and "age^2" is its squared value. T-statistics are reported in parenthesis. We include year dummy and firm fixed effects. We use robust standard errors clustered by firm-level.

	(1)	(2)	(3)	(4)
CTS	0.0614**	0.0633**		
	(2.137)	(2.202)		
CTS∗MTB			0.0566**	0.0564**
			(2.337)	(2.344)
MTB	0.00433	0.000150	0.00226	-0.00169
	(0.545)	(0.0190)	(0.284)	(-0.211)
CF/L.asset	0.0293*	0.0301*	0.0287*	0.0296*
	(1.933)	(1.944)	(1.948)	(1.959)
leverage		0.0189		0.0187
		(0.363)		(0.360)
ln(asset)		0.0439**		0.0404*
		(2.058)		(1.949)
age		0.000481		0.000477
		(0.518)		(0.512)
age^2		3.87e-07		6.16e-07
		(0.0424)		(0.0678)
Constant	0.110***	-0.425*	0.113***	-0.383
	(12.33)	(-1.744)	(12.56)	(-1.615)
Observations	5,391	5,384	5,391	5,384
Parents	922	922	922	922

*** p<0.01, ** p<0.05, * p<0.1

Table 7: Capital expenditure: Subsidiaries

The dependent variable is subsidiary's capital expenditure divided by lagged fixed tangible assets. The independent variables are defined as follows. "CTSS" is a dummy variable that takes one when the subsidiary's parent has introduced the CTS. "WS" is a dummy variable that takes one when the subsidiary is wholly owned. "MTBP" is the parent's market to book ratio defined by the sum of parent's market value of stocks and debts divided by the parent's assets. "CTSS∗WS" is an interaction term of CTSS and WS dummy variables. "CTSS∗WS∗MTBP" is an interaction term of CTSS, WS, and MTBP dummy variables. "L.asset" is the subsidiary's lagged fixed tangible assets. "CF" is the subsidiary's cash flow that is defined as income before extraordinary items and taxes plus depreciation. "own" is the parent's ownership stake of the subsidiary. "leverage" is the sum of the subsidiary's short-term and long-term debts divided by assets. "ln(asset)" is log of assets. "age" is the firm's age and "age^2" is its squared value. T-statistics are reported in parenthesis. We include year dummy and firm fixed effects. We use robust standard errors clustered by firm-level.

	(1)	(2)	(3)	(4)	(5)	(6)
CTSS∗WS	0.0650***	0.0645***	0.0760***			
	(3.059)	(2.618)	(3.006)			
CTSS∗WS∗MTBP				0.0414***	0.0428***	0.0425***
				(3.761)	(3.873)	(3.734)
CTSS		0.00426	-0.00547			
		(0.226)	(-0.290)			
MTBP	0.0224**	0.0228**	0.0196*	0.0199*	0.0202*	0.0170
	(2.090)	(2.122)	(1.782)	(1.850)	(1.884)	(1.540)
CF/L.asset	0.0258	0.0257	0.0215	0.0258	0.0257	0.0215
	(1.601)	(1.598)	(1.487)	(1.601)	(1.599)	(1.488)
own		-0.00110**	-0.000797		-0.00109**	-0.000752
		(-2.017)	(-1.529)		(-1.982)	(-1.432)
leverage			0.0389***			0.0389***
			(2.894)			(2.895)
ln(asset)			0.174***			0.173***
			(6.747)			(6.704)
age			-0.00747***			-0.00745***
			(-2.598)			(-2.597)
age^2			7.52e-05*			7.50e-05*
			(1.822)			(1.819)
Constant	0.158***	0.255***	-1.216***	0.161***	0.257***	-1.204***
	(9.310)	(5.278)	(-4.968)	(9.475)	(5.269)	(-4.902)
Observations	16,172	16,172	16,049	16,172	16,172	16,049
Subsidiaries	3,816	3,816	3,798	3,816	3,816	3,798

*** p<0.01, ** p<0.05, * p<0.1

Table 8: R&D investment: Subsidiaries

The dependent variable is subsidiary's R&D investment divided by lagged fixed tangible assets. The independent variables are defined as follows. "CTSS" is a dummy variable that takes one when the subsidiary's parent has introduced the CTS. "WS" is a dummy variable that takes one when the subsidiary is wholly owned. "MTBP" is the parent's market to book ratio defined by the sum of parent's market value of stocks and debts divided by the parent's assets. "CTSS∗WS" is an interaction term of CTSS and WS dummy variables. "CTSS∗WS∗MTBP" is an interaction term of CTSS, WS, and MTBP dummy variables. "L.asset" is the subsidiary's lagged fixed tangible assets. "CF" is the subsidiary's cash flow that is defined as income before extraordinary items and taxes plus depreciation. "own" is the parent's ownership stake of the subsidiary. "leverage" is the sum of the subsidiary's short-term and long-term debts divided by assets. "ln(asset)" is log of assets. "age" is the firm's age and "age^2" is its squared value. T-statistics are reported in parenthesis. We include year dummy and firm fixed effects. We use robust standard errors clustered by firm-level.

	(1)	(2)	(3)	(4)	(5)	(6)
CTSS∗WS	0.0766*	0.0985**	0.0987**			
	(1.718)	(2.007)	(2.069)			
CTSS∗WS∗MTBP				0.0308*	0.0293*	0.0282*
				(1.959)	(1.827)	(1.855)
CTSS		-0.0286	-0.0301			
		(-1.398)	(-1.447)			
MTBP	-0.00599	-0.00579	-0.00659	-0.00816	-0.00830	-0.00905
	(-0.506)	(-0.492)	(-0.552)	(-0.650)	(-0.662)	(-0.714)
CF/L.asset	0.0112	0.0112	0.0106	0.0111	0.0111	0.0106
	(0.799)	(0.800)	(0.778)	(0.796)	(0.796)	(0.774)
own		0.000493	0.000709		0.000682	0.000906
		(0.796)	(1.263)		(1.111)	(1.567)
leverage			0.0184			0.0181
			(1.375)			(1.366)
ln(asset)			0.0539			0.0524
			(1.549)			(1.504)
age			0.00141			0.00181
			(0.394)			(0.492)
age^2			-3.17e-05			-3.68e-05
			(-0.623)			(-0.706)
Constant	0.104***	0.0611	-0.466	0.106***	0.0486	-0.471
	(6.528)	(1.074)	(-1.333)	(6.579)	(0.859)	(-1.322)
Observations	7,364	7,364	7,337	7,364	7,364	7,337
Subsidiaries	2,086	2,086	2,082	2,086	2,086	2,082

*** p<0.01, ** p<0.05, * p<0.1

Table 9: Capital expenditure: Business groups

The dependent variable is group's capital expenditure divided by the group's lagged fixed tangible assets. The independent variables are defined as follows. "CTSP" is a dummy variable that takes one when the group's parent has introduced the CTS. "MTBP" is the market to book ratio defined by the sum of the parent's market value of stocks and parent's debts divided by the parent's assets. "CTSP*MTBP" is an interaction term of CTSP and MTBP dummy variables. "L.asset" is the group's lagged fixed tangible assets. "CF" is the group's cash flow that is defined as the group's income before extraordinary items and taxes plus depreciation. "leverage" is the sum of the group's short-term and long-term debts divided by the group's assets. "ln(asset)" is log of group's assets. "age" is the parent's age and "age^2" is its squared value. T-statistics are reported in parenthesis. We include year dummy and firm fixed effects. We use robust standard errors clustered by firm-level.

	(1)	(2)	(3)	(4)
CTSP	0.0264**	0.0327**		
	(1.981)	(2.472)		
CTSP*MTBP			0.0132	0.0135
			(1.164)	(1.203)
MTBP	0.0872***	0.0874***	0.0869***	0.0871***
	(3.103)	(3.097)	(3.083)	(3.080)
CF/L.asset	0.0709*	0.0638	0.0708*	0.0637
	(1.693)	(1.583)	(1.688)	(1.579)
leverage		0.111**		0.109**
		(2.409)		(2.373)
ln(asset)		0.0873***		0.0863***
		(3.175)		(3.156)
age		0.00155		0.00147
		(1.007)		(0.950)
age^2		-6.26e-06		-5.58e-06
		(-0.465)		(-0.413)
Constant	0.0383	-1.080***	0.0387	-1.065***
	(1.238)	(-3.557)	(1.247)	(-3.530)
Observations	6,820	6,809	6,820	6,809
Business groups	1,026	1,026	1,026	1,026

*** p<0.01, ** p<0.05, * p<0.1

Table 10: R&D investment: Business groups

The dependent variable is group's R&D investment divided by the group's lagged fixed tangible assets. The independent variables are defined as follows. "CTSP" is a dummy variable that takes one when the group's parent has introduced the CTS. "MTBP" is the market to book ratio defined by the sum of the parent's market value of stocks and parent's debts divided by the parent's assets. "CTSP∗MTBP" is an interaction term of CTSP and MTBP dummy variables. "L.asset" is the group's lagged fixed tangible assets. "CF" is the group's cash flow that is defined as the group's income before extraordinary items and taxes plus depreciation. "leverage" is the sum of the group's short-term and long-term debts divided by the group's assets. "ln(asset)" is log of group's assets. "age" is the parent's age and "age^2" is its squared value. T-statistics are reported in parenthesis. We include year dummy and firm fixed effects. We use robust standard errors clustered by firm-level.

	(1)	(2)	(3)	(4)
CTSP	0.0388**	0.0374**		
	(2.399)	(2.319)		
CTSP∗MTBP			0.0290**	0.0283**
			(2.289)	(2.236)
MTBP	0.00209	-5.53e-05	0.00114	-0.000891
	(0.346)	(-0.00985)	(0.188)	(-0.158)
CF/L.asset	0.0341**	0.0355**	0.0337**	0.0352**
	(2.376)	(2.322)	(2.374)	(2.320)
leverage		0.00254		0.00271
		(0.0742)		(0.0798)
ln(asset)		0.00393		0.00219
		(0.352)		(0.199)
age		-0.00140		-0.00144
		(-1.197)		(-1.229)
age^2		1.43e-05		1.47e-05
		(1.319)		(1.347)
Constant	0.0778***	0.0626	0.0789***	0.0843
	(11.08)	(0.444)	(11.18)	(0.604)
Observations	6,820	6,809	6,820	6,809
Business groups	1,026	1,026	1,026	1,026

*** p<0.01, ** p<0.05, * p<0.1

Table 11: R&D investment with capital expenditure: Parents

The dependent variable is R&D investment divided by lagged fixed tangible assets. The independent variables are defined as follows. "CTS" is a dummy variable that takes one when the company has introduced the CTS. "MTB" is the market to book ratio defined by the sum of market value of stocks and debts divided by assets. "CTS∗MTB" is an interaction term of CTS and MTB dummy variables. "L.asset" is lagged fixed tangible assets. "CF" is the cash flow that is defined as income before extraordinary items and taxes plus depreciation. "leverage" is the sum of short-term and long-term debts divided by assets. "ln(asset)" is log of assets. "age" is the firm's age and "age^2" is its squared value. Capex is the firm's capital expenditure. F.(·) refers to the firm's next year's value of the specified variable. T-statistics are reported in parenthesis. We include year dummy and firm fixed effects. We use robust standard errors clustered by firm-level.

	(1)	(2)	(3)	(4)	(5)	(6)
CTS	0.0347*	0.0406**	0.0388*			
	(1.731)	(2.084)	(1.934)			
CTS∗MTB				0.0313*	0.0360**	0.0354**
				(1.935)	(2.297)	(2.160)
MTB	0.00305	0.00951	0.00310	0.00181	0.00772	0.00132
	(0.427)	(1.223)	(0.410)	(0.258)	(1.022)	(0.181)
CF/L.asset	0.0240**	0.0224**	0.0200**	0.0238**	0.0221**	0.0198**
	(1.985)	(2.049)	(2.115)	(1.990)	(2.062)	(2.133)
Capex/L.asset	0.0468***		0.0551***	0.0467***		0.0550***
	(4.903)		(5.613)	(4.916)		(5.659)
F.(Capex/L.asset)		0.00289	0.0140**		0.00249	0.0136**
		(0.466)	(2.347)		(0.397)	(2.269)
Constant	0.106***	0.105***	0.103***	0.107***	0.107***	0.106***
	(12.42)	(10.93)	(11.17)	(12.87)	(11.50)	(11.79)
Observations	5,269	4,430	4,373	5,269	4,430	4,373
Parents	917	876	872	917	876	872

*** p<0.01, ** p<0.05, * p<0.1

Table 12: R&D investment with capital expenditure: Business groups

The dependent variable is group's R&D investment divided by group's lagged fixed tangible assets. The independent variables are defined as follows. "CTSP" is a dummy variable that takes one when the group's parent has introduced the CTS. "MTBP" is the market to book ratio defined by the sum of the parent's market value of stocks and parent's debts divided by the parent's assets. "CTSP$*$MTBP" is an interaction term of CTSP and MTBP dummy variables. "L.asset" is the group's lagged fixed tangible assets. "CF" is the group's cash flow that is defined as the group's income before extraordinary items and taxes plus depreciation. Capex is group's capital expenditure. F.($\cdot$) refers to the group's next year's value of the specified variable. T-statistics are reported in parenthesis. We include year dummy and firm fixed effects. We use robust standard errors clustered by firm-level.

	(1)	(2)	(3)	(4)	(5)	(6)
CTSP	0.0382**	0.0339**	0.0329**			
	(2.349)	(2.065)	(1.988)			
CTSP$*$MTBP				0.0287**	0.0262**	0.0257*
				(2.249)	(1.987)	(1.931)
MTBP	-4.68e-05	0.00530	0.00225	-0.000990	0.00419	0.00116
	(-0.00766)	(0.834)	(0.355)	(-0.161)	(0.655)	(0.181)
CF/L.asset	0.0324**	0.0282**	0.0258**	0.0320**	0.0278**	0.0255**
	(2.331)	(2.340)	(2.338)	(2.330)	(2.350)	(2.350)
Capex/L.asset	0.0245**		0.0303***	0.0245**		0.0303***
	(2.368)		(2.638)	(2.374)		(2.646)
F.(Capex/L.asset)		0.00324	0.00771		0.00306	0.00753
		(0.519)	(1.056)		(0.490)	(1.030)
Constant	0.0768***	0.0768***	0.0756***	0.0780***	0.0782***	0.0770***
	(11.05)	(10.13)	(10.08)	(11.15)	(10.24)	(10.19)
Observations	6,820	5,655	5,655	6,820	5,655	5,655
Business groups	1,026	984	984	1,026	984	984

*** p<0.01, ** p<0.05, * p<0.1

Table 13: Capital expenditure using IV method: Subsidiaries

The dependent variable is subsidiary's capital expenditure divided by lagged fixed tangible assets. The independent variables are defined as follows. "CTSS" is a dummy variable that takes one when the subsidiary's parent has introduced the CTS. "WS" is a dummy variable that takes one when the subsidiary is wholly owned. "CTSS∗WS" is an interaction term of CTSS and WS dummy variables. "MTBP" is the parent's market to book ratio defined by the sum of parent's market value of stocks and debts divided by the parent's assets. "L.asset" is the subsidiary's lagged fixed tangible assets. "CF" is the subsidiary's cash flow that is defined as income before extraordinary items and taxes plus depreciation. "own" is the parent's ownership stake of the subsidiary. "leverage" is the sum of the subsidiary's short-term and long-term debts divided by assets. "ln(asset)" is log of assets. "age" is the firm's age and "age^2" is its squared value. The endogenous variable is "CTSS∗WS" and we use "CTSS" as an instrument. Z-statistics are reported in parenthesis. We include year dummy and firm fixed effects. Constants are included but not reported. We use robust standard errors clustered by firm-level.

	(1)	(2)	(3)
CTSS∗WS	0.0717***	0.0714***	0.0670**
	(2.587)	(2.583)	(2.411)
MTBP	0.0225**	0.0229**	0.0195*
	(2.093)	(2.135)	(1.776)
CF/L.asset	0.0258	0.0257	0.0215
	(1.602)	(1.599)	(1.487)
own		-0.00112**	-0.000772
		(-2.013)	(-1.443)
leverage			0.0389***
			(2.900)
ln(asset)			0.174***
			(6.755)
age			-0.00743**
			(-2.573)
age^2			7.47e-05*
			(1.800)
Observations	15,461	15,461	15,341
Subsidiaries	3,105	3,105	3,090

*** p<0.01, ** p<0.05, * p<0.1

Table 14: R&D investment using IV method: Subsidiaries

The dependent variable is subsidiary's R&D investment divided by lagged fixed tangible assets. The independent variables are defined as follows. "CTSS" is a dummy variable that takes one when the subsidiary's parent has introduced the CTS. "WS" is a dummy variable that takes one when the subsidiary is wholly owned. "CTSS∗WS" is an interaction term of CTSS and WS dummy variables. "MTBP" is the parent's market to book ratio defined by the sum of parent's market value of stocks and debts divided by the parent's assets. "L.asset" is the subsidiary's lagged fixed tangible assets. "CF" is the subsidiary's cash flow that is defined as income before extraordinary items and taxes plus depreciation. "own" is the parent's ownership stake of the subsidiary. "leverage" is the sum of the subsidiary's short-term and long-term debts divided by assets. "ln(asset)" is log of assets. "age" is the firm's age and "age^2" is its squared value. The endogenous variable is "CTSS∗WS" and we use "CTSS" as an instrument. Z-statistics are reported in parenthesis. We include year dummy and firm fixed effects. Constants are included but not reported. We use robust standard errors clustered by firm-level.

	(1)	(2)	(3)
CTSS∗WS	0.0489	0.0483	0.0458
	(1.007)	(0.987)	(0.954)
MTBP	-0.00666	-0.00683	-0.00769
	(-0.564)	(-0.579)	(-0.647)
CF/L.asset	0.0112	0.0111	0.0106
	(0.798)	(0.798)	(0.776)
own		0.000672	0.000901
		(1.008)	(1.471)
leverage			0.0177
			(1.334)
ln(asset)			0.0533
			(1.525)
age			0.00180
			(0.508)
age^2			-3.66e-05
			(-0.729)
Observations	6,739	6,739	6,713
Subsidiaries	1,461	1,461	1,458

*** p<0.01, ** p<0.05, * p<0.1

Table 15: Capital expenditure: CTS subsidiaries

The dependent variable is subsidiary's capital expenditure divided by lagged fixed tangible assets. The independent variables are defined as follows. "WS" is a dummy variable that takes one when the subsidiary is wholly owned. "MTBP" is the parent's market to book ratio defined by the sum of parent's market value of stocks and debts divided by the parent's assets. "WS∗MTBP" is an interaction term of WS and MTBP dummy variables. "L.asset" is the subsidiary's lagged fixed tangible assets. "CF" is the subsidiary's cash flow that is defined as income before extraordinary items and taxes plus depreciation. "own" is the parent's ownership stake of the subsidiary. "leverage" is the sum of the subsidiary's short-term and long-term debts divided by assets. "ln(asset)" is log of assets. "age" is the firm's age and "age^2" is its squared value. Z-statistics are reported in parenthesis. We include year dummy and use random effect model. We use robust standard errors clustered by firm-level.

	(1)	(2)	(3)	(4)	(5)	(6)
WS	0.0564***	0.106***	0.0834***			
	(2.812)	(3.729)	(3.057)			
WS∗MTBP				0.0389***	0.0625***	0.0549***
				(3.056)	(4.172)	(3.691)
MTBP	0.0596***	0.0574***	0.0601***	0.0372**	0.0217	0.0289
	(3.484)	(3.426)	(3.527)	(1.961)	(1.197)	(1.599)
CF/L.asset	0.0517***	0.0513***	0.0428***	0.0517***	0.0513***	0.0427***
	(3.995)	(3.985)	(3.318)	(3.981)	(3.958)	(3.297)
own		-0.00181**	-0.00106		-0.00158**	-0.00106
		(-2.005)	(-1.122)		(-2.092)	(-1.322)
leverage			0.0139			0.0139
			(1.237)			(1.217)
ln(asset)			0.0468***			0.0467***
			(4.407)			(4.368)
age			-0.00257			-0.00269
			(-0.912)			(-0.953)
age^2			8.45e-06			9.76e-06
			(0.294)			(0.340)
Constant	0.0613	0.196***	-0.243**	0.0929**	0.234***	-0.193
	(1.538)	(2.657)	(-1.978)	(2.202)	(3.316)	(-1.525)
Observations	2,395	2,395	2,365	2,395	2,395	2,365
Subsidiaries	762	762	756	762	762	756

*** p<0.01, ** p<0.05, * p<0.1

Table 16: R&D investment: CTS Subsidiaries

The dependent variable is subsidiary's R&D investment divided by lagged fixed tangible assets. The independent variables are defined as follows. "WS" is a dummy variable that takes one when the subsidiary is wholly owned. "MTBP" is the parent's market to book ratio defined by the sum of parent's market value of stocks and debts divided by the parent's assets. "WS∗MTBP" is an interaction term of WS and MTBP dummy variables. "L.asset" is the subsidiary's lagged fixed tangible assets. "CF" is the subsidiary's cash flow that is defined as income before extraordinary items and taxes plus depreciation. "own" is the parent's ownership stake of the subsidiary. "leverage" is the sum of the subsidiary's short-term and long-term debts divided by assets. "ln(asset)" is log of assets. "age" is the firm's age and "age^2" is its squared value. T-statistics are reported in parenthesis. We include year dummy and firm fixed effects. We use robust standard errors clustered by firm-level.

	(1)	(2)	(3)	(4)	(5)	(6)
WS	0.127	-0.0119	-0.0319			
	(1.329)	(-0.167)	(-0.507)			
WS∗MTBP				0.0582	-0.0169	-0.0262
				(1.117)	(-0.445)	(-0.711)
MTBP	-0.0840*	-0.0831*	-0.0835*	-0.115**	-0.0741*	-0.0696*
	(-1.687)	(-1.681)	(-1.688)	(-2.402)	(-1.731)	(-1.789)
CF/L.asset	-0.0217	-0.0190	-0.0221	-0.0224	-0.0188	-0.0219
	(-0.532)	(-0.461)	(-0.512)	(-0.552)	(-0.457)	(-0.509)
own		0.00501	0.00606**		0.00519	0.00609**
		(1.526)	(1.986)		(1.633)	(2.006)
leverage			0.0113			0.0123
			(0.155)			(0.170)
ln(asset)			0.150			0.150
			(1.451)			(1.451)
age			0.0165			0.0167
			(1.243)			(1.252)
age^2			-0.000201			-0.000203
			(-1.094)			(-1.102)
Constant	0.151**	-0.210	-2.018*	0.217***	-0.231	-2.035*
	(2.352)	(-0.781)	(-1.693)	(5.162)	(-0.852)	(-1.694)
Observations	1,359	1,359	1,350	1,359	1,359	1,350
Subsidiaries	462	462	462	462	462	462

*** p<0.01, ** p<0.05, * p<0.1

Table 17: Capital expenditure: Wholly owned subsidiaries

The dependent variable is subsidiary's capital expenditure divided by lagged fixed tangible assets. The independent variables are defined as follows. "CTSS" is a dummy variable that takes one when the subsidiary's parent introduces the CTS. "MTBP" is the parent's market to book ratio defined by the sum of parent's market value of stocks and debts divided by the parent's assets. "CTSS$*$MTBP" is an interaction term of CTSS and MTBP dummy variables. "L.asset" is the subsidiary's lagged fixed tangible assets. "CF" is the subsidiary's cash flow that is defined as income before extraordinary items and taxes plus depreciation. "own" is the parent's ownership stake of the subsidiary. "leverage" is the sum of the subsidiary's short-term and long-term debts divided by assets. "ln(asset)" is log of assets. "age" is the firm's age and "age^2" is its squared value. T-statistics are reported in parenthesis. We include year dummy and firm fixed effects. We use robust standard errors clustered by firm-level.

	(1)	(2)	(3)	(4)
CTSS	0.0656**	0.0655**		
	(2.509)	(2.464)		
CTSS$*$MTBP			0.0419***	0.0399***
			(3.239)	(3.002)
MTBP	0.0229*	0.0208	0.0193	0.0175
	(1.798)	(1.567)	(1.501)	(1.301)
CF/L.asset	0.0166	0.0141	0.0166	0.0141
	(1.207)	(1.111)	(1.209)	(1.115)
leverage		0.0325**		0.0321**
		(2.258)		(2.231)
ln(asset)		0.146***		0.144***
		(5.138)		(5.071)
age		-0.0100**		-0.0100**
		(-2.440)		(-2.446)
age^2		0.000102		0.000102
		(1.611)		(1.612)
Constant	0.176***	-0.957***	0.181***	-0.934***
	(7.172)	(-3.594)	(7.300)	(-3.502)
Observations	9,825	9,738	9,825	9,738
Subsidiaries	2,529	2,516	2,529	2,516

*** p<0.01, ** p<0.05, * p<0.1

Table 18: R&D investment: Wholly owned subsidiaries

The dependent variable is subsidiary's R&D investment divided by lagged fixed tangible assets. The independent variables are defined as follows. "CTSS" is a dummy variable that takes one when the subsidiary's parent introduces the CTS. "MTBP" is the parent's market to book ratio defined by the sum of parent's market value of stocks and debts divided by the parent's assets. "CTSS∗MTBP" is an interaction term of CTSS and MTBP dummy variables. "L.asset" is the subsidiary's lagged fixed tangible assets. "CF" is the subsidiary's cash flow that is defined as income before extraordinary items and taxes plus depreciation. "own" is the parent's ownership stake of the subsidiary. "leverage" is the sum of the subsidiary's short-term and long-term debts divided by assets. "ln(asset)" is log of assets. "age" is the firm's age and "age^2" is its squared value. T-statistics are reported in parenthesis. We include year dummy and firm fixed effects. We use robust standard errors clustered by firm-level.

	(1)	(2)	(3)	(4)
CTSS	0.0730	0.0707		
	(1.366)	(1.376)		
CTSS∗MTBP			0.0263	0.0242
			(1.524)	(1.524)
MTBP	-0.00200	-0.00162	-0.00461	-0.00411
	(-0.114)	(-0.0902)	(-0.247)	(-0.217)
CF/L.asset	0.0100	0.00930	0.0101	0.00935
	(0.682)	(0.656)	(0.682)	(0.656)
leverage		0.0306		0.0306
		(1.585)		(1.576)
ln(asset)		0.0772		0.0771
		(1.250)		(1.233)
age		0.00248		0.00249
		(0.394)		(0.394)
age^2		-5.88e-05		-5.94e-05
		(-0.666)		(-0.670)
Constant	0.102***	-0.624	0.106***	-0.620
	(4.326)	(-0.993)	(4.477)	(-0.978)
Observations	4,047	4,030	4,047	4,030
Subsidiaries	1,298	1,297	1,298	1,297

*** p<0.01, ** p<0.05, * p<0.1

Table 19: Capital expenditure: Partly owned subsidiaries

The dependent variable is subsidiary's capital expenditure divided by lagged fixed tangible assets. The independent variables are defined as follows. "CTSS" is a dummy variable that takes one when the subsidiary's parent has introduced the CTS. "PS" is a dummy variable that takes one when the subsidiary is partly owned. "MTBP" is the parent's market to book ratio defined by the sum of parent's market value of stocks and debts divided by the parent's assets. "CTSS∗PS" ("CTSS∗PS∗MTBP") is an interaction term of CTSS and PS (CTSS, PS, and MTBP) dummy variables. "L.asset" is the subsidiary's lagged fixed tangible assets. "CF" is the subsidiary's cash flow that is defined as income before extraordinary items and taxes plus depreciation. "own" is the parent's ownership stake of the subsidiary. "leverage" is the sum of the subsidiary's short-term and long-term debts divided by assets. "ln(asset)" is log of assets. "age" is the firm's age and "age^2" is its squared value. T-statistics are reported in parenthesis. We include year dummy and firm fixed effects. We use robust standard errors clustered by firm-level.

	(1)	(2)	(3)	(4)	(5)	(6)
CTSS∗PS	-0.00362	-0.0645***	-0.0760***			
	(-0.196)	(-2.618)	(-3.006)			
CTSS∗PS∗MTBP				-0.00734	-0.00926	-0.0161
				(-0.708)	(-0.907)	(-1.551)
CTSS		0.0687***	0.0705***			
		(3.139)	(3.161)			
MTBP	0.0223**	0.0228**	0.0196*	0.0228**	0.0234**	0.0207*
	(2.072)	(2.122)	(1.782)	(2.107)	(2.158)	(1.867)
CF/L.asset	0.0258	0.0257	0.0215	0.0258	0.0258	0.0215
	(1.599)	(1.598)	(1.487)	(1.599)	(1.597)	(1.484)
own		-0.00110**	-0.000797		-0.000971*	-0.000652
		(-2.017)	(-1.529)		(-1.770)	(-1.248)
leverage			0.0389***			0.0400***
			(2.894)			(2.999)
ln(asset)			0.174***			0.175***
			(6.747)			(6.758)
age			-0.00747***			-0.00714**
			(-2.598)			(-2.522)
age^2			7.52e-05*			7.05e-05*
			(1.822)			(1.732)
Constant	0.158***	0.255***	-1.216***	0.157***	0.242***	-1.242***
	(9.262)	(5.278)	(-4.968)	(9.165)	(4.991)	(-5.062)
Observations	16,172	16,172	16,049	16,172	16,172	16,049
Subsidiaries	3,816	3,816	3,798	3,816	3,816	3,798

*** p<0.01, ** p<0.05, * p<0.1

Table 20: R&D investment: Partly owned subsidiaries

The dependent variable is subsidiary's R&D investment divided by lagged fixed tangible assets. The independent variables are defined as follows. "CTSS" is a dummy variable that takes one when the subsidiary's parent has introduced the CTS. "PS" is a dummy variable that takes one when the subsidiary is partly owned. "MTBP" is the parent's market to book ratio defined by the sum of parent's market value of stocks and debts divided by the parent's assets. "CTSS∗PS" ("CTSS∗PS∗MTBP") is an interaction term of CTSS and PS (CTSS, PS, and MTBP) dummy variables. "L.asset" is the subsidiary's lagged fixed tangible assets. "CF" is the subsidiary's cash flow that is defined as income before extraordinary items and taxes plus depreciation. "own" is the parent's ownership stake of the subsidiary. "leverage" is the sum of the subsidiary's short-term and long-term debts divided by assets. "ln(asset)" is log of assets. "age" is the firm's age and "age^2" is its squared value. T-statistics are reported in parenthesis. We include year dummy and firm fixed effects. We use robust standard errors clustered by firm-level.

	(1)	(2)	(3)	(4)	(5)	(6)
CTSS∗PS	-0.0450**	-0.0985**	-0.0987**			
	(-1.992)	(-2.007)	(-2.069)			
CTSS∗PS∗MTBP				-0.0315**	-0.0301*	-0.0311*
				(-1.965)	(-1.887)	(-1.918)
CTSS		0.0699	0.0686			
		(1.530)	(1.546)			
MTBP	-0.00711	-0.00579	-0.00659	-0.00514	-0.00543	-0.00620
	(-0.575)	(-0.492)	(-0.552)	(-0.418)	(-0.442)	(-0.497)
CF/L.asset	0.0112	0.0112	0.0106	0.0111	0.0111	0.0105
	(0.794)	(0.800)	(0.778)	(0.791)	(0.791)	(0.769)
own		0.000493	0.000709		0.000737	0.000957*
		(0.796)	(1.263)		(1.261)	(1.678)
leverage			0.0184			0.0178
			(1.375)			(1.346)
ln(asset)			0.0539			0.0555
			(1.549)			(1.561)
age			0.00141			0.00163
			(0.394)			(0.433)
age^2			-3.17e-05			-3.55e-05
			(-0.623)			(-0.663)
Constant	0.104***	0.0611	-0.466	0.102***	0.0394	-0.504
	(6.533)	(1.074)	(-1.333)	(6.374)	(0.733)	(-1.365)
Observations	7,364	7,364	7,337	7,364	7,364	7,337
Subsidiaries	2,086	2,086	2,082	2,086	2,086	2,082

*** p<0.01, ** p<0.05, * p<0.1