Essays on Tax and Environmental Policies

by

Makoto Hasegawa

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Economics)
in The University of Michigan
2013

Doctoral Committee:

Professor Joel B. Slemrod, Chair
Professor James R. Hines Jr.
Professor Stephen W. Salant
Associate Professor Jagadeesh Sivadasan

ACKNOWLEDGEMENTS

I am especially grateful to the members of my dissertation committee, Joel Slemrod (Chair), James Hines, Stephen Salant, and Jagadeesh Sivadasan, for their invaluable advice, encouragement, and mentoring. I also appreciate the helpful comments and suggestions received from David Agrawal, David Albouy, Michael Devereux, Christian Gillitzer, Tom Neubig, Masanori Orihara, seminar participants at the U.S. Department of the Treasury, the University of Michigan, the National Graduate Institute for Policy Studies (GRIPS), and Florida State University, and participants in the Michigan Tax Invitational, the Centre for Business Taxation Doctoral Meeting at the University of Oxford, and the National Tax Association Conference. I gratefully acknowledge the financial support from the Nakajima Foundation and the University of Michigan (Department of Economics, Center for Japanese Studies, Center for International Business Education and Research, Office of Tax Policy Research). The research for Chapter I was conducted as part of the research project "Determinants of the Productivity Gap among Firms in Japan," which was undertaken at the Research Institute of Economy, Trade and Industry (RIETI). All errors are my own.

TABLE OF CONTENTS

LIST OF FIGURES

Figure

LIST OF TABLES

Table

LIST OF APPENDICES

Appendix

ABSTRACT

Essays on Tax and Environmental Policies

by

Makoto Hasegawa

Chair: Joel Slemrod

This dissertation concerns tax and environmental policy issues central to recent policy-making debates. Chapter I is written with Kozo Kiyota and concerns the design of international tax systems. In 2009, Japan introduced a foreign dividend exemption that exempts from home taxation dividends remitted by Japanese-owned foreign affiliates to their parent firms. This paper examines the effect of dividend exemption on profit repatriations by Japanese multinationals. We find the heterogeneous responses of Japanese multinationals to dividend exemption. Foreign affiliates with a large stock of retained earnings increased dividend payments more than other affiliates with the enactment of dividend exemption in 2009. However, the increase in dividend payments was not associated with foreign corporate tax rates.

Chapter II is motivated by corporate tax reforms of OECD countries that tend to include both statutory tax rate reductions and base broadening (tax-cut-cum-base-broadening reforms). Analyzing an international tax competition model over tax rates and bases, I show that when the profitability of outward foreign direct investment increases relative to the domestic rent of a firm in the home country, the country

undertakes a tax-cut-cum-base-broadening reform. I also show that if the domestic rent is large relative to the amount of income shifting by multinational firms at the symmetric equilibrium, larger countries set higher statutory tax rates and a narrower tax bases.

Chapter III is written with Stephen Salant. Previous analyses of cap-and-trade programs regulating carbon emissions assumed that firms must surrender permits as they pollute. If so, then the price of permits may remain constant over measurable intervals if the government injects additional permits at a ceiling price or may even collapse if more permits are injected through an auction. However, no cap-and-trade program actually requires continual compliance. The three federal bills and California's AB-32, for example, instead require that firms surrender permits only periodically to cover their cumulative emissions since the last compliance period. We develop a methodology for analyzing the effects of such permit injections and show that anticipated injections of additional permits during the compliance period should have different effects than under continual compliance.

CHAPTER I

The Effect of Moving to a Territorial Tax System on Profit Repatriations: Evidence from Japan

1.1 Introduction

In an increasingly globalized world, the design of international tax policies, regarding whether and how to tax corporate incomes earned in foreign countries by multinational firms, has received a great deal of attention from policymakers and economists in advanced countries. While taxing foreign source income would raise revenue, international tax rules significantly influence the business activities of multinational corporations, including the location of foreign direct investment, income reallocation (income shifting) through transfer pricing, and profit repatriation. The United States taxes foreign income upon repatriation, allowing foreign tax credits for corporate income taxes and other related taxes paid to foreign governments under the so-called *worldwide income tax system*. In contrast to a worldwide income tax system, a *territorial tax system* exempts foreign income from home taxation; such systems are employed by many advanced countries, including Australia, Belgium, Canada, France, Germany, Italy, and the Netherlands.[1] In the United States, policymakers and economists have long discussed changing the current worldwide tax system to a

[1] As of 2008, 21 of the 30 OECD countries employed a territorial tax system (METI, 2008).

territorial tax system.

Japan, the focus of this study, had a worldwide income tax system until the end of March 2009. At that time, the Japanese government was concerned that under the worldwide tax system, Japanese multinational corporations retained abroad a large portion of foreign profits earned by their affiliates and did not repatriate them to Japan. Japanese firms arguably had incentive to do so because their foreign incomes were taxed at high rates (as high as 40 percent) upon such repatriation.[2] To stimulate dividend repatriations from Japanese-owned foreign affiliates, Japan introduced a permanent foreign dividend exemption in April 2009 and exempted from home taxation dividends remitted by foreign affiliates to their Japanese parent firms. Thus, with the introduction of the dividend exemption system, the Japanese corporate tax system moved to a territorial tax system.

This paper examines the effect of dividend exemption on profit repatriations by Japanese multinationals. Using affiliate-level data, we investigate whether the switch to the dividend exemption system increased the amount of dividend payments by foreign affiliates, as the Japanese government expected, and whether the responsiveness of dividend remittances to foreign tax rates (corporate income taxes and withholding income taxes on repatriated dividends) was changed by the adoption of the dividend exemption system. Few studies have empirically tested the effects of a "permanent" dividend exemption and examined the actual outcomes of changing the regime from a worldwide tax system to a territorial tax system.[3] Egger et al. (2011) study foreign dividend exemption enacted in the tax reform of the United Kingdom in 2009 and find that foreign affiliates owned by U.K. multinational firms responded to the tax reform by increasing dividend payments to their owners. Tajika et al. (2012) inves-

[2]In 2009, the corporate income tax rate of Japan was the highest among the OECD member countries (OECD, 2010).

[3]The previous literature utilizes cross-country differences in international tax systems to examine the effect of corporate taxes under the two tax regimes on foreign direct investment (Slemrod, 1990; Hines, 1996; Altshuler and Grubert, 2001). Desai and Hines (2004) estimate a tax burden on foreign income of $50 billion per year under the U.S. worldwide income tax system.

tigate the impact of Japan's dividend exemption on dividends received by Japanese parent firms from their foreign subsidiaries. They find that more parent firms, especially those facing greater demand for cash, increased dividends received from their foreign affiliates in response to the enactment of dividend exemption in 2009.[4] Unlike Tajika et al. (2012), this paper studies the effect of dividend exemption on dividend payments at the affiliate level and the responsiveness of dividend payments to repatriation tax costs. Each foreign affiliate faced a different tax cost of paying dividends to its parent firm in Japan under the worldwide tax system, depending on the corporate tax payments to the host country and the withholding tax payments on dividends. Thus, the advantage of our study is that we can utilize the variations in the tax costs of dividend repatriations among affiliates to identify the impact of the tax reform on dividend repatriations.

We use the micro database of the annual survey conducted by the Ministry of Economy, Trade and Industry of Japan (METI), *The Survey of Overseas Business Activities*. The survey provides information on the financial and operating characteristics of Japanese firms operating abroad, including dividends paid to Japanese investors. We analyze the data from 2007 to 2009 to focus on the first-year response of Japanese multinationals to the dividend exemption system, noting that the first-year response is likely to be different from that in subsequent years for two reasons. First, as we will explain in detail in the next section, most Japanese multinationals expected the introduction of the dividend exemption system before the end of the 2008 accounting year. Thus, they might have reduced dividend repatriations in 2008 in anticipation of the adoption of the dividend exemption system and increase them in 2009. Second, some firms may have repatriated as a one-time choice in 2009 large amounts of foreign income that they had retained and accumulated over a long period

[4] Some studies have investigated the effects of the one-time dividend deductions permitted by the American Jobs Creation Act of 2004 on the profit repatriations, domestic investment and employment, market values, and income shifting behavior of U.S. multinational corporations (Oler et al., 2007; Blouin and Krull, 2009; Redmiles, 2009; Bradley, 2011; Dharmapala et al., 2011).

to avoid taxation in Japan.[5]

We find that Japanese corporate taxes had a significant negative effect on dividend repatriations before 2009 under the worldwide income tax system. Despite the dividend exemption system substantially eliminating corporate tax liabilities on repatriated dividends in Japan, our analysis of the survey data provides no evidence that the dividend exemption system stimulated dividend repatriations of the typical foreign affiliate that had paid no dividends under the worldwide tax system. However, the response of Japanese multinationals to dividend exemption was heterogeneous. Foreign affiliates that had retained and accumulated large profits under the worldwide tax system increased dividend payments more than other affiliates with the enactment of dividend exemption in 2009. Therefore, dividend exemption fulfilled the main aim to stimulate dividend repatriations from foreign affiliates with a large stock of retained earnings in line with the expectation of the Japanese government.

Surprisingly, we find no evidence that the responsiveness of dividend repatriations to foreign tax rates changed with the enactment of dividend exemption. More precisely, the increase in dividend payments was not associated with either the grossed-up tax rate difference between Japan and foreign countries, or the withholding tax rates on repatriated dividends. The Japanese government was concerned that adopting a territorial tax system may facilitate tax avoidance by multinational corporations shifting foreign income to low tax countries. Though it might take more time for companies to change their tax strategies in response to the tax reform, our results suggest that Japanese parent firms did not immediately respond to dividend exemptions by reallocating their foreign profits to their foreign affiliates in low tax countries and increasing dividend repatriations by those affiliates in 2009.

[5] In addition, the response specific to the first year of the dividend exemption system, if any, would be important in the comparison with the American Job Creation Act of 2004 enacted in the United States, which gave U.S. corporations a one-time deduction of 85 percent of dividends received from their foreign affiliates under some conditions. As we will discuss in the next section, the laws enacted in Japan and the United States are quite different in terms of the conditions and procedures of exempting received dividends.

The paper proceeds as follows. The next section describes the background and the provisions of dividend exemption enacted in Japan. Section 1.3 calculates the tax costs of remitting profits from foreign subsidiaries to their parent firms in Japan by dividends, royalties or interest, and shows how Japanese dividend exemption has changed the tax costs of profit repatriations. Section 1.4 describes the data we use. Section 1.5 presents empirical results from our preliminary analysis regarding the first-year response of Japanese multinationals to dividend exemption. Section 1.6 extends the empirical model in Section 1.5 to analyze the heterogeneity of the responses to dividend exemption depending on the size of the stock of retained earnings of foreign affiliates. Section 1.7 present the results of robustness tests and alternative specifications. Section 1.8 concludes.

1.2 The Dividend Exemption System Enacted in Japan in 2009

In May 2008, a subcommittee on international taxation at METI began to discuss the introduction of a dividend exemption in the corporate tax reform for 2009; this was publicly known because newspaper articles reported this development at the time.[6] In August 2008, the subcommittee released an interim report and proposed introducing a dividend exemption (METI, 2008). In the report, METI estimated that the stock of retained earnings of Japanese-owned foreign affiliates was 17 trillion Japanese yen as of 2006.[7] Their concern was that an excessive amount of profit was retained in foreign countries to avoid home-country taxation in Japan, which distorted the decisions of Japanese corporations on the timing of profit repatriations and reduced domestic R&D investment that could be financed from foreign-source

[6] The discussion of Japan's foreign dividend exemption in this section largely draws on Aoyama (2009) and Masui (2010).

[7] Seventeen trillion yen are worth about 15 billion U.S. dollars at the 2006 exchange rate of 1 USD = 116.299 JPY (UNCTAD, 2012).

income. In November 2008, the Tax Commission also recommended the introduction of a dividend exemption system. Finally, this regime change was included in the legislation of the 2009 tax reform. The legislation was passed into law on March 27, 2009 and came into effect on April 1, 2009.[8]

The dividend exemption system permits Japanese resident corporations to deduct from taxable income 95 percent of dividends received from foreign affiliates in accounting years commencing on or after April 1, 2009. The rest (five percent) of the dividends are regarded as expenses incurred by parent firms for earning the dividends and are added to the calculation of their taxable incomes in Japan.[9] In order to qualify for dividend exemption, a parent firm must have held at least 25 percent of the shares of its affiliate for at least six months as of the dividend declaration date. While dividend exemption would reduce corporate tax liabilities on repatriated dividends in Japan, foreign tax credits no longer apply to withholding taxes on repatriated dividends imposed by host countries.

The new system is still quite distant from pure source-based taxation. As the term "dividend" exemption suggests, it only exempts foreign income in the form of paid dividends and does not apply to other types of foreign source income, including royalties, interest payments, income earned by foreign branches, and capital gains. Foreign taxes imposed on those income types continue to be creditable under the direct foreign tax credit system in Japan.

Finally, because this paper focuses on the first-year response to dividend exemption, the difference between Japan's foreign dividend exemption enacted under the

[8]The subcommittee also examined the possibility of introducing a one-time dividend exemption similar to the American Jobs Creation Act of 2004, limiting the use of dividends exempted from home taxation. However, the subcommittee concluded that a one-time dividend exemption would stimulate dividend repatriations only during the period under the exemption rule and would have an aftereffect that would counteract the effect of dividend exemption. They were also concerned that limiting the use of exempted dividends would distort the managerial decisions and undermine managerial efficiency of Japanese corporations (METI, 2008).

[9]The expenses corresponding to the five percent of the repatriated dividends are assumed to be deducted from the taxable incomes of parent firms when they invest in their subsidiaries, and thus, would not be exempted upon repatriation under the new exemption system.

2009 tax reform and the dividend tax deduction under the American Jobs Creation Act of 2004 (AJCA) is also noteworthy. First, while the AJCA provides U.S. multinational corporations with a special one-time deduction of 85 percent of dividends received from their foreign affiliates, Japan's dividend exemption is permanent. Second, under the AJCA, the 85 percent exemption applies only to "extraordinary dividends," which are defined as dividend payments exceeding average repatriations over a five-year period ending before July 1, 2003, excluding the highest and lowest years.[10] Therefore, the exemption is limited to a part of dividends paid (extraordinary dividends), and U.S. multinationals could claim the exemption only if they received foreign dividends more than the average amount. On the other hand, Japan's dividend exemption applies to 95 percent of *all* dividends as long as the conditions described above are satisfied.[11] Thus, we note that the exemption permitted under the new tax system in Japan is quite different from and more generous than the exemption under the AJCA in the United States.

1.3 How Dividend Exemption Affects Profit Repatriations of Japanese Multinationals

Hartman (1985) demonstrated that under certain conditions, repatriation taxes do not affect the decisions on marginal investment and dividend payments made by "mature" subsidiaries that finance their marginal investment out of their own retained earnings. However, this result depends on the assumption that repatriation tax rates are constant over time. This assumption could fail to hold because repatriation tax rates on dividends change depending on the foreign tax credit positions of parent firms under a worldwide income tax system and the definition of taxable income (tax

[10] In addition, to be eligible for the dividends-received deduction, dividends must be paid in cash and invested in approved activities in the United States, although this requirement may not be binding for U.S. multinationals (Blouin and Krull, 2009; and Dharmapala et al., 2011).

[11] The Japanese government estimates that given the requirements described above, more than 95 percent of foreign affiliates would be eligible for dividend exemption.

bases) in host countries.[12]

In addition to those cases, repatriation tax rates also vary because of changes in the international tax regime. As we discussed in the previous section, Japanese firms learned at the latest in May 2008 that the government was discussing the introduction of a dividend exemption. Thus, they could expect the tax regime change before the end of the 2008 accounting year, and some firms may have expected it even earlier. In this situation, as we show in Appendix A, even mature foreign affiliates would increase dividend payments to their parent firms in response to a decrease in the repatriation tax rate due to the enactment of dividend exemption.

In what follows, we calculate the tax costs of remitting profits from foreign subsidiaries to their parent firms in Japan by dividends, royalties, or interest, given their decisions on foreign direct investment and show how Japan's dividend exemption has changed the tax costs of profit repatriations. We will then make predictions for our empirical analysis based on the changes in the repatriation tax costs.

To consider tax liabilities on foreign dividends under Japan's worldwide tax system (before April 2009) and the new exemption system (after April 2009), we calculate the tax costs of remitting an additional dollar of foreign income to Japan by dividends, royalties or interest. Let Y_{ijc} denote the pre-tax profit of affiliate i operating in country c owned by parent j and T_{ijc} the foreign corporate income tax paid by subsidiary i. We define the average subsidiary tax rate as $\tau_{ijc} = T_{ijc}/Y_{ijc}$. Denote the statutory corporate tax rate of Japan and country c by τ_H and τ_c, respectively. The withholding tax rates on dividends, royalties, and interest payments are w_c^D, w_c^R, and w_c^I, respectively.

Under the worldwide tax system in Japan before April 2009, the tax liability of parent j to receive one dollar of dividends from its own affiliate i in country c

[12] There is evidence that repatriation taxes discourage dividend payouts of U.S. corporations (Hines and Hubbard, 1990; Grubert, 1998; Desai et al., 2001). In contrast, using Japanese affiliate-level data, Tajika and Nakamura (2008) find no evidence of a significant effect of corporate taxes on dividend repatriation by Japanese multinationals.

depends on the excess foreign tax credit position of parent j: whether the parent is in a situation of *excess limit* or *excess credit*. A parent firm whose foreign tax payments are less than the foreign tax credit limit, where the foreign tax credit limit is calculated as the total foreign taxable income times the Japanese corporate tax rate, is referred to as being in excess limit. In contrast, if the foreign tax payments are greater than the foreign tax credit limit, the parent is referred to as being in excess credit and can use excess foreign tax credits — the difference between the foreign tax payments and the foreign tax credit limit — to reduce the Japanese tax obligations on foreign source income in the next three years.

Suppose parent firm j is in excess limit. Then it could claim foreign tax credits for the taxes paid to host country c when affiliate i remits one dollar of dividends. The dollar of dividends would be deemed as $1/(1-\tau_{ijc})$ dollars of taxable income in Japan (gross-up formula), which yields the corporate tax liability of $\tau_H/(1-\tau_{ijc})$. Parent i also has to pay withholding taxes on the dividend w_c^D to country i. Thus, the total tax payment to receive one dollar of dividends is $\left[\tau_H/(1-\tau_{ijc})+w_c^D\right]$. Parent i can also claim foreign tax credits for the taxes paid to country c: the corporate tax payment $\tau_{ijc}/(1-\tau_{ijc})$ and the withholding tax on the dollar of dividends w_c^D. Thus, the net tax payment of parent j to receive one dollar of dividends from its affiliate i in country c can be written as P_{ijc} such that

$$P_{ijc} \equiv \left[\frac{\tau_H}{1-\tau_{ijc}}+w_c^D\right]-\left[\frac{\tau_{ijc}}{1-\tau_{ijc}}+w_c^D\right]=\frac{\tau_H-\tau_{ijc}}{1-\tau_{ijc}},$$

which is the difference between the Japanese statutory tax rate and the subsidiary average tax rate grossed up by the subsidiary average tax rate.

If parent j is in an excess credit position, the parent can use excess foreign tax credits to wipe out the Japanese corporate tax liability.[13] Then the net tax payment

[13] Even when parent j is in an excess credit position, the foreign tax credit that parent j can claim is limited up to the Japanese tax liability on the dollar of dividends ($\tau_H/(1-\tau_{ijc})$).

is w_c^D. In sum, the tax costs of remitting one dollar of dividends can be written as

$$\begin{cases} P_{ijc} = (\tau_H - \tau_{ijc})/(1-\tau_{ijc}) & \text{if parent } j \text{ is in excess limit;} \\ w_c^D & \text{if parent } j \text{ is in excess credit.} \end{cases} \tag{1.1}$$

After the introduction of the dividend exemption system (after April 2009), parent j can exclude 95 percent of dividends from its taxable income and has to include only five percent of the dividends in taxable income. Thus, the net tax payment to receive the dollar of dividends from affiliate i, or the repatriation tax rate under the new exemption system, is

$$0.05\tau_H + w_c^D. \tag{1.2}$$

Therefore, if parent j is in an excess limit position, the dividend exemption system eliminates almost the entire corporate tax liability in Japan.[14] The repatriation tax cost of repatriating dividends decreases from $(\tau_H - \tau_{ijc})/(1-\tau_{ijc})$ to $0.05\tau_H$ when controlling for the withholding tax rate on dividends w_c^D.[15] On the other hand, because the withholding taxes on dividends are no longer creditable under the dividend exemption system, parent i has to pay w_c^D, which would have been creditable under the worldwide tax system before 2009.

When the repatriation tax costs decrease to $0.05\tau_H$ (controlling for w_c^D), which is the same for all firms, foreign affiliates will increase dividend payments under the new exemption system as long as repatriation taxes are a binding constraint on their dividend payout decisions. In addition, Japanese multinationals face different repatriation tax costs depending on their foreign tax credit positions and the corporate

[14] We note that most Japanese corporations are expected to be in excess limit positions because of the relatively high corporate tax rate of Japan. In the data from 2007 to 2009, only 6.9 percent of foreign affiliates faced average tax rates higher than the Japanese corporate tax rate. Thus, it is reasonable to assume that most parent firms are in excess limit situations or that even if they are in excess credit, they do not have ssubstatial excess foreign tax credits.

[15] In this section, we assume $P_{ijc} = (\tau_H - \tau_{ijc})/(1-\tau_{ijc}) > 0.05\tau_H$. In the data from 2007 to 2009, 91.8 percent of foreign affiliates satisfy this condition.

tax policies of the host countries. Because dividend exemption eliminates Japanese corporate tax liability on repatriated dividends (P_{ijc}), dividend payments should become less sensitive to the difference between the Japanese statutory tax rate and the subsidiary average tax rate grossed up by the subsidiary average tax rate (P_{ijc}) after 2009. In other words, when we measure dividend payments as a fraction of affiliate sales to control for the firm size, foreign affiliates in lower-tax countries (higher P_{ijc}) should pay more dividends scaled by sales than other affiliates under the exemption system. Therefore, we expect the following effects of dividend exemption on profit repatriations by Japanese multinationals:

H1: Dividend repatriations from foreign affiliates increase when controlling for the withholding tax rate on dividends.

H2: Foreign affiliates in lower-tax countries (higher P_{ijc}) should pay more dividends scaled by sales than other affiliates.[16]

H3: Dividend payments become more sensitive to the withholding tax rates on dividends.

While the dividend exemption system substantially changes the tax costs of repatriating foreign dividends, it does not change the tax treatments of repatriated royalties and interest payments at all. Consider the tax costs of remitting one dollar of a royalty or interest from affiliate i to its parent j. Because they are deductible payments, remitting an additional dollar as a royalty or interest will reduce the corporate tax payment in country c by τ_c. The corporate tax liability on the dollar of

[16] Under the Japanese worldwide tax system, foreign tax credits apply to dividends paid by foreign subsidiaries directly owned by Japanese parent firms and their second-tier subsidiaries (sub-subsidiaries). Our data has information on dividend paid by foreign subsidiaries owned by Japanese parents but does not have information on dividend indirectly paid by the second-tier subsidiaries through the first-tier subsidiaries. Therefore, the tax differential P_{ijct} could misrepresent the tax costs for dividends paid by first-tier foreign subsidiaries if a large portion of those dividends originally come from second-tier subsidiaries and if the second tier-subsidiaries face substantially different corporate tax rates in their host countries from those faced by the first-tier subsidiaries.

deductible payments is τ_H. Parent j also has to remit to the government of country c the withholding tax on one dollar of a royalty w_c^R or on the dollar of interest w_c^I.

Then, if parent j is in excess limit, it would claim a foreign tax credit for the withholding tax on the dollar of royalty or interest (w_c^R or w_c^I). The net tax payment of remitting one dollar of deductible payments is $(\tau_H - \tau_c)$. If parent j is in an excess credit position, excess foreign tax credits would reduce the tax liability in Japan by up to τ_H, and the net tax costs would be $\left(w_c^R - \tau_c\right)$ for the royalty payment and $\left(w_c^I - \tau_c\right)$ for the interest payment.

In summary, regardless of the introduction of the dividend exemption system, the net tax costs of remitting one dollar of a royalty can be written as

$$\begin{cases} \tau_H - \tau_c & \text{if parent } j \text{ is in excess limit;} \\ w_c^R - \tau_c & \text{if parent } j \text{ is in excess credit.} \end{cases} \tag{1.3}$$

The net tax costs of remitting one dollar of interest payments can be written as

$$\begin{cases} \tau_H - \tau_c & \text{if parent } j \text{ is in excess limit;} \\ w_c^I - \tau_c & \text{if parent } j \text{ is in excess credit.} \end{cases} \tag{1.4}$$

As Grubert (1998) shows, those tax costs could affect dividend repatriations to the extent that royalties and interest payments substitute or complement dividends as an alternative means of profit repatriations. In the following sections, we empirically examine how the response of dividend payments by Japanese-owned foreign affiliates to the repatriation tax costs changed due to the introduction of the dividend exemption regime and test hypotheses H1-H3.

1.4 Data

We use the micro database of the annual survey conducted by METI, *The Survey of Overseas Business Activities*. The main purpose of this survey is to obtain basic information on the business activities of foreign subsidiaries of Japanese firms. The survey covers all Japanese firms that owned affiliates abroad as of the end of the fiscal year (March 31). A foreign affiliate of a Japanese firm is defined as a firm that is located in a foreign country in which the Japanese firm had at least a 10 percent equity share. The survey provides data on the financial and operating characteristics of Japanese firms operating abroad, including dividends and royalties paid to Japanese investors. Industrial classification is available at the two-digit level.

To control for parent-firm characteristics, we use another METI survey, *The Basic Survey of Japanese Business Structure and Activities*. This survey covers all firms with 50 or more employees and capital or an investment fund of at least 30 million yen, for both manufacturing and non-manufacturing industries. The survey provides data on the financial and operating characteristics of Japanese parent firms.

We merge these two annual cross-section surveys to develop a longitudinal (panel) data set of foreign subsidiaries from 2007 to 2009. Each subsidiary is traced throughout the period using information such as parent and affiliate IDs as a key.[17] After dropping observations with missing dividend values, our panel from the METI surveys contains 27,713 observations of foreign affiliates from 2007 to 2009 with information on dividend payments available.[18]

Table 1.1 provides summary statistics of dividend payments by foreign affiliates for each year from 2007 to 2009. Notably, both the sum and mean of dividend payments in 2009 are larger than those in 2007 and 2008. The total amount of dividend payments

[17] The parent ID is obtained from *The Basic Survey of Japanese Business Structure and Activities*. We also used the information on location and establishment year to trace each subsidiary.

[18] Before 2007, the first METI survey collected dividend payments to Japanese investors every four years.

decreased from 2007 to 2008 by 22.5 percent and increased from 2008 to 2009 by 70 percent. There is a similar trend in the mean of dividend payments. However, it is worth noting that those changes are caused by a small number of foreign affiliates. Although the sum and means of dividends are larger in 2009 than in 2007 and 2008, dividend payments in the seventy-fifth and ninety-fifth percentiles in 2009 are smaller than in 2007 and 2008. This implies that dividend payments above the ninety-ninth percentile in 2009 were larger by far than those in 2007 and 2008.[19] We also note that the distribution of dividend payments is heavily skewed to the left. Most foreign affiliates paid no dividends (as detailed in Table 1.3).

=== Table 1.1 ===

Table 1.2 provides summary statistics of dividend payments by foreign affiliates scaled by their sales to control for the size of the affiliates and changes in foreign exchange rates.[20] While the mean in 2009 is lower that in 2007, the dividend payments as a fraction of sales are larger in 2009 than those in 2007 and 2008 in the ninety-fifth percentile and above. Table 1.3 shows the numbers of foreign affiliates that paid no dividends and that paid dividends to Japanese investors in each year from 2007 to 2009. Strikingly, the proportion of foreign affiliates paying dividends is lowest in 2009 (25.8 percent) among the three years.

=== Tables 1.2 and 1.3 ===

In summary, while dividend payments at higher percentiles increased, the proportion of foreign affiliates paying dividends did not increase in 2009. This is suggestive of the heterogeneous response of Japanese multinationals to dividend exemption. Although the dividend exemption system may not stimulate profit repatriations from

[19]We cannot indicate the maximum and minimum values for the sake of maintaining the confidentiality of the data.

[20]The Japanese yen consistently appreciated over the period as follows: 1 USD = 118 JPY in 2007, 103 JPY in 2008, and 94 JPY in 2009 (UNCTAD, 2012). Thus, the increase in dividend repatriations could be undervalued as measured by Japanese yen without scaling.

most foreign affiliates that had not paid dividends under the worldwide tax system, a small portion of firms that had paid large amounts of dividends under the worldwide tax system may increase dividends paid further as a result of dividend exemption. Those observations motivate our regression analysis in the following sections by taking into account the possibility that the response of foreign affiliates to dividend exemption varies depending on the stock of retained earnings right before 2009.

1.5 Preliminary Analysis

To test our hypotheses H1-H3, we examine how the dividend exemption system affected the repatriation behavior of Japanese multinational corporations and changed the responsiveness of repatriated dividends to repatriation taxes (corporate taxes and withholding taxes) in 2009. One limitation in our data set is that it does not include information on the foreign tax credit positions of parent firms (*excess limit* or *excess credit*). Thus, we cannot identify the tax costs of remitting dividends for each affiliate based on its parent's credit position. However, as Grubert (1998) and Desai et al. (2001) point out, because companies are uncertain about their long-run credit positions and foreign tax credit positions are endogenous to repatriation behavior, adjusting the repatriation tax costs depending on parent foreign tax credit positions would also be problematic.

As a preliminary analysis of dividend repatriation patterns before and after the tax reform, our identification strategy in this section employs a before-and-after comparison using a post-reform dummy variable.[21] We attempt to control for confounding factors that potentially affect dividend payments (measured in Japanese yen), such as macroeconomic conditions, foreign exchange rates, tax policies of host countries, and parent firm characteristics, as follows. First, we scale dividend payments by affil-

[21] Several studies have employed a before-and-after comparison approach to examine policy effects. See, for example, Kim and Kross (1998), Blouin et al. (2004), Chetty and Saez (2005), and Kiyota and Okazaki (2005).

iate sales. Second, in our regression analysis described below, country-industry fixed effects are included to control for systematic differences in dividend payments across different industries and countries, which are possibly due to country-specific macroeconomic conditions over the entire data period. We also control for foreign exchange rates between Japanese yen and local currencies. To take into account demand for internal cash by parent firms, we will control for the profitability and the total debt of parent firms.[22]

We estimate the following equation in the spirit of Grubert (1998):

$$\begin{aligned}\text{Dividend}_{ijct} \quad = \quad & \alpha_0 + \alpha_1 P_{ijct} + \alpha_2 w_{ct}^D + \alpha_3 w_{ct}^R + \alpha_4 w_{ct}^I + \alpha_5 \tau_{ct} \\ & + \beta_0 DE_t + \beta_1 \left(DE_t * P_{ijct}\right) + \beta_2 \left(DE_t * w_{ct}^D\right) + \beta_3 \left(DE_t * w_{ct}^R\right) \\ & + \beta_4 \left(DE_t * w_{ct}^I\right) + \beta_5 \left(DE_t * \tau_{ct}\right) + \gamma X_{ijct} + u_{ijct}, \end{aligned} \tag{1.5}$$

where Dividend_{ijct} is the dividend payments of affiliate i located in country c to its Japanese parent j divided by affiliate sales, in year t. The dummy variable DE_t is equal to one if $t = 2009$ and equal to zero otherwise. This dummy variable and its interaction terms with the tax variables are intended to capture the changes in dividends paid and responsiveness of dividends to the tax variables. As defined in the previous section, P_{ijct} is the grossed-up tax rate differential between Japan and foreign country c.[23] The withholding tax rates of country c in year t on dividends,

[22]One may argue that we can create control and treatment groups using the information on fiscal year end months of parent companies and employ a difference-in-differences estimation, noting that dividend exemption applies to dividends received by parent companies in the accounting years starting on or after April 1, 2009. This requirement implies that parent firms whose accounting years end in March can apply for dividend exemption in the accounting years from 2009, while other firms can do so in the accounting years from 2010. However, we cannot tell from the data exactly when foreign subsidiaries pay dividends to their parents in a year. In addition, if fiscal year end months of parent companies are not March, their foreign subsidiaries should have an incentive to delay dividend payments so that the parents receive them in the accounting year of 2010 (but in the data period for 2009) and can claim exemption for those dividends. Therefore, it is difficult to identify dividends that did not qualify for dividend exemption in the data for 2009.

[23]To apply the gross-up calculation to $P_{ijc} = (\tau_H - \tau_{ijc})/(1 - \tau_{ijc})$ appropriately, we dropped observations with negative corporate tax payments ($T_{ijct} < 0$). The average subsidiary tax rate ($\tau_{ijc} = T_{ijct}/Y_{ijct}$) is set to 0 if $T_{ijct} = 0$ and $Y_{ijct} = 0$, where Y_{ijct} is the pre-tax profit of affiliate j,

royalties, and interest payments are w_{ct}^D, w_{ct}^R, and w_{ct}^I, respectively.[24] The statutory tax rate of country c in year t is τ_{ct}.[25] The vector of other control variables are denoted as X_{ijct}, including the exchange rate between Japanese yen and the local currency in country c normalized to one at the level in 2005, lagged parent net profit scaled by total assets, lagged parent total debt scaled by total assets, country dummies, and industry dummies. To mitigate the influence of outliers, we winsorize all the scaled variables used in the analysis at the top and bottom one percent. The definitions of the variables are summarized in Table 1.4. Table 1.5 provides summary statistics for all of these variables before the winsorization.

=== Tables 1.4 and 1.5 ===

From the hypotheses proposed in the previous section, we expect the signs of the key parameters to be as follows. If the dividend exemption system uniformly stimulated dividend repatriations by foreign affiliates of Japanese multinational firms, the coefficient on DE_t would be estimated to be positive, as hypothesized in H1 ($\beta_0 > 0$). The coefficient on P_{ijct} is expected to be negative ($\alpha_1 < 0$) because higher repatriation tax costs would discourage dividend payments under the worldwide tax system. If dividend payments became less sensitive to the tax rate differential between Japan and foreign countries under the new exemption system as hypothesized in H2,

---

and is also set to 0.5 because foreign tax credits would apply up to 50% of foreign taxable income.

[24]We collect information on withholding tax rates on dividends, royalties, and interest from the database of the Japan External Trade Organization (JETRO), J-FILE (http://www.jetro.go.jp/world/search/cost/). These data provide up-to-date information on the withholding tax rates of 75 countries for 2011. We also collect information on the withholding tax rates of 46-51 countries for 2007-2010 from the reports published by JETRO (http://www.jetro.go.jp/world/reports/). To supplement the information on the withholding tax rates for the countries that JETRO's data do not cover, in cases where Japan has tax treaties with these countries, we use the withholding tax rates determined in the tax treaties. We also obtain the information on the withholding tax rates from the *Worldwide Corporate Tax Guide*, which is published by Ernst & Young, and the *Worldwide Tax Summaries*, which is published by PricewaterhouseCoopers. Finally, our data contains information on the withholding tax rates of 96 countries from 2007 to 2009, which is used in our current analysis.

[25]Data on statutory corporate income tax rates are obtained from the KPMG Corporate and Indirect Tax Survey 2011. The statutory tax rates include sub-central (statutory) corporate income tax rates.

the coefficient on $(DE_t * P_{ijct})$ would be estimated to be positive ($\beta_1 > 0$). Another interpretation of H2 is that if dividend repatriations from lower-tax countries (high P_{ijct}) were discouraged under the worldwide tax system, foreign affiliates in these countries should pay more dividends scaled by sales than other affiliates when dividend exemption substantially eliminates the repatriation tax burden.

The coefficient on w_{ct}^D is expected to be negative ($\alpha_2 < 0$) because the tax price of dividends equals the withholding tax rate on dividends (w_{ct}^D) if a parent firm is in excess credit. If dividend repatriation becomes more sensitive to the withholding tax rates on dividends under the new exemption system, as hypothesized in H3, the coefficient on $(DE_t * w_{ct}^D)$ would be estimated to be negative ($\beta_2 < 0$). The signs of the coefficients on the withholding tax rates and the statutory tax rates would depend on how strongly dividends substitute for royalties or interest as an alternative means of profit repatriations.

We employ a Tobit procedure because most affiliates (72 percent of all affiliates in the sample) pay zero dividends, and thus, the dependent variable in equation (1.5) could be considered as a right-censored variable. We estimate the equation including country and industry fixed effects to control for systematic difference in dividend payments across different industries and countries, and thus use across-affiliate variations to identify the parameters.[26].

Table 1.6 presents the estimation results. The point estimates are marginal effects on the latent dependent variable, which can be interpreted as a "desired" amount of dividend payments.[27] Notably, the estimated coefficient on DE_t is not positive and

[26]We do not include affiliate fixed effects in the Tobit models because of the incidental parameters problem, which renders estimators in non-linear panel data models with fixed effects inconsistent and biased and would be especially serious in a short panel like ours (Greene, 2007).

[27]In our analysis, the key parameters of interest are the interaction terms of DE_t and other tax variables. As Ai and Norton (2003) shows, the interaction effect in nonlinear models is different from the marginal effect of the interaction term. Therefore, in the estimation of our empirical models using a Tobit procedure, the marginal effect of the interaction terms on the observed dividend payments (conditional on positive dividend payments) cannot be calculated in a normal manner. Thus, we focus on the marginal effects on the latent variable for dividend payments, which is a linear function of independent variables.

significantly different from zero in any specifications. This suggests that the dividend exemption system did not increase dividend payments of the "typical" (or median) affiliate that did not pay dividends under the worldwide tax system. This result is inconsistent with hypothesis H1. The coefficient on DE_t, of course, could falsely attribute the change in dividend payments in 2009 due to unobserved macroeconomic factors or the relevant structural shift in the Japanese economy during the data period.[28] However, this result is still surprising because we had expected that multinational firms demonstrate the largest response in the first year of the new exemption system by repatriating accumulated profits in foreign countries.

=== Table 1.6 ===

The estimated coefficient on the tax price of dividends (P_{ijct}) is negative and statistically different from zero at the one-percent level in all specifications. This suggests that the Japanese worldwide tax system significantly discouraged dividend repatriations from foreign affiliates in low tax countries because dividend repatriations triggered an additional tax liability proportional to the difference between Japanese and foreign tax rates under the worldwide tax system. However, the estimated coefficient on ($DE_t * P_{ijct}$) is also negative in all specifications, which is inconsistent with hypothesis H2. This suggests that dividend payments did not become less sensitive to the tax rate differential between Japan and foreign countries in the first year of the dividend exemption system. In other words, foreign affiliates in lower tax countries did not significantly increase dividend payments to their parents more than other affiliates. The coefficient on ($DE_t * w^D_{ct}$) is estimated to be negative, which is consistent with hypothesis H3 but not significant in either of specifications (3) and (4).

In summary, we find no evidence that the dividend exemption system stimulated dividend repatriations of "typical" foreign affiliates as hypothesized in H1 and H2.

[28]Most notably, the financial crisis triggered by the bankruptcy of Lehman Brothers severely hit the Japanese economy in 2008.

There are caveats for interpreting the estimation results. First, one limitation of relying on the DE_t dummy variable to measure the average change in the level of dividend payments of foreign affiliates is that the estimated coefficient on DE_t might falsely capture possible effects of cyclical and secular macroeconomic trends on profit repatriations in spite of our attempt to control for those confounding factors by the various control variables described above. Second, as Tables 1.1 and 1.2 may imply, the response of foreign affiliates to dividend exemption is heterogeneous. Foreign affiliates that have larger payout capacity of dividends than other affiliates, for example those with a large stock of retained earnings, may have responded more flexibly to dividend exemption by increasing dividend payments to their parent firms.

1.6 Heterogeneous Response to Dividend Exemption: By Stock of Retained Earnings

As we described in Section 1.2, one of the main goals of dividend exemption is to stimulate dividend repatriations from foreign affiliates that had retained and accumulated large amounts of foreign profit to avoid home taxation in Japan. Foreign affiliates with a large stock of retained earnings are also expected to show a stronger response to dividend exemption because dividends are distributed from after-tax profits and the stock of retained earnings. In this section, we study a heterogeneous response to dividend exemption depending on the size of retained earnings of foreign affiliates and examine whether foreign affiliates with a large stock of retained earnings in 2008 increased dividend payments in a manner consistent with our hypotheses H1 and H2.

We use information on the stock of retained earnings at the end of years 2007 and 2008 and construct a dummy variable equal to one if the stock of retained earnings scaled by sales is greater than the median value in the sample in the previous year, which is denoted as R_{ijct}, where i is the index for the affiliate owned by parent firm

j. Table 1.7 summarizes dividend payments by foreign affiliates with the stock of retained earnings is larger than the median value in 2008 ($R_{ijc2009} = 1$) and dividend payments by foreign affiliates with $R_{ijc2009} = 0$. While the mean of dividend payments increased by 28.4 percent from 34 million yen in 2008 to 43 million yen in 2009 for foreign affiliates with $R_{ijc2009} = 0$, the mean of dividend payments by those with $R_{ijc2009} = 1$ increased much more sharply by 76.9 percent from 180 million yen in 2008 to 319 million yen in 2009. The mean of dividend payments as a fraction of affiliate sales for affiliates with $R_{ijc2009} = 1$ increased from 4.7 percent in 2008 to 5.5 percent in 2009 while the mean for affiliates with $R_{ijc2009} = 0$ remained almost at the same level between the two years (0.4 percent of affiliate sales). This suggests that foreign affiliates that retained large amounts of foreign profits at the end of 2008 paid larger amount of dividends in 2008 than other affiliates and, in addition, increased sharply dividend payments more sharply in 2009 than other affiliates.

=== Table 1.7 ===

To take into account the heterogeneity of the response to dividend exemption in the regression equation, we estimate equation (1.5) including the dummy variable R_{ijct} and the interaction terms of the dummy variable with each of DE_t, P_{ijct}, w^D_{ct}, $(DE_t * P_{ijct})$, and $(DE_t * w^D_{ct})$ as independent variables. Table 1.8 presents the estimation results. The coefficient on DE_t is still estimated to be negative as in Table 1.6. The coefficient on R_{ijct} is significantly positive, implying that foreign affiliates that had a large stock of retained earnings in the previous year paid more dividends in the next year. In addition, the coefficient on $(R_{ijct} * DE_t)$ is also significantly positive. This suggests that a foreign affiliate with a larger stock of retained earnings in 2008 paid more dividends than other affiliates in 2009, which is consistent with hypothesis H1.[29]

[29] To investigate whether foreign affiliates with a large stock of retained earnings increased desired dividend payments, we also tested whether the sum of the coefficients on DE_t and $(R_{ijct} * DE_t)$ is positive and statistically different from zero. However, we cannot reject the null hypothesis that the sum of these coefficient is less than or equal to zero, possibly because the coefficient on DE_t is not precisely estimated.

The estimated coefficient on $(T_{ij} * DE_t)$ in column (4) implies that foreign affiliates with a large stock of retained earnings desired more dividend payments than other affiliates by 1.8 percent of affiliate sales in 2009.[30]

=== Table 1.8 ===

The coefficients on $(DE_t * P_{ijct})$ and $(R_{ijct} * DE_t * P_{ijct})$ are not precisely estimated in specifications (3) and (4), although we expected that foreign affiliates with a large stock of retained earnings should pay more dividends than other affiliates in 2009 as the grossed-up tax differential between Japan and the host country becomes larger. The coefficient on $(R_{ijct} * DE_t * w^D_{ct})$ is negative, which is consistent with our hypothesis H3, but is not significantly different from zero. These results suggest that the changes in dividend payments in 2009 were not associated with foreign tax rates (corporate income tax rates and withholding tax rates on dividends), while the negative and significant coefficients on P_{ijct} and w^D_{ct} imply that the tax costs on dividends discouraged dividend payments under the worldwide tax system. This may suggest that Japanese multinationals did not aggressively pursue the opportunity to reduce the repatriation tax cost by repatriating more incomes through foreign affiliates in low tax countries in 2009, or that they just did not enough time to change their tax strategies in the first year after the tax regime change.[31]

In summary, the response of Japanese-owned affiliates to dividend exemption is heterogeneous depending on the size of the stock of retained earnings. Even though we could not find an significant effect of dividend exemption on the typical affiliates, foreign affiliates that had retained large amounts of foreign profits increased dividend payments more than other affiliates with the enactment of dividend exemption. In

[30]For the reason described in footnote 27, we focus on the marginal effect on the latent dependent variable (desired amount of dividend payments).

[31]Similar results are obtained when we define the dummy variable R_{ijct} equal to one if the stock of retained earnings scaled by sale is greater than the 75 percentile value in the previous year's sample, and when we define R_{ijct} as a continuous variable equal to the stock of retained earnings scaled by affiliate sales in the previous year.

this sense, dividend exemption helped to fulfill the main aim to stimulate dividend repatriations from foreign affiliates with a large stock of retained earnings in line with the expectation of the Japanese government.

On the other hand, we find no evidence that the responsiveness of dividend repatriations to foreign tax rates significantly changed with the enactment of dividend exemption. The change in dividend payments was not associated with either the grossed-up tax rate difference between Japan and foreign countries, or the withholding tax rates on dividends, which is inconsistent with our hypotheses H2 and H3. The Japanese government was concerned that adopting a territorial tax system may facilitate tax avoidance by multinational corporations shifting foreign income to low tax countries. Though it might take more time for companies to change their tax strategies in response to the tax reform, our results suggest that Japanese parent firms did not immediately respond to dividend exemption by reallocating their foreign profits to their foreign affiliates in low tax countries and increasing dividend repatriations by those affiliates in 2009, and thus may alleviate the concern of the Japanese government.

1.7 Robustness Tests and Alternative Specifications

1.7.1 Robustness Tests

In this section, we describe the results from various robustness tests to see how sensitive the above results are to different specifications. First, one possible concern about the results obtained in the previous sections is that, because the dividend payout capacity increases as the profits of foreign subsidiaries increase, the significant positive coefficient on $(R_{ijct} * DE_t)$ may be caused by an increase in the profitability of foreign subsidiaries with a large stock of retained earnings in 2009 and may not be due to the enactment of dividend exemption. To investigate this issue, we estimate the same regression equations as those in Tables 1.6 and 1.8 replacing the dependent variable by pre-tax profit scaled by affiliate sales.[32] While the coefficient on DE_t is not significant and the coefficient on R_{ijct} is significantly positive, the coefficient on $(R_{ijct} * DE_t)$ is then estimated to be no longer significantly positive. This implies that the positive effect of dividend exemption on dividend payments by foreign affiliates with a large stock of retained earnings is not passed through the improvement of the profitability of foreign subsidiaries with large retained earnings. We also estimate the regression equations using dividend payments scaled by pre-tax profit as a dependent variable and then find similar results to those in Tables 1.6 and 1.8. This implies that foreign affiliates that had accumulated large foreign profits increased dividend payments relative to its pre-tax profit in 2009 than other affiliates.

Second, there may be a concern about division bias when we used dividend payments scaled by affiliate sales. Though the scaling variable is used to control for the subsidiary size, the dependent variable could be overly affected by the year-to-year fluctuation of subsidiary sales, which may bias the estimated coefficients. To explore this issue, we try scaling dividend payments by affiliate capital and estimating the same regression equations in Tables 1.6 and 1.8 by replacing the dependent variable by dividend payments scaled by capital. We then obtain similar results to those in Tables 1.6 and 1.8. Therefore, noting that we also obtained the similar results when scaling dividends by pre-tax profit, we conclude that our results do not depend on whether to scale dividend payments by affiliate sales, pre-tax profit, or capital, which alleviates the concern about division bias.

[32] Unlike the estimation equation for dividend payments, there is no issue on the right-censoring for the pre-tax profits of foreign subsidiaries. Thus, we employ ordinary least squares to estimate the pre-tax profit equation.

1.7.2 Alternative Specifications with One Summary Tax Price

The estimation equations in Section 1.5 and 1.6 focus on capturing the change in the dividend repatriation behavior of Japanese-owned foreign subsidiaries by the dummy variable DE_t and its interaction terms with foreign tax rates including the tax rate differential between Japan and foreign countries (P_{ijct}), the withholding tax rates, and the statutory tax rates of host countries. We employed that specification because our three hypotheses feature the changes in the sensitiveness of dividend repatriations to each of those foreign tax rates separately. However, as an alternative specification, we could use one tax price summarizing the tax costs of dividend repatriations over 2007-2009 and see the responsiveness of dividend payments by foreign affiliates to the summary tax variable.

Assuming parent firm j is in excess limit position, dividend exemption changed the tax cost of paying a dollar of dividends by foreign affiliate i in country c in 2009 from P_{ijc} to $(0.05\tau_H + w_c^D)$, where P_{ijc} is the grossed-up difference between Japan's statutory tax rate and the average subsidiary tax rate, τ_H is the Japanese statutory corporate tax rate, and w_c^D is the withholding tax rate on dividends in country c. Thus the tax price on dividends over the data period can be summarized by

$$\text{Tax Price}_{ijct} \begin{cases} P_{ijc} = (\tau_H - \tau_{ijc})/(1 - \tau_{ijc}) & \text{if } t = 2007, 2008 \\ 0.05\tau_H + w_c^D. & \text{if } t = 2009. \end{cases}$$

We estimate a version of the regression equations in Tables 1.6 and 1.8 including Tax Price_{ijct} as an independent variables instead of using P_{ijct} , w_c^D, and the interaction terms of DE_t with other tax variables as independent variables. Tables 1.9 and 1.10 present the estimation results. Specifications (1) and (2) in Table 1.9 and specification (1) in Table 1.10 do not include DE_t or its interaction terms with Tax Price_{ijct} and R_{ijct}. In these specification, the significantly negative coefficient on Tax

Price$_{ijct}$ suggests that the tax price on dividends discouraged dividend payments by Japanese multinationals over the entire data period.

=== Tables 1.9 and 1.10 ===

Specifications (3) and (4) in Table 1.9 and specifications (2)-(4) in Table 1.10 include DE_t or its interaction terms with Tax Price$_{ijct}$ and R_{ijct} as independent variables. The coefficients on (DE_t*Tax Price$_{ijct}$) and ($R_{ijct} * DE_t*$Tax Price$_{ijct}$) are intended to capture the possible change in the responsiveness of dividend payments to the tax price in 2009. The coefficients on DE_t and $(R_{ijct} * DE_t)$ are intended to capture the change in the level of dividend payments that is not related to the tax price in 2009. In specification (4) in Table 1.9 and specifications (3) and (4) in Table 1.10, the estimated coefficient on DE_t is negative. The coefficient on $(R_{ijct} * DE_t)$ is estimated to be significantly positive in both specifications (3) and (4) in Table 1.10. This suggests that while the typical affiliate decreased dividend payments in 2009, foreign affiliates that had a large retained earnings in 2008 increased dividend payments more than other affiliates with the enactment of dividend exemption and supports the robustness of the result in the previous section.

On the other hand, the estimated coefficients on (DE_t*Tax Price$_{ijct}$) and ($R_{ijct} * DE_t*$Tax Price$_{ijct}$) is more difficult to interpret because as the signs of these coefficients change depending on whether to include DE_t and $(R_{ijct} * DE_t)$ as in specification (4) in Tables 1.9 and 1.10. While the coefficient on Tax Price$_{ijct}$ is significantly negative in all specifications, the sum of the coefficient on Tax Price$_{ijct}$ and that on (DE_t*Tax Price$_{ijct}$) is 0.002 in specification (4) in Table 1.9 and the sum of the coefficients on Tax Price$_{ijct}$ and its interaction terms with DE_t and R_{ijct} is also close to zero in specifications (2) and (4) in Table 1.10. This may suggest that dividend payments became less sensitive to the tax price on dividends in 2009.

1.8 Conclusion

Japan introduced a permanent dividend exemption and moved to a territorial tax system in April 2009. We provide the first evidence about the behavioral response of foreign affiliates to the transition from a worldwide income tax system to a territorial tax system by studying Japan's dividend exemption. We find no evidence that the dividend exemption system stimulated dividend repatriations of the typical foreign affiliate that had paid no dividends under the worldwide tax system. However, the response of Japanese multinationals to dividend exemption was heterogeneous. Foreign affiliates that had retained large amounts of profits were more responsive to the tax system change and started to pay more dividends than other affiliates in 2009. Therefore, dividend exemption helped to fulfill the main aim to stimulate dividend repatriations from foreign affiliates with a large stock of retained earnings in line with the expectation of the Japanese government. On the other hand, we find no evidence that the responsiveness of dividend repatriations to foreign tax rates significantly changed with the enactment of dividend exemption. The change in dividend payments was not associated with either the grossed-up tax rate difference between Japan and foreign countries, or the withholding tax rates on dividends in 2009.

Our results may be informative for international corporate tax policy design in the United States. The Japanese worldwide tax system was similar to that of the United States, and the two countries have the highest corporate tax rates among OECD countries. However, the response of U.S. multinationals to dividend exemption could be somewhat different than that of Japanese multinationals for two reasons.

First, the impact of a dividend exemption on profit repatriations should crucially depend on the proportion of parent firms in excess credit positions. Because foreign affiliates owned by parent firms in excess credit would not face repatriation taxes (P_{ijct}) in home countries under the worldwide tax system, their repatriation behavior would not change substantially with the introduction of dividend exemption. Thus, if the proportion of Japanese multinationals in excess credit positions under the worldwide tax system was larger than that of U.S.-owned affiliates, the impact of dividend exemption in Japan would be smaller than in the United States. In addition, unlike that of the United States, the Japanese worldwide tax system did not require multinational firms to calculate their foreign tax credits for foreign taxes on passive and active incomes separately. Thus, it might have been easier for Japanese multinationals to avoid the repatriation taxes by using excess foreign tax credits (cross-crediting) under the worldwide tax system than for U.S. multinationals.

Second, unlike the United States, Japan has tax-sparing agreements with several countries (Bangladesh, Brazil, China, Philippines, Sri Lanka, Thailand, and Zambia as of June 2012) in its tax treaties. Foreign affiliates in those countries may be less responsive to dividend exemption because the tax sparing provisions could substantially decrease their repatriation tax costs under the worldwide tax system for some of those foreign affiliates. Therefore, the response of U.S. multinationals to dividend exemption could be different (possibly larger) than that of Japanese multinationals. However, even given those considerations, our findings about the heterogeneous response depending on the stock of retained earnings are worth noting.

In conclusion, there are several research issues for the future that are worth mentioning. First, from the policy point of view, it important to analyze a general equilibrium effect of dividend exemption, focusing on the potential trade-off between the decline in tax revenues and the increases in dividend payments; however this issue is beyond the scope of this paper.[33] Second, a focus on foreign direct investment would be an important extension. Under the new exemption system, because foreign dividends are exempt from home taxation and Japanese multinationals must pay corporate income taxes only to host country governments, they should be likely to have more incentive to invest in low-tax countries than they did before April 2009. Because

[33] See Caves (2007, Chapter 8) for a survey on the welfare effects of taxation.

foreign direct investment is conducted from mid- to long-term perspectives, to address these issues, it is imperative that the quality and coverage of firm-affiliate-level panel data be improved and expanded.

Table 1.1: Dividend Payments by Foreign Affiliates (in million yen)

year	sum	mean	sd	p50	p75	p95	p99	N
2007	1109637	131.29	1552.53	0	11	338	2116	8452
2008	859563	92.10	811.13	0	5	287	1575	9333
2009	1458072	146.86	2296.52	0	2	253	1651	9928
Total	3427272	123.67	1687.13	0	5	293	1731	27713

Table 1.2: Dividend Payments by Foreign Affiliates as a Proportion of Sales

year	mean	sd	p50	p75	p95	p99	N
2007	.0473	1.2753	0	.0055	.0623	.2185	8076
2008	.0264	.7823	0	.0037	.0627	.2004	8871
2009	.0404	1.3320	0	.0025	.0762	.2954	9399
Total	.0378	1.1565	0	.0039	.0667	.2451	26346

Table 1.3: Proportion of Foreign Affiliates Paying Dividends

Year	Dividend > 0	Dividend = 0	Total Number of Affiliates	Proportion
2007	2530	5922	8452	30.0 %
2008	2587	6746	9333	27.7 %
2009	2564	7364	9928	25.8 %
Total	7681	20032	27713	27.7 %

Table 1.4: Definitions of Variables

Variable	Definition
Sales	Subsidiary operating revenues without including non-operating income
Dividend/Sales	Subsidiary dividend payments scaled by sales
P_{ijct}	Grossed-up difference between Japanese statutory tax rate and the subsidiary average tax rate
w_{ct}^{D}	Withholding tax rate on dividends
w_{ct}^{R}	Withholding tax rate on royalties
w_{ct}^{I}	Withholding tax rate on interest
τ_{ijct}	Average subsidiary tax rate, which is defined as the corporate tax payment divided by the pretax profit of subsidiary i
τ_{ct}	Statutory corporate tax rate
Exchange_{ct}	Exchange rate between Japanese yen and local currency, which is normalized to one in 2005
Parent Net Profit/Assets	Parent net profit scaled by total assets
Parent Total Debt/Assets	Parent total debt (total current and fixed liabilities) scaled by total assets
Retained Earning/Sales	Subsidiary retained earnings at the end of the account year scaled by sales
Pre-tax Profit/Sales	Subsidiary pretax profit scaled by sales

The subscripts i, j, c, and t intend to indicate the subsidiary, its parent firm, the country where the subsidiary is located, and the year, respectively.

Table 1.5: Descriptive Statistics

variable	**mean**	**sd**	**p25**	**p50**	**p75**	**N**
Dividend/Sales	.0378	1.1565	0	0	.0039	26346
P_{ijct}	.2648	.1673	.1660	.3188	.4069	29009
w_{ct}^{D}	.0672	.0627	0	.1	.1	39034
w_{ct}^{R}	.0887	.0598	.0525	.1	.1	39011
w_{ct}^{I}	.1035	.0448	.1	.1	.1	39011
τ_{ijct}	.1574	.1613	0	.1293	.2889	29009
τ_{ct}	.2883	.0702	.25	.2944	.33	39048
Exchange_{ct}	.9921	.1392	.8832	.9505	1.0664	39105
Parent Net Profit/Assets	.0074	.0668	-.0003	.0149	.0337	39031
Parent Total Debt/Assets	.5699	.2265	.3995	.5908	.7550	39181
Retained Earning/Sales	-.1360	36.8798	-.0098	.0839	.2733	28226
Pre-tax Profit/Sales	.0199	5.8587	.0005	.0336	.0914	31981

Table 1.6: Regressions of the Dividend Equation

	Affiliate Dividend Payment/Sales			
	(1)	(2)	(3)	(4)
DE_t	-0.001		-0.001	-0.012
	(0.002)		(0.008)	(0.011)
P_{ijct}	-0.117***	-0.113***	-0.109***	-0.126***
	(0.005)	(0.005)	(0.006)	(0.008)
$DE_t * P_{ijct}$		-0.014***	-0.024***	-0.005
		(0.005)	(0.008)	(0.010)
w^D_{ct}	-0.066	-0.067	-0.071	-0.063
	(0.059)	(0.059)	(0.061)	(0.083)
$DE * w^D_{ct}$			-0.002	-0.023
			(0.029)	(0.036)
w^R_{ct}	-0.077	-0.079*	-0.062	-0.030
	(0.047)	(0.047)	(0.048)	(0.100)
$DE_t * w^R_{ct}$			0.050	0.078
			(0.048)	(0.060)
w^I_{ct}	-0.055	-0.038	-0.023	-0.124
	(0.115)	(0.115)	(0.117)	(0.178)
$DE_t * w^I_{ct}$			-0.077	-0.064
			(0.052)	(0.064)
τ_{ct}	0.027	0.015	0.020	-0.030
	(0.027)	(0.027)	(0.027)	(0.244)
$DE_t * \tau_{ct}$			0.036	0.063*
			(0.028)	(0.035)
Foreign Exchange Rate	0.005	0.013*	0.002	-0.009
	(0.008)	(0.007)	(0.008)	(0.035)
Lagged Parent Net Profit/Assets				0.044**
				(0.022)
Lagged Parent Total Debt/Assets				-0.018***
				(0.006)
Constant	-0.052*	-0.058**	-0.051*	0.027
	(0.027)	(0.027)	(0.028)	(0.130)
Country and Industry Dummies	Yes	Yes	Yes	Yes
Observations	24,084	24,084	24,084	12,696

DE_t: dummy variable equal to one if $t = 2009$ and equal to zero otherwise. P_{ijct}: grossed-up difference between Japanese statutory corporate tax rate and the subsidiary average tax rate. w^D_{ct}, w^R_{ct}, w^I_{ct}: withholding tax rates on dividends, royalties, and interest, respectively. τ_{ct}: statutory tax rate of country c. Robust standard errors clustered by affiliate in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 1.7: Dividend Payments of Foreign Afffiliates and the Size of the Stock of Retained Earnings

	Affiliates with $R_{ijc2009} = 0$		Affiliates with $R_{ijc2009} = 1$	
Year	Dividend (million yen)	Dividend/Sales	Dividend (million yen)	Dividend/Sales
2008	33.58	0.00413	180.26	0.0468
2009	43.11	0.00405	318.91	0.0597

This table shows the mean of dividend payments in 2008 and 2009 by foreign affiliates in each of the two groups ($R_{ijc2009} = 0$ and $R_{ijc2009} = 1$). Foreign affiliates with $R_{ijc2009} = 0$ are those with a stock of retained earnings scaled by sales less than or equal to the median value in the 2008 sample. Foreign affiliates with $R_{ijc2009} = 1$ are those with a stock of retained earnings scaled by sales greater than the median value in the 2008 sample.

Table 1.8: Regressions of the Dividend Equation including the Stock of Retained Earnings

	Affiliate Dividend Payments/Sales			
	(1)	(2)	(3)	(4)
DE_t	-0.004		-0.016	-0.017
	(0.004)		(0.011)	(0.011)
R_{ijct}	0.062***	0.042***	0.031***	0.031***
	(0.003)	(0.004)	(0.005)	(0.005)
$R_{ijct} * DE_t$	0.011***		0.016**	0.018***
	(0.003)		(0.007)	(0.007)
P_{ijct}	-0.085***	-0.136***	-0.146***	-0.146***
	(0.007)	(0.009)	(0.011)	(0.011)
$DE_t * P_{ijct}$		-0.019**	-0.001	0.001
		(0.009)	(0.013)	(0.013)
$R_{ijct} * P_{ijct}$		0.095***	0.115***	0.114***
		(0.013)	(0.015)	(0.015)
$R_{ijct} * DE_t * P_{ijct}$		0.020*	-0.016	-0.019
		(0.011)	(0.019)	(0.019)
w_{ct}^D	-0.113	-0.086	-0.160*	-0.157*
	(0.078)	(0.075)	(0.084)	(0.085)
$DE_t * w_{ct}^D$			0.022	0.020
			(0.051)	(0.051)
$R_{ijct} * w_{ct}^D$			0.056	0.055
			(0.044)	(0.044)
$R_{ijct} * DE_t * w_{ct}^D$			-0.047	-0.045
			(0.052)	(0.053)
w_{ct}^R	-0.027	-0.067	0.017	0.008
	(0.097)	(0.092)	(0.099)	(0.101)
$DE_t * w_{ct}^R$			0.068	0.061
			(0.059)	(0.059)
w_{ct}^I	-0.047	-0.046	-0.001	-0.004
	(0.184)	(0.182)	(0.186)	(0.188)
$DE_t * w_{ct}^I$			-0.070	-0.065
			(0.063)	(0.064)
τ_{ct}	-0.047	0.112	-0.153	-0.097
	(0.236)	(0.203)	(0.239)	(0.243)
$DE_t * \tau_{ct}$			0.046	0.048
			(0.035)	(0.035)
Foreign Exchange Rate$_{ct}$	-0.014	0.016	-0.031	-0.022
	(0.033)	(0.019)	(0.034)	(0.034)
Constant	-0.012	-0.092	0.069	0.034
	(0.125)	(0.098)	(0.126)	(0.128)
Parent Controls	Yes	Yes	No	Yes
Country and Industry Dummies	Yes	Yes	Yes	Yes
Observations	11,731	11,731	11,881	11,731

R_{ijct}: dummy variable equal to one if the stock of retained earnings scaled by sales is greater than the median value in the previous year's sample. Parent controls include the lagged net profit and the lagged total debt scaled by parent assets. Robust standard errors clustered by affiliate in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 1.9: Dividend Regression Equation with the Single Tax Price

	Affiliate Dividend Payment/Sales			
	(1)	(2)	(3)	(4)
DE_t				-0.033***
				(0.005)
Tax Price_{ijct}	-0.084***	-0.097***	-0.084***	-0.115***
	(0.005)	(0.007)	(0.005)	(0.008)
DE_t*Tax Price_{ijct}			-0.030**	0.117***
			(0.012)	(0.023)
w^R_{ct}	-0.064	0.025	-0.069	-0.120
	(0.042)	(0.078)	(0.043)	(0.081)
w^I_{ct}	-0.165	-0.187	-0.167	-0.114
	(0.108)	(0.149)	(0.108)	(0.148)
τ_{ct}	0.071***	-0.242	0.058**	0.343*
	(0.027)	(0.178)	(0.027)	(0.206)
Foreign Exchange Rate	-0.050***	-0.103***	-0.042***	0.045
	(0.006)	(0.014)	(0.006)	(0.030)
Lagged Parent Net Profit/Assets		0.047**		0.040*
		(0.022)		(0.022)
Lagged Parent Total Debt/Assets		-0.017***		-0.018***
		(0.006)		(0.006)
Constant	-0.020	0.199**	-0.022	-0.190*
	(0.027)	(0.087)	(0.027)	(0.113)
Country and Industry Dummies	Yes	Yes	Yes	Yes
Observations	24,998	13,386	24,998	13,386

DE_t: dummy variable equal to one if $t = 2009$ and equal to zero otherwise. Tax Price_{ijct} is the tax cost on dividends. w^R_{ct}, w^I_{ct}: withholding tax rates on royalties and interest, respectively. τ_{ct}: statutory tax rate of country c. Robust standard errors clustered by affiliate in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 1.10: Dividend Regression Equation with the Single Tax Price and the Stock of Retained Earnings

	Affiliate Dividend Payment/Sales			
	(1)	(2)	(3)	(4)
DE_t			-0.019***	-0.043***
			(0.004)	(0.006)
R_{ijct}	0.071***	0.055***	0.064***	0.035***
	(0.003)	(0.004)	(0.003)	(0.004)
$R_{ijct} * DE_t$			0.013***	0.039***
			(0.003)	(0.006)
Tax Price$_{ijct}$	-0.057***	-0.096***	-0.066***	-0.140***
	(0.007)	(0.009)	(0.007)	(0.011)
$DE_t *$Tax Price$_{ijct}$		-0.086***		0.110***
		(0.027)		(0.040)
$R_{ijct} *$Tax Price$_{ijct}$		0.064***		0.118***
		(0.012)		(0.015)
$R_{ijct} * DE_t *$Tax Price$_{ijct}$		0.125***		-0.082*
		(0.030)		(0.047)
w^R_{ct}	-0.031	-0.019	-0.104	-0.094
	(0.079)	(0.080)	(0.082)	(0.082)
w^I_{ct}	-0.081	-0.070	-0.029	0.005
	(0.169)	(0.171)	(0.168)	(0.173)
τ_{ct}	-0.074	-0.094	0.235	0.237
	(0.179)	(0.188)	(0.206)	(0.207)
Foreign Exchange Rate	-0.056***	-0.058***	0.008	0.020
	(0.015)	(0.019)	(0.029)	(0.030)
Lagged Parent Net Profit/Assets	0.038*	0.038*	0.036*	0.035
	(0.021)	(0.021)	(0.021)	(0.021)
Lagged Parent Total Debt/Assets	0.009*	0.009	0.009	0.008
	(0.006)	(0.006)	(0.006)	(0.006)
Constant	0.029	0.051	-0.160	-0.154
	(0.087)	(0.095)	(0.111)	(0.112)
Country and Industry Dummies	Yes	Yes	Yes	Yes
Observations	12,243	12,243	12,243	12,243

DE_t: dummy variable equal to one if $t = 2009$ and equal to zero otherwise. R_{ijct}: dummy variable equal to one if the stock of retained earnings scaled by sales is greater than the median value in the previous year's sample. Tax Price$_{ijct}$ is the tax cost on dividends. w^R_{ct}, w^I_{ct}: withholding tax rates on royalties and interest, respectively. τ_{ct}: statutory tax rate of country c. Robust standard errors clustered by affiliate in parentheses. *** p<0.01, ** p<0.05, * p<0.1

CHAPTER II

International Tax Competition over Rate and Base: Why Do Countries Undertake Tax-Cut-cum-Base-Broadening Reforms?

2.1 Introduction

Statutory tax rates on corporate incomes of developed countries have fallen substantially in the last three decades. As Figure 2.1 shows, both the mean and the median statutory tax rates of OECD countries have consistently declined since 1985 and fell from 48 percent in 1981 to 26 percent in 2010.[1] Though the weighted mean declined more slowly than the median and the mean because countries with large GDP tend to set higher tax rates, it still decreased from 49 percent in 1981 to 33 percent in 2010. Policy-makers have been concerned that the decline of statutory tax rates is due to tax competition. The theoretical literature on tax competition shows that countries set their tax rates at inefficiently low levels, which leads to the under-provision of public goods (Wilson, 1986; Zodrow and Mieszkowski, 1986).

However, in contrast to the clear reductions of corporate tax rates, the size of corporate tax revenues relative to GDP was quite stable over the same period and

[1] I obtain information on statutory corporate tax rates and on GDP from the OECD Tax Database and the World Banks World Development Indicators database, respectively.

even increased in some measures. Figure 2.2 shows the mean, weighted mean by GDP and median of corporate tax revenues of OECD countries as a percentage of GDP from 1980 to 2010.[2] Both the mean and median increased as a whole. The mean rose from 2.3 percent to 2.9 percent and the median raised from 2 percent to 2.7 percent over the entire period. The weighted mean fluctuated between 2.3 percent and 3.6 percent and remained largely unchanged over the entire period (2.9 percent in 1980 and 2.7 percent in 2010).

As Devereux et al. (2002) summarized, this is mainly because most countries have broadened corporate tax bases while lowering statutory tax rates (tax-cut-cum-base-broadening reforms). Kawano and Slemrod (2011) construct unique measures of corporate tax base changes in OECD countries and find that the probability that a tax broadening reform is undertaken increases significantly when the corporate tax rate is decreased. More recently, corporate tax reforms in Japan and the United States call for tax-cut-cum-base-broadening policies. In 2012, Japan lowered its statutory corporate tax rate from 30 percent to 25.5 percent (28.05 percent including a temporary tax increase) and broadened the tax base by lowering the rate of depreciation allowances. In the U.S., President Obama's 2012 Framework for Business Tax Reform proposes lowering the corporate tax rate from 35 percent to 28 percent and broadening the tax base by eliminating business tax loopholes and tax expenditures.

This paper examines the causes of this tendency in corporate tax reforms and the determinants of corporate tax rate and base changes. For this purpose, I analyze, both theoretically and empirically, international tax competition over statutory tax rates and tax bases to attract mobile capital and profits. The tax-competition literature has exclusively focused on only tax-rate competition, except for Haufler and Schjelderup (2000), Devereux et al. (2008), Becker and Fuest (2011) and Egger and Raff (2011), and thus cannot fully explain government decisions over both corporate tax rates and

[2]The data on corporate tax revenues as percentage of GDP is obtained from the OECD Revenue Statistics database.

bases.

Haufler and Schjelderup (2000) show that when multinational firms have a opportunity to shift their profits across countries through transfer pricing, governments reduce tax rates and distort firms' investment decisions by limiting the deductibility of investment costs from taxable income. In their model, because governments have fixed revenue requirements from corporate taxation, one of two tax instruments (tax rate and base) is automatically determined by the revenue requirement condition. Devereux et al. (2008) set up a model where governments choose both statutory rates and the rates of allowance on capital costs independently and calculate the slope of best response functions of the statutory tax rates and the effective marginal tax rates. Their theoretical model focuses on the slopes of the best response function to make predictions on their empirical model. Becker and Fuest (2011) analyze optimal tax policy regarding tax rate and base in the presence of internationally mobile firms. They show that if the marginal mobile firm that locate in the home country is more profitable than the average firm in the country, the government of the home country sets lower rate of allowance on capital costs compared to the case without the mobility of firms. Egger and Raff (2011) examines the effect of regional integration (a reduction in trade costs) on corporate tax policy over rate and base.

I advance the literature by working on the comparative statics of the Nash equilibrium when countries set both their tax rates and bases and identifying under what conditions and how countries change their tax rates and bases. In my model, an exogenous number of firms reside in each of two countries. Each firm determines whether to become a multinational firm by setting up a foreign subsidiary in the other country, or produce only in the home country. Firms are heterogeneous in the profitability of foreign direct investment (FDI). Once a firm becomes a multinational, the firm can engage in income shifting between the two countries to save tax payments. The tax rate differentials between the two countries affect the choice of a firm taking a multinational form and also the amount of income shifting by multinationals.

I find that optimal tax policy crucially depends on the profitability of FDI relative to the domestic rent in the home country and the distribution of the profitability of FDI. I show that when the profitability of FDI exogenously increases relative to the domestic rent in the home country or the cost of setting up a foreign subsidiary decreases, if the slope of the density function of the profitability is downward sloping or relatively flat, the country undertakes a tax-cut-cum-base-broadening reform. By contrast, if the slope of the density function of the profitability of FDI is sufficiently increasing, the country undertakes a tax-increase-cum-base-narrowing reform. I also find that when the value of intra-firm transactions (in the model, the value of input goods produced by foreign subsidiaries) increases, the country undertakes a tax-cut-cum-base-broadening reform.

I also examine the equilibrium tax rate and base in the presence of asymmetry in country size. The previous literature has demonstrated that larger countries in terms of population set higher tax rates than smaller countries. The main reason of this result is that the supply of capital to a large country is less responsive to its tax rate than smaller countries (Bucovetsky, 1991; Wilson, 1991). The tax rate differentials arising from asymmetric country sizes have been examined under various situations.[3] I show that if the domestic rent of a firm is large relative to the amount of income shifting by multinationals at the symmetric equilibrium, when the size of one of two countries becomes larger, the larger country sets a higher statutory tax rate and a higher rate of allowance. By contrast, if the domestic rent is small relative to the amount of income shifting at the symmetric equilibrium, the larger country sets a lower statutory tax rate and a lower rate of allowance. This result implies that, in

[3]See the following papers that analyze the asymmetric country sizes in tax competition models under the situations such as FDI by a monopolist (Haufler and Wooton, 1999), agglomeration economies (Baldwin and Krugman, 1999), trade costs and agglomeration economies (Ottaviano and Ypersele, 2005), firms' choice of multinational organizational form (Bucovetsky and Haufler, 2008), and heterogenous firms (Davies and Eckel, 2010). These papers show that large countries still set higher tax rates under the different situations even though the mechanisms are somewhat different.

addition to the size differences in population, the size of the corporate sector and the business activities of multinational firms are also important factors to explain tax rate differentials across countries. The remainder of the paper is organized as follows. Section 2.2 describes the basic model. Section 2.3 analyzes the comparative statics of the symmetric Nash equilibrium. Section 2.4 provides conclusions.

2.2 The Model

2.2.1 Basic Setup

There are two countries, country 1 and country 2. In country i ($i \in \{1, 2\}$), N_i firms produce outputs using capital inputs with identical technologies in a perfectly competitive setting. The production function of each firm is given by $f(k_i)$, where $f(\cdot)$ is defined for $k_i \geq 0$ and k_i is the amount of capital used by a firm producing in country i. $f(k_i)$ is strictly increasing, strictly concave, continuous, and continuously differentiable ($f' > 0$ and $f'' < 0$) satisfying the Inada conditions $f(0) = 0$ and $\lim_{k_i \downarrow 0} f'(k_i) = \infty$. Outputs are freely tradable between the two countries. Thus the price of outputs is normalized to unity in both countries. Capital is freely mobile between two countries and is infinitely elastically supplied at the world net rate of return r.

Firms can choose their organizational forms, domestic or multinational. While a domestic firm operates only in a country of residence, each firm can take a multinational form by incurring fixed costs β to set up a foreign subsidiary. Firms are heterogeneous in the fixed set-up costs. For ease of interpretation, I define $\alpha = -\beta$ as a measure of the profitability of foreign direct investment of a multinational firm. I interpret that lower set-up costs (lower β) implies higher profitability (larger α). I assume α is continuously distributed following the distribution function $G(\alpha)$ over the support $(-\infty, \overline{\alpha})$ for each country, where $\overline{\alpha} > 0$.[4] The distributions of α in the

[4] The assumption of $\overline{\alpha} > 0$ implies that fixed costs β are negative for some firms. As will be shown

two countries are identical and independent. Once a firm takes a multinational form, the firm not only produces domestically in the home country but also can engage in income shifting through transfer pricing between the parent firm and its subsidiary to save the corporate tax payments. I denote the proportion of multinational firms in country i as m_i, where $0 \leq m_i \leq 1$. The numbers of multinational and domestic firms can be expressed as $N_i m_i$ and $N_i(1 - m_i)$, respectively. A firm will choose to become a multinational if the tax saving from income shifting exceeds β.

The procedures of transfer pricing follows Haufler and Schjelderup (2000). A foreign subsidiary in country j ($j \in \{1, 2\}$ and $i \neq j$) produces one unit of an input good with a fixed cost, normalized to zero for notational simplicity, and sell it to its parent in country i at the price q_i. The true price of the input, the "arm's length price," is p for a parent in country i. But the transfer price q_i is not costlessly observable for tax authorities. Thus the subsidiary located in country j can set any price incurring a transaction cost. I denote the transaction cost as $c(q_i)$, where $c(\cdot)$ is a strictly convex, continuous, and continuously differentiable function with $c(p) = c'(p) = 0$. This means that selling the input at the true price is costless for multinational firms and that the transaction cost increases as the subsidiary overprices ($q_i > p$) or underprices ($q_i < p$) more because then it is more likely that the tax authorities could detect the deviation from the arm's length price and also multinational firms have to pay higher fines if tax authorities audit their tax returns.

Each country's government sets the statutory tax rate on corporate taxable incomes (t_i) and the rate of allowance on the cost of capital (a_i) so as to maximize the corporate tax revenue, where $0 \leq t_i \leq 1$ and $0 \leq a_i \leq 1$. The order of decisions is as follows. First, each country sets the statutory tax rate and the rate of allowance

in subsection 2.2.3, sufficiently large $\overline{\alpha}$ will need to be assumed to guarantee that some firms with negative β will choose to engage in FDI even when there is no benefit from income shifting (or, when the home country's tax rate is equal or lower than the host country's tax rate). As Bucovetsky and Haufler (2008) discuss, this assumption reflect that there are non-tax reasons for firms to determine their multinational structures. Another interpretation is that there exits some multinational firms in each country *before* countries commit to their tax policies.

simultaneously. Second, given those statutory tax rates and rates of allowance, each firm chooses whether to take a multinational form by setting up a subsidiary in the foreign county. Third, both domestic and multinational firms make investment decisions. In addition, multinational firms also choose the price of the input good selling from the foreign subsidiary to its parent (q_i).

2.2.2 Investment and Income-shifting Decisions

The after-tax total profit for a parent in country i and the foreign affiliate in country j can be written as

$$\begin{aligned} \pi_i^M &= (1-t_i)(f(k_i) - q_i - a_i r k_i) - (1-a_i) r k_i + (1-t_j) q_i - c(q_i) \\ &= (1-t_i)(f(k_i) - q_i - z_i r k_i) + (1-t_j) q_i - c(q_i), \end{aligned}$$

where $z_i = \frac{1-a_i t_i}{1-t_i}$ for $0 \leq t_i < 1$ and $z_i - 1 = \frac{t_i(1-a_i)}{1-t_i}$ is the effective marginal tax rate on investment (Devereux et al., 2008).[5] The first order conditions for the profit maximization with respect k_i and q_i are

$$\frac{\partial \pi_i^M}{\partial k_i} = (1-t_i)(f'(k_i) - z_i r) = 0, \tag{2.1}$$

$$\frac{\partial \pi_i^M}{\partial q_i} = t_i - t_j - c'(q_i) = 0. \tag{2.2}$$

For $0 \leq t_i < 1$, equation (2.1) implies $f'(k_i) = z_i r$. Solving that equation for k_i implicitly defines the demand function of capital with respect to z_i as $k_i = k(z_i)$. The effect of the effective marginal tax rate on the demand function of capital can become clear from the total differentiation of (2.1) with respect to z_i as follows

$$k'(z_i) = \frac{r}{f''(k_i)} < 0,$$

[5] I assume that the transaction cost and the set-up cost are not tax deductible.

which implies that a higher effective marginal tax rate decreases the demand for capital of the parent firm in country i. Equation (2.2) implicitly defines the amount of income shifting from the parent in country i to its subsidiary in country j such that $q_i = q_i(\tau_i)$, where q_i is the inverse function of $c'(q_i)$ and $\tau_i = t_i - t_j$. This implies that the income shifting from country i to country j depends only on the tax rate differential between country i and country j. Totally differentiating equation (2.2) with respect to the statutory tax rates yields

$$\begin{aligned}\frac{\partial q_i}{\partial t_i} &= q_i'(\tau_i) = \frac{1}{c''(q_i)} > 0,\\ \frac{\partial q_i}{\partial t_j} &= -q_i'(\tau_i) = -\frac{1}{c''(q_i)} < 0,\end{aligned}$$

which implies that more (less) income will flow out from country i into country j when the statutory tax rate of country i (j) goes up. Domestic firms in country i demand the same amount of capital as $k(z_i)$, but they cannot shift their profits between the two countries. The profit function of domestic firms in country i can be written as

$$\pi_i^D = (1 - t_i)\left(f\left(k(z_i)\right) - z_i r k(z_i)\right).$$

2.2.3 Choice of Taking a Multinational Form

A firm in country i chooses to take a multinational form if and only if doing so is more profitable than operating only domestically when taking into account fixed costs β to set up a subsidiary: $\pi_i^M - \pi_i^D \geq \beta$, which yields

$$\tau_i q_i - c(q_i) + \alpha \geq 0.$$

Assuming the interior solution, where some firms become multinationals, the firm in country i with α_i^* such that $\alpha_i^* = -\left(\tau_i q_i - c(q_i)\right)$ is indifferent between becoming a multinational or not. Then firms with $\alpha \geq \alpha_i^*$ become multinationals. I assume the upper bound of α is sufficiently large so that $\overline{\alpha} > \alpha_i^*$ to guarantee an interior solution for α_i^*. Thus, the proportion of multinational firms can be determined as $m_i = 1 - G(\alpha_i^*)$. Note that because q_i depends on the statutory tax rate differentials τ_i, m_i also depends on τ_i and can be written as a function of τ_i: $m_i = m_i(\tau_i)$.

Taking a derivative of m_i with respect to τ_i yields

$$m_i'(\tau_i) = -G'(\alpha_i^*)\frac{d\alpha_i^*}{d\tau_i} = G'(\alpha_i^*)q_i > 0. \tag{2.3}$$

We used equation (2.2) to derive $d\alpha_i^*/d\tau_i = -q_i$. Condition (2.3) implies that as the tax rate differential between country i and country j becomes larger, more firms choose to engage in FDI because then they can get more benefits (tax saving) from income shifting.

2.2.4 Optimal Tax Rate and Base

I assume that each country set the statutory tax rate and the rate of allowance so as to maximize the corporate tax revenue. Following Devereux et al. (2008), I define the rent from production of a firm in country i as $\widehat{\pi}(z_i) = \max_{k_i}(f(k_i) - z_i r k_i) > 0$, which is the tax base for the statutory tax rate t_i but does not depend on t_i given z_i. The envelope theorem implies that the rent is decreasing in the effective marginal tax rate z_i: $\widehat{\pi}'(z_i) = -rk(z_i)$. The country i's government revenue can be written as

$$\begin{aligned} R^i &= N_i(1-m_i)\left[t_i\left(f\left(k(z_i)\right) - a_i r k(z_i)\right)\right] + N_i m_i\left[t_i\left(f\left(k(z_i)\right) - q_i - a_i r k(z_i)\right)\right] + t_i N_j m_j q_j \\ &= N_i\left(t_i \widehat{\pi}(z_i) + (z_i - 1) r k(z_i)\right) - t_i N_i m_i q_i + t_i N_j m_j q_j. \end{aligned} \tag{2.4}$$

By the definition of the effective marginal tax rate $z_i - 1 = \frac{t_i(1-a_i)}{1-t_i}$, for each country's government, choosing independently the statutory rate t_i and the rate of deductibility for capital cost a_i is equivalent to choosing the statutory tax rate t_i and the effective marginal tax rate ($z_i - 1$) separately. Therefore, I characterize the optimal tax policy over (t_i, z_i) and then translate it into the tax policy over (t_i, a_i) at Nash equilibria.

Assuming the interior solutions, $0 < t_i < 1$ and $z_i > 1$ (or $0 < a_i < 1$), the first order conditions for the revenue maximization problem implies that country i sets t_i and z_i so that both the marginal revenue of increasing the statutory tax rate ($MRST_i$) and the marginal revenue of increasing the effective marginal tax rate ($MRET_i$) are zero.

$$\begin{aligned} & MRST_i = \frac{\partial R^i}{\partial t_i} \\ = \ & N_i \widehat{\pi}(z_i) - N_i m_i \left(q_i + t_i q_i'\right) + N_j m_j \left(q_j - t_i q_j'\right) - t_i q_i N_i m_i' - t_i q_j N_j m_j' = 0, \quad (2.5) \\ & MRET_i = \frac{\partial R^i}{\partial z_i} = N_i \left((1 - t_i) r k(z_i) + (z_i - 1) r k'(z_i)\right) = 0. \quad (2.6) \end{aligned}$$

I calculate the second derivatives to characterize the second order conditions.

$$\begin{aligned} R^i_{t_i t_i} &= \frac{\partial^2 R^i}{\partial t_i^2} = -2(N_i m_i q_i' + N_j m_j q_j') - t_i N_i m_i q_i'' + t_i N_j m_j q_j'' \\ & \quad -2 N_i m_i'(q_i + t q_i') - 2 N_j m_j'(q_j - t_i q_j') - t_i q_i N_i m_i'' + t_i q_j N_j m_j'', \quad (2.7) \\ R^i_{t_i z_i} &= \frac{\partial^2 R^i}{\partial t_i \partial z_i} = N_i \widehat{\pi}'(z_i) = -N_i r k(z_i) < 0, \quad (2.8) \\ R^i_{z_i z_i} &= \frac{\partial^2 R^i}{\partial z_i^2} = N_i \left((2 - t_i) r k'(z_i) + (z_i - 1) r k''(z_i)\right). \quad (2.9) \end{aligned}$$

In what follows, I assume the existence of a symmetric Nash equilibrium such that $N_i = N_j = N$, $t_i = t_j = t$, and $z_i = z_j = z$. At the symmetric Nash equilibrium, $q_i = q_j = p$ from equation (2.2), and $c'(p) = 0$ and $m_i(0) = m_j(0) = m$ because $\tau_i = \tau_j = 0$. Evaluating the second derivatives (2.7), (2.8), and (2.9) at the symmetric equilibrium, I construct the Hessian of the revenue function (2.4) as follows:

$$H = \begin{pmatrix} R_{tt} & R_{tz} \\ R_{zt} & R_{zz} \end{pmatrix} = \begin{pmatrix} -4N\left(mq'(0) + G'(\alpha^*)p^2\right) & -Nrk(z) \\ -Nrk(z) & N\left((2-t)rk'(z) + (z-1)rk''(z)\right) \end{pmatrix}. \tag{2.10}$$

The sufficient conditions to satisfy the second order conditions are

$$R_{tt} = -4N\left(mq'(0) + G'(\alpha_i^*)p^2\right) < 0, \tag{2.11}$$

$$R_{zz} = N\left((2-t)rk'(z) + (z-1)rk''(z)\right) < 0, \tag{2.12}$$

$$|H| = R_{tt}R_{zz} - R_{tz}R_{zt} > 0, \tag{2.13}$$

where $|H|$ is the determinant of the Hessian H. Condition (2.11) holds because $q_i'(\tau_i) = 1/c''(q_i) > 0$. Condition (2.12) requires $k''(z) \geq 0$, or that the absolute value of $k'(z) < 0$ is sufficiently large, which means that the elasticity of capital demand is sufficiently high so that $\epsilon^k = -\frac{zk'(z)}{k(z)} > \frac{z(z-1)rk''(z)}{rk(z)(2-t)}$.

Condition (2.13) can be rewritten as

$$\epsilon^I + \epsilon^M > -\frac{tR_{tz}^2}{4NmpR_{zz}}, \text{ where } \epsilon^I = \frac{t}{p}q'(0) \text{ and } \epsilon^M = \frac{t}{m}m'(0), \tag{2.14}$$

where ϵ^I is the elasticity of income shifting and ϵ^M is the elasticity of the number of multinationals in country i with respect to the statutory tax rate t_i at the symmetric equilibrium. More generally, these elasticities in country i can be defined as $\epsilon_i^I = \frac{t_i}{q_i}q_i'(\tau_i)$ and $\epsilon_i^M = \frac{t_i}{m_i}m'(\tau_i)$. Condition (2.14) implies that the amount of income shifting and the decision on becoming a multinational firm are sufficiently responsive to the tax rate differential. To guarantee the second order conditions at the symmetric Nash equilibrium, I impose those assumption described above on the production function and the transaction cost function so that both conditions (2.12) and (2.13) hold.

I calculate the slope of the best response functions at the symmetric equilibrium. The total differentiation of the first order conditions (2.5) and (2.6) with respect to t_i, t_j, and z_i at the symmetric equilibrium yields

$$\begin{pmatrix} R_{tt} & R_{tz} \\ R_{zt} & R_{zz} \end{pmatrix} \begin{pmatrix} dt_i/dt_j \\ dz_i/dt_j \end{pmatrix} = \begin{pmatrix} -2N\left(mq'(0) + G'(\alpha^*)p^2\right) \\ 0 \end{pmatrix}.$$

Using the Cramer's rule, I obtain

$$\frac{\partial t_i}{\partial t_j} = -\frac{2N\left(mq'(0) + G'(\alpha^*)p^2\right)R_{zz}}{|H|} > 0, \tag{2.15}$$

$$\frac{\partial z_i}{\partial t_j} = \frac{2N\left(mq'(0) + G'(\alpha^*)p^2\right)R_{zt}}{|H|} < 0. \tag{2.16}$$

Equation (2.15) and (2.16) imply that, as Devereux et al. (2008) showed, the statutory tax rates t_i and t_j are strategic complements and that the effective marginal tax rate of country i, $(z_i - 1)$, and the statutory tax rate of country j are strategic substitutes. The total differentiation of the first order conditions (2.5) and (2.6) with respect to t_i, z_i, and z_j yields $\frac{\partial t_i}{\partial z_j} = \frac{\partial z_i}{\partial z_j} = 0$. This implies that neither the statutory tax rate nor the effective marginal tax rate responds directly to the effective marginal tax rate of the other country. This result comes from the assumption that capital is infinitely elastically supplied at the world capital market at the fixed rate of return r.[6]

2.3 Comparative Statics

In this section, I analyze the comparative statics of the symmetric Nash equilibrium. I examine the effects on the tax policies of the two countries of changes in the

[6]In Devereux et al. (2008), the rate of return is endogenously determined so that capital demand and fixed capital supply are balanced. Then countries respond to the effective marginal tax rate to each other, though the slopes of the best responses $\partial t_i/\partial z_j$ and $\partial z_i/\partial z_j$ cannot be signed analytically.

following four parameters in the model: (1) an exogenous increase in the profitability of foreign direct investment (FDI), (2) an exogenous increase in the domestic rent, (3) an exogenous increase in the value of input goods produced by foreign subsidiaries, and (4) the asymmetry in the size of the corporate sector between the two countries.

2.3.1 Increase in the profitability of FDI

Suppose that the profits from FDI exogenously increases for all parent firms in country i in the sense that the distribution function of α shifts to the right along the horizontal axis by $\alpha_i \geq 0$ in country i. This changes the distribution function of α from $G(\alpha)$ to $G(\alpha - \alpha_i)$. I examine the effect of an increase in α_i on tax policies evaluating at $\alpha_i = 0$. By the definition of $\alpha = -\beta$, this effect is essentially equivalent to that of an decrease in the fixed costs of setting up a foreign subsidiary (β). I establish the following proposition.

Proposition II.1. *Suppose that the profitability of FDI increases for parent firms in country i at the symmetric equilibrium. Then, (i) country i sets a lower statutory tax rate, a higher effective marginal tax rate, and a lower rate of allowance than country j. The tax rate differentials is smaller as the sum of the elasticity of income shifting and that of becoming a multinational ($\epsilon^I + \epsilon^M$) is larger. (ii) If $G'' < 0$ or the absolute value of G'' is small, country i undertakes a tax-cut-cum-base-broadening policy. (iii) If $G'' > 0$ and the absolute value of G'' is large, both countries undertake tax-increase-cum-base-narrowing policies.*

Proof. The total differentiation of the two first order conditions for country i, equations (2.5) and (2.6), and the two first order conditions for country j with respect to

t_i, t_j, z_i, z_j, and α_i at the symmetric equilibrium yields

$$\begin{pmatrix} R_{tt} & R_{tz} & 2N\left(mq'+G'p^2\right) & 0 \\ R_{zt} & R_{zz} & 0 & 0 \\ 2N\left(mq'+G'p^2\right) & 0 & R_{tt} & R_{tz} \\ 0 & 0 & R_{zt} & R_{zz} \end{pmatrix} \begin{pmatrix} \partial t_i/\partial\alpha_i \\ \partial z_i/\partial\alpha_i \\ \partial t_j/\partial\alpha_i \\ \partial z_j/\partial\alpha_i \end{pmatrix}$$

$$= \begin{pmatrix} N\left(p+tq'\right)G' - tp^2NG'' \\ 0 \\ -N\left(p-tq'\right)G' - tp^2NG'' \\ 0 \end{pmatrix}. \tag{2.17}$$

We denote Π as follows.

$$\Pi = \begin{pmatrix} R_{tt} & R_{tz} & 2N\left(mq'+G'p^2\right) & 0 \\ R_{zt} & R_{zz} & 0 & 0 \\ 2N\left(mq'+G'p^2\right) & 0 & R_{tt} & R_{tz} \\ 0 & 0 & R_{zt} & R_{zz} \end{pmatrix}.$$

Note that all the derivatives with respect to α_i are evaluated at $\alpha_i = 0$. Solving the system of equations (2.17) for $dt_i/\partial\alpha_i$, $dz_i/\partial\alpha_i$, $dt_j/\partial\alpha_i$, and $dz_j/\partial\alpha_i$ yields

$$\frac{\partial t_i}{\partial\alpha_i} = \frac{R_{zz}N}{|\Pi|}\Omega_1, \tag{2.18}$$

$$\frac{\partial z_i}{\partial\alpha_i} = -\frac{R_{tz}N}{|\Pi|}\Omega_1, \tag{2.19}$$

$$\frac{\partial t_j}{\partial\alpha_i} = \frac{R_{zz}N}{|\Pi|}\Omega_2, \tag{2.20}$$

$$\frac{\partial z_j}{\partial\alpha_i} = -\frac{R_{tz}N}{|\Pi|}\Omega_2, \tag{2.21}$$

where $|\Pi|$ is the determinant of Π and

$$\begin{aligned}
\Omega_1 &= |H|\left(\left(p+tq'\right)G' - tp^2G''\right) - 2N\left(mq' + G'p^2\right)\left(-\left(p-tq'\right)G' - tp^2G''\right)R_{zz}, \\
\Omega_2 &= |H|\left(-\left(p-tq'\right)G' - tp^2G''\right) - 2N\left(mq' + G'p^2\right)\left(\left(p+tq'\right)G' - tp^2G''\right)R_{zz}.
\end{aligned}$$

I first look at the changes of the differentials $(t_i - t_j)$ and $(z_i - z_j)$ by subtracting equation (2.20) from equation (2.18) and subtracting (2.21) from (2.19) as follows:

$$\begin{aligned}
\frac{\partial t_i}{\partial \alpha_i} - \frac{\partial t_j}{\partial \alpha_i} &= \frac{2pNG'R_{zz}}{|H| - 2N\left(mq' + G'p^2\right)R_{zz}} < 0, \\
\frac{\partial z_i}{\partial \alpha_i} - \frac{\partial z_j}{\partial \alpha_i} &= -\frac{2pNG'R_{tz}}{|H| - 2N\left(mq' + G'p^2\right)R_{zz}} > 0,
\end{aligned}$$

which implies $\frac{\partial t_i}{\partial \alpha_i} < \frac{\partial t_j}{\partial \alpha_i}$ and $\frac{\partial z_i}{\partial \alpha_i} > \frac{\partial z_j}{\partial \alpha_i}$. The denominators of the above expressions can be written as

$$|H| - 2N\left(mq' + G'p^2\right)R_{zz} = -6N(mp/t)\left(\epsilon^I + \epsilon^M\right)R_{zz} - R_{tz}^2.$$

Thus, the tax differential $(t_i - t_j)$ and $(z_i - z_j)$ is smaller in absolute value as $\left(\epsilon^I + \epsilon^M\right)$ is larger. This complete the proof of part (i) of this proposition.

To fix signs in the comparative statics, I assume that the symmetric equilibrium is locally strictly stable. One of the necessary conditions for stability imply that the determinant of Π is positive: $|\Pi| > 0$ (see the proof in Appendix B). $|\Pi|$ can be expressed as

$$\begin{aligned}
|\Pi| &= |H|^2 - R_{zz}^2\left[2N\left(mq' + G'p^2\right)\right]^2 \\
&= \left(|H| - 2N\left(mq' + G'p^2\right)R_{zz}\right)\left(|H| + 2N\left(mq' + G'p^2\right)R_{zz}\right).
\end{aligned}$$

Because $|H| > 0$ from condition (2.13) and $R_{zz} < 0$, $|\Pi| > 0$ implies $|H| -$

$2N\left(mq' + G'p^2\right) R_{zz} > 0$. Thus the stability condition $|\Pi| > 0$ can be rewritten as

$$
\begin{aligned}
& |H| + 2N\left(mq' + G'p^2\right) R_{zz} = -2N\left(mq' + G'p^2\right) R_{zz} - R_{tz}^2 > 0, \\
\Longleftrightarrow \quad & \epsilon^I + \epsilon^M > -\frac{tR_{tz}^2}{2NmpR_{zz}}.
\end{aligned} \tag{2.22}
$$

This condition implies that the business activities of multinationals are sufficiently responsive to the statutory tax rates in the sense that the sum of the elasticity of income shifting and that of taking a multinational form is large enough so that $\epsilon^I + \epsilon^M > -tR_{tz}^2/(2NmpR_{zz})$ holds at the symmetric equilibrium.

The sign of equation (2.18) depends on that of Ω_1. It can be written as:

$$
\begin{aligned}
& \Omega_1 \\
= \; & |H| \left((p + tq') G' - tp^2 G'' \right) - 2N\left(mq' + G'p^2\right) \left(-(p - tq') G' - tp^2 G'' \right) R_{zz} \\
= \; & pG' \left(|H| + 2N\left(mq' + G'p^2\right) R_{zz} \right) \\
& + \left(tq'G' - tp^2 G'' \right) \left(|H| - 2N\left(mq' + G'p^2\right) R_{zz} \right).
\end{aligned} \tag{2.23}
$$

Note $p > 0$, $G' \geq 0$, $q' > 0$, $t > 0$. Therefore, if $G'' < 0$, or $G'' > 0$ but the absolute value is small, equation (2.23) is positive and this yields $\frac{\partial t_i}{\partial \alpha_i} < 0$. By contrast, if G'' is sufficiently large so that

$$
\left(tq'G' - tp^2 G'' \right) + pG' < 0 \Leftrightarrow G''/G' > (tq' + p) / \left(tp^2 \right),
$$

then $\frac{\partial t_i}{\partial \alpha_i} > 0$ because $(|H| - 2N(mq' + G'p^2) R_{zz}) > (|H| + 2N(mq' + G'p^2) R_{zz}) > 0$.

The sign of equation (2.20) depends on that of Ω_2 as follows:

$$\begin{aligned} & \frac{\partial t_j}{\partial \alpha_i} \gtreqless 0, \\ \Longleftrightarrow\ & \Omega_2 \lesseqgtr 0, \\ \Longleftrightarrow\ & -pG'\left(|H| + 2N\left(mq' + G'p^2\right)R_{zz}\right) + \left(tq'G' - tp^2G''\right)\left(|H| - 2N\left(mq' + G'p^2\right)R_{zz}\right) \lesseqgtr 0. \end{aligned}$$

Because $|H| - 2N\left(mq' + G'p^2\right)R_{zz} > |H| + 2N\left(mq'G' + G'p^2\right)R_{zz} > 0$, if G'' is negative and sufficiently small (sufficiently large in absolute value) so that

$$-pG' + \left(tq'G' - tp^2G''\right) > 0 \Longleftrightarrow G''/G' < (tq' - p)/\left(tp^2\right),$$

$\Omega_2 > 0$ and so $\frac{dt_j}{d\alpha_i} < 0$. If G'' is positive and sufficiently large so that

$$tq'G' - tp^2G'' < 0 \Longleftrightarrow G''/G' > q'/p^2,$$

$\Omega_2 < 0$ and so $\frac{\partial t_i}{\partial \alpha_i} > 0$. The signs of $\partial z_i/\partial \alpha_i$ and $\partial z_j/\partial \alpha_i$ are opposite to those of $\partial t_i/\partial \alpha_i$ and $\partial t_j/\partial \alpha_i$, respectively. Finally, I complete the proof by noting that by definition of z_i: $z_i - 1 = \frac{t_i(1-a_i)}{1-t_i}$, higher t_i and lower z_i implies higher a_i and that lower t_i and higher z_i implies lower a_i. □

The intuition of Proposition II.1 is as follows. Note that when the profitability of FDI increases or the fixed costs of setting up a foreign subsidiary decreases for parent firms in country i, two effects come in. First, given any tax policies of the two countries, parent firms in country i have more incentive to engage in FDI because doing so is more profitable or less costly. Second, with the increase in the profitability of FDI or the decrease in the costs of taking a multinational form, the responsiveness of the number of multinationals to the tax statutory tax rates also changes. These two effects can be clearly shown by differentiating the marginal revenue of the statutory tax rate ($MRST_i$) with respect to α_i:

$$\frac{\partial MRST_i}{\partial \alpha_i} = -N_i \left(q_i + t_i q_i'\right) G'(\alpha_i^*) + t_i N_i q_i^2 G''(\alpha_i^*). \tag{2.24}$$

The first term in the above equation is negative and corresponds to the first effect. When more firms become multinationals, the marginal revenue of the statutory tax rate goes down. This is because when more multinationals engage in income shifting, increasing the statutory tax rate would make larger revenue losses from their income shifting from country i to country j. The second effect, the change in the effect of the tax rate differential on the number of multinationals, corresponds to the second term of equation (2.24). This term comes from the derivative of $(-t_i N_i q_i m_i')$ in equation (2.5), which is change in the marginal revenue loss from higher tax rates inducing more multinationals. The sign of this term depends on the slope of the density function of α_i, $G''(\alpha_i^*)$.

If the slope of the density function of the profitability is downward sloping or relatively flat ($G'' < 0$ or the absolute value of G'' is small), the first term dominates the second term in equation (2.24) and thus $\frac{\partial MRST_i}{\partial \alpha_i} < 0$. Then $MRST_i$ goes down given any tax policy (t_i, z_i) and because $MRST_i$ is decreasing in t_i at the symmetric equilibrium by the second order condition for the revenue maximization problem (2.11), country i has incentive to lower its statutory tax rate. With lower statutory tax rates, the marginal revenue of the effective marginal tax rate ($MRET_i$) in equation (2.6) goes up for any z_i. Then, noting that $MRET_i$ is decreasing in z_i from the second order condition (2.12), the country i has incentive to increase the effective marginal tax rate. Therefore, the government of country i raises corporate revenues more effectively by lowering the statutory tax rate and increasing the effective marginal tax rate with a broader tax base (a lower rate of allowance).

By contrast, if the slope of the density function of the profitability of FDI is sufficiently increasing ($G'' > 0$ and the absolute value of G'' is large), the second term (positive) dominates the first term in equation (2.24). Then with higher α_i, $MRST_i$ goes up given any tax policy (t_i, z_i) and has incentive to increase the statutory tax rate. With higher statutory tax rates, $MRET_i$ goes down for any z_i. Thus the government raise revenues more effectively by increasing the statutory tax rate and lowering the effective marginal tax rate with a narrower tax base (a higher rate of allowance).

2.3.2 Increase in the domestic rent

Proposition II.1 demonstrates that the profitability of FDI and its distribution affect the optimal tax policy over tax rate and base. This subsection examines the effect of a change in the profitability in the home country on optimal tax policy. Suppose that the domestic rent in country i ($\widehat{\pi}_i$) increases exogenously, for example, with higher productivity of production or a positive demand shock. Then I establish the following proposition.

Proposition II.2. *When the domestic rent from production increases in country i at the symmetric equilibrium, county i sets a higher statutory tax rate, a lower effective marginal tax rate, and a higher rate of allowance than country j, and both countries undertake tax-rate-increase-cum-base-narrowing policies.*

Proof. The total differentiation of the two first order conditions for country i, equations (2.5) and (2.6), and the two first order conditions for country j with respect to

t_i, t_j, z_i, z_j, and $\widehat{\pi}_i$ at the symmetric equilibrium yields

$$\begin{pmatrix} R_{tt} & R_{tz} & 2N\left(mq' + G'p^2\right) & 0 \\ R_{zt} & R_{zz} & 0 & 0 \\ 2N\left(mq' + G'p^2\right) & 0 & R_{tt} & R_{tz} \\ 0 & 0 & R_{zt} & R_{zz} \end{pmatrix} \begin{pmatrix} \partial t_i/\partial\widehat{\pi}_i \\ \partial z_i/\partial\widehat{\pi}_i \\ \partial t_j/\partial\widehat{\pi}_i \\ \partial z_j/\partial\widehat{\pi}_i \end{pmatrix} = \begin{pmatrix} -N \\ 0 \\ 0 \\ 0 \end{pmatrix}. \tag{2.25}$$

Solving the system of equations (2.25) for $\partial t_i/\partial\widehat{\pi}_i$, $\partial z_i/\partial\widehat{\pi}_i$, $\partial t_j/\partial\widehat{\pi}_i$, and $\partial z_j/\partial\widehat{\pi}_i$ yields

$$\frac{\partial t_i}{\partial\widehat{\pi}_i} = -\frac{NR_{zz}\,|H|}{|\Pi|} > 0, \tag{2.26}$$

$$\frac{\partial z_i}{\partial\widehat{\pi}_i} = \frac{NR_{tz}\,|H|}{|\Pi|} < 0, \tag{2.27}$$

$$\frac{\partial t_j}{\partial\widehat{\pi}_i} = \frac{2N^2\left(mq' + G'p^2\right)R_{zz}^2}{|\Pi|} > 0, \tag{2.28}$$

$$\frac{\partial z_j}{\partial\widehat{\pi}_i} = -\frac{2N^2\left(mq' + G'p^2\right)R_{tz}R_{zz}}{|\Pi|} < 0. \tag{2.29}$$

The changes in the differentials $(t_i - t_j)$ and $(z_i - z_j)$ can be obtained by subtracting equation (2.28) from equation (2.26) and subtracting (2.29) from (2.27)

$$\begin{aligned} \frac{\partial t_i}{\partial\widehat{\pi}_i} - \frac{\partial t_j}{\partial\widehat{\pi}_i} &= -\frac{NR_{zz}}{|H| - 2N\left(mq' + G'p^2\right)R_{zz}} > 0, \\ \frac{\partial z_i}{\partial\widehat{\pi}_i} - \frac{\partial z_j}{\partial\widehat{\pi}_i} &= \frac{NR_{tz}}{|H| - 2N\left(mq' + G'p^2\right)R_{zz}} < 0. \end{aligned}$$

□

Note that the size of the domestic rent does not affect the number of multinationals and their income shifting behavior. Thus, when the domestic rent increases in country i, the government of country i raises more revenues by increasing the tax rate on the rent (t_i). In addition, (2.6) implies that with higher statutory tax rates, $MRET_i$ goes up for any z_i. Thus country i will increase the tax rate on the rent while narrowing the tax base with a lower effective marginal tax rate and a higher rate of allowance.

Propositions II.1 and II.2 suggest that the profitability of FDI increases relatively more than the domestic rent in the home country, the country will undertake a tax-cut-cum-base-broadening reform. We can also interpret that a country with multinational firms whose foreign affiliates are relatively more profitable will set a lower statutory tax rate and a broader tax base compared to other countries.

2.3.3 Increase in the value of input goods produced by foreign subsidiaries

In the current model, the amount of income shifting from a parent in country i to its subsidiary in country j (q_i) does not affect the pre-tax total profit for the parent and its subsidiary. In other words, q_i determines the distribution of reported taxable incomes of multinational firms between the two countries. Because the cost function of income shifting $c\left(q_i\right)$ is strictly convex and increasing with $c(p) = c'(p) = 0$, an exogenous increase in the value (or the arm's length price) of input good (p) would affect q_i, which also would affect tax policies of the two countries at the Nash equilibrium. To focus on the effect of a marginal change in p without changing the shape of the cost function $c(q_i)$, I consider that the the value of input goods increases by p_i so that the cost function shifts to the right by p_i from $c(q_i)$ to $c(q_i - p_i)$. Then I examines derivatives of $c(q_i - p_i)$ with respect to p_i at the symmetric equilibrium ($p_i = 0$). Then I establish the following proposition.

Proposition II.3. *When the value of the input good sold by a foreign subsidiary in country j to its parent in country i increases at the symmetric equilibrium, county i sets a lower statutory tax rate, a higher effective marginal tax rate, and a lower rate of allowance than country j, and both countries undertake tax-cut-cum-base-broadening policies.*

Proof. Differentiating with respect to p_i the first order condition to determine q_i: $t_i - t_j - c'(q_i - p_i) = 0$, which comes from equation (2.2), provides

$$c''(q_i - p_i)\left(\frac{\partial q_i}{\partial p_i} - 1\right) = 0,$$

which yields $\frac{\partial q_i}{\partial p_i} = 1$ (also $\frac{\partial^2 q_i}{\partial p_i^2} = 0$). This implies the amount of income shifting increases by the same amount as an increase in the value of input goods. Differentiating $m_i = 1 - G(\alpha_i^*)$ with respect to p_i, where $\alpha_i^* = -\left(\tau_i q_i - c(q_i - p_i)\right)$ yields

$$\frac{\partial m_i}{\partial p_i} = -G'(\alpha_i^*)\frac{\partial \alpha_i^*}{\partial p_i} = G'(\alpha_i^*)\tau_i.$$

Evaluating the above derivative at $p_i = 0$ and at the symmetric equilibrium ($t_i = t_j$), $\frac{\partial m_i}{\partial p_i} = 0$ (also, $\frac{\partial^2 m_i}{\partial p_i^2} = 0$). This implies that an increase in the value of input goods does not affect firms' decisions on taking a multinational form at the symmetric equilibrium.

Given those derivatives, the total differentiation of the two first order conditions for country i, equations (2.5) and (2.6), and the two first order conditions for country j with respect to t_i, t_j, z_i, z_j, and p_i at the symmetric equilibrium yields

$$\begin{pmatrix} R_{tt} & R_{tz} & 2N\left(mq' + G'p^2\right) & 0 \\ R_{zt} & R_{zz} & 0 & 0 \\ 2N\left(mq' + G'p^2\right) & 0 & R_{tt} & R_{tz} \\ 0 & 0 & R_{zt} & R_{zz} \end{pmatrix} \begin{pmatrix} \partial t_i/\partial p_i \\ \partial z_i/\partial p_i \\ \partial t_j/\partial p_i \\ \partial z_j/\partial p_i \end{pmatrix} = \begin{pmatrix} N(m + tG'p) \\ 0 \\ 0 \\ 0 \end{pmatrix}. \tag{2.30}$$

Solving the system of equations (2.30) for $\partial t_i/\partial p_i$, $\partial z_i/\partial p_i$, $\partial t_j/\partial p_i$, and $\partial z_j/\partial p_i$

yields

$$\frac{\partial t_i}{\partial p_i} = \frac{N(m+tG'p)R_{zz}\,|H|}{|\Pi|} < 0, \tag{2.31}$$

$$\frac{\partial z_i}{\partial p_i} = -\frac{N(m+tG'p)R_{tz}\,|H|}{|\Pi|} > 0, \tag{2.32}$$

$$\frac{\partial t_j}{\partial p_i} = -\frac{2N^2(m+tG'p)\,(mq'+G'p^2)\,R_{zz}^2}{|\Pi|} < 0, \tag{2.33}$$

$$\frac{\partial z_j}{\partial p_i} = \frac{2N^2(m+tG'p)\,(mq'+G'p^2)\,R_{tz}R_{zz}}{|\Pi|} > 0. \tag{2.34}$$

The changes in the differentials $(t_i - t_j)$ and $(z_i - z_j)$ can be obtained by subtracting equation (2.33) from equation (2.31) and subtracting (2.34) from (2.32)

$$\frac{\partial t_i}{\partial p_i} - \frac{\partial t_j}{\partial p_i} = \frac{(m+tG'p)NR_{zz}}{|H| - 2N\,(mq'+G'p^2)\,R_{zz}} < 0,$$

$$\frac{\partial z_i}{\partial p_i} - \frac{\partial z_j}{\partial p_i} = \frac{-(m+tG'p)NR_{tz}}{|H| - 2N\,(mq'+G'p^2)\,R_{zz}} > 0.$$

□

Note again that at the symmetric equilibrium, a marginal increase in p_i does not change the number of multinationals in either country. When the true price of input goods increases, the amount of income shifting by a foreign subsidiary in country j increases by the same amount as $\frac{\partial q_i}{\partial p_i} = 1$ indicates. Then $MRST_i$ goes down and revenue losses from increasing the statutory tax rate becomes large for country i. Thus country i will cut the tax rate and also broadens the tax base because the tax rate and base are substitute in the current model as explained above. The proposition suggests that when more profits are shifted to foreign countries or when the value of intra-firm transaction increases, the home country undertakes a tax-cut-cum-base-broadening reform.

2.3.4 Asymmetry in the size of the corporate sectors

The previous literature on tax competition has examined how an asymmetry in country size affects equilibrium tax rates. One of the main results is that larger countries in terms of population set higher tax rates than smaller countries because the supply of capital to larger countries is less responsive to its tax rate than smaller countries. In the current model, though population size is not explicitly taken into account, the total number of firms N_i reflects the size of the corporate sector and the gross domestic product (GDP) of country i. I examine how the asymmetry in the size of the corporate sector affects the optimal tax rates and bases. To highlight the asymmetry in N_i and N_j, I take the total derivatives with respect to N_i and N_j holding the total number of firms in the world constant: $N_i + N_j = N$. Then I establish the following proposition.

Proposition II.4. *If the domestic rent of a firm is large relative to the amount of income shifting by multinationals ($\widehat{\pi} > 2mp$) at the symmetric equilibrium, when the size of one of two countries becomes larger, the larger country sets a higher statutory tax rate, a lower effective marginal tax rate, and a higher rate of allowance. If the domestic rent of a firm is small relative to the amount of income shifting by multinationals ($\widehat{\pi} < 2mp$) at the symmetric equilibrium, the larger country sets a lower statutory tax rate, a higher effective marginal tax rate, and a lower rate of allowance.*

Proof. The total differentiation of the two first order conditions for country i, equations (2.5) and (2.6), and the two first order conditions for country j with respect to

t_i, t_j, z_i, z_j, N_i and N_j such that $dN_j = -dN_i$ at the symmetric equilibrium yields

$$\begin{pmatrix} R_{tt} & R_{tz} & 2N\left(mq' + G'p^2\right) & 0 \\ R_{zt} & R_{zz} & 0 & 0 \\ 2N\left(mq' + G'p^2\right) & 0 & R_{tt} & R_{tz} \\ 0 & 0 & R_{zt} & R_{zz} \end{pmatrix} \begin{pmatrix} \partial t_i/\partial N_i \\ \partial z_i/\partial N_i \\ \partial t_j/\partial N_i \\ \partial z_j/\partial N_i \end{pmatrix} = \begin{pmatrix} -\widehat{\pi} + 2mp \\ 0 \\ \widehat{\pi} - 2mp \\ 0 \end{pmatrix}. \tag{2.35}$$

Solving the system of equations (2.35) for $\partial t_i/\partial N_i$, $\partial z_i/\partial N_i$, $\partial t_j/\partial N_i$, and $\partial z_j/\partial N_i$ yields

$$\frac{\partial t_i}{\partial N_i} = \frac{R_{zz}\left(-\widehat{\pi} + 2mp\right)\left(|H| + 2N\left(mq' + G'p^2\right)R_{zz}\right)}{|\Pi|}, \tag{2.36}$$

$$\frac{\partial z_i}{\partial N_i} = -\frac{R_{tz}\left(-\widehat{\pi} + 2mp\right)\left(|H| + 2N\left(mq' + G'p^2\right)R_{zz}\right)}{|\Pi|}, \tag{2.37}$$

$$\frac{\partial t_j}{\partial N_i} = \frac{R_{zz}\left(\widehat{\pi} - 2mp\right)\left(|H| + 2N\left(mq' + G'p^2\right)R_{zz}\right)}{|\Pi|}, \tag{2.38}$$

$$\frac{\partial z_j}{\partial N_i} = -\frac{R_{tz}\left(\widehat{\pi} - 2mp\right)\left(|H| + 2N\left(mq' + G'p^2\right)R_{zz}\right)}{|\Pi|}. \tag{2.39}$$

Equations (2.36) and (2.38) can be written as

$$\frac{\partial t_i}{\partial N_i} = -\frac{\partial t_j}{\partial N_i} = \frac{\left(-\widehat{\pi} + 2mp\right)R_{zz}}{|H| - 2N\left(mq' + G'p^2\right)R_{zz}}.$$

Thus if $\widehat{\pi} \gtrless 2mp$, $\frac{\partial t_i}{\partial N_i} \gtrless 0$ and $\frac{\partial t_j}{\partial N_i} \lessgtr 0$ hold. Noting that the signs of $\partial z_i/\partial N_i$ and $\partial z_j/\partial N_i$ are opposite to those of $\partial t_i/\partial N_i$ and $\partial t_j/\partial N_i$, respectively, I complete the proof. $\square$

When the total number of firms increases, both the number of domestic firms and that of multinational firms increases keeping the proportion of multinationals unchanged. Because each government of the two countries has the two tax instruments, the statutory tax rate and the effective marginal tax rate (or, the rate of allowance on capital cost), the government chooses whether to raise more revenues by increasing the tax rate on the rent (t_i) or on capital (z_i).

If the rent is relatively larger than the amount of income shifting by multinationals at the symmetric equilibrium ($\widehat{\pi} > 2mp$), the government would need to care less about revenue losses induced by multinationals' income shifting and has more incentive to raise revenues by raising the statutory tax rate on the rent. Thus the government chooses to increase the statutory tax rate while narrowing the tax base with a higher rate of allowance.

By contrast, if the rent is relatively smaller than the amount of income shifting by multinationals ($\widehat{\pi} < 2mp$) at the symmetric equilibrium, a higher corporate tax rate would induce multinationals to shift a large amount of incomes to the other country. Thus the government has no incentive to raise the statutory tax rate. Instead, the government will raise more revenue by lowering the statutory tax rate (caring about income shifting by multinationals) while broadening the tax base with a lower rate of allowance.

This result is comparable to those of previous studies. Starting from Bucovetsky (1991) and Wilson (1991), the literature has demonstrated that larger countries set higher tax rates in Nash equilibrium. Because country size is usually measure by population in the literature, the results in Proposition II.4 cannot be directly compared to those of Bucovetsky (1991) and Wilson (1991). However the size of the corporate sector, or the total number of firms, is a reasonable measure of country size in the current model. Proposition II.4 suggests that a larger country could set a lower tax rate depending on the relative importance of domestic profitability to foreign business activities of multinationals. The proposition also suggests that, in addition to the differences in population, the size of the corporate sector and the intensity of the business activities of multinational firms are also important factors to explain tax rate differentials across countries.

2.4 Conclusions

Corporate tax reforms of OECD countries have tended to include both statutory rate reductions and base broadening (tax-cut-cum-base-broadening reforms). To analyze the causes of this tendency and the determinants of corporate tax rate and base changes, this paper develops the model of international tax competition over statutory tax rates and the rates of allowance on capital cost. I find that optimal tax policy crucially depends on the profitability of foreign direct investment (FDI) relative to the domestic rent in the home country and the distribution of the profitability of FDI. Propositions II.1 and II.2 suggest that countries undertake tax-cut-cum-base-broadening policies when the profitability of FDI increases relatively more than the domestic rent. When the profitability of FDI increases or the cost of setting up a foreign subsidiary decreases, more firms would like to engage in FDI. Then the marginal revenue of the statutory tax rate goes down and the marginal revenue of the effective marginal tax rate goes up with lower statutory tax rates. Thus the government raises corporate tax revenues more effectively by lowering the statutory tax rate and broadening the tax base with a lower rate of allowance.

My analysis also sheds light on the equilibrium tax rates and bases in the presence of asymmetric country size. Proposition II.4 shows that the asymmetry in the size of the corporate sector affects optimal tax policy differently depending on whether the domestic rent is relatively larger than the amount of income shifting by multinationals or not. With the two tax instruments, the statutory tax rate and the rate of allowance on capital cost, the government can choose whether to raise more revenue by increasing the tax rate on the rent or on capital. If the rent is relatively larger than the amount of income shifting by multinationals, increasing the tax rate on the rent is more effective way to raise revenues than taxing more on capital. Then the government chooses to increase the statutory tax rate while narrowing the tax base with a higher rate of allowance. The reverse is true if the rent is relatively smaller than the amount of income shifting. These results imply that in addition to the differences in population, the size of the corporate sector and the intensity of the business activities of multinational firms are also important factors to explain the tax rate differentials across countries.

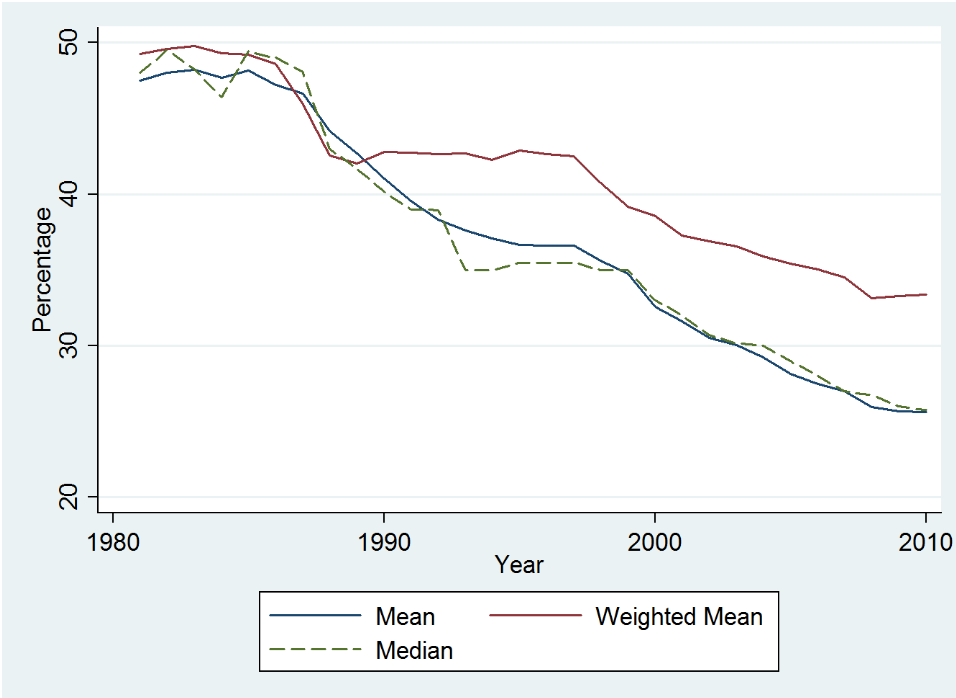

Figure 2.1: Mean, Weighted Mean by GDP, and Median of Statutory Tax Rates of OECD Countries, 1981-2010

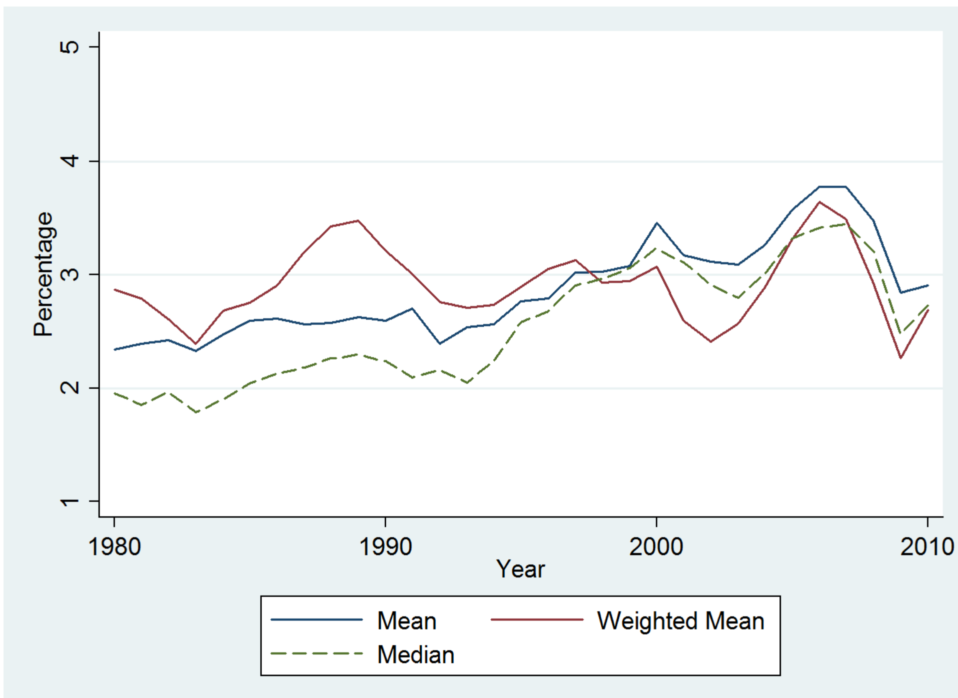

Figure 2.2: Mean, Weighted Mean by GDP, and Median of Corporate Tax Revenues of OECD Countries as a Proportion of GDP, 1980-2010

CHAPTER III

Cap-and-Trade Programs under Delayed Compliance: Consequences of Interim Injections of Permits

3.1 Introduction

Cap-and-trade programs are being utilized as the main vehicle to combat global warming by national and state governments of advanced countries. Such regulations are sometimes exceedingly complex. Nonetheless they share some common features. First, although firms subject to the regulations are required to surrender permits to cover their carbon emissions, they are not required to surrender permits on a continuing basis ("continual compliance") but only periodically. As a result, a firm may emit carbon without possessing the permits to cover its emissions as long as it acquires sufficient permits by the compliance date. We refer to this aspect of the regulations as "delayed compliance." In the case of the California law (AB-32), for example, the compliance period is initially two years and subsequently three years (although a fraction of the permits must be surrendered earlier as a down-payment). In the case of the three federal bills that failed to become law, the compliance period was one year.[1]

[1] Waxman-Markey's "American Clean Energy and Security Act of 2009,", Kerry-Boxer's "Clean Energy Jobs and American Power Act of 2009," and Kerry-Lieberman's "American Power Act of 2010."

Second, while some permits are issued at the outset of a compliance period, provision is made in most recent proposals for the government to inject *additional* permits into the market later in the compliance period.[2] Third, while permits may be stored ("banked") over time for later use, these programs prohibit or severely restrict the opportunity to borrow from future allocations. For example, California AB-32 allows unlimited banking and prohibits borrowing from the future compliance periods.

These common features have consequences that have escaped notice. Virtually all previous analyses have assumed that firms must be in continual compliance.[3] Under this assumption, a sizable literature has developed to assess the welfare benefits of holding back some of the permits that could have been allocated at the outset and using them subsequently to hold down the price through auctions or sales at fixed prices. Such policies are classified as "price collars" or "safety valves."[4] Burtraw et al. (2010) find that a price collar (also called a "symmetric safety valve" in the paper) outperforms a safety valve in a static setting. Fell and Morgenstern (2010) and Fell et al. (2012) simulate a dynamic stochastic model of a cap-and-trade program with a price collar or a safety valve.[5] Fell and Morgenstern (2010) find that price collar

[2]We do not discuss the European trading program since it has no interim injections during its annual compliance period. However, such injections have been proposed. Stavins (2012) regards the absence of a safety valve or price collar in the European system as a "design flaw" and Hone (2012) notes that "One approach is...to [require] a sufficient proportion of allowances to be auctioned, instead of being allocated free of charge and auctions to be held periodically throughout the commitment period. It is too late to do this for Phase III of the EU ETS (2013-2020) but it could be introduced as part of the expected legislative process to set the parameters for Phase IV (2021 and beyond, probably extending to 2030)."

[3]The single exception is the contemporaneous working paper of Holland and Moore (2012), which complements our work. They consider a wide variety of cap-and-trade programs, including the carbon-trading programs of primary concern to us. After classifying these programs in terms of their compliance timing, banking, and borrowing provisions, Holland and Moore provide a sufficient condition for delayed and continual compliance to yield the *same* equilibrium price path. Although their sufficient condition holds in programs to limit SO_x and NO_x (e.g. RECLAIM and the Acid Rain Program), their condition is violated in all four of the carbon-trading programs we analyze as they acknowledge when discussing our work.

[4]For a valuable explanation of the origins of the safety valve concept and its evolution in the climate context, see Jacoby and Ellerman (2004).

[5]In a dynamic context, intertemporal trading of emissions permits matters for economic efficiency. Cronshaw and Kruse (1996) and Rubin (1996) show that emissions trading allowing banking and borrowing of emission permits achieves the least-cost outcome.

mechanisms are more cost-effective than both purely quantity-based mechanisms and safety valve mechanisms for a given level of expected cumulative emissions. They also find that the combination of a price collar with banking and borrowing systems can achieve expected cost as low as a tax with lower emissions variance. Fell et al. (2012) find that *hard* collars, which ensure unlimited supply of reserve allowances to defend a ceiling price yield lower net present value of expected abatement costs than *soft* collars, price collars with limited supply of reserve allowances, for the same level of the expected cumulative emissions net of offsets. Most recently, Hasegawa and Salant (2012) have shown that if firms must cover their emissions on a continuing basis, then in the competitive equilibrium, the price path of permits may remain constant over periods while the government is selling additional permits at a ceiling price or may even collapse in response to a government auction. Clearly, no rational private agent would hold permits in the face of such capital losses. But the government sales of additional permits would enable firms to acquire the necessary permits to remain continually in compliance.[6]

Despite this sizable literature analyzing the effects of permit auctions and sales under a regime of continual compliance, such policies remain to be investigated under the actual regime of delayed compliance. With delayed compliance, firms purchase the permits they will ultimately need only at those instants within the compliance period when the permit price has the lowest capitalized value at the compliance date.

Much of the literature assumes discrete time and defines the period length in a way that obscures the distinction between delayed compliance and "contemporaneous" (the discrete-time analog of "continual") compliance. To understand this distinction, consider a discrete-time model where one period represents one day. If

[6] If unlimited "borrowing" were permitted, such price drops would not occur since permits could be borrowed from a future low-price period and sold earlier at a higher price. We assume here that a firm cannot borrow permits it expects to acquire in the future to cover current emissions under continual compliance. A distinction between delayed and continual compliance would remain even if borrowing was allowed provided it was constrained enough that the constraint on it was binding.

the government will inject permits on some of the days within the next year, the policy of requiring that permits be surrendered every day to match that day's emissions ("contemporaneous compliance") *differs* from the policy of requiring that permits be surrendered once every 365 days to cover cumulative emissions during the entire year. If, as in most of the discrete-time literature, the length of each period is *defined* to be the same as the length of the compliance period, nothing by definition can happen between periods and, by this modeling choice, one prevents oneself from investigating the consequences of a government injection of permits *between* one compliance date and the next. To consider the effects of government policies conducted *within* a compliance period, we adopt a continuous-time formulation as less cumbersome than its discrete-time counterpart.

In contrast to the case of continual compliance, under delayed compliance prices can never rise *slower* than the rate of interest. For suppose the contrary. Then the highest capitalized price would *strictly exceed* the lowest capitalized price. But then everyone with an initial allocation of permits would want to sell them at the highest capitalized price and there would be no one on the other side of the market willing to buy permits at that price; as a result, there would be massive excess supply.[7] Under both compliance regimes, prices can never rise faster than the rate of interest in the absence of uncertainty; otherwise traders would attempt to buy low and sell high on an infinite scale. It follows that in any equilibrium under delayed compliance, prices must rise throughout the compliance period at the rate of interest. Anticipated government auctions or sales from a finite reserve at a fixed price will not slow this rate of price appreciation although, as we will show, they will determine the position of the price path or, equivalently, the permit price prevailing at the compliance date.

The equilibrium permit price at the compliance date equates the demand for

[7]This argument implicitly assumes that private agents are the only purchasers of permits. We assume that the government never purchases permits since none of the delayed compliance programs we consider envision that. If the government did purchase permits, the equilibrium price path under delayed compliance could rise slower than the rate of interest.

permits required to cover the cumulative emissions which have occurred since the last compliance date with the cumulative supply of permits provided by the government over that period.[8] The following algorithm can then be used to determine the permit price at the compliance date.

For each possible terminal price, determine the (unique) associated price path over the compliance period. To determine the cumulative demand for permits along that path, note that at every instant firms will abate up to the point where their marginal cost of abatement capitalized to the compliance date equals the permit price anticipated to prevail at that date. Compute the aggregate cumulative emissions of the regulated entities over time. Firms will need a matching number of permits at the compliance date. This procedure provides one price-quantity pair on the cumulative demand curve for permits. Repeat the procedure to generate the other points on the demand curve.[9]

Deriving the cumulative supply of permits as a function of the terminal price is somewhat trickier. Since all prices on each associated price path will have the same capitalized value, private agents will not care when they sell as long as they hold zero permits after the compliance period ends. Hence *cumulative* supply of permits over the period will consist of the initial allocations *plus* the subsequent injections of additional permits. These injections depend on the fine details of particular regulations as we will illustrate using provisions from California's cap-and-trade program

[8]As an analytical simplification, we assume that it is illegal or unprofitable to carry permits from one compliance period to the next. The following algorithm can then be used to determine the permit price at the compliance date. However, the algorithm in the text is easily modified if carryovers between compliance periods is permitted.

[9]To simplify the exposition, we assume that firms do not abate by investing in new or altered technology. Otherwise a firm's current abatement decision would affect its future cost of emissions, and each firm would have a dynamic investment problem to solve. Accounting for this would complicate the derivation of cumulative emissions if the permit price rises at the rate of interest and hence the aggregate cumulative demand for permits, but it would not alter any of our points. The equilibrium price path under delayed compliance would still be determined at a terminal price that equates cumulative supply to the altered cumulative demand, and this path would fail to equilibrate markets under continual compliance for the reasons we discuss. We have chosen, therefore, to abstract from this real world complication. As noted in the concluding section, one cannot abstract from this complication when conducting welfare analysis.

AB-32 which begins later this year and from the three Congressional bills which died in Congress. All four programs envision an initial allocation of permits supplemented by subsequent injections of additional permits during the compliance period. The programs differ, however, in the rules governing these injections. For example, while all these programs prescribe a periodic sequence of auctions with pre-announced reserve prices, the programs differ in whether permits unsold in one auction can be re-offered in subsequent auctions. As we show, California AB-32 has a troublesome provision for offering unsold permits in subsequent auctions that induces a jump in the supply of permits; under this rule, there may be no price path that will clear the permit market.

In addition to auctions, the programs envision sales at pre-determined prices; but here too the terms of these sales differ. The California plan contemplates sales of specified amounts at specified prices from an "Allowance Price Containment Reserve" shortly after each quarterly auction whereas the Kerry-Lieberman (2010) bill proposed sales of permits at a fixed price over a designated time interval or until the "Cost Containment Reserve" was depleted.

In the next section, we discuss the determination of cumulative demand for permits as a function of the last price on a price path rising at the rate of interest. We then discuss the cumulative supply of permits as a function of the last price on that path. We show how the supply curve depends on the particular provisions of the emissions trading program. The last price on the equilibrium price path is determined by the intersection of the cumulative demand and supply curves. We will also note when the equilibrium price path under continual compliance differs from the path under delayed compliance. Such differences occur when firms would not receive injections of permits soon enough to surrender them under continual compliance. In such cases, excess demand occurs and permit prices must initially be higher (and emissions per unit time initially lower) under continual compliance.

3.2 Preliminaries

Under delayed compliance, firms will purchase permits at the lowest price, capitalized to the date of compliance. Since, as explained previously, the equilibrium price path under delayed compliance must rise at the rate of interest, every price is lowest and we may index such paths by the price expected to prevail at the date of compliance. Denote that price as $\mathbf{P}$.

We assume that firm i ($i \in \{1, \ldots, n\}$) can reduce its emissions per unit time to $e_i(t)$ at time t by abating at cost $c_i(e_i(t))$, where firm i's cost is a strictly decreasing, strictly convex, differentiable function of emissions. To avoid corners, we assume the Inada condition holds: $-c_i'(e) \to \infty$ as $e \to 0$. Moreover, at a sufficiently high level of emissions ("baseline emissions," $\bar{e}_i$), the firm's cost declines to zero and approaches that level at a zero slope: $c_i(\bar{e}_i) = c_i'(\bar{e}_i) = 0$. Then firm i chooses its emissions path $e_i(t)$ to minimize its total cost of complying with the cap-and-trade regulation. It minimizes $c_i(e_i(t))e^{r(T-t)} + e_i(t)\mathbf{P}$, where T is the compliance date. Its optimal emissions path therefore solves:

$$-c_i'(e_i(t)) = \mathbf{P}e^{r(t-T)}, \text{ for } t \in [0, T] \text{ and } i = 1, \ldots n. \tag{3.1}$$

Given the properties of the n cost functions, the emissions of each firm at any instant are a continuous, strictly decreasing function of $\mathbf{P}$. From the emissions paths of the firms, we can determine the cumulative aggregate demand for permits through time τ as a function of $\mathbf{P}$:

$$D(\mathbf{P}, \tau) = \int_{t=0}^{\tau} \sum_{i}^{n} e_i(t)dt \text{ for } \tau \in [0, T]. \tag{3.2}$$

$D(\mathbf{P}, \tau)$ is continuous, strictly decreasing in its first argument and strictly increasing and strictly concave in its second argument. The intercepts are $D(\mathbf{P}, 0) = 0$ and

$D(0,\tau) = \tau \sum_{i=1}^{n} \bar{e}_i$. We will make extensive use of this function in the subsequent analysis.

For any particular government method of injecting permits, we can define $S(\mathbf{P},\tau)$ as the government's cumulative supply of permits until time τ on a price path rising at the rate of interest and ending at $\mathbf{P}$. Under delayed compliance, any price path such that $D(\mathbf{P},T) = S(\mathbf{P},T)$ equilibrates the market.

To determine when the equilibrium price path under delayed compliances generates a disequilibrium under continual compliance, we will have to compute the cumulative supply and demand for permits at any time τ under continual compliance when the price rises throughout at the rate of interest, reaching $\mathbf{P}$ at T. A given method of injecting permits will generate the same cumulative supply $S(\mathbf{P},\tau)$ under the two regimes. Moreover, under continual compliance firm i's demand for permits at τ is also given by equations (3.1) and (3.2). Provided the price path rises at the rate of interest, each firm's cumulative demand from the outset to time T will be the same under the two regimes.[10]

However, equilibrium under continual compliance requires that $D(\mathbf{P},\tau) \leq S(\mathbf{P},\tau)$ for *all* $\tau \in [0,T)$ in addition to $D(\mathbf{P},T) = S(\mathbf{P},T)$. That is, in the continual compliance regime, agents must be provided enough permits to be able to cover their emissions at *every* instant and not merely the last one. Since the requirement of equilibrium is more restrictive under continual compliance, price paths that equilibrate the market under delayed compliance but where $D(\mathbf{P},\tau) > S(\mathbf{P},\tau)$ for some $\tau \in [0,T)$, fail to equilibrate it under continual compliance.

[10] The cumulative demands no longer coincide on price paths that rise somewhere more slowly than the rate of interest. Suppose, for example, that the price is constant at $\mathbf{P}$ until T. Then at every instant under continual compliance emissions would solve $-c_i'(e_i(t)) = \mathbf{P}$, for $t \in [0,T]$ and $i = 1,\ldots n$ which is strictly smaller than the solution to (3.1); hence, cumulative demand until T would be strictly smaller on such a price path under continual compliance. However, this observation is unimportant since the equilibrium price path under delayed compliance must always rise at the rate of interest and we will be checking whether such a price path equilibrates the permit market under continual compliance.

3.3 Auctions with Reserve Prices

Throughout we will assume that g permits are "grandfathered" at the outset and that the number grandfathered is smaller than the cumulative emissions that would have occurred without a cap-and-trade program ($g < T \sum_{i=1}^{n} \bar{e}_i$).

In this section, we assume that the government commits at the outset to conduct a sequence of auctions. The date, amount, and reserve price of each auction is announced at the outset. Let t_i denote the date of the i^{th} auction, a_i its amount, and $\underline{p}_i$ its reserve price (assumed strictly positive) for $i = 1, \ldots A$, where A is the total number of auctions to be held during the compliance period, $[0, T]$.

To determine the equilibrium price path under delayed compliance, we construct the cumulative demand and cumulative supply curves and determine their unique point of intersection. The cumulative demand curve is simply $D(\mathbf{P}, T)$, which is downward-sloping with respect to $\mathbf{P}$. The cumulative supply curve $S(\mathbf{P}, T)$ is a step-function. For the price path with the terminal price of zero, aggregate supply consists of the g grandfathered permits. As the terminal price is increased, it eventually equals lowest capitalized reserve price. At that terminal price, the cumulative supply is indeterminate—as small as g and as large as g plus the amount offered at the auction with the lowest capitalized reserve price. If the terminal price is slightly higher, the cumulative supply equals the upper end of this interval. Cumulative supply would remain at that level until the terminal price reached the next-to-the-lowest capitalized reserve price. A sufficiently high terminal price will equal the highest of the capitalized reserve prices of the A auctions. Any higher terminal price will elicit the maximal supply of $g + \sum_{i=1}^{A} a_i$ permits.

There exists a unique equilibrium price path and terminal price, $\mathbf{P}$. Existence follows since a zero terminal price would generate excess cumulative demand (by assumption, $T \sum_{i=1}^{n} \bar{e}_i > g$) while a sufficiently high terminal price would generate excess cumulative supply (cumulative supply $g + \sum_{i=1}^{A} a_i$ is bounded away from zero and cumulative demand approaches zero for sufficiently high $\mathbf{P}$). Moreover the intersection point must be unique since, at any higher price, demand is strictly smaller and supply weakly larger while, at any lower price, demand is strictly larger and supply weakly smaller.

To construct the supply curve geometrically, proceed as follows: (1) on a diagram with time on the horizontal axis and price per permit on the vertical axis (see Figure 3.1), record the date and reserve-price pair $(t_i, \underline{\mathrm{p}}_i)$ of each of the A auctions; (2) determine the capitalized value ($\mathbf{P_i}$) of each reserve price by drawing through each of these A points a price path rising at the rate of interest and noting its height at T ($\mathbf{P_i} = \underline{\mathrm{p}}_i e^{r(T-t_i)}$). For terminal prices smaller than the smallest capitalized reserve price, only the g grandfathered permits are supplied to the market. For higher prices, the cumulative supply function $S(\mathbf{P}, T)$ will have a horizontal step of length a_i at height $\mathbf{P_i}$ for $i = 1, \dots A$.

Our methodology can be used to predict the consequences of *any* exogenous path of auction reserve prices. For example, suppose the auction reserve price rises exactly at the rate of interest. Then, if bids at one auction strictly exceed its reserve price, bids at the other auctions will strictly exceed their reserve prices. Conversely, if no bids meet the reserve price in one auction, none will meet it in any other auction.

If instead the exogenous auction reserve price rises faster than the rate of interest, then if bids fail to meet the reserve price in one auction, no bids will be acceptable in subsequent auctions while if bids *do* meet the reserve price in one auction, bids in prior auctions will also be acceptable. Consequently, when the exogenous reserve price rises faster than the rate of interest, auctions where bids fail to meet the reserve price cluster at the end of the compliance period.

If instead the exogenous auction reserve prices rise slower than the rate of interest, then if bids fail to meet the reserve price in one auction, no bids will be acceptable in earlier auctions while if bids do meet the reserve price in one auction, bids in subsequent auctions will also be acceptable. Consequently, when the exogenous reserve price rises slower than the rate of interest, auctions where bids fail to meet the reserve price cluster at the beginning of the compliance period.

Although our methodology can be applied to any exogenous path of reserve prices, we illustrate it below in the simplest manner. Hence, we assume that all the reserve prices are the same. In Figure 3.1, all auctions have the same reserve price ($\underline{p}_i = \underline{p}_j$). Since these reserve prices rise by less than the rate of interest, $\mathbf{P_1} > \mathbf{P_2} > \mathbf{P_3} > \mathbf{P_4}$. In the example portrayed, the equilibrium terminal price $\mathbf{P}^*$ is contained in the open interval $(\mathbf{P_4}, \mathbf{P_3})$. Hence, no bids are accepted at the first three auctions but all of a_4 permits are sold at the fourth auction at the price $\mathbf{P}^* e^{r(t_4 - T)} > \underline{p}$. Therefore, in equilibrium emissions equal $g + a_4$.

[Figure 3.1]

If the government had auctioned no permits at t_4 but had instead added these a_4 permits to the number grandfathered, then the cumulative supply curve would become $g + a_4$ for terminal prices below $\mathbf{P_4}$ but the modified cumulative supply curve would still intersect the unchanged cumulative demand curve at the same point. Hence, the equilibrium price path would not change under delayed compliance nor would the cumulative emissions it induces. Alternatively, if the government had grandfathered no permits but had instead auctioned these g permits along with the a_4 permits at t_4, then the cumulative supply at prices below $\mathbf{P_4}$ would be zero and the cumulative supply at $\mathbf{P_4}$ would be as large as $g + a_4$. Nonetheless this modified cumulative supply curve would still intersect the cumulative demand curve at the same point. Neither change would affect the equilibrium under delayed compliance.

If the entire sum of permits $(g + a_4)$ was grandfathered at the outset, then this same price path would also equilibrate the market under *continual* compliance. But if all of these permits were made available instead at t_4, then a disequilibrium would inevitably occur since, for some $\tau < T, D(\mathbf{P}, \tau) > S(\mathbf{P}, \tau)$. In Figure 3.2, we plot cumulative supply and demand until τ along the equilibrium price path under delayed compliance (the price path ending at $\mathbf{P}^*$). Since the path generates an equilibrium under delayed compliance, the two curves intersect at T and $D(\mathbf{P}^*, T) = g + a_4$. An equilibrium under continual compliance requires in addition that the cumulative supply curve lies nowhere strictly below the cumulative demand curve for $\tau \in [0, T)$. Let $\tilde{g}$ be the number of permits the government chooses to grandfather initially. We have drawn the boundary case where $\tilde{g} = D(\mathbf{P}^*, t_4)$ permits are grandfathered and $(g + a_4) - \tilde{g}$ are auctioned at t_4. If the government grandfathered strictly less than $D(\mathbf{P}^*, t_4)$ permits and added them instead to the amount auctioned at t_4, then the equilibrium under delayed compliance could no longer be supported as an equilibrium under continual compliance. Instead, the price path would consist of segments rising at the rate of interest, separated by a downward jump at t_4.[11]

[Figure 3.2]

3.3.1 Non-existence of Equilibrium Induced by the Rules of California's AB-32

Returning to the case of delayed compliance, suppose that cumulative demand was so large that $\mathbf{P}^* \in (\mathbf{P_2}, \mathbf{P_1})$. That is, every auction after t_1 sells out, but bids in this first auction are below its reserve price ($\underline{p}_1$). Under the rules of California's AB-32, the a_1 permits which failed to sell in the first auction would be returned to the "Auction Holding Account."[12] Some of these permits would be available for sale in

[11]We note that, although we have assumed throughout that g permits are grandfathered at the outset, distributing some of these g permits later would not affect the equilibrium price path under delayed compliance. No matter when the g permits are distributed the cumulative supply curve $S(\mathbf{P}, T)$ will remain unchanged. On the other hand, under continual compliance, distributing some of the g permits at a subsequent date may induce a higher price initially and a drop of the permit price when the subsequent permit injection occurs (Hasegawa and Salant, 2012).

[12]Final Regulation Order, §95911. Format for Auction of California GHG Allowances. (b) (4) (A)

the fourth auction since it would have occurred "after two consecutive auctions have resulted in an auction settlement price greater than the applicable Auction Reserve Price."[13] However, not all of the a_1 permits could be made available. At most the number of permits which can be added to the auction at t_4 is 25% of a_4.[14] It is not clear to us how many of these permits would be offered and who decides, but at the old equilibrium price excess supply would occur because these unsold additional permits would be offered in an auction where the market price exceeds the reserve price. As a result, the equilibrium price path under delayed compliance would rise to a lower terminal price.

Offering unsold permits for sale if and only if permits are sold at two preceding auctions in a row can create a situation where no competitive equilibrium exists. Suppose, for example, that every bid is strictly below the reserve price in the first auction but the next two auctions sell out. Suppose cumulative demand is sufficiently high that in the absence of the rule regarding unsold permits that $\mathbf{P}^* \in (\mathbf{P_2}, \mathbf{P_1})$. Under this rule $\min(a_1, 0.25a_4)$ of the permits from the first auction can be offered in the fourth auction. If $\min(a_1, 0.25a_4) \geq D(\mathbf{P_2}) - g - a_2 - a_3 - a_4 = D(\mathbf{P_2}) - D(\mathbf{P}^*)$ then there will be excess supply at any terminal price strictly exceeding $\mathbf{P_2}$.[15] But at any terminal price equal to or strictly below $\mathbf{P_2}$, there will be excess demand since, in the absence of two consecutive auctions where permits are sold at prices strictly higher than the reserve price, *none* of the unsold permits from auction 1 can be offered for sale in the fourth auction, and then $D(\mathbf{P}) > g + a_2 + a_3 + a_4$ holds for all $\mathbf{P} \leq \mathbf{P_2}$. We illustrate a situation with no equilibrium in Figure 3.3.[16]

[13] Quoted from Final Regulation Order, §95911. Format for Auction of California GHG Allowances. (b) (4) (B)

[14] Final Regulation Order, §95911. Format for Auction of California GHG Allowances. (b) (4) (C)

[15] We use the excess supply condition at any terminal price higher than $\mathbf{P_2}$: $D(\mathbf{P_2}) \leq g + \min(a_1, 0.25a_4) + a_2 + a_3 + a_4$ and the definition of $\mathbf{P}^*$: $D(\mathbf{P}^*) = g + a_2 + a_3 + a_4$.

[16] Our analysis clarifies that existing regulations should be changed. Indeed, it suggests a remedy: re-word the regulation so permits may be sold as long as the settlement price in each of the two preceding auctions equals or exceeds the auction's reserve price.

[Figure 3.3]

3.4 Sales at Specified Prices

Permits can also be injected during the compliance period by sales at a specified price, which we denote $\bar{p}$. To simplify, we assume in this section that all permits not grandfathered at the outset are injected by such sales. Such sales can occur over a specified time interval which commences at t_c and finishes at t_f or until all of the R permits in the "Cost Containment Reserve" have been sold. The Kerry-Lieberman bill envisioned such sales over a finite interval. They resemble a continuum of auctions with reserve price $\underline{\text{p}}$ over the time interval $[t_c, t_f]$ but with R available in the initial auction, and *everything* unsold in one auction immediately available for sale in subsequent auctions.

Since the sales price over the interval is constant, the price at t_f has the smallest capitalized value ($\mathbf{P_f} = \bar{p}e^{r(T-t_f)}$). In Figure 3.4, we depict the interval of offers and the sales price. As in Figure 3.1, we depict $\mathbf{P_f}$ by noting the terminal price on the path through the point $(t_f, \bar{p})$ rising at the rate of interest. To derive the cumulative supply curve, note that if the terminal price is strictly smaller than $\mathbf{P_f}$, then nothing would sell during this time interval and the cumulative supply would just be g. If the terminal price is strictly larger, then the cumulative supply would be $g + R$. If the terminal price is exactly $\mathbf{P_f}$ then the cumulative supply is any number of permits in the closed interval $[g, g + R]$.

[Figure 3.4]

Suppose cumulative demand is sufficiently large that under delayed compliance the terminal price strictly exceeds $\mathbf{P_f}$. Then R permits sell instantaneously, either at some interior date $\tau^* \in (t_c, t_f)$ or at the first moment of the sale (t_c), where τ^* is determined so that $\mathbf{P}^* e^{-r(T-\tau^*)} = \bar{p}$ for $\mathbf{P_f} < \mathbf{P}^* < \mathbf{P_c}$. In either case, such purchases at an infinite rate are just like "first-generation" speculative attacks which have been widely discussed in the literatures on foreign exchange markets and on commodity agreements.[17]

In commodity markets or foreign exchange markets, defending the ceiling price typically requires the government to sell at a slow rate over a finite interval prior to the attack. Then, at some endogenously determined date, further defense of the ceiling requires the instantaneous sale of the remaining stock to buyers who store it for later re-sale to private agents at higher prices. If government stocks are sufficiently small, however, the attack occurs as soon as the ceiling price is reached.

In the market for emissions trading under delayed compliance, defense of the ceiling never involves selling permits at a slow rate over a finite interval prior to the attack. For no one would buy those permits. No one needs to surrender permits until the compliance date and, if the government did sell permits over an interval at the same ceiling price, it would always be cheaper to postpone their purchase until the end of the interval. With emissions permits under delayed compliance, therefore, the speculative attack occurs the moment the ceiling price is reached. The permits are then held by private agents until the compliance date, when they are returned to the government to cover emissions since the end of the previous compliance period.

Suppose in the equilibrium under delayed compliance that the terminal price is $\mathbf{P}^*$ and cumulative emissions are $g+R$. Hence, $D(\mathbf{P}^*, T) = g+R$. Suppose the speculative attack occurs at the interior point $\tau^* > t_c$. Reallocating the $g+R$ permits between the initial allocation and the Cost Containment Reserve will not alter the equilibrium price path or the date of the attack under delayed compliance. Such reallocation may

[17] For a discussion of speculative attacks on commodity ceilings defended by bufferstock sales, see Salant and Henderson (1978) and Salant (1983). For discussions of how their idea was developed further in the international finance literature, see Krugman (1999) and Flood et al. (2012).

however affect the price path under continual compliance. In Figure 3.5, we depict the boundary case where the government chooses to grandfather $\tilde{g} = D(\mathbf{P}^*, \tau^*)$ and to stock the cost containment reserve with the remaining permits. Hence, $g+R-\tilde{g} = D(\mathbf{P}^*, T) - D(\mathbf{P}^*, \tau^*)$. If $\tilde{g}$ were reduced so that more permits were moved from the initial allocation to the Cost Containment Reserve, the equilibrium under continual compliance will differ from the equilibrium under delayed compliance. In that case, the equilibrium price path under continual compliance will have a segment rising at the rate of interest until t_c and then (weakly) dropping to $\bar{p}$ for an endogenous interval of time before rising continuously from $\bar{p}$ again at the rate of interest. A speculative attack must occur here too but it occurs later than under delayed compliance. We also note that when a speculative attack occurs ($\mathbf{P}^* > \mathbf{P_f}$), marginally changing the level of the price ceiling $\bar{p}$ does not affect the equilibrium price path and only alters the date of the attack under delayed compliance.

[Figure 3.5]

3.5 Conclusion

Cap-and-trade programs rather than emissions taxes are being utilized as the main vehicle to combat global warming by national (and state) governments of advanced countries. In the United States, some permits are withheld from the initial allocation and injected subsequently into the market by auctions or sales at fixed prices in an attempt to limit price increases (through so-called "price collars" or "safety valves"). The effect of these subsequent injections depends on whether the program requires regulated firms to be in compliance continually or merely periodically. Until now, virtually all analyses have assumed continual compliance even though actual programs always require delayed compliance.

The purpose of our paper has been to develop a methodology for analyzing the effects of such injections in a regime of delayed compliance. In the process of illustrating the use of this methodology, we identified two consequences of the provisions of cap-and-trade programs (potential speculative attacks and nonexistence of equilibrium) that have escaped notice.

We have also clarified when the equilibrium under continual compliance differs from the equilibrium under delayed compliance. We have not described in detail the effects of such injections under continual compliance since no actual programs require that.[18]

We have assumed away all forms of uncertainty in the current analysis but will address this issue in the future. Permit markets may be subject to three kinds of uncertainty: (1) uncertainty about the aggregate demand for permits that will be resolved by an information disclosure at a fixed date in the future; (2) aggregate demand shocks in each period; and (3) regulatory uncertainty.

The consequences of disclosing information at a known time about the demand for permits is illustrated by the collapse of the permit price in Europe following the disclosure of low demand for permits. In the case of demand shocks each period, the price path would become stochastic rather than deterministic. But if agents are risk neutral, little would change. If one works backward from the compliance period, assuming that on that date (1) all permits will be surrendered to the government and (2) agents with uncovered cumulative emissions must pay a well-specified penalty then, to equilibrate the market in the penultimate period under delayed compliance, the penultimate price must equal the discounted price expected in the next period. For, if that expected price were strictly higher, there would be excess demand for permits in the current period; and, if that expected price were strictly lower, there would be excess supply in the current period. But the same argument can be repeated

[18]Interested readers are referred to our companion paper (Hasegawa and Salant, 2012) where such a detailed analysis is presented.

as one works backward. In the stochastic equilibrium under delayed compliance, therefore, the price in every period must *equal* the discounted price then expected to prevail in any future period.

Regulatory uncertainty arises in part from the government's understandable goal of having the flexibility to cope with future circumstances. Regulators tend to avoid committing to future actions or policy rules. They prefer "discretion" to "precommitment." However, government flexibility, while understandable, distorts the intertemporal decision-making of private agents. This is true whether the private agents fully understand the regulator's objectives (Kydland and Prescott, 1977) or regard government actions as somewhat random (Salant and Henderson, 1978). McWilliams et al. (2011) have shown the importance of regulatory uncertainty in one permit market. Participants in the SO_2 market anticipated that at some unknown time in the future more permits would be required to cover each unit of SO_2 emissions and the price of permits would jump up. Anticipation of this uncertain event resulted in higher permit prices and more abatement; moreover, agents were willing to hold permits even though the permit price was rising by less than the rate of interest because of the capital gain they would receive when the uncertainty was resolved.

An important topic left for future work is welfare analysis. Under our assumptions, the cumulative emissions that arise in the equilibrium will be generated at least discounted costs since the marginal cost of abatement has the same present value in every period. However, under the plausible assumption that the stock of greenhouse gasses generates a flow of damages at each point in time, it has been shown (Kling and Rubin, 1997; Leiby and Rubin, 2001) that such an emissions path does not minimize the more relevant welfare functional—*the discounted sum of damages plus abatement costs*. In determining the socially optimal emissions path given such a damage function and in quantifying the welfare loss that would occur under a delayed compliance regime, we will have to take explicit account of when firms install their abatement technologies.[19]

Once we have calculated the welfare consequences of periods of delayed compliance of any given length, we can formally assess the optimal length of each compliance period. But some observations need not await formal analysis. Intuitively, the longer is each compliance period, the less likely is the government to wait for a period to end before intervening. In addition, the longer the compliance period, the greater the chance that (1) firms with uncovered pollution will go out of business before having to comply and (2) large utilities which have not complied before the end of the compliance period will evade regulation by threatening to shut down if forced to comply.

[19] See footnote 9.

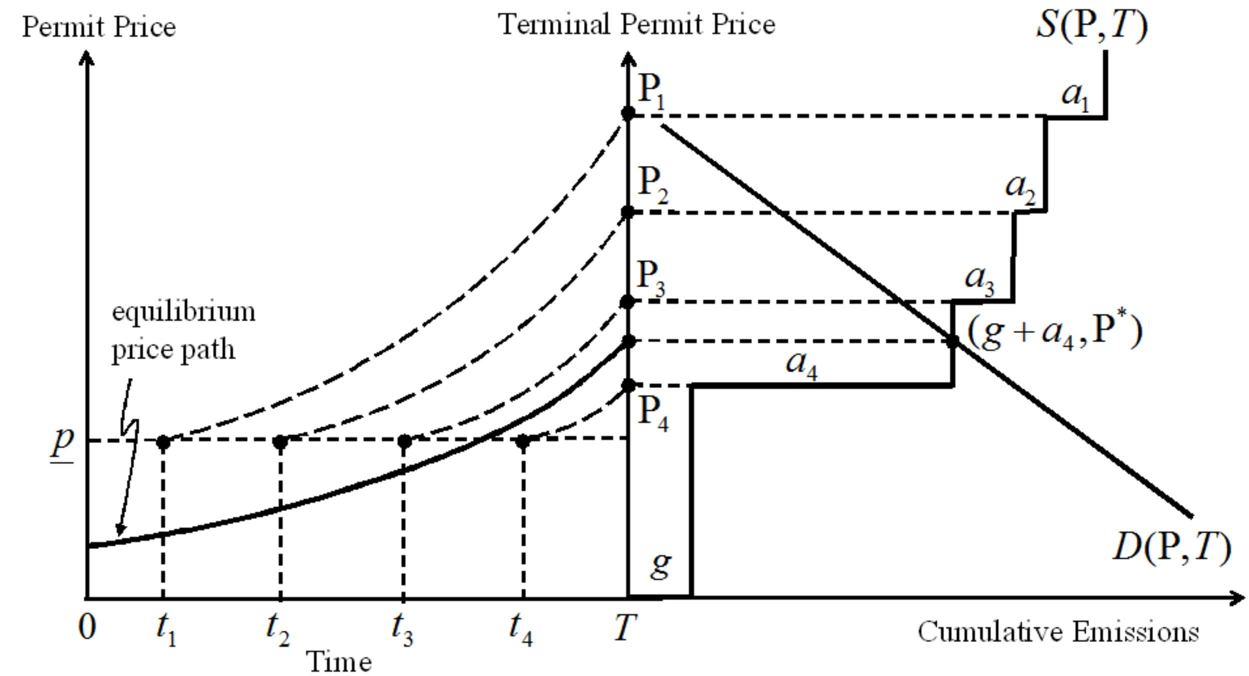

Figure 3.1: The Cumulative Demand and Supply, and the Equilibrium Price Path in the Case of Reserve Price Auctions

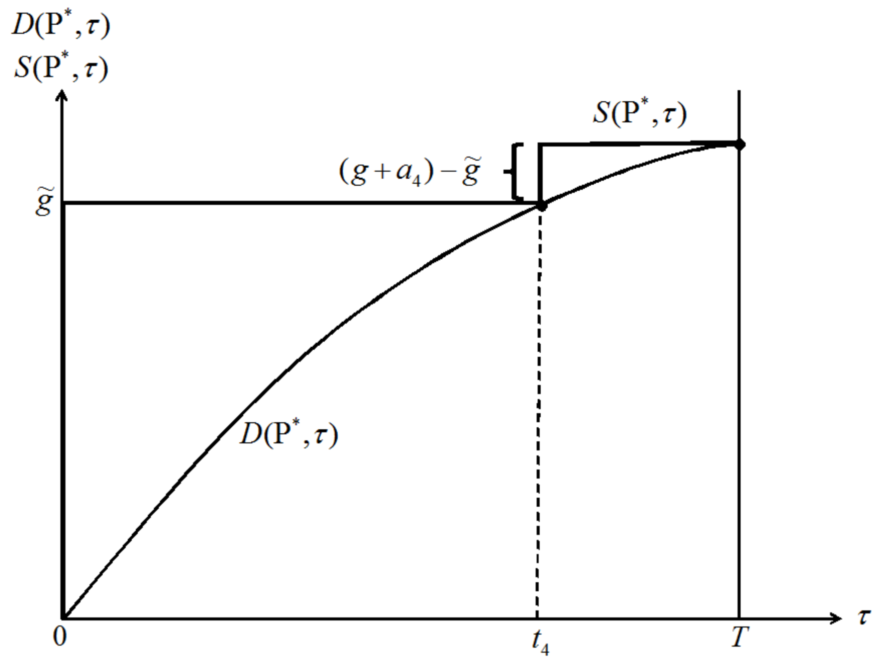

Figure 3.2: The Boundary Case in the Reserve Price Auctions

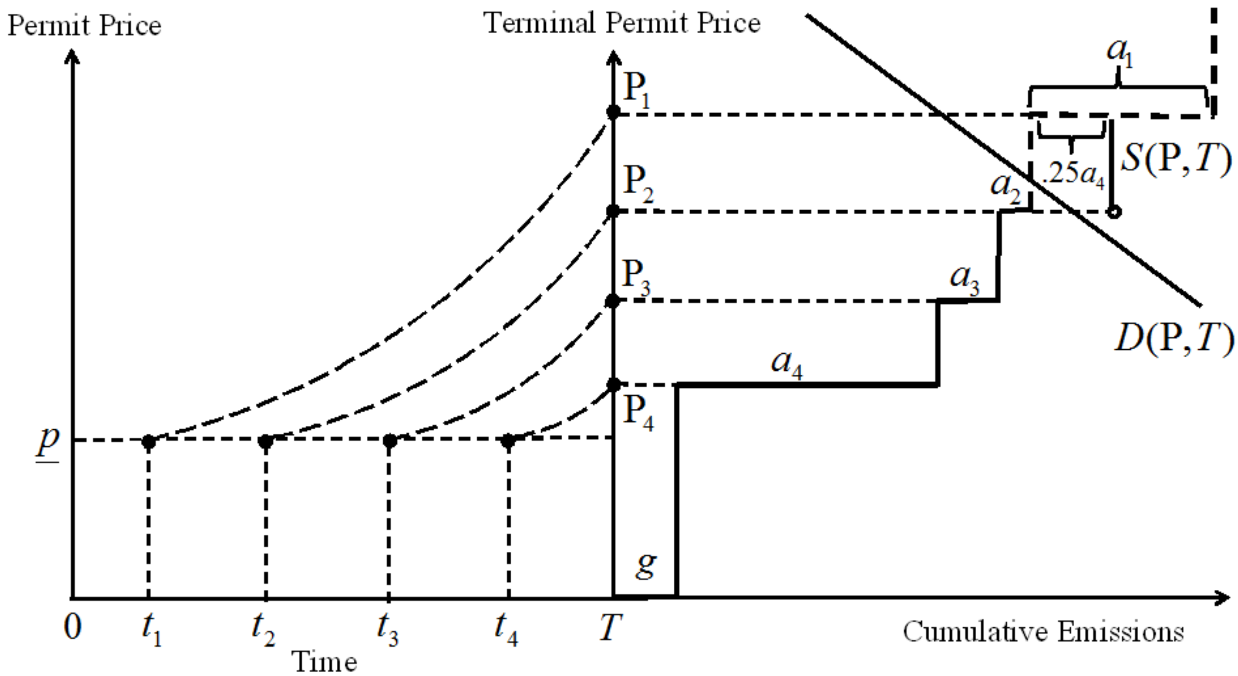

Figure 3.3: The Case of No Competitive Equilibrium under the Rules of California's AB-32

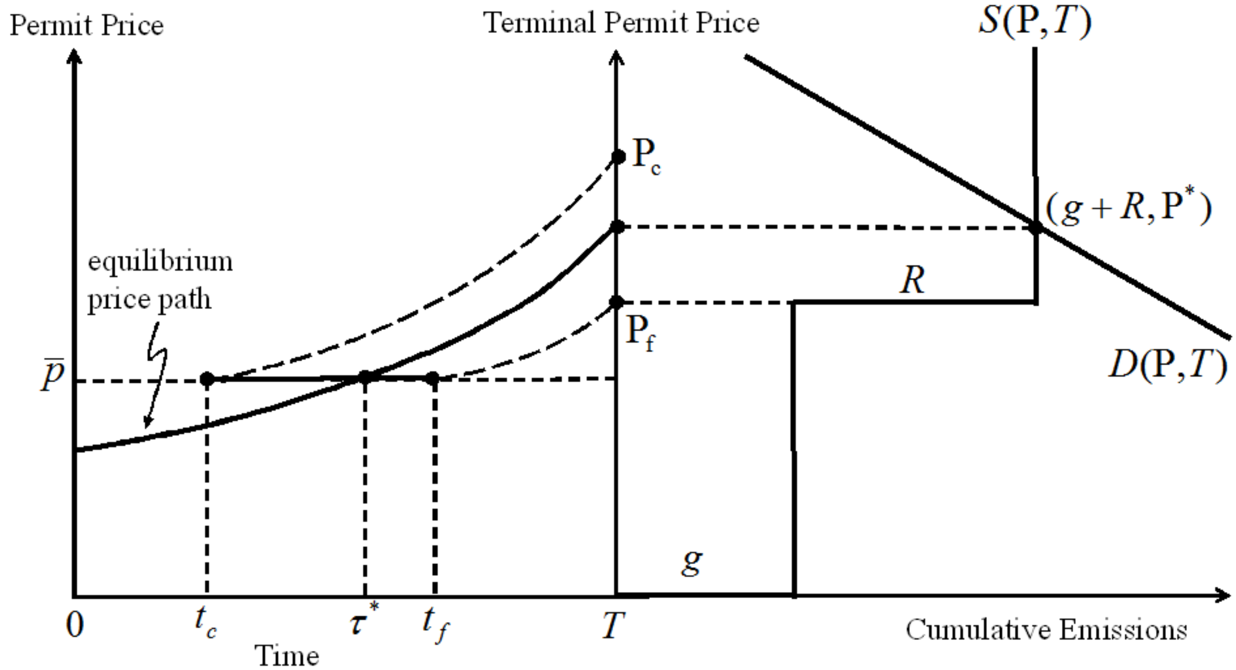

Figure 3.4: The Cumulative Demand and Supply, and the Equilibrium Price Path in the Case of Sales at Fixed Prices

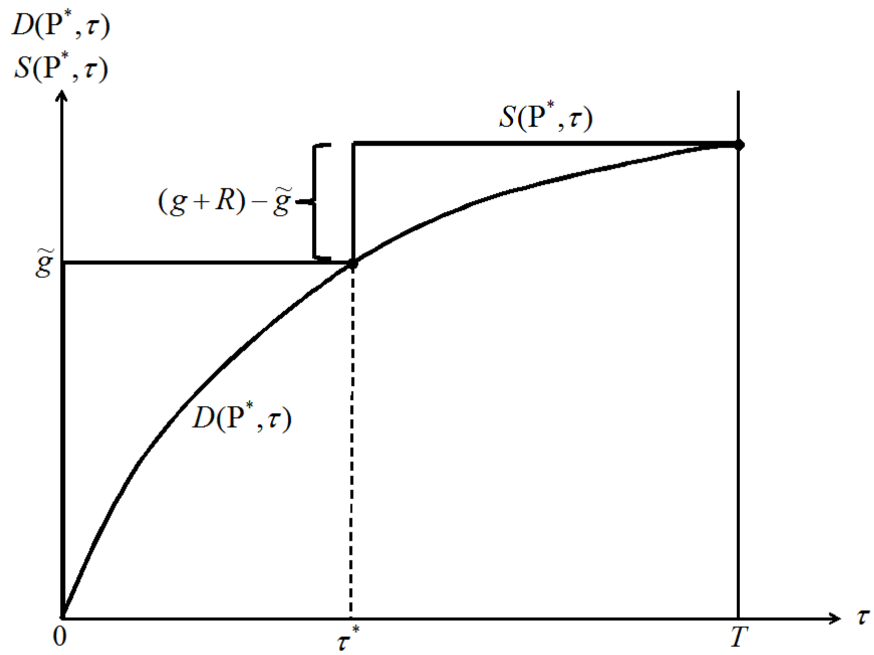

Figure 3.5: The Boundary Case in the Sales at Fixed Prices

APPENDICES

APPENDIX A

The Impact of Repatriation Tax rates on Dividend Payments by Foreign Subsidiaries

In this appendix, we theoretically examine how the Hartman result changes when firms expect a decrease in repatriation tax rates on dividends using a simple three-period model based on Grubert (1998) and Altshuler and Grubert (2003). The model consists of three periods, 0, 1, and 2. Periods 0 and 1 are the periods before the introduction of the dividend exemption system, and period 2 is the period under the new exemption system. Denote the repatriation tax rates on dividends in period t by τ_t^D for $t = 0, 1, 2$. Dividend exemption decreases the repatriation tax rates on dividends. Thus we assume that $\tau_0^D = \tau_1^D > \tau_2^D$. Consider a parent firm in Japan and its "mature" foreign affiliate located in country c that has enough retained earnings ($\overline{R}$) to finance its investment. The foreign affiliate produces output using capital with the production function $f(K)$, where K is capital input. The production function is strictly concave, strictly increasing, continuous, and continuously differentiable, and satisfies the Inada condition: $\lim_{K \downarrow 0} f'(K) = \infty$. For simplicity, we assume that capital does not depreciate over time.

At the end of period 0, the affiliate determines the amount of retained earnings out of the stock of retained earnings $\overline{R}$ for reinvestment in period 1, denoted by

E. The rest of earnings $(\overline{R} - E)$ is repatriated to the parent by dividends. At the beginning of period 1, investment takes place using capital input E and the profit from the investment comes at the end of period 1. At the end of period 1, the affiliate repatriates D_1 of the after-tax affiliate income, retaining R to reinvest in period 2. Denote the statutory tax rate of country c by τ_c. Then D_1 can be written as $D_1 = ((1-\tau_c)f(E) - R)$. In period 2, the affiliate produces using $(E+R)$ of capital and repatriates the entire net wealth to the parent firm in Japan at the end of the period by dividends. Thus $D_2 = (1-\tau_c)f(E+R) + E + R$. The parent firm determines E and R so as to maximize the present value of the net cash flows:

$$\begin{aligned}\max_{E,R} \quad & \left(1-\tau_1^D\right)\left(\overline{R} - E\right) + \frac{1}{1+r}\left(1-\tau_1^D\right)((1-\tau_c)f(E) - R) \\ & + \frac{1}{(1+r)^2}\left[\left(1-\tau_2^D\right)(1-\tau_c)f(E+R) + \left(1-\tau_2^D\right)(E+R)\right],\end{aligned}$$

where r is the real interest rate.

The first order conditions for the maximization problem with respect to E and R are

$$\begin{aligned}-\left(1-\tau_1^D\right) + \frac{1}{1+r}\left(1-\tau_1^D\right)(1-\tau_c)f'(E) + \frac{1}{(1+r)^2}\left[\left(1-\tau_2^D\right)(1-\tau_c)f'(E+R) + 1 - \tau_2^D\right] &= 0 \\ -\frac{1}{1+r}\left(1-\tau_1^D\right) + \frac{1}{(1+r)^2}\left[\left(1-\tau_2^D\right)(1-\tau_c)f'(E+R) + 1 - \tau_2^D\right] &= 0\end{aligned}$$

These two conditions can be rewritten as

$$(1-\tau_c)f'(E) = r, \tag{A.1}$$

$$(1-\tau_c)f'(E+R) = \frac{(1+r)\left(1-\tau_1^D\right) - \left(1-\tau_2^D\right)}{1-\tau_2^D}. \tag{A.2}$$

Equation (A.1) implies that the initial investment E does not depend on the repatriation tax rates. If the repatriation tax rate is constant over all the periods

($\tau_1^D = \tau_2^D$), R also does not depend on the repatriation tax rate because equation (A.2) then yields $(1-\tau_c)f'(E+R) = r$. Therefore, as Hartman (1985) shows, if $\tau_1^D = \tau_2^D$, the repatriation tax rate affects neither foreign investment nor dividend payments by the subsidiary.

However, if $\tau_1^D \neq \tau_2^D$, Hartman's result fails to hold. The total differentiation of equations (A.1) and (A.2) with respect to τ_1^D and τ_2^D yields

$$\frac{\partial R}{\partial \tau_1^D} = -\frac{1+r}{(1-\tau_2^D)(1-\tau_c)f''(E+R)} > 0, \tag{A.3}$$

$$\frac{\partial R}{\partial \tau_2^D} = \frac{(1-\tau_c)f'(E+R)+1}{(1-\tau_2^D)(1-\tau_c)f''(E+R)} < 0. \tag{A.4}$$

Equation (A.3) says that when the repatriation tax rate in period 1 is higher given the repatriation tax rate in the next period, the affiliate increases dividend payments in period 2. Equation (A.4) says that when the repatriation tax rate decreases in period 2, the affiliate will retain more profits in period 1 by decreasing dividend payments in that period and will increase them in period 2.

These results imply that Japan's foreign dividend exemption will stimulate dividend repatriations in two ways. Dividend exemption decreases the repatriation tax rate, and as a result, Japanese multinationals face the same lowered repatriation tax rate after the introduction of the dividend exemption system ($\tau_1^D > \tau_2^D$). Thus, as equation (A.4) shows, the lower repatriation tax rate (τ_2^D) will stimulate the dividend repatriations of Japanese multinationals given τ_1^D. Japanese multinational firms had faced different repatriation tax rates under the worldwide tax system (τ_1^D) depending on their foreign tax credit positions and the corporate tax policies of host countries (e.g., corporate tax rates and bases). Therefore, as equation (A.3) implies, foreign affiliates that had faced higher repatriation tax rates will pay out more dividends under the new exemption system.

APPENDIX B

Proof of $|\Pi| > 0$

To sign $|\Pi|$, I assume local stability of the symmetric Nash equilibrium. Denote country i's revenue function as $R^i(t_i, z_i, t_j, z_j)$. Following Dixit (1986), I consider the myopic adjustment process under which each country increases its statutory tax rate and the effective marginal tax rate if it perceives positive marginal tax revenue from doing so. The adjustment process is defined as

$$\begin{aligned} \dot{t_i} &= s_t^i R_{t_i}^i(t_i, z_i, t_j, z_j), \\ \dot{z_i} &= s_z^i R_{z_i}^i(t_i, z_i, t_j, z_j), \end{aligned}$$

where $\dot{t_i}$ and $\dot{z_i}$ are the time derivatives of t_i and z_i, respectively. Subscripts t_i and z_i on $R^i(t_i, z_i, t_j, z_j)$ denote partial derivatives. $s_t^i > 0$ and $s_z^i > 0$ are the adjustment speeds of t_i and z_i, respectively. Taking linear approximation of the symmetric equilibrium $t_i = t_j = t^*$ and $z_i = z_j = z^*$, I obtain

$$\begin{pmatrix} \dot{t}_i \\ \dot{z}_i \\ \dot{t}_j \\ \dot{z}_j \end{pmatrix} = \begin{pmatrix} s_t^i R_{t_i t_i} & s_t^i R_{t_i z_i} & s_t^i R_{t_i t_j} & s_t^i R_{t_i z_j} \\ s_z^i R_{z_i t_i} & s_z^i R_{z_i z_i} & s_z^i R_{z_i t_j} & s_z^i R_{z_i z_j} \\ s_t^j R_{t_j t_i} & s_t^j R_{t_j z_i} & s_t^j R_{t_j t_j} & s_t^j R_{t_j z_j} \\ s_z^j R_{z_j t_i} & s_z^j R_{z_j z_i} & s_z^j R_{z_j t_j} & s_z^j R_{z_j z_j} \end{pmatrix} \begin{pmatrix} t_i - t^* \\ z_i - z^* \\ t_j - t^* \\ z_j - z^* \end{pmatrix}$$

$$= \begin{pmatrix} s_t^i R_{tt} & s_t^i R_{tz} & 2N\left(mq' + G'p^2\right) s_t^i & 0 \\ s_z^i R_{zt} & s_z^i R_{zz} & 0 & 0 \\ 2N\left(mq' + G'p^2\right) s_t^j & 0 & s_t^j R_{tt} & s_t^j R_{tz} \\ 0 & 0 & s_z^j R_{zt} & s_z^j R_{zz} \end{pmatrix} \begin{pmatrix} t_i - t^* \\ z_i - z^* \\ t_j - t^* \\ z_j - z^* \end{pmatrix}.$$

The symmetric equilibrium is locally stable if and only if all eigenvalues of the matrix on the right hand side of the above equation have negative real parts, which implies that the determinant of the matrix is positive:

$$\det \begin{pmatrix} s_t^i R_{tt} & s_t^i R_{tz} & 2N\left(mq' + G'p^2\right) s_t^i & 0 \\ s_z^i R_{zt} & s_z^i R_{zz} & 0 & 0 \\ 2N\left(mq' + G'p^2\right) s_t^j & 0 & s_t^j R_{tt} & s_t^j R_{tz} \\ 0 & 0 & s_z^j R_{zt} & s_z^j R_{zz} \end{pmatrix} = s_t^i s_z^i s_t^j s_z^j \left|\Pi\right| > 0.$$

Since $s_t^i > 0$, $s_z^i > 0$, $s_t^j > 0$, and $s_z^j > 0$, the above condition yields $|\Pi| > 0$.

BIBLIOGRAPHY

BIBLIOGRAPHY

[1] Ai, Chunrong and Edward C. Norton.2003. "Interaction Terms in Logit and Probit models." *Economics Letters* 80(1), 123–129.

[2] Altshuler, Rosanne and Harry Grubert. 2001. "Where Will They Go if We Go Territorial? Dividend Exemption and the Location Decisions of U.S. Multinational Corporations." *National Tax Journal* 54(4), 787–809.

[3] Altshuler, Rosanne and Harry Grubert. 2003. "Repatriation Taxes, Repatriation Strategies and Multinational Financial Policy." *Journal of Public Economics* 87(1), 73–107.

[4] Aoyama, Keiji. 2009. "A Note on the New Japanese Exemption Policy of Foreign Subsidiary's Dividends (Gaikoku Kogaisha Haito Ekikin Fusannyu Seido no Kosatsu)." *Tsukuba Law Journal* 6, 99–117 (In Japanese).

[5] Baldwin, Richard E. and Paul Krugman. 1999. "Agglomeration, Integration and Tax Harmonisation." *European Economic Review* 48(1), 1–23.

[6] Becker, Johannes and Clemens Fuest. 2011. "Optimal Tax Policy when Firms are Internationally Mobile." *International Tax and Public Finance* 18(5), 580–604.

[7] Blouin, Jennifer and Linda Krull. 2009. "Bringing It Home: A Study of the Incentives Surrounding the Repatriation of Foreign Earnings Under the American Jobs Creation Act of 2004." *Journal of Accounting Research* 47(4), 1027–1059.

[8] Blouin, Jennifer L., Jana Smith Raedy, and Douglas A. Shackelford. 2004. "The Initial Impact of the 2003 Reduction in the Dividend Tax Rate." Working Paper, University of Pennsylvania.

[9] Bradley, Sebastien. 2011. "Round-tripping of Domestic Profits under the American Jobs Creation Act of 2004." Working Paper.

[10] Bucovetsky, Sam. 1991. "Asymmetric Tax Competition." *Journal of Urban Economics* 30(2), 167–181.

[11] Bucovetsky, Sam and Andreas Haufler. 2008. "Tax Competition when Firms Choose their Organizational Form: Should Tax Loopholes for Multinationals be Closed?" *Journal of International Economics* 74(1), 188–201.

[12] Burtraw, Dallas, Karen Palmer, and Danny Kahn. 2010. "A Symmetric Safety Valve." *Energy Policy* 38(9), 4921–4932.

[13] California Air Resources Board. 2011. "Final Regulation Order (corrected on December 21, 2011), Article 5: California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms." available at http://www.arb.ca.gov/regact/2010/capandtrade10/finalrevfro.pdf.

[14] Caves, Richard E. 2007. *Multinational Enterprise and Economic Analysis*, 3rd edition, New York: Cambridge University Press.

[15] Chetty, Raj and Emmanuel Saez. 2005. "Dividend Taxes and Corporate Behavior: Evidence from the 2003 Dividend Tax Cut." *Quarterly Journal of Economics* 120(3), 791–833.

[16] Cronshaw, Mark B. and Jamie B. Kruse. 1996. "Regulated Firms in Pollution Permit Markets with Banking." *Journal of Regulatory Economics* 9(2), 179–189.

[17] Davies, Ronald B. and Carsten Eckel. 2010. "Tax Competition for Heterogeneous Firms with Endogenous Entry." *American Economic Journal: Economic Policy* 2(1), 77–102.

[18] Desai, Mihir A. and James R. Hines Jr. 2004. "Old Rules and New Realities: Corporate Tax Policy in a Global Setting." *National Tax Journal* 57(4), 937–960.

[19] Desai, Mihir A., C. Fritz Foley, and James R. Hines Jr. 2001. "Repatriation Taxes and Dividend Distortions." *National Tax Journal* 54(4), 829–851.

[20] Devereux, Michael P., Rachel Griffith and Alexander Klemm. 2002. "Corporate Income Tax Reforms and International Tax Competition." *Economic Policy* 17(35), 449–495.

[21] Devereux, Michael P., Ben Lockwood, and Michela Redoano. 2008. "Do Countries Compete over Corporate Tax Rates?" *Journal of Public Economics* 92(5-6), 1210–1235.

[22] Dharmapala, Dhammika, C. Fritz Foley, and Kristin J. Forbes. 2011. "Watch What I Do, Not What I Say: The Unintended Consequences of the Homeland Investment Act." *Journal of Finance* 66(3), 753–787.

[23] Dixit, Avinash. 1986. "Comparative Statics for Oligopoly." *International Economic Review* 27(1), 107–122.

[24] Egger, Peter, Valeria Merlo, Martin Ruf, and Georg Wamser. 2012. "Consequences of the New UK Tax Exemption System: Evidence from Micro-Level Data." CESifo Working Paper Series No. 3942.

[25] Egger, Peter and Horst Raff. 2011. "Tax Rate and Tax Base Competition for Foreign Direct Investment." CESifo Working Paper Series No. 3596.

[26] Fell, Harrison, Dallas Burtraw, Richard D. Morgenstern, and Karen L. Palmer. 2012. "Soft and Hard Price Collars in a Cap-and-Trade System: A Comparative Analysis." *Journal of Environmental Economics and Management* 64(2), 183–198.

[27] Fell, Harrison and Richard D. Morgenstern. 2010. "Alternative Approaches to Cost Containment in a Cap-and-Trade System." *Environmental and Resource Economics* 47(2), 275–297.

[28] Flood, Robert, Nancy Marion, and Juan Yepez. 2012. "A Common Framework for Thinking about Currency Crises," In Lucio Sarno, Jessica James, and Ian Marsh (eds.), *Handbook of Exchange Rates*, John Wiley & Sons, Inc., Chapter 25.

[29] Greene, William. 2007. *Econometric Analysis*, 6th Edition. Upper Saddle River, New Jersey: Prentice Hall.

[30] Grubert, Harry. 1998. "Taxes and the Division of Foreign Operating Income among Royalties, Interest, Dividends and Retained Earnings," *Journal of Public Economics* 68(2), 269–290.

[31] Hartman, David G. 1985. "Tax Policy and Foreign Direct Investment." *Journal of Public Economics* 26(1), 107–121.

[32] Hasegawa, Makoto and Stephen Salant. 2012. "Cap-and-Trade Programs under Continual Compliance." Discussion paper 12-33. Washington, DC: Resources for the Future.

[33] Haufler, Andreas and Marco Runkel. 2008. "Firms' Financial Choices and Thin Capitalization Rules under Corporate Tax Competition." CESifo Working Paper Series No. 2429.

[34] Haufler, Andreas and Guttorm Schjelderup. 2000. "Corporate Tax Systems and Cross Country Profit Shifting." *Oxford Economic Papers* 52(2), 306–325.

[35] Haufler, Andreas and Ian Wooton. 1999. "Country Size and Tax Competition for Foreign Direct Investment." *Journal of Public Economics* 71(1), 121–139.

[36] Hines, James R. Jr. 1996. "Altered States: Taxes and the Location of Foreign Direct Investment in America." *American Economic Review* 86(5), 1076–1094.

[37] Hines, James R., Jr. and R. Glenn Hubbard. 1990. "Coming Home to America: Dividend Repatriations by U.S. Multinationals." In Assaf Razin and Joel Slemrod (eds.), *Taxation in the Global Economy*, Chicago: University of Chicago Press, 161–200.

[38] Holland, Stephen P. and Michael R. Moore. 2012. "Market Design in Cap and Trade Programs: Permit Validity and Compliance Timing." NBER Working Paper 18098.

[39] Hone, David. 2012. "The Case for an Auction Reserve Price." available at http://blogs.shell.com/climatechange/2012/06/auction/.

[40] Jacoby, Henry D. and A. Denny Ellerman. 2004. "The Safety Valve and Climate Policy." *Energy Policy* 32(4), 481–491.

[41] Kawano, Laura and Joel Slemrod. 2011. "What is the (Endogenous) Tax Rate Elasticity of Corporate Taxable Income? With Implications for the Revenue-Maximizing Tax Rate." Working Paper.

[42] Kim, Myung-Sun and William Kross. 1998. "The impact of the 1989 Change in Bank Capital Standards on Loan Loss Provisions and Loan Write-offs." *Journal of Accounting and Economics* 25(1), 69–99.

[43] Kiyota, Kozo and Tetsuji Okazaki. 2005. "Foreign Technology Acquisition Policy and Firm Performance in Japan, 1957–1970" *International Journal of Industrial Organization*, 23(7-8), 563–586.

[44] Kling, Catherine and Jonathan Rubin. 1997. "Bankable Permits for the Control of Environmental Pollution." *Journal of Public Economics* 64(1), 101–115.

[45] Krugman, Paul. 1999. "Currency Crises," available at: http://web.mit.edu/krugman/www/crises.html.

[46] Kydland, Finn E. and Edward C. Prescott. 1977. "Rules Rather than Discretion: The Inconsistency of Optimal Plans." *Journal of Political Economy* 85(3), 473–492.

[47] Leiby, Paul and Jonathan Rubin. 2001. "Intertemporal Permit Trading for the Control of Greenhouse Gas Emissions." *Environmental and Resource Economics* 19(3), 229–256.

[48] Masui, Yoshihiro. 2010. "Taxation of Foreign Subsidiaries: Japan's Tax Reform 2009/10." *Bulletin for International Taxation* 64(4), 242–248.

[49] McWilliams, Michael, Michael R. Moore, Gloria Helfand, and Yimin Liu. 2011. "Explaining Price Movements of the SO_2 Market," work in progress.

[50] Ministry of Economy, Trade and Industry of Japan (METI). 2008. *Repatriations of Foreign Profits by Japanese Enterprises: Toward the introduction of a dividend exemption regime* (*Wagakuni Kigyo no Kaigairieki no Kanryu nitsuite*). (In Japanese).

[51] Oler, Mitchell, Terry Shevlin, and Ryan Wilson. 2007. "Examining Investor Expectations concerning Tax Savings on the Repatriations of Foreign Earnings under the American Jobs Creation Act of 2004." *Journal of the American Taxation Association* 29(2), 25–55.

[52] Organisation for Economic Co-operation and Development (OECD). 2010. *OECD Tax Database*, Paris: OECD.

[53] Ottaviano, Gianmarco I.P. and Tanguy van Ypersele. 2005. "Market Size and Tax Competition." *Journal of International Economics* 67(1), 25–46

[54] Redmiles, Melissa. 2008. "The One-Time Received Dividend Deduction." *Statistics of Income Bulletin*, 102–114.

[55] Rubin, Jonathan D. 1996. "A Model of Intertemporal Emission Trading, Banking, and Borrowing." *Journal of Environmental Economics and Management* 31(3), pp. 269-286.

[56] Salant, Stephen W. 1983. "The Vulnerability of Price Stabilization Schemes to Speculative." *Journal of Political Economy* 91(1), pp. 1-38.

[57] Salant, Stephen W. and Dale Henderson. 1978. "Market Anticipations of Government Policies and the Price of Gold." *Journal of Political Economy* 86(4), pp. 627-648.

[58] Slemrod, Joel. 1990. "Tax Effects on Foreign Direct Investment in the United States: Evidence From a Cross-Country Comparison," in Assaf Razin and Joel Slemrod (eds.), *Taxation in the Global Economy*, Chicago, IL: University of Chicago Press, 79–117.

[59] Stavins, Robert N. 2012. "Low Prices a Problem? Making Sense of Misleading Talk about Cap-and-Trade in Europe and the USA." available at http://www.robertstavinsblog.org/2012/.

[60] Tajika, Eiji, Masaki Hotei, and Keiko Shibata. 2012. "The Effect of Japan's Tax Reform 2009 on Dividend Repatriations by Japanese Multinationals: An Analysis with a Focus on the Cash Demand of Parent Companies (2009 Nendo Zeisei Kaisei ga Genchi Hojin no Haito Sokin ni Oyoboshita Koka)." PRI Discussion Paper Series (No.12A-16), Policy Research Institute, Ministry of Finance (In Japanese).

[61] Tajika, Eiji and Ryota Nakatani. 2008. "Welcome Home to Japan: Repatriation of Foreign Profits by Japanese Multinationals." Discussion Paper No. 2008-04, Hitotsubashi University.

[62] United Nations Conference on Trade and Development (UNCTAD). 2012. *UNCTADStat Database*, http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx.

[63] Wilson, John D. 1986. “A Theory of Interregional Tax Competition.” *Journal of Urban Economics* 19(3), 296–315.

[64] Wilson, John D. 1991. “Tax Competition with Interregional Differences in Factor Endowments.” *Regional Science and Urban Economics* 21(3), 423–451.

[65] Zodrow, George R. and Peter Mieszkowski. 1986. “Pigou, Tiebout, Property Taxation, and the Underprovision of Local Public Goods.” *Journal of Urban Economics* 19(3), 356–370.