Thammasat Review of Economic and Social Policy
Volume 5, Number 1, January – June 2019

Received: 30 October 2018
Revised: 5 January 2019
Accepted: 10 January 2019

Tax competition when transfer price is regulated

Sirikamon Udompol
Senior Economist
Ministry of Finance
Thailand
sudompol@hotmail.com

Gareth D. Myles
Professor
Head of School of Economics
University of Adelaide, Australia
Research Fellow of the Institute for Fiscal Studies, UK
gareth.myles@adelaide.edu.au

ABSTRACT

This paper aims to find the government's optimal corporate tax that maximises revenue (or welfare), as well as minimises distortions of the firm's choices of investment and profit location. We construct a theoretical model of tax competition and tax coordination between two governments when a multinational firm minimises taxes through transfer pricing and the governments have two policy instruments: the tax rate and the transfer pricing penalty rate. We find that (1) tax competition results in too-low a tax rate and under-provision of public goods; (2) when the countries' exogenous penalty rates are different, under government cooperation, the optimal tax rate in each country also different; (3) an attempt by the OECD to have a single transfer pricing penalty rule may not be the only optimal solution for small cooperative governments; and (4) countries over-regulate the multinational firm's transfer prices when they compete on transfer pricing penalty rates. The paper suggests that a country with lenient transfer pricing rules (tax rates) should maintain low tax rates (transfer pricing rule) and a country with a tougher transfer pricing rule (tax rates) should maintain high tax rates (transfer pricing rule).

Keywords: Corporate tax policy, Transfer pricing, International trade, Multinational enterprises

JEL Classification: F2, H3, H4

1. Introduction

Countries compete on tax rates for the mobile capital and tax base. After competing upon their tax rates, however, governments find that the efficiency and effectiveness of their tax policy is undermined by the profit-shifting behaviour of multinational companies. Recognising that a multinational company can minimise its global tax payment by manipulating the intra-firm transfer price, countries implement transfer pricing regulations with penalties to protect their tax bases. As these regulations and penalties vary from one country to another, however, it leads to further differences in their tax systems and corporate tax rates. Consequently, fiscal competition distorts a multinational firm's decision on where to locate its production and profit even further. Besides, if fiscal competition results in a lower tax rate (or too high a penalty rate) compared to the result under government cooperation, there is an inefficient provision of public goods. Because of these strong linkages between the issues of tax competition and transfer pricing manipulation and regulation, the study of tax competition is incomplete without considering the issue of a multinational firm's transfer pricing.

A government aims for a corporate income tax which raises revenue as efficiently as possible. The term efficiency means that a government wants a corporate tax system with minimal distortions to the firm's decisions on production location, scale of investment, profit location, choice of financing, and choice of legal form of business (Devereux and Sørensen, 2005). Public economic literature has long suggested a view that a government should tax only the economic rent of the firm to minimise efficiency distortion caused by the corporate income tax. Since the corporate income tax on economic rent is non-distortionary, it will not

distort a firm's decisions, for example, on investment or choice of financing between equity and debt. However, this view is only true in the case of a close economy. In an open economy, on the contrary, a multinational firm has choices on where (in which countries) to locate its investment and profit. In this case, even a tax on economic rent is distortionary. This is because the firm's decisions, on location of production or profit for example, are influenced by differences in countries' tax rates (Devereux and Sørensen, 2005, p.3). As it is most likely that profit is more mobile than capital, the importance of a multinational firm's cross-country profit shifting is too large for any country to ignore. This raises the view that the difference in countries' tax rates may distort the multinational firm's decision on profit location more than its decision on real investment even when the firm's profit shifting is, to some extent, restrained by the government's rule (Devereux and Sørensen, 2005).

This paper is motivated by our aim to find the government's optimal corporate tax that maximises revenue (or welfare), as well as minimises distortions of the firm's choices of investment and profit location when the government is faced with international mobility of capital and profit, inter-governmental fiscal competition or cooperation, and multinational firms that use transfer pricing to shift profit. Because of the international mobility of the tax base, our theoretical model will demonstrate that even when each country imposes a corporate income tax on a multinational firm's pure profit, the firm's decisions on level of production (capital investment and production of intermediate goods), and profit location are distorted by the difference in the host and the home countries' tax rates and transfer pricing penalty rates.

Evidence of multinational companies' practice of transfer pricing is documented in Liu et al. (2017). By

analyzing UK's tax data on tangible goods during 2005-2011, they found that MNCs' transfer pricing practice is escalated when government uses territorial system in taxing foreign profit and is concentrated in R&D intensive companies. In addition, MNCs mispricing occurs more in countries with low-to-medium level of corporate tax rates than tax haven countries. Similarly, Vicard (2014) also found evidence of French government's tax loss in 2008 through MNCs' mispricing to shift profit to low tax jurisdictions.

In this paper, we construct a theoretical model of tax competition and tax coordination between two governments when a multinational firm minimises taxes through transfer pricing and the governments have two policy instruments: the tax rate and the transfer pricing penalty rate. In addition, to reflect the real world situation, we assume that the government applies both source and residence principle by taxing worldwide income of its resident company and gives foreign tax credit and taxing source-based income of foreign firm. We aim to address the following questions: firstly, what would be an optimal profit tax rate and transfer pricing penalty rate for a revenue maximising government? Secondly, does cooperation between governments result in a higher or a lower equilibrium profit tax rate and transfer pricing penalty rate compared with the equilibrium under competition? Thirdly, is an attempt by an international organisation such as the European Union to have a single transfer pricing documentation rule Pareto improving?

Although there are number of papers that have studied intergovernmental tax competition under the context of the multinational firm's profit shifting through transfer prices such as Elitzur and Mintz (1996), Haufler and Schjelderup (2000), Devereux et al. (2004), and Devereux et al. (2008), they, however, did not allow countries to compete on transfer pricing penalty rates. On the other hand, Raimondos-Møller

and Sharf (2002) studied government competition on transfer pricing rules, however, they did not allow countries to compete on tax rate. This makes our model different from other standard tax competition models with transfer pricing as we allow governments to compete on two corporate tax instruments: the corporate tax rate on pure profit and the transfer pricing penalty rate to provide a disincentive to the firm from profit shifting.

Employing game theory, the model is constructed as a two-stage game. In the first stage, the governments maximise tax revenue by either cooperatively or competitively choosing profit tax rates and/or penalty rates. In the second stage, the multinational firm (also called "the firm") maximises global profit after taxes and penalties by choosing the level of capital use, the level of production, and the transfer price in each country given the country's profit tax rate and penalty rate. The Nash equilibrium is found using backward induction. By comparing the Nash equilibrium of corporate tax instruments (rate and penalty) under governments' cooperation and governments' competition, our theoretical model shows how government competition diverges corporate tax policies from a second-best result under cooperation[1].

At this point, it should also be noted that tax competition has been discussed under various different definitions. We focus, however, on horizontal tax competition between governments which is a 'narrow' definition of tax competition used in Wilson and Wildasin (2004). They define tax competition as "*non-cooperative tax setting by independent*

[1] Governments' cooperation on corporate tax policies when the multinational firm still shift profit through transfer pricing is still a second best result comparing to the first best result under a situation where there is no transfer pricing and governments can tax away all of the firm's economic rent.

governments, under which each government's policy choices influence the allocation of a mobile tax base among "regions" represented by these governments". Moreover, multinational firms manipulate transfer pricing for other reasons as well as the tax saving motive. For example, the transfer price can be strategically used to gain local market shares (Nielsen et al., 2003). We focus, however, only on the tax-saving incentive for transfer pricing.

The paper is organised as follows. Section 2 gives an overview of transfer pricing and transfer pricing related regulation, followed by Section 3 which reviews the formal literature on tax competition, tax policies and transfer pricing, and fiscal competition and transfer pricing. Section 4 provides theoretical models based on the two governments' coordination and competition. Lastly, Section 5 provides conclusion which summarises our findings, points out policy implications and suggestions for further research.

2. Transfer pricing

What price is a transfer price? According to the OECD, *"Transfer prices are the prices at which an enterprise transfers physical goods and intangible property or provides services to associated enterprises"* (OECD, 1995). Since the transfer of goods and services between associated divisions or enterprises within a firm is part of the firm's routine operation, the transfer price also inevitably coexists with those transactions. Getting the right transfer price is important since the transfer price affects the firm's activities and total profit. But what is the "optimal" transfer price of the firm?

Without considering the issue of taxation, Hirshleifer (1956) suggests that when output is jointly determined by divisions within the firm or when a market for the transferred

good is imperfectly competitive, the optimal transfer price should equal the marginal cost of the seller (supply) division. And when there is a competitive market for the transferred goods, the transfer price should equal the market price for that good (Hirshleifer, 1956)[2]. In reality, however, determining the optimal transfer price involves more factors than simply marginal cost or market price especially when the firm operates in several jurisdictions with different tax rates. Taking advantage of the differences in the countries' tax rates, the multinational firm can strategically set its transfer price to minimise global tax payment[3]. However, the firm's ability to manipulate its transfer price is constrained by government regulations on transfer price, which could result in a heavy tax penalty to the firm.

With globalisation increasing cross-country intra-company transactions, the risk to a country's tax revenue from transfer pricing escalates. On the other hand, the risk to the firm of tax audit and penalty also increases with tougher government scrutiny of transfer prices. As a result, transfer pricing continues to be an international tax issue concerning both multinational firms and governments (Ernst and Young, 2005).

According to the second instalment of the Ernst and Young 2005-2006 Global Transfer Pricing Survey (the Survey)[4], tax directors completing the survey indicated that

[2] The idea that the transfer price should equal market price is an origin to the "arm's length" principle of transfer price.

[3] This point is based on Horst (1971) and Copithorne (1971). These two papers are explored in more details later.

[4] The Ernst and Young's 2005-2006 Global Transfer Pricing Surveys was released in three instalments. The first instalment conducted a web-based survey of more than 100 financial institutions globally. The second instalment, published in November 2005, interviewed 3.8 parent companies and 128 subsidiaries corporate in 22 countries worldwide.

transfer pricing is the most important tax issue to them, followed by issues of tax minimisation and double taxation. Moreover, nearly 77% of the responding companies think that transfer pricing will continue to be an important issue in the next two years. In relation to these findings, 68% of the respondents indicated that the tax department is involved in the business project at an early stage and 32% of the respondents stated that they used more business change to implement transfer pricing or tax planning than in the previous two years. More importantly, the collective view on transfer pricing by the respondent firms is best described by a quotation in the survey that *"Transfer pricing is increasingly perceived as less of a compliance issue and more of a planning issue that contributes value"* (Ernst and Young, 2005). This is backed up by the finding that 29% of the respondents more frequently used transfer pricing in their tax planning strategy. These findings indicate that multinational firms will continue to take both proactive and defensive strategies in globally determining their transfer prices.

Regarding government enforcement, in its second instalment of the Survey, Ernst and Young find that more countries have tax laws regulating transfer pricing including transfer pricing documentation requirements and penalties for transfer pricing adjustment. To be specific, the number of countries that have effective transfer pricing documentation rules increased from 6 countries in the year 1997 to 32 countries in the year 2005, while 7 more countries are expected to have documentation rules put in place soon (Ernst and Young, 2005). In its third instalment[5] of the

[5]The third instalment of the Survey, published in September 2006, focuses on tax authority's perspectives, interpretations and regulatory changes regarding transfer pricing.

Survey, Ernst and Young interviewed tax authorities in 39 countries. They find that not only have the number of countries with transfer pricing regulations increased, but countries which already had well established transfer pricing rules have increased their resources and the level of sophisticated effort in tackling transfer price manipulation. The Survey indicates that countries increasingly follow the "arm's length" principle set out in the OECD (1995) Transfer Pricing Guideline. Even the non-OECD countries are found to apply this guideline. However, the Survey also states that countries have different approaches and interpretations when dealing with transfer pricing regardless of whether they apply the same OECD guidelines. This difference in individual countries' enforcement of transfer price results in disputes between tax authorities. As a result, there are attempts by the Pacific Association of Tax Administrators (PATA)[6] and the European Union Joint Transfer Pricing Forum (EUJTPF)[7] to have a common approach to transfer pricing documentation. Nonetheless, PATA and EUJTPF take different approaches in their initiations (Ernst and Young, 2006). From the Ernst and Young Survey, it seems that transfer pricing will continue to cause disputes not only between corporate taxpayers and tax authorities but also between tax authorities themselves.

3. Review of literature

The literature on tax competition mainly focuses on capital tax competition with the orthodox assumption that

[6]PATA is an association of the tax administrations of Australia, Canada, Japan and the United States of America.

[7]EUJTPF consists of representatives of governments and the private sector who advise and consult on transfer pricing issues.

capital is mobile while labour is immobile between countries. Among the early theoretical papers, Zodrow and Mieszkowski (1986) model tax competition between local governments and find that, under fixed and perfectly mobile national capital stock and the identical local governments, an increase in the use of property tax on capital while reducing the lump-sum tax (or head tax) decreases the provision of public goods (Zodrow and Mieszkowski, 1986). Wilson (1986) also constructs a tax competition model between local governments and find that tax competition occurs when the rate of substitution between mobile capital and immobile labour is sufficiently high and tax competition causes a low tax rate and low local government spending. Moreover, welfare improves when the local government increases public spending (Wilson, 1986). Moving from symmetric country, Kanbur and Keen (1993) suggest that country size differences also contribute to the inefficiency arising from tax competition. By assuming that countries differ in size, they find that when the border is opened the smaller country cuts its tax rate. Furthermore, the small country's tax revenue per capita is higher than that of the larger country even if total tax revenue of the larger country is higher (Kanbur and Keen, 1993).

Another recent stream of the tax competition literature looks at the effects of tax coordination and harmonization such as Free Trade Agreements (FTA) and Custom Unions (CU) on investment. Raff (2004), for example, theoretically explains why FTAs may induce Foreign Direct Investment (FDI). They find that when at the equilibrium the external tariff is too low, FTAs do not attract FDI and so it is better for countries to agree on a CU (Raff, 2004). Kanbur and Keen (1993), and Tiebout (1956) suggests that tax harmonisation can be a welfare improvement. Baldwin and Krugman (2004), however, argue that when taking into

account an 'agglomeration rent' of industrial concentration which is location specific, tax harmonisation can make one or both governments worse off (Baldwin and Krugman, 2004).

Theoretical model on country's tax competition is confirmed by empirical findings in Devereux et al. (2004) that during 1982-1999 OECD member countries competed on both the effective marginal tax rate (EMTR) and the statutory tax rate. Bretschger and Hettich (2002), using a panel data of 14 OECD countries during 1967-1997 and a measure of country openness, find that the corporate tax rate decreases with an increase in the country's openness.

The earliest and the most well-known papers that look at government taxation and a multinational firm's transfer pricing decision are those of Horst (1971) and Copithorne (1971). They show that, besides losing revenue from engaging in tax competition, governments inevitably lose their tax bases through multinational companies' transfer pricing manipulation. Horst (1971) points out the importance of transfer pricing as a tax-saving device for multinational firms as he states *'Even if foreign production is unprofitable, a foreign sales agency may be established to permit the firm to set its transfer price below the market value in the importing country'*. Copithorne (1971) highlights the role of transfer pricing as a profit-shifting device by a company that operates in more than one country. Moreover, Copithorne mentions that a government may introduce what it considered 'a fictitious transfer price' for tax calculation purposes or it can negotiate with the firm on 'an acceptable transfer price' (Copithorne, 1971).

Booth and Jensen (1977) extend Copithorne's work and find that when the firm is constrained to make a minimum local profit in each country and country tax rates are equal, there is an interior solution for the transfer price where the equilibrium transfer price is bounded by profit constraints

(Booth and Jensen, 1977). Samuelson (1982), Eden (1983), and Kant (1988, 1990) demonstrate that when a government regulates the transfer price, a multinational firm's optimal transfer price is bounded.

The literatures which look directly at the issue of the multinational firm's transfer price and tax competition between governments, which is what we will construct our theoretical model on similar setting, are Elitzur and Mintz (1996), Haufler and Schjelderup (2000), Devereux et al. (2004), and Devereux et al. (2008). Also, Raimondos-Møller and Scharf (2002) studies government competition on transfer pricing rules. Elitzur and Mintz (1996) model a multinational firm who has a subsidiary located in a foreign country. They find that when both governments compete on the effective corporate tax rate under Nash strategy, it results in one country responding by reducing its effective tax rate while the other country increases its effective tax rate (Elitzur and Mintz, 1996). In addition, when the tax rate is harmonised to reduce negative externalities, both countries' tax rates are lower than in the competitive case (Elitzur and Mintz, 1996, p. 418). There are some precautions when it comes to interpreting the Elitzur and Mintz (1996) findings. Firstly in their model the transfer price is not determined by the firm but assigned by the home government. Secondly, the cost of input (manager's compensation) is tax non-deductible. Finally the home country exempts the foreign income of its resident company even when that company is the parent company of the multinational firm.

Haufler and Schjelderup (2000) study an optimal tax policy when two small home and host governments compete on both a profit tax rate and a tax base. They find that when the governments use source-based taxation, foreign investors jointly own the local firm, and the issue of transfer pricing is presented, it is optimal for the governments to allow less than

a full deduction of the investment expenditure. The less than full deduction of investment cost results in an investment distortion but allows a tax rate reduction which discourages profit shifting (Haufler and Schjelderup, 2000). Considering the Nash equilibrium, they show that if the countries are symmetric, there will be no problem of transfer price manipulation at the Nash equilibrium but both governments would lose from the investment distortion from the less than full deduction of investment expenditure (Haufler and Schjelderup, 2000). When allowing for an asymmetric setting, the equilibrium is characterised by one country's tax rate being higher than that of another country. At the equilibrium the transfer price results in a higher declared profit in the country with a lower tax rate. However, under the asymmetric setting it is still optimal for both countries to allow a less than full deduction of investment expenditure (Haufler and Schjelderup, 2000). Lastly, they mention that due to the government's revenue constraint, their findings cannot be interpreted as a competition in Effective Marginal Tax Rate (EMTR) (Haufler and Schjelderup, 2000). This point, however, is picked up by the work by Devereux et al. (2004).

The Devereux et al. (2004) paper comprises of both theoretical and empirical aspects of tax competition. As mentioned earlier, they find evidence of tax competition between OECD countries during 1982-1999. We focus here, however, on their theoretical model, which endogenises the decision on transfer price into the multinational firm's decision through governments' transfer pricing penalties. Inspired by Zodrow and Mieszkowski (1986) and Wilson (1986), they construct a corporate tax competition model between two governments who finance their public goods with a source-based corporate tax when capital is freely mobile across countries. Also, like Elitzur and Mintz (1996)

and Haufler and Schjelderup (2000), in their model, the governments impose the transfer pricing penalties on an intra-firm's transfer price manipulation. However, their model is a complex extension of the previous literature in two ways. Firstly, the governments compete on EMTR to attract capital and on statutory tax rate to attract profit (Devereux et al., 2004). Secondly, the price of capital is market determined (Devereux et al., 2004).

Although we find the Devereux et al. (2004) model thoroughly analysed and very well constructed, there are certain points that we think can be altered to make the model more realistic especially on the cost of producing transferred intermediate goods and the formulation of tax penalty. Firstly, the cost of producing intermediate goods should not be normalised to zero as assumed in their model. Rather, these should be constructed to reflect the firm's true cost of production, i.e. labour cost. Secondly, the penalty on the transfer price manipulation should be proportional to quantity of trade between the related firms, which we think is more realistic since the tax penalty is usually calculated on unpaid tax. Since Devereux et al. (2004) assumes a discrete unit of transferred intermediate goods this issue is not considered in their model. Lastly, there is a possibility that countries can compete on both the statutory tax rate and the transfer pricing penalty rate, especially if one country wants to be viewed as a tax haven country, which is characterised by a low profit tax rate and a lenient transfer pricing rule. So, the model should allow for competition on penalties. Devereux et al. (2004) assumes equal penalty rates and so they only consider competition on tax rates. In Devereux et al. (2008), which is the published version of the paper, the cost of producing an intermediate good is, now, a positive constant, which is also a government's 'arm's length' price. And, the government imposes a penalty with probability equals to the difference

between the firm's transfer price and the 'arm's length' price. Although the transfer pricing penalty in Devereux et al. (2008) is more simplified, their results are similar to their previous version of the paper.

Government competition on transfer pricing rules is analysed in Raimondos-Møller and Scharf (2002). They consider a theoretical model with a global profit maximising multinational enterprise (MNE) with a parent firm located in a home country and a subsidiary located in a host country. They find that the MNE's production reacts negatively (positively) to the home country's (host country's) imputed transfer price. Also, when the government's marginal effective cost of public funds is positive and its residents do not fully own the MNE, the government's optimal imputed transfer price reacts positively to the other country's imputed transfer price (Raimondos-Møller and Scharf, 2002). Moreover, the home country's (host country's) optimal imputed transfer price decreases (increases) when its resident's ownership of MNE increases (Raimondos-Møller and Scharf, 2002). They also conclude that the government's competition results in an over-regulated transfer price. As a result, a country's welfare may be improved when the transfer pricing rule is harmonised (Raimondos-Møller and Scharf, 2002). However, a Pareto improvement may not occur when the "imputed transfer price" is harmonised to the marginal cost of production of the firm which is commonly regarded as an arm's length price (Raimondos-Møller and Scharf, 2002). Although we agree that the "imputed transfer price" in Raimondos-Møller and Scharf (2002) can be considered as the transfer pricing rule, we want to investigate whether their results change when a different form of transfer pricing rule is assumed. Moreover, we aim to analyse whether the country's reaction to the transfer pricing rule changes when the governments compete on both the transfer price rule and

the statutory tax rate.

In the next sub-section, we construct an alternative setting for the model of the tax rate and transfer pricing rule from the previous literature, especially from that of Kant (1988, 1990), Devereux et al. (2004), and Raimondos-Møller and Scharf (2002). Our theoretical model studies the profit tax rate and transfer pricing penalty competition between two governments under both symmetric and asymmetric settings.

4. Theoretical model

The model studies government competition over the level of the profit tax rate and/or the transfer pricing penalty rate. Applying the Nash equilibrium concept, we observe a multinational firm's decisions on the level of transfer price, capital investments, and production in responding to both a home country and a host country tax rate and transfer pricing penalty rate. Taking into account the multinational firm's optimal decisions, we then analyse each country's decision regarding the profit tax rate and the transfer pricing penalty rate.

Our model aims to answer the following questions: firstly, what would be an optimal profit tax rate and transfer pricing penalty rate for a revenue maximising government? Secondly, does cooperation between governments result in a higher or a lower equilibrium profit tax rate and transfer pricing penalty rate compared with the equilibrium under competition? Thirdly, is an attempt by an international organisation such as the European Union to have a single transfer pricing documentation rule Pareto improving? Since the focus of this paper is on the government's optimal decision on the corporate profit tax rate (also called tax rate) and the transfer pricing penalty rate (also called penalty rate), other issues of international taxation and trade such as import

tariff, a profit repatriation rule, an exchange control, and an ownership limitation are not considered in the model.

This section of the theoretical model begins with the general description and assumptions underlying the model, which are divided into assumptions on the multinational firm, and assumptions on the government's taxation and transfer pricing penalty. While the assumptions remain largely the same throughout our analysis, they are slightly adjusted to suit our analysis as we proceed. Next follows our definition of the government's transfer pricing penalty which is developed from the work of Devereux et al. (2004). After that, we analyse the theoretical models which are constructed as a two-stage game. In the first stage, the governments maximise tax revenue by either cooperatively or competitively choosing the profit tax rates and/or the transfer pricing penalty rates. In the second stage, the multinational firm (also called "the firm") maximises global profit after taxes and penalties by choosing the amount of capital, the production of intermediate goods, and the transfer price in each country given the countries' profit tax rates and transfer pricing penalty rates. The equilibrium profit tax rates and/or the transfer pricing penalty rates are found using backward induction.

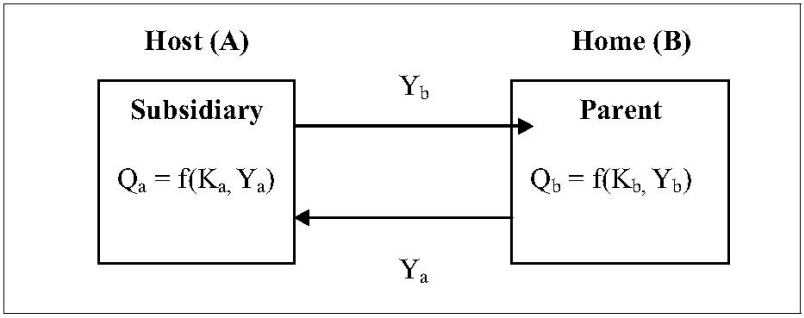
As a result, based on the backward induction process, we begin by analysing the first best solution for governments' corporate tax policies when there is no transfer pricing. Then, the rest of the analysis is based on the situation where the multinational firm engages in transfer pricing manipulation which begins with the multinational firm's optimal decisions. This is followed by an analysis of the governments' optimal decisions on the profit tax rates given the transfer pricing penalty rates. Then, we analyse the governments' decisions on the penalty rates given the profit tax rates. This is followed by the last model where the governments decide on

both the profit tax rates and the penalty rates. In all the analyses of the governments' choices, we consider the governments' decisions in two scenarios: when the governments take cooperative decisions and when they take competitive actions. The equilibriums from the two scenarios are compared to provide answers the above three questions, which are the objectives of this chapter. Moreover, in the last model when the governments decide on both instruments, we construct the comparative static to investigate the change in the equilibrium when we allow exogenous variables to change their values.

4.1. General description and assumptions

We consider a multinational firm operating in two countries. It has a parent company operating in the home country and a subsidiary operating in the host country. The host country is labelled country A and the home country is labelled country B. Each country imposes a profit tax (t_a,t_b) and a transfer pricing penalty (Z_a,Z_b).The subsidiary in country A produces a final good (Q_a) and intermediate goods (Y_b) and exports Y_b to its parent company in country B at a transfer price (q_a). The parent produces a final good (Q_b) and intermediate goods (Y_a) and exports Y_a to its subsidiary in country A at a transfer price (q_b). The model description is illustrated in the diagram below:

Figure 1. Description of model



Assumptions on the multinational firm

1. The firm consists of a parent firm located in the home country (country B), which is the resident country of the firm and a subsidiary firm located in the host country (country A). The subsidiary in country A is wholly owned by the parent company.
2. The firm locates in countries A and B. The location decision is decided prior and so is not considered in our analysis. This can be thought of as a situation where the relocation of the multinational firm is too costly and is not economically viable.
3. The objective of the multinational firm is to maximise its global profit after taxes and expected penalties. The level of the multinational firm's profit is denoted Π_g.
4. The firm's production of final goods ($\underline{Q_i}$) and intermediate goods (Y_i), capital investments (K_i), and transfer prices (q_i) are centrally decided, where subscript i represents country A or B.
5. The firm's transfer prices take values between zero and one, $q_i \in [0,1]$. This assumption is essential to the model as it simplifies the transfer pricing penalty defined in the model. Moreover, the range between zero and one of the transfer price may be interpreted as the range of

percentage points of the firm's cost of sale. For example, 60 percent of cost of production plus mark-up.

6. The parent and the subsidiary have the same production technology and their production functions of the final goods are assumed to be Cobb-Douglas with decreasing returns to scale, so $\alpha+\beta < 1$.
7. The final good (Q_i) is sold only on the market where it is produced. It is produced using capital (K_i) and intermediate good (Y_i) as factors of production. The production function for final goods is
$$Q_i = f(K_i, Y_i) = K_i^{\alpha} Y_i^{\beta}$$
where i is the country where production takes place (country A, B).
8. The intermediate goods (Y_i) is produced using only labour (L_i) as a factor of production. Moreover, we assume that a unit of the intermediate goods (Y_i) is produced using a unit of labour (L_i).
$$Y_i = L_i$$
9. The firms are small price-takers who operate in large and competitive markets in each country. Based on this assumption, we assume that;
    9.1. Capital (K_i) in both countries is available to the firm at a constant world marginal cost of r.
    9.2. Labour (L_i) in both countries is available to the firm at a constant marginal cost of w.
    9.3. Prices of the firm's final goods (p) are greater than zero, $p > 0$, and equal in both countries and are determined by the world market and unchanged with the firm's supply.
    Moreover, we assume that r, w and p are not affected by taxes and transfer pricing penalties.

Assumptions on taxation and transfer pricing penalties

1. Each government's objective is to maximise tax revenue

(T_i)[8]. Both governments apply transfer pricing rules and penalties.

2. The home government taxes the worldwide profit of its resident company but provides a tax credit for foreign tax payment. The host government imposes a corporate tax on the profit of the firm operating in its jurisdiction. The corporate profit tax rate (t_i) is bounded between zero and one, $0 \leq t_i \leq 1$. In calculating income tax liability, the firm's capital expenses are fully deductible.
3. Each government applies the same transfer pricing rule, which results in the same value of tax authority's transfer price ($h_a = h_b = h$). Having countries apply the same internationally accepted transfer pricing rule, our model reflects the practice of tax authorities in most countries who usually follow the transfer pricing guidelines set by OECD or UN. The transfer pricing guideline verifies the method that a country uses to derive the "arm's length transfer price" or the tax authority's transfer price. When the countries' derived transfer prices (h) are equal, there is no double taxation occurring from inconsistent values of h. Based on Devereux et al. (2004) we assume properties of h such that
   3.1. h is a random variable and the actual value of h is unknown to taxpayers.
   3.2. The distribution of h is common knowledge to both taxpayers and governments and h is uniformly distributed on [0,1] (Standard uniform distribution).
   By assuming h as a random variable and $h \in [0,1]$, our assumption reflects the audit practices of the

[8]An alternative setting is to have the governments maximise country welfare. However, this involves a parameter for the firm's ownership structure by domestic and foreign residents, which further complicates the model.

governments. As when conducting a tax audit, the government may define an acceptable range of the firm's transfer price with attached probability. This acceptable range of transfer price may result from different methods used in calculating the "arm's length transfer price" or it may base on an estimated industrial average[9]. As a result, h does not necessarily equal the firm's actual production cost. Moreover, the range between zero and one of the government's transfer price may be interpreted as a percentage point, for example, 80 percent of the estimated cost of production for the whole industry.

4. The transfer pricing penalty rate (ζ) is assumed to have a positive value but can be different in the two countries, $\zeta_i > 0$.
5. A tax audit is undertaken costlessly. The probability of the firm being audited in each country equals θ_i

4.2. Defining the transfer pricing penalty

The analysis of the transfer pricing penalty is developed from Devereux et al. (2004). Each country's transfer pricing penalty (Z_i) is a function of the penalty rate (ζ_i), and the proportional difference between the firm's transfer price (q_i) and the tax authority's transfer price (h). However, the model differs from that of Devereux et al (2004) by assuming that Z_i is also a function of the intra-firm trade. The transfer pricing penalty (Z_i) in our model is defined in the most general form by

[9] For example, in Elitzur and Mintz (1996) the host country employs an industrial estimate on the firm's rate profit on sales (Elitzur and Mintz, 1996, pp. 406-407).

$$Z_i = z(\zeta_i, Y_i, q_i, h)$$

Having the penalty determined by the volume of trade, the penalty is calculated on the firm's under-reported tax base. A more realistic setting is to have the penalty based on underpaid tax, which reflects the tax regulations in most countries. However, such a setting creates further complexity in the penalty function. Nonetheless, the transfer pricing penalty rate, in our model, can also be interpreted as a combining rate between the profit tax rate and the transfer pricing penalty rate, which will result in the penalty based on an underpaid tax.

In each country, the government treats the intra-firm transfer price differently depending on whether that transfer price is the price of the import or the price of the export. On the one hand, the government wants the firm in its jurisdiction to pay the lowest possible imported price so that the firm's cost of production is minimal. As a result, the importing firm is penalised only when it is over-paying for its import. We define that the level of the over-pricing or under-pricing of the intermediate goods as determined by the divergence of the firm's transfer price (q_i) from the government's arm's length price (h). So, the firm over-prices the import when $q_i - h > 0$. As a result, the penalty of the importing government depends on the maximum between $q_i - h$ and 0, max $\{(q_i - h),0\}$.

On the other hand, the government prefers the firm in its jurisdiction to charge the highest possible exported price so that the firm can earn the highest possible profit. As a result, the exporting firm is penalised only when it under-charging for its export. Since the firm under-prices the export when $h - q_i > 0$, as a result, the penalty of the exporting government depends on the maximum between $h - q_i$ and 0, max $\{(h - q_i),0\}$.

As we assume that the government's transfer price (h) is a random variable, the magnitude of the firm's over-pricing or under-pricing are attached to probabilities. The governments' penalties, then, depend upon the probability of the firm overpricing its import ($P(h < q_i)$) and the probability of the firm under-pricing its export ($P(h > q_i)$).

From the assumptions that the firm's transfer price (q_i) takes the value between zero and one, $q_i \in [0,1]$, the government's transfer price (h) is uniformly distributed on [0,1], and the distribution of h is common knowledge, the value of $P(h < q_i)$ and $P(h > q_i)$ are;

$$P(h < q_i) = q_i$$

and

$$P(h > q_i)=(1-q_i)$$

Since in our model each government is both the importing-country and the exporting-country, we define the governments' penalties in each case as the following.

(i) When the country is the importing-country

$$Z_i^{im} = \zeta_i Y_i P(h < q_j) max\{(q_j - h),0\}$$

where Z_i^{im} is the transfer pricing penalty in the importing-country; Subscript j represents either country A or country B, where $j \neq i$.

Substituting $P(h < q_j)= q_j$ into Z_i^{im}

$$Z_i^{im} = \zeta_i Y_i q_j max\{(q_j - h),0\} \quad (1)$$

(ii) When the country is the exporting-country

$$Z_i^{ex} = \zeta_i Y_i P(h > q_i) max\{(h - q_i), 0\}$$

where Z_i^{ex} is the transfer pricing penalty in the exporting-country.

Substituting $P(h>q_i)=(1- q_i)$ into Z_i^{ex}

$$Z_i^{ex} = \zeta_i Y_i (1- q_i) max\{(h - q_i), 0\} \qquad (2)$$

In the following sections, our models are based on a two-stage game. In the first stage of the game, the tax authority in each country maximises its tax revenue by choosing the tax rate (t_i) and/or the transfer pricing penalty rate (ζ_i) taking into account how the multinational firm reacts. Our model considers both situations where t_i and/or ζ_i are the outcome of cooperation and the outcome of competition. In the second stage, the multinational firm maximises its profit after tax and penalty by choosing the amount of capital (K_i), the amount of intermediate good (Y_i), and the level of intra-firm's transfer price (q_i) in each country given the countries' profit tax rates and transfer pricing penalty rates. The equilibrium tax rates and transfer pricing penalty rates are found using backward induction, which is a method commonly used in the tax competition literature.

4.3. The firm's optimal decisions

In the second stage of the two-stage game, the multinational firm maximises its global profit (Π_g) after taxes and penalties, which are a combination of its profit after taxes less expected penalties in country A and B, given the countries' profit tax rates and transfer pricing penalty rates.

Note that the firm's expected penalty in each country also depends upon the probability (θ_i) of the firm being audited in each country. The firm's global profit after taxes and penalties is given by,

$$\begin{aligned}\Pi_g = {} & (1-t_a)\left(pK_a^{\alpha}\, Y_a^{\beta} + Y_b(q_a - w) - rK_a - q_b Y_a\right) \\ & + (1-t_b)\left(pK_b^{\alpha}\, Y_b^{\beta} + Y_a(q_b - w) - rK_b - q_a Y_b\right) \\ & - \theta_a E(Z_a) - \theta_b E(Z_b)\end{aligned}$$

The firm operates in each country as both an importer and an exporter. As a result, the firm's expected penalty in each country consists of the expected penalties as an exporter and an importer.

The firm's expected transfer pricing penalty in country A, $E(Z_a)$, is

$$E(Z_a) = \theta_a\left(E\left(Z_a^{im}\right) + E(Z_a^{ex})\right)$$

Substitute Z_a^{im} and Z_a^{ex} from (1) and (2)

$$\begin{aligned}E(Z_a) = {} & \theta_a(\zeta_a\, Y_a\, q_b E(max\{(q_b - h), 0\}) \\ & + (\zeta_a\, Y_b\, (1-q_a) E(max\{(h - q_a), 0\})\end{aligned} \quad (3)$$

From the assumption that h is uniformly distributed on [0,1] and the distribution of h is common knowledge, the values of $E(max\{(q_b - h),0\})$ and $E(max\{(h - q_a),0\})$ are

$$E(max\{(q_b - h), 0\}) = \mathrm{E}(q_b) - E(h) = q_b - \frac{q_b}{2} = \frac{q_b}{2} \quad (4)$$

$$E(max\{(h - q_a), 0\}) = E(h) - \mathrm{E}(q_a) = (1 - q_a) - \left(\frac{1 - q_a}{2}\right) = \left(\frac{1 - q_a}{2}\right) \quad (5)$$

Substitute (4) and (5) into (3)

$$E(Z_a) = \theta_a \left(\frac{1}{2}\zeta_a Y_a q_b^2 + \frac{1}{2}\zeta_a Y_b (1 - q_a)^2\right) = \frac{1}{2}\theta_a \zeta_a \left(Y_a q_b^2 + Y_b (1 - q_a)^2\right) \quad (6)$$

The firm's expected transfer pricing penalty in country B, *E(Z$_b$)*, is

$$E(Z_b) = \theta_b (E(Z_b^{im}) + E(Z_b^{ex}))$$

Substitute Z_b^{im} and Z_b^{ex} from (1) and (2)

$$E(Z_b) = \theta_b (\zeta_b Y_b q_a E(max\{(q_a - h), 0\}) + (\zeta_b Y_a (1 - q_b) E(max\{(h - q_b), 0\}) \quad (7)$$

Again, from the assumption that *h* is uniformly distributed on [0,1] and the distribution of *h* is the common knowledge, the value of *E(max{(q$_a$ -h),0})* and *E(max{(h-q$_b$),0})* are

$$E(max\{(q_a - h), 0\}) = E(q_a) - E(h) = q_a - \frac{q_a}{2} = \frac{q_a}{2} \quad (8)$$

$$E(max\{(h - q_b), 0\}) = E(h) - \mathrm{E}(q_b)$$
$$= (1 - q_b) - \left(\frac{1 - q_b}{2}\right) = \left(\frac{1 - q_b}{2}\right) \quad (9)$$

Substitute (8) and (9) into (7)

$$E(Z_b) = \theta_b \left(\frac{1}{2}\zeta_b Y_b q_a^2 + \frac{1}{2}\zeta_b Y_a (1 - q_b)^2\right)$$
$$= \frac{1}{2}\theta_b \zeta_b \left(Y_b q_a^2 + Y_a (1 - q_b)^2\right) \quad (10)$$

To simplify our analysis, we assume that θ_i equals one, which means the tax authorities always detect when the firm's transfer price deviates from *h*. This assumption can be relaxed without changing the results of the following analysis. By assuming $\theta_a = \theta_b = 1$, (6) and (10) become

$$E(Z_a) = \frac{1}{2}\zeta_a \left(Y_a q_b^2 + Y_b (1 - q_a)^2\right) \quad (11)$$

$$E(Z_b) = \frac{1}{2}\zeta_b \left(Y_b q_a^2 + Y_a (1 - q_b)^2\right) \quad (12)$$

From (11) and (12), the firm's global profit after taxes and penalties becomes

$$\Pi_g = (1-t_a)\Big(pK_a^{\alpha}\,Y_a^{\beta} + Y_b(q_a - w) - rK_a - q_bY_a\Big) + (1-t_b)\Big(pK_b^{\alpha}\,Y_b^{\beta} + Y_a(q_b - w) - rK_b - q_aY_b\Big) - \frac{1}{2}\zeta_a\,(Y_aq_b^2 + Y_b(1-q_a)^2) - \frac{1}{2}\zeta_b\,(Y_bq_a^2 + Y_a(1-q_b)^2)$$

The firm maximises its global profit by choosing K_i, Y_i and q_i. Solving the firm's first order conditions gives the optimal solutions for K_i, Y_i and q_i, which are

$$K_a = CA^{\frac{\beta}{\alpha+\beta-1}} \tag{13}$$

$$Y_a = EA^{\frac{1-\propto}{\alpha+\beta-1}} \tag{14}$$

$$K_b = CB^{\frac{\beta}{\alpha+\beta-1}} \tag{15}$$

$$Y_b = EB^{\frac{1-\propto}{\alpha+\beta-1}} \tag{16}$$

$$q_b = \frac{t_a - t_b + \zeta_b}{\zeta_a+\zeta_b} \tag{17}$$

$$q_a = \frac{t_b - t_a + \zeta_a}{\zeta_a+\zeta_b} \tag{18}$$

where

$$A = \frac{2\zeta_a w - 2\zeta_b t_b w + \zeta_a\zeta_b + 2\zeta_b t_b - 2\zeta_b t_a + 2\zeta_b w - 2\zeta_b t_b w - (t_a - t_b)^2}{(1-t_a)(\zeta_a+\zeta_b)}$$

$$B = \frac{2\zeta_a w - 2\zeta_a t_a w + \zeta_a\zeta_b + 2\zeta_a t_a - 2\zeta_a t_b + 2\zeta_b w - 2\zeta_b t_a w - (t_a - t_b)^2}{(1-t_b)(\zeta_a+\zeta_b)}$$

$$C = \left(\frac{1}{2\beta}\right)^{\frac{\beta}{\alpha+\beta-1}} \left(\frac{r}{\alpha}\right)^{\frac{1-\beta}{\alpha+\beta-1}} \left(\frac{1}{p}\right)^{\frac{1}{\alpha+\beta-1}}$$

$$E = \left(\frac{1}{2\beta}\right)^{\frac{1-\alpha}{\alpha+\beta-1}} \left(\frac{r}{\alpha}\right)^{\frac{\alpha}{\alpha+\beta-1}} \left(\frac{1}{p}\right)^{\frac{1}{\alpha+\beta-1}}$$

From (13) to (16), the firm's optimal decisions on its production and capital use depend on the price of final goods, the cost of production, the tax rates, and the transfer pricing penalty rates but not the transfer prices.

The second-order sufficient conditions for a local maxima at the above optimal solutions require that Hessian matrix is negative definite which means that the determinants of the odd-numbered principle minors of the Hessian matrix are negative and the determinants of the even-numbered principle minors of the Hessian matrix are positive (Chiang, 1984). In this case, we checked that the Hessian matrix at the above optimal solutions is negative definite and, so, satisfies the second-order conditions.

Having the transfer pricing penalty in the model, we find that the government's corporate profit tax affects the firm's optimal production even though the tax is levied on the firm's pure profit[10]. Similar to our findings, Elitzur and Mintz (1996) find that the transfer pricing rules affect the multinational firms. These results differ from what is suggested in Copithrone (1971) that the international firm's outputs are not affected by the tax rate when the tax is levied on the firm's pure profit.

Furthermore, from (17) and (18), the firm's optimal

[10] A pure profit tax, in our model, is represented by the model's structure that all of the firm's cost of production is tax-deductible.

transfer pricing depends on the tax and transfer pricing penalty rates. The transfer price (q_i) decreases when the country, where the production takes place, increases the profit tax rate (t_i). And q_i increases when the other country, where the firm exports to, increases the profit tax rate (t_j) (where j represents either country A or B and $j \neq i$). These results are consistent with most of the literature, which states that the multinational firm's transfer price depends on country's tax rates (Horst, 1971; Haufler and Schjelderup, 2000; and Devereux et al., 2004).

4.4. Government decision on profit tax rates given penalty rates

In this section, we present models of the governments' decisions on profit tax rates (ti) when the transfer pricing penalty rates (ζi) are exogenously determined. In the first stage of the game, given that the transfer pricing penalty rates (ζi) are exogenously determined, countries maximise tax revenue (or joint-tax revenue) by choosing tax rates (ti) taking into account how the multinational firm reacts. In the second stage, the multinational firm maximises its profit after tax and penalty by choosing the amount of capital (Ki), the amount of intermediate goods (Yi) and the level of the intra-firm transfer price (qi) in each country. The equilibrium tax rates are found using backward induction.

In the cooperative case, each country takes into consideration the effect of its tax and penalty rates on the other country's tax revenue. Technically, this is done by having the countries maximise their joint tax revenue given the firm's optimal solutions presented in (13) to (18). The governments' tax revenue are

$$T_a = t_a\left(pK_a^{\alpha}Y_a^{\beta} + Y_b(q_a - w) - rK_a - q_bY_a\right) + \frac{1}{2}\zeta_a(Y_aq_b^2 + Y_b(1-q_a)^2) \tag{19}$$

$$T_b = t_b\left(pK_b^{\alpha}Y_b^{\beta} + Y_a(q_b - w) - rK_b - q_aY_b\right) + \frac{1}{2}\zeta_b(Y_bq_a^2 + Y_a(1-q_b)^2) \tag{20}$$

With a cooperative decision, the governments' joint-revenue is

$$\begin{aligned} T = T_a + T_b = {} & t_a\left(pK_a^{\alpha}Y_a^{\beta} + Y_b(q_a - w) - rK_a - q_bY_a\right) \\ & + \frac{1}{2}\zeta_a(Y_aq_b^2 + Y_b(1-q_a)^2) \\ & + t_b\left(pK_b^{\alpha}Y_b^{\beta} + Y_a(q_b - w) - rK_b - q_aY_b\right) \\ & + \frac{1}{2}\zeta_b(Y_bq_a^2 + Y_a(1-q_b)^2) \end{aligned} \tag{21}$$

The first-order condition for t_a is

$$\frac{\partial T}{\partial t_a} = \frac{\partial T}{\partial K_a}\frac{\partial K_a}{\partial t_a} + \frac{\partial T}{\partial Y_a}\frac{\partial Y_a}{\partial t_a} + \frac{\partial T}{\partial q_a}\frac{\partial q_a}{\partial t_a} + \frac{\partial T}{\partial K_b}\frac{\partial K_b}{\partial t_a} + \frac{\partial T}{\partial Y_b}\frac{\partial Y_b}{\partial t_a} + \frac{\partial T}{\partial q_b}\frac{\partial q_b}{\partial t_a} + \frac{\partial T}{\partial t_a} = 0 \tag{22}$$

The first-order condition for t_b is

$$\frac{\partial T}{\partial t_b} = \frac{\partial T}{\partial K_a}\frac{\partial K_a}{\partial t_b} + \frac{\partial T}{\partial Y_a}\frac{\partial Y_a}{\partial t_b} + \frac{\partial T}{\partial q_a}\frac{\partial q_a}{\partial t_b} + \frac{\partial T}{\partial K_b}\frac{\partial K_b}{\partial t_b} + \frac{\partial T}{\partial Y_b}\frac{\partial Y_b}{\partial t_b} + \frac{\partial T}{\partial q_b}\frac{\partial q_b}{\partial t_b} + \frac{\partial T}{\partial t_b} = 0 \quad (23)$$

Ideally, given that the transfer pricing penalty rates are exogenously determined, simultaneously solving the first-order conditions in (22) and (23) would give us the equilibrium tax rates when countries take a cooperative decision. Also, solutions which result from simultaneously solving the first-order conditions must satisfy the following second-order sufficient conditions to ensure that they maximise the countries' joint-tax revenue. The second-order sufficient conditions are

$$\frac{\partial^2 T}{\partial t_a^2} < 0, \frac{\partial^2 T}{\partial t_b^2} < 0$$

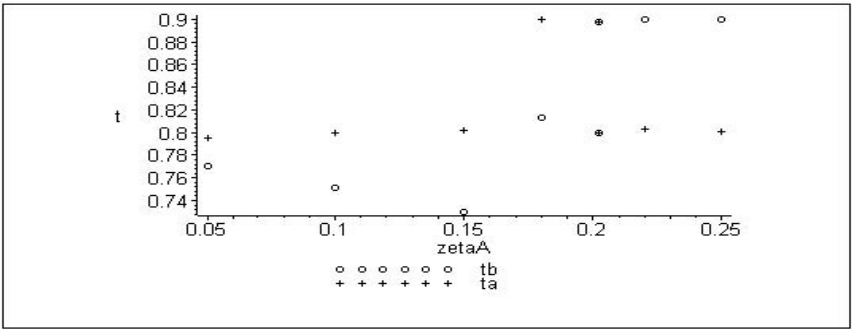
and

$$\frac{\partial^2 T}{\partial t_a^2}\frac{\partial^2 T}{\partial t_b^2} > \frac{\partial^2 T}{\partial t_a \partial t_b}$$

The equilibrium tax rates cannot be found without adopting numerical values of p,w,r,α and β. The numerical analysis assumes baseline values of $p = 10$; $w = 0.1$; $r = 0.5$; $\alpha = 0.4$ and $\beta = 0.4$. Based on these values, we solve the first-order conditions for t_i given exogenous values of ζ_i. The following figure plots the optimal tax rates at a given value of ζ_a and ζ_b =0.202. The reason for choosing the constant value of country B's transfer pricing penalty rate

(ζ_b) to be ζ_b =0.202 is derived from our symmetric model, which is shown later.

Figure 2. Cooperative optimal tax rates given ζ_b = 0.202



From Figure 2, holding ζ_b =0.202 when the penalty rate of country A is lower than that of country B (ζ_a < 0.202), country A's tax rate in the cooperative regime is higher than that of country B *($t_a > t_b$).* On the contrary, when the penalty rate of country A is higher than that of country B (ζ_a > 0.202), country A's tax rate in the cooperative regime is lower than that of country B *($t_a < t_b$).* Moreover when both countries' penalty rates are equal ($\zeta_a = \zeta_b$ = 0.202), there are two optimal tax rates which maximise the countries' joint-tax revenue: *(t_a,t_b)* = (0.897,0.800) and *(t_a,t_b)* = (0.800,0.897).

Appendix A1 shows the government's optimal tax rates at a given pair of transfer pricing penalty rates and its effect on the firm's capital use and the production in country A *(A),* capital use and production in country B *(B),* the transfer prices *(q_a, q_b),* the country's revenue *(T_a, T_b),* the governments' joint-revenue *(T),* and the firm's net profit *(I_g).* From Appendix A1, we find that when the governments cooperatively decide on the profit tax rates, it is optimal for the country with a lower (higher) exogenous penalty rate to

have a higher (lower) profit tax rate. In addition, at a given pair of exogenous penalty rates when the optimal tax rate of country A is greater than that of country B ($t_a > t_b$), the firm's capital investment and production in country A is less than that of country B. Moreover, regardless of the level of the exogenous penalty rates, the firm reports a higher transfer price in the country with a higher optimal tax rate. The joint-tax revenue is at a maximum when both countries' penalty rates are at the minimum. Appendix A1 demonstrates that when the exogenous penalty rate of country B, which is held constant, is set to increase (from $\zeta_b = 0.180$ to $\zeta_b = 0.202$ and 0.220), the countries' joint-tax revenue is at a maximum when the penalty rate of country A is at a minimum and the penalty rate of country B is also at a minimum (in this case when $(\zeta_a, \zeta_b) = (0.05, 0.180)$). This finding suggests that both countries should set their penalty rates at the minimum rates possible in order to maximise their joint tax revenue.

In the Competitive case, we investigate equilibrium tax rates when countries compete in the choice of tax rates (t_i) given that transfer pricing penalty rates (ζ_i) are exogenously determined. Each government simultaneously maximises its tax revenue by choosing t_i given ζ_i, the firm's optimal solutions for K_i, Y_i and q_i as presented in (13) to (18), and the other country's tax rate. The objective functions of country A and B, T_a and T_b, are as presented in (19) and (20) respectively.

Country A's first-order condition is

$$\frac{\partial T_a}{\partial t_a} = \frac{\partial T_a}{\partial K_a}\frac{\partial K_a}{\partial t_a} + \frac{\partial T_a}{\partial Y_a}\frac{\partial Y_a}{\partial t_a} + \frac{\partial T_a}{\partial q_a}\frac{\partial q_a}{\partial t_a} + \frac{\partial T_a}{\partial K_b}\frac{\partial K_b}{\partial t_a} + \frac{\partial T_a}{\partial Y_b}\frac{\partial Y_b}{\partial t_a} + \frac{\partial T_a}{\partial q_b}\frac{\partial q_b}{\partial t_a} + \frac{\partial T_a}{\partial t_a} = 0 \quad (24)$$

Country B's first-order condition is

$$\frac{\partial T_b}{\partial t_b} = \frac{\partial T_b}{\partial K_a}\frac{\partial K_a}{\partial t_b} + \frac{\partial T_b}{\partial Y_a}\frac{\partial Y_a}{\partial t_b} + \frac{\partial T_b}{\partial q_a}\frac{\partial q_a}{\partial t_b} + \frac{\partial T_b}{\partial K_b}\frac{\partial K_b}{\partial t_b} + \frac{\partial T_b}{\partial Y_b}\frac{\partial Y_b}{\partial t_b} + \frac{\partial T_b}{\partial q_b}\frac{\partial q_b}{\partial t_b} + \frac{\partial T_b}{\partial t_b} = 0 \quad (25)$$

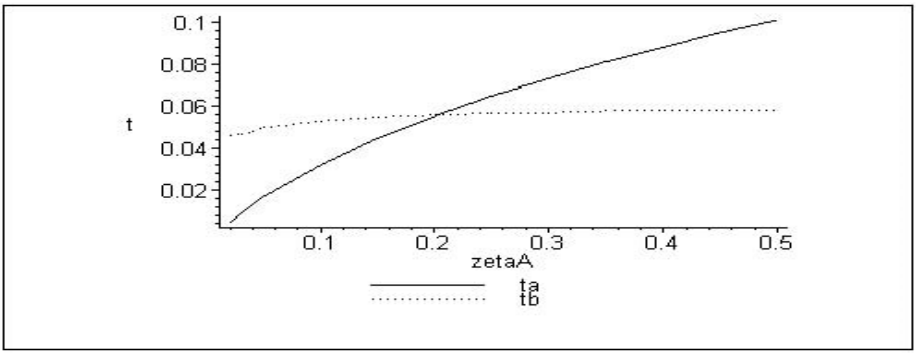
The Nash equilibrium tax rates in this competitive game are found by simultaneously solving the countries' first-order conditions in (24) and (25) for t_a and t_b. Also, solutions which results from simultaneously solving the first-order conditions must satisfy the following second-order sufficient conditions to ensure that they maximise each country's tax revenue. The second-order sufficient conditions for country A and B are

$$\frac{\partial^2 \mathrm{T}_a}{\partial t_a^2} < 0 \; and \; \frac{\partial^2 \mathrm{T}_b}{\partial t_b^2} < 0$$

We consider equilibrium tax rates using the numerical analysis where p = 10; w =0.1; r =0.5; α = 0.4 and β =0.4. By solving the countries' first-order conditions, the equilibrium tax rates at a given value of ζ_a and ζ_b =0.202 are shown in the following figure. Again, the constant exogenous value of ζ_b =0.202 is derived from the symmetric model which is presented later.

From the figure below, by holding ζ_b =0.202 the optimal tax rates of both countries increase as ζ_a increases. The tax rate of country A increases faster than that of country B. Moreover, the optimal tax rates are equal, $t_a = t_b = 0.56$, when $\zeta_a = \zeta_b = 0.202$.

Figure 3. Competitive optimal tax rates given ζ_b =0.202



Further analysis in Appendix A2 shows the optimal tax rates in the competitive regime at a given pair of transfer pricing penalty rates and its effect on the firm's capital use and production in country A (A), capital use and production in country B (B), transfer prices (q_a,q_b), country's revenue (T_a,T_b), and the firm's net profit (Π_g). From Appendix A2, we find that as the transfer pricing penalty rate of country A (ζ_a) increases (holding the penalty rate of country B constant), the optimal tax rates of both country A and B increase. Moreover, when both countries compete on the profit tax rates, it is optimal for the country with a higher exogenous penalty rate to have a higher profit tax rate and the country with a lower exogenous penalty rate to have a lower profit tax rate. However, an increase in both countries' optimal tax rates when ζ_a increases does not always increase a country's tax revenue. Lastly, Appendix A2 shows that the firm's net profit after taxes is maximised when ζ_a, t_a and t_b are at the lowest level. Moreover, the firm's net profit is at a maximum when ζ_b is at a minimum (in this case when ζ_b =0.180). Interestingly, as the optimal tax rates of both countries increase, the firm increases its capital investment and production in both countries. Moreover, the firm reports a

higher transfer price in a country with a higher exogenous transfer pricing penalty rate.

To conclude, although we cannot find the general equilibrium of tax rates given that transfer pricing penalty rates are exogenously determined, some points can still be made. By assuming the same set of numerical values of p, w ,r ,α ,β ,ζa and holding ζb constant, we are able to make some comparison of the equilibrium tax rates and its effects when governments take either cooperative or competitive decisions. Based on our numerical analysis, it is clear that at given penalty rates, the optimal tax rates for both countries are higher when governments take a cooperative decision than when they take competitive actions. This finding suggests that tax competition results in too-low tax rates, which is in-line with most of the tax competition literature such as Wilson (1986), though Elitzur and Mintz (1996) suggested that tax harmonisation requires a reduction of tax rates.

However, moving from the competitive to the cooperative equilibrium tax rates does not guarantee an increase in a country's tax revenue and, also, its provision of public goods. For example, when ζ_a and ζ_b are exogenously given at 0.10 and 0.202 respectively, the equilibrium tax rates for both countries are higher in the cooperative case (t_a =0.800 and t_b =0.751) than in the competitive case (t_a =0.032 and t_b =0.053). If the government moves from competitive to cooperative equilibrium tax rates, country A's revenue decreases (from 59,729 to -1,609,800) while country B's revenue increases (from 65,456 to 1,834,981). Nonetheless, moving from competitive to cooperative regime is Pareto improving when considering the world level of public goods, which is financed by tax revenue. This point suggests that governmental cooperation on tax rate is efficiency enhancing as it increases global level of public goods compared to the

results under government's competition. In addition, the countries' joint-tax revenue, under cooperative regime, is at a maximum when the penalty rates of both countries are at a minimum. This finding suggests that both countries should set their penalty rates at the minimum rates possible in order to maximise their joint-tax revenue and also the public goods provision.

Moreover, in the competitive case, when the exogenous penalty rate in country A is lower than that of country B ($\zeta_a < \zeta_b$), the optimal tax rate in country A is also lower than that of country ($t_a < t_b$) and the firm's capital investment and production is higher in country A than that in country B. The opposite occurs when $\zeta_a > \zeta_b$. Furthermore, in the competitive case, the firm reports a higher transfer price in a country with a higher exogenous transfer pricing penalty rate. This suggests that when governments compete on tax rate for mobile tax base, it is optimal for a country whose transfer pricing rule is relatively more lenient than the other to maintain a relatively lower tax rate than the other. This is what we observe in small tax haven countries which usually have a low tax rate and a less restrictive transfer pricing rule.

On the contrary, in the cooperative case, when the exogenous penalty rate in country A is lower than that of country B ($\zeta_a < \zeta_b$), the optimal tax rate in country A is higher than that of country B ($t_a > t_b$) and the firm's capital investment and production is lower in country A than that in country B. The opposite occurs when $\zeta_a > \zeta_b$. Also, when $\zeta_a = \zeta_b$, it is both optimal for cooperative governments to either have $t_a > t_b$ or $t_a < t_b$. In addition, under the cooperative regime the firm reports a higher transfer price in a country with a higher optimal tax rate (regardless of the difference in the countries' transfer pricing penalty rates).

4.5. Government decision on penalty rates given tax rates

In this section, we present models of the governments' decisions on transfer pricing penalty rates (ζ_i) when profit tax rates (t_i) are exogenously determined. These models reflect a situation where countries first compete on tax rates and later on either cooperate or compete on transfer pricing penalty rules. In both the cooperative and competitive cases, the equilibrium transfer pricing penalty rates are based on a two-stage game. In the first stage of the game, given that tax rates (t_i) are exogenously determined, countries maximise tax revenue (or joint-tax revenue) by choosing transfer pricing penalty rates (ζ_i) taking into account how the multinational firm will react. In the second stage, the multinational firm maximises its profit after taxes and penalties by choosing the amount of capital (K_i), the amount of intermediate good (Y_i), and the level of intra-firm transfer price (q_i) in each country. The equilibrium transfer pricing penalty rates are found using backward induction.

In the cooperative case, given that tax rates are exogenously determined, countries A and B maximise their joint-tax revenue (T) presented in (21) by choosing the transfer pricing penalty rates (ζ_i), taking into account the firm's optimal solutions for K_i, Y_i, and q_i as presented in (13) to (18). The first-order conditions can be written as

$$\frac{\partial T}{\partial \zeta_a} = \frac{\partial T}{\partial K_a}\frac{\partial K_a}{\partial \zeta_a} + \frac{\partial T}{\partial Y_a}\frac{\partial Y_a}{\partial \zeta_a} + \frac{\partial T}{\partial q_a}\frac{\partial q_a}{\partial \zeta_a} + \frac{\partial T}{\partial K_b}\frac{\partial K_b}{\partial \zeta_a} + \frac{\partial T}{\partial Y_b}\frac{\partial Y_b}{\partial \zeta_a} + \frac{\partial T}{\partial q_b}\frac{\partial q_b}{\partial \zeta_a} + \frac{\partial T}{\partial \zeta_a} = 0 \quad (26)$$

$$\frac{\partial T}{\partial \zeta_b} = \frac{\partial T}{\partial K_a}\frac{\partial K_a}{\partial \zeta_b} + \frac{\partial T}{\partial Y_a}\frac{\partial Y_a}{\partial \zeta_b} + \frac{\partial T}{\partial q_a}\frac{\partial q_a}{\partial \zeta_b} + \frac{\partial T}{\partial K_b}\frac{\partial K_b}{\partial \zeta_b} + \frac{\partial T}{\partial Y_b}\frac{\partial Y_b}{\partial \zeta_b} + \frac{\partial T}{\partial q_b}\frac{\partial q_b}{\partial \zeta_b} + \frac{\partial T}{\partial \zeta_b} = 0 \quad (27)$$

Given that the tax rates are exogenously determined, simultaneously solving (26) and (27) would give us the equilibrium transfer pricing penalty rates when countries take a cooperative decision. Also, solutions which result from simultaneously solving the first-order conditions must satisfy the following second-order sufficient conditions to ensure that they maximise the countries' joint-tax revenue. The second-order sufficient conditions are

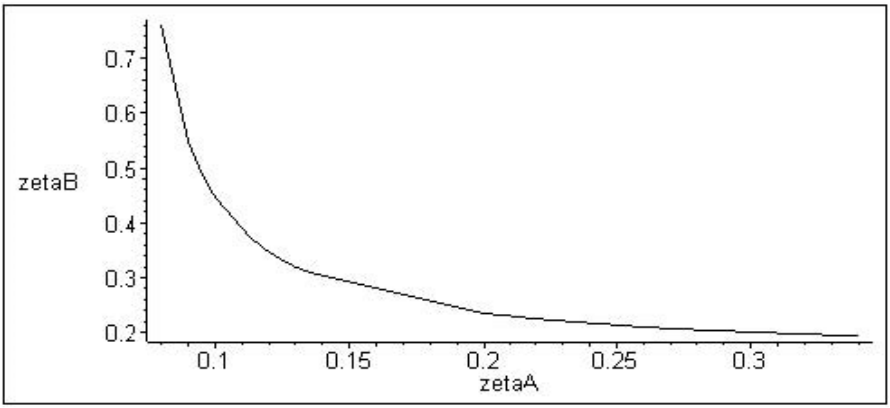
$$\frac{\partial^2 T}{\partial \zeta_a^2} < 0, \frac{\partial^2 T}{\partial \zeta_b^2} < 0$$

and

$$\frac{\partial^2 T}{\partial \zeta_a^2}\frac{\partial^2 T}{\partial \zeta_b^2} > \frac{\partial^2 T}{\partial \zeta_a \partial \zeta_b}$$

We undertake a numerical simulation where p = 10; w =0.1; r =0.5; α =0.4 and β =0.4 and solve the governments' first-order conditions for ζ_a and ζ_b for given exogenous values of t_a and t_b. More specifically, we hold country B's tax rate at a constant value of t_b =0.056 while country A's tax rate (t_a) takes the values $t_a \in \{0.01, 0.056, 0.10\}$. Our choice of a constant value of t_b =0.056 is justified by the symmetric model which is presented later. The following figure illustrates the equilibrium transfer pricing penalty rates given t_a =0.01 and t_b =0.056.

Figure 4. Cooperative optimal penalty rates given t_a =0.01, t_b =0.056



In Appendix A3 we show the government's optimal transfer pricing penalty rates under the cooperative regime at a given pair of tax rates and its effect on the firm's capital use and production in country A (A), capital use and production in country (B), transfer prices (q_a and q_b), country's revenue (T_a and T_b), country's joint-revenue (T), and the firm's net profit (Π_g). We find that for a given pair of exogenous tax rates although there are multiple equilibriums for the optimal penalty rates; each equilibrium yields the same effects on the firm's capital use and production in each country, and the government's joint-revenue. However, each equilibrium, at a given pair of exogenous tax rate, causes different results on the level of transfer prices, the firm's profit after taxes and penalties, and the tax revenue in each country. Our numerical simulation finds that the firm does not always report a higher transfer price in the country with the higher optimal penalty rate. For example, given t_a =0.100 and t_b =0.056, the optimal cooperative penalty rates of countries A and B are ζ_a = 0.212 and ζ_b =0.184 respectively. Based on these values of ζ_a and ζ_b, the firm reported transfer prices in countries A and B are q_a

=0.451 and q_b =0.548 respectively. Furthermore, the countries' joint-tax revenue is at a maximum when the exogenous tax rates are harmonized ($t_a = t_b = 0.056$). In addition, the firm's profit after taxes and penalties is at a maximum when the exogenous tax rates are harmonised. Lastly, we find that the optimal penalty rate of a country with a lower exogenous tax rate can be either higher, lower, or equal to the optimal penalty rate of another country with a higher exogenous tax rate.

In the competitive case, countries compete only on the transfer pricing penalty rates while tax rates are exogenously determined. Countries A and B maximise their tax revenues given the firm's optimal solutions presented in (13) to (18). The objective functions of countries' A and B (T_a and T_b) are as presented in (19) and (20) respectively. The first-order condition can be written as

$$\frac{\partial T_a}{\partial \zeta_a} = \frac{\partial T_a}{\partial K_a}\frac{\partial K_a}{\partial \zeta_a} + \frac{\partial T_a}{\partial Y_a}\frac{\partial Y_a}{\partial \zeta_a} + \frac{\partial T_a}{\partial q_a}\frac{\partial q_a}{\partial \zeta_a} + \frac{\partial T_a}{\partial K_b}\frac{\partial K_b}{\partial \zeta_a} + \frac{\partial T_a}{\partial Y_b}\frac{\partial Y_b}{\partial \zeta_a} + \frac{\partial T_a}{\partial q_b}\frac{\partial q_b}{\partial \zeta_a} + \frac{\partial T_a}{\partial \zeta_a} = 0 \quad (28)$$

$$\frac{\partial T_b}{\partial \zeta_b} = \frac{\partial T_b}{\partial K_a}\frac{\partial K_a}{\partial \zeta_b} + \frac{\partial T_b}{\partial Y_a}\frac{\partial Y_a}{\partial \zeta_b} + \frac{\partial T_b}{\partial q_a}\frac{\partial q_a}{\partial \zeta_b} + \frac{\partial T_b}{\partial K_b}\frac{\partial K_b}{\partial \zeta_b} + \frac{\partial T_b}{\partial Y_b}\frac{\partial Y_b}{\partial \zeta_b} + \frac{\partial T_b}{\partial q_b}\frac{\partial q_b}{\partial \zeta_b} + \frac{\partial T_b}{\partial \zeta_b} = 0 \quad (29)$$

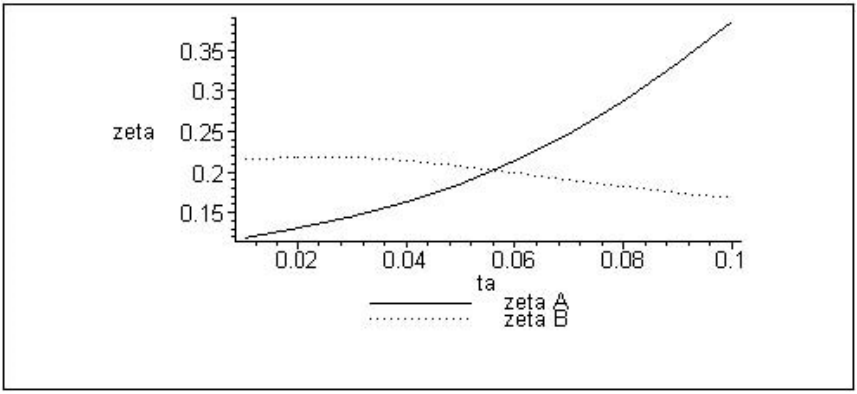
Ideally, solving the first-order conditions as presented in (28) and (29) given various exogenous values of ta and t_b would give us optimal ζ_a and ζ_b for the competitive regime. Also, solutions which results from simultaneously solving the

first-order conditions must satisfy the following second-order sufficient conditions to ensure that they maximise each country's tax revenue. The second-order sufficient conditions for country A and B are

$$\frac{\partial^2 T_a}{\partial \zeta_a^2} < 0, \frac{\partial^2 T_b}{\partial \zeta_b^2} < 0$$

We employ a numerical analysis where we assume p = 10; w =0.1; r =0.5; α =0.4 and β = 0.4 and solve the government's first-order conditions for ζ_a and ζ_b at a given exogenous values of ta and t_b. Moreover, we hold country B's tax rate at a constant value of t_b =0.056. The following figure shows the countries' optimal transfer pricing penalty rates at a given value of t_{ba} and t_b =0.056.

Figure 5. Competitive optimal penalty rates given t_b =0.056



From the above graph, as country A's tax rate increases (holding country B's tax rate constant at t_b =0.056), its transfer pricing penalty rate also increases while country B's transfer pricing penalty rate decreases. When the exogenous tax rates are equal, t_a = t_b = 0.056, both countries' optimal

penalty rates are equal at ($\zeta_a = \zeta_b = 0.202$. Moreover, when $t_a < 0.056$, country A's optimal penalty rate is lower than that of country B and when $t_a > 0.056$, country B's optimal penalty rate is lower than that of country A.

Appendix A4 shows the governments' optimal transfer pricing penalty rates under the competitive regime at a given pair of tax rates and its effect on the firm's capital use and production in country A (A), capital use and production in country B (B), transfer prices (q_a,q_b), country's revenue (T_a,T_b), and the firm's net profit (Π_g). From Appendix A4, when country A's tax rate increases (holding country B's tax rate constant), the optimal transfer pricing penalty rates of country A increases. Moreover, when the exogenous tax rate of country A is higher than that of country B ($t_a > t_b$), the optimal penalty rate of country A is higher than that of country B ($\zeta_a > \zeta_b$). When the exogenous tax rate of country A is lower than that of country B ($t_a < t_b$), the optimal penalty rate of country A is lower than that of country B ($\zeta_a < \zeta_b$). And when both countries' exogenous tax rates are equal ($t_a = t_b$), their optimal penalty rates are equal ($\zeta_a < \zeta_b$). However, a higher (a lower) optimal penalty rate in a country does not always result in a higher (a lower) reported transfer price in that country. For example, for $0.02 \leq t_a \leq 0.05$ and $t_b = 0.01$, the optimal transfer pricing penalty rate of country A is greater than that of country B ($\zeta_a > \zeta_b$). With these optimal choices, the firm reports a lower transfer price in country A than in country B ($q_a < q_b$).

Furthermore, when t_a increases while holding t_b constant at 0.01, the firm increases capital use and production in both countries. On the contrary, when t_a increases while holding t_b constant at 0.056 and 0.10, the firm decreases its capital use and production in country A but increases its capital use and production in country B. This finding suggests that when an

exogenous tax rate of the other country is low enough (in this case, when t_b = 0.01), an increase in a country's exogenous tax rate may increase the firm's capital use and production in that later country. Lastly, we find that the firm's profit after taxes and penalties is at a maximum when the exogenous tax rates of both countries are at the minimum.

To conclude, although we could not make a point comparison of equilibrium transfer pricing penalty rates given the exogenous tax rates between cooperative and competitive governments, some points can still be made from our numerical simulation. Firstly, the multiple equilibrium under the cooperative regime leads us to conclude that even if countries compete on tax rates (or have different tax rates) if they work in cooperation in setting the transfer pricing rules, it can be optimal for them to have different transfer pricing penalty rates. The "optimal" transfer pricing penalty rates mean those rates which maximise the joint-tax revenue and, so, maximise the world level of public goods provision. As a result, we think that an attempt by the OECD to have a single transfer pricing penalty rules (or rates in our model) may not be an only optimal solution for small cooperative governments who still compete on tax rates or have different exogenous tax rates. Moreover, even when the exogenous tax rates are harmonised, the optimal penalty rates of the cooperative governments can either be different rates or be the same rates. A similar argument is suggested by Raimondos-Møller and Scharf (2002) that harmonising the arm's length principle may not be a Pareto improving.

Secondly, we find that when the countries compete on transfer pricing penalty rates, the country with a high tax rate should maintain a high penalty rate and only reduce the penalty rate (or become more lenient toward transfer pricing) when the other country increases its tax rate. On the other hand, the country with a low tax rate (such as a tax haven

country) should keep its penalty rate low and only increase its penalty rate when it can increase its tax rate. This is what we observe in small tax haven countries which usually have a low tax rate and a less restrictive transfer pricing rule.

4.6. Government decision on both tax and penalty rates

In this section we assume that countries A and B are identical and each country maximises its tax revenue by simultaneously choosing both a profit tax rate and a transfer pricing penalty rate. Under both cooperative and competitive regimes, by assuming that both countries are identical it will be the case that there is a symmetric equilibrium with $t_a = t_b$ *and* $\zeta_a = \zeta_b$.

In the cooperative case, we assume that country A and country B harmonise their tax rates and transfer pricing penalty rates such that $t_a = t_b = t$ and $\zeta_a = \zeta_b = \zeta$ and maximise their joint-tax revenue with respect to these harmonised tax and penalty rates. In the second stage, taking the governments' harmonised tax rates and penalty rates as given, the firm maximises its profit after taxes and penalties by choosing K_i, Y_i, and q_i. The firm's objective function when the countries harmonise tax rates and transfer pricing penalty rates is

$$\begin{aligned}\Pi_g = {} & (1-t)\left(pK_a^{\alpha}\,Y_a^{\beta} + Y_b(q_a - w) - rK_a - q_bY_a\right) \\ & + (1-t)\left(pK_b^{\alpha}\,Y_b^{\beta} + Y_a(q_b - w)\right. \\ & \left. - rK_b - q_aY_b\right) \\ & + \frac{1}{2}\zeta\,(Y_a q_b^2 + Y_b(1-q_a)^2) \\ & - \frac{1}{2}\zeta\,(Y_b q_a^2 + Y_a(1-q_b)^2)\end{aligned}$$

Simultaneously solving the firm's first-order conditions with respect to K_i, Y_i and q_i give the following optimal solutions for the firm.

$$K_a = C\left(\frac{4w - 4tw + \zeta}{1 - t}\right)^{\frac{\beta}{\alpha+\beta-1}}$$

$$Y_a = E\left(\frac{4w - 4tw + \zeta}{1 - t}\right)^{\frac{1-\propto}{\alpha+\beta-1}}$$

$$K_b = C\left(\frac{4w - 4tw + \zeta}{1 - t}\right)^{\frac{\beta}{\alpha+\beta-1}}$$

$$Y_b = E\left(\frac{4w - 4tw + \zeta}{1 - t}\right)^{\frac{1-\propto}{\alpha+\beta-1}}$$

$$q_b = \frac{1}{2}$$

$$q_a = \frac{1}{2}$$

Note that we checked that the Hessian matrix at the above optimal solutions is negative definite and, so, satisfies the second-order sufficient conditions.

In the first stage, the governments maximises their joint-tax revenue ($T_a + T_b$) given the above optimal decisions of the firm. As the tax rates and the penalty rates of country A and country B are equal under harmonisation, their objective functions are also equal, $T_a = T_b$. So, maximising the countries' joint-tax revenue is equivalent to maximising $2T_a$. With harmonised tax rates and transfer pricing penalty rates,

country A's objective function is

$$T_a = t\left(pK_a^{\alpha}Y_a^{\beta} + Y_b(q_a - w) - rK_a - q_bY_a\right) + \frac{1}{2}\zeta(Y_aq_b^2 + Y_b(1 - q_a)^2)$$

The first-order conditions are

$$\frac{\partial T_a}{\partial t} = \frac{\partial T_a}{\partial K_a}\frac{\partial K_a}{\partial t} + \frac{\partial T_a}{\partial Y_a}\frac{\partial Y_a}{\partial t} + \frac{\partial T_a}{\partial q_a}\frac{\partial q_a}{\partial t} + \frac{\partial T_a}{\partial K_b}\frac{\partial K_b}{\partial t} + \frac{\partial T_a}{\partial Y_b}\frac{\partial Y_b}{\partial t} + \frac{\partial T_a}{\partial q_b}\frac{\partial q_b}{\partial t} + \frac{\partial T_a}{\partial t} = 0 \quad (30)$$

$$\frac{\partial T_a}{\partial \zeta} = \frac{\partial T_a}{\partial K_a}\frac{\partial K_a}{\partial \zeta} + \frac{\partial T_a}{\partial Y_a}\frac{\partial Y_a}{\partial \zeta} + \frac{\partial T_a}{\partial q_a}\frac{\partial q_a}{\partial \zeta} + \frac{\partial T_a}{\partial K_b}\frac{\partial K_b}{\partial \zeta} + \frac{\partial T_a}{\partial Y_b}\frac{\partial Y_b}{\partial \zeta} + \frac{\partial T_a}{\partial q_b}\frac{\partial q_b}{\partial \zeta} + \frac{\partial T_a}{\partial \zeta} = 0 \quad (31)$$

Simultaneously solving (30) and (31) would give us the optimal harmonised tax rate and transfer pricing penalty rate (t and ζ) for the cooperative regime. Also, solutions which results from simultaneously solving the first order conditions must satisfy the following second-order sufficient conditions to ensure that they yield maximum value of the countries' joint-tax revenue (in this case, the joint-tax revenue is represented by the country A's tax revenue). The second-order sufficient conditions are

$$\frac{\partial^2 T_a}{\partial t^2} < 0, \frac{\partial^2 T_a}{\partial \zeta^2} < 0$$

and

$$\frac{\partial^2 T_a}{\partial t^2}\frac{\partial^2 T_a}{\partial \zeta^2} > \frac{\partial^2 T_a}{\partial t \partial \zeta}$$

We consider a numerical simulation with the parameter values p = 10; w =0.1; r =0.5; α =0.4 and β =0.4. Based on this parameter values, we find that the harmonised solution which is a global maxima is (t,ζ) = (1,0).

In the competitive case, each government maximises its tax revenue by choosing t_i and ζ_i given firm's optimal solutions for K_i, Y_i and q_i presented in (13) to (18), and other country's t_j and ζ_j as fixed. Because the countries are symmetric, solving the first-order conditions for country A also gives the solution for country B. As a result, the following algebra is shown only for country A's maximisation problem. The objective functions of country A (T_a) is as presented in (19). Country A's first-order conditions are

$$\frac{\partial T_a}{\partial t_a} = \frac{\partial T_a}{\partial K_a}\frac{\partial K_a}{\partial t_a} + \frac{\partial T_a}{\partial Y_a}\frac{\partial Y_a}{\partial t_a} + \frac{\partial T_a}{\partial q_a}\frac{\partial q_a}{\partial t_a} + \frac{\partial T_a}{\partial K_b}\frac{\partial K_b}{\partial t_a} + \frac{\partial T_a}{\partial Y_b}\frac{\partial Y_b}{\partial t_a} + \frac{\partial T_a}{\partial q_b}\frac{\partial q_b}{\partial t_a} + \frac{\partial T_a}{\partial t_a} = 0 \quad (32)$$

$$\frac{\partial T_a}{\partial \zeta_a} = \frac{\partial T_a}{\partial K_a}\frac{\partial K_a}{\partial \zeta_a} + \frac{\partial T_a}{\partial Y_a}\frac{\partial Y_a}{\partial \zeta_a} + \frac{\partial T_a}{\partial q_a}\frac{\partial q_a}{\partial \zeta_a} + \frac{\partial T_a}{\partial K_b}\frac{\partial K_b}{\partial \zeta_a} + \frac{\partial T_a}{\partial Y_b}\frac{\partial Y_b}{\partial \zeta_a} + \frac{\partial T_a}{\partial q_b}\frac{\partial q_b}{\partial \zeta_a} + \frac{\partial T_a}{\partial \zeta_a} = 0 \quad (33)$$

Simultaneously solving (32) and (33) would give us both country A and country B optimal tax rates and transfer pricing penalty rates for the competitive regime. Also,

solutions which results from simultaneously solving the first order conditions must satisfy the following second-order sufficient conditions to ensure that they maximise each country's tax revenue. The second-order sufficient conditions for each country (in this case, country A) are

$$\frac{\partial^2 T_a}{\partial t_a^2} < 0, \frac{\partial^2 T_a}{\partial \zeta_a^2} < 0$$

and

$$\frac{\partial^2 T_a}{\partial t_a^2} \frac{\partial^2 T_a}{\partial \zeta_a^2} > \frac{\partial^2 T_a}{\partial t_a \partial \zeta_a}$$

Again, we consider the same numerical simulation as in all previous models with the parameter values p = 10; w =0.1; r =0.5; α =0.4 and β =0.4. Based on these parameter values, we solve country A's first-order conditions for t_a and ζ_a, which gives an optimal solution of (t_a , ζ_a) = (0.056, 0.202). In the previous models, this optimal solution for t_a and ζ_a (also t_b and ζ_b) was used as the constant rates for the exogenous tax rates or transfer pricing penalty rates. Moreover, since in the previous numerical simulation we assume the same parameter values for *p, w, r, α,* and *β*, this enables us to cross check the results of our models[11]. Also, it should be emphasised that at (t_a , ζ_a) =(0.056, 0.202) the second-order sufficient conditions are satisfied, which ensures that it maximises country A's tax revenue.

By comparing the results from our numerical simulation, we find that the equilibrium tax rate when the two identical

[11] Recall that for the competitive regime, when the exogenous penalty rates are equal, $\zeta_a = \zeta_b$ =0.202, the optimal tax rate also equal, $t_a = t_b$ =0.056 and when the exogenous tax rates are equal, $t_a = t_b$ = 0.056, the optimal penalty rate also equal, $\zeta_a = \zeta_b$ =0.202.

governments take a cooperative decision is higher than the equilibrium tax rate when they take competitive actions. On the contrary, the equilibrium transfer pricing penalty rate when the two identical governments take a cooperative decision is lower than the equilibrium penalty rate when they take competitive actions. These results suggest that government competition results in too low a tax rate and too high a transfer pricing penalty rate. Next, we provide comparative statics analysis in order to investigate further if these results still hold when we change the parameter values for p, w, r, α, and β.

Furthermore, we compare the equilibrium tax rate and transfer pricing penalty rate for the cooperative regime with those for the competitive regime for various parameter values of rate of return on capital (α), rate of return on intermediate goods (β), cost of labour (w), cost of capital (r) and price of final goods (p). The result, shown in Appendix A5, suggests that regardless of the value of the exogenous variables α, β, w, r, and p, the equilibrium tax rate for the cooperative regime is higher than those for the competitive regime while the equilibrium transfer pricing penalty rate for the cooperative regime is lower than those for the competitive regime. Moreover, the equilibrium tax rate and penalty rate for the competitive regime decrease with an increase in the numerical values of α and β. Furthermore, changes in r and p have no effect on equilibrium tax and penalty rates for both regimes, while change in w only affects equilibrium for the competitive regime.

Some conclusions can be drawn from this comparative analysis. Firstly, when the firm's production efficiency is improved (when α or β increases), for example from an improvement in production technology or efficiency of labour, the firm's cost of production decreases. Consequently, the firm's profit before taxes and penalties increases and, so,

each government's tax base increases. As a result, each government can afford to reduce further both its tax rate and transfer pricing penalty rate when competing with each other over both policy instruments.

Secondly, since we assume that capital in both countries is available to the firm at a constant world marginal cost r and the firm's price of final goods (p) in both countries is equal and determined by the world market, as a result changes in r and p will affect each country symmetrically. Consequently, changes in r and p will not change the equilibrium tax rate and penalty rate for neither cooperative case nor competitive case.

Thirdly, although we also assume that labour in both countries is available to the firm at a constant world marginal cost w, its change affects the equilibrium tax rate and penalty rate for the competitive case. This is because the firm uses labour to produce intermediate goods (Y) which are traded between countries. As a result, a change in w does not necessarily affect each country symmetrically. Consequently, we find that an increase in w raises the equilibrium tax rate and transfer pricing penalty rate for the competitive case. Regarding the cooperative case, since the objective for the cooperative case is to maximise the joint-tax revenue, it does not matter if the change in w does not affect each country symmetrically. Consequently, the change in w does not change the equilibrium for the cooperative case.

5. Conclusion and Policy Implications

This paper is motivated by our aim to find a government's optimal corporate tax that maximises revenue (or welfare) as well as minimises distortions of the firm's choices of investment and profit location[12] when government

[12] It is assumed that firm's production location has already been decided.

faces internationally mobile capital and profit, inter-governmental fiscal competition or cooperation, and a multinational firm that uses transfer pricing to shift profit. In doing so, we constructed theoretical models of tax competition and tax coordination between two governments when a multinational firm minimises taxes through transfer pricing and the governments have two policy instruments: the tax rate and the transfer pricing penalty rate. To our knowledge, although there are number of papers that have studied inter-governmental tax competition under the context of the multinational firm's profit shifting through transfer prices such as Elitzur and Mintz (1996), Haufler and Schjelderup (2001), Devereux et al. (2004), and Devereux et al. (2008), they, however, did not allow countries to compete on transfer pricing penalty rates. On the other hand, Raimondos-Møller and Sharf (2002) studied government competition on transfer pricing rules, however, they did not allow countries to compete on tax rate. This makes our theoretical model different from other standard tax competition models with transfer pricing as we allow governments to compete on two corporate tax instruments: the corporate tax rate on pure profit and the transfer pricing penalty rate to provide a disincentive to the firm from profit-shifting.

The objectives were to answer the following questions: firstly, what would be an optimal profit tax rate and transfer pricing penalty rate for a revenue maximising government? Secondly, does cooperation between the government results in a higher or a lower equilibrium profit tax rate and transfer pricing penalty rate compared with the equilibrium under

Also, our models do not consider the firm's choices of financing. The latter point could be viewed as assuming the firm is only financed by equity.

competition? Finally, is an attempt by an international organisation such as the European Union to have a single transfer pricing documentation rule a Pareto improving? We approached these three questions by constructing our models under two circumstances: when the governments take cooperative decisions and when they take competitive decisions. We investigated the governments' decisions when the multinational firm engages in transfer pricing manipulation. Our analysis based on three cases: when governments compete or cooperate on corporate tax rates, on transfer pricing penalty rates, and on both rates. In all three cases, we demonstrated that even when each country impose corporate income tax on a multinational firm's pure profit, because of international mobility of tax base, the firm's decisions on level of production (capital investment and production of intermediate goods), and profit location are distorted by the difference in the host and the home countries' tax rates and transfer pricing penalty rates.

In the first case, the governments decide on the tax rates given the exogenous transfer pricing penalty rates. Based on our numerical analysis, we found that at given penalty rates, the optimal tax rates for both countries are higher when governments take a cooperative decision than when they take competitive actions. This suggests that tax competition results in too-low tax rates, which is suggested in most tax competition literature, such as Wilson (1986). Also, we found that moving from competitive to cooperative regime is Pareto improving when considering the world level of public goods, which is financed by tax revenue. This point suggests that governmental cooperation on tax rate is efficiency enhancing as it increases global level of public goods compared to the results under government's competition, which is suggested in most tax competition literature such as Elitzur and Mintz (1996), and Zodrow and Mieszkowski (1999). Also, we

found that when the countries' exogenous penalty rates are different, under the government cooperation, the optimal tax rate in each country also different, which is similar to what was suggested in Dhillon et al. (1999) that tax cooperation between asymmetric governments results in unequal tax rates. In addition, the countries' joint-tax revenue, under cooperative regime, is at a maximum when the penalty rates of both countries are at a minimum. This finding suggests that both countries should set their penalty rates at the minimum rates possible in order to maximise their joint-tax revenue and also the public goods provision. Moreover, we found that when government competes on tax rate for mobile tax base, it is optimal for a country whose transfer pricing rule is relatively more lenient than the other to maintain a relatively lower tax rate than the other. This is what we observe in small tax haven countries which usually have a low tax rate and a less restricted transfer pricing rule.

In the second case, the governments decide on the transfer pricing penalty rates given the exogenous tax rates. We found that that even if countries compete on tax rates (or have different tax rates) if they work in cooperation in setting the transfer pricing rules, it is optimal for them to either have different or equal transfer pricing penalty rates. As a result, an attempt by the OECD to have a single transfer pricing penalty rules (or rates in our model) may not be the only optimal solution for small cooperative governments. Moreover, we found that when the governments take competitive decisions it is optimal for a country with a lower exogenous tax rate to set a lower penalty rate and for a country with a higher exogenous tax rate to set a higher penalty rate. Again, our results from the competitive regime reflects what we observe in the small tax haven countries who usually have low to zero tax rates, and the less restricted transfer pricing rules.

In the third case, the symmetric governments decide on both the tax rates and the transfer pricing penalty rates. We found that the fiscal competition results in too-low a tax rate and too-high a transfer pricing penalty rate compared with the results when governments make cooperative decisions.

Some policy implications can be suggested from the above findings. **First**, when the transfer pricing penalty rates are decided prior to the tax rates, to compete for a mobile tax base a country with a lenient transfer pricing rule should maintain a low tax rate and a country with a tougher transfer pricing rule should maintain a high tax rate. **Second**, when the tax rates are decided prior to the penalty rates and the governments compete on the transfer pricing rules for a mobile tax base, again, it is optimal for a country with a low tax rate to have a lenient transfer pricing rule and a country with a high tax rate to have a tougher transfer pricing rule. **Third**, when the tax rates are decided prior to the penalty rates and the governments cooperate on the transfer pricing rules, the optimal penalty rate of a country with a lower tax rate can either be higher, lower, or equal to the optimal penalty rate of another country with a higher tax rate. **Fourth**, even when the tax rates are harmonised prior to the penalty rates, the optimal penalty rate of each government can either be different or be equal. As a result, an attempt by the OECD to have a single transfer pricing rule may not necessary be an only optimal solution for the cooperative governments. **Lastly,** taking into account that countries compete on tax base with each other, either openly or closely, a country must identify who are major competitors before strategically choosing combination of tax rate and/or penalty rate to effectively save its tax base and tax revenue.

References

Baldwin, R. & Krugman, P. (2004). Agglomeration, integration and tax harmonization. *European Economic Review*, *48*(1), 1-23.

Booth, E. J. R. & Jensen, O.W. (1977). Transfer Prices in the Global Corporation under Internal and External Constraints. *The Canadian Journal of Economics*, *10*(3), 434- 446.

Bretschger, L. & Hettich, F. (2002). Globalisation, capital mobility and tax competition: theory and evidence for OECD countries. *European Journal of Political Economy*, *18*, 695-716.

Chiang, A. C. (1984). *Fundamental methods of mathematical economics*, Singapore, McGraw-Hill Inc.

Copithorne, L. W. (1971). International Corporate Transfer Prices and Government Policy. *The Canadian Journal of Economics*, *4*(3), 324 - 341.

Devereux, M.P. & Sørensen, P.B. (2005). The corporate income tax: international trends and options for fundamental reform. *EPRU-Analysis No. 24*. http://www.econ.ku.dk/epru, quoted on July 2008.

Devereux, M. P., Lockwood, B., & Redoano, M. (2004). Do Countries Compete over Corporate Tax Rates? University of Warwick, http://www2.warwick.ac.uk/fac/soc/ economics/ staff/ faculty/ lockwood/ dlrrev.pdf, quoted on 14 April 2007.

Devereux, M. P., Lockwood, B., & Redoano, M. (2008). Do Countries Compete over Corporate Tax Rates? *Journal of Public Economics*, *92*, 1210-1235 .

Dhillon, A., Perroni, C., & Scharf, K. A., (1999). Implementing tax coordination. *Journal of Public Economics*, *72*, 243- 268.

Eden, L. (1983). Transfer pricing policies under tariff barriers. *Canadian journal of economics*, *16*(4), 669-685.

Elitzur, R. & Mintz, J. (1996). Transfer pricing rules and corporate tax competition. *Journal of Public Economics*, *60*, 401-422.

Ernst and Yong (2005), *2005-2006 Global Transfer Pricing Survey: Global Transfer Pricing Trends, Practices, and Analysis, November 2005*, http://www.ey.com/global/download.nsf/ International/ Transfer_Pricing_Global_Surveys_Q4_2005/ $_le/ GlobalTPSurvey_Q4_2005.pdf, quoted on 28 June 2007.

Ernst and Yong (2006), *2005-2006 Global Transfer Pricing Survey: Tax Authority Interviews: Perspectives, Interpretations, and Regulatory Changes*, http://www2.eycom.ch/publications/ items/global_tp_survey_200511/en.pdf, quoted on 28 June 2007.

Haufler, A. & Schjelderup, G. (2000). Corporate tax systems and cross country profit shifting. *Oxford Economic Papers*, *52*, 306-25.

Hirshleifer, J. (1956). On the Economics of Transfer Pricing. *The Journal of Business*, *29*(3), 172- 184.

Horst, T. (1971). The Theory of the Multinational Firm: Optimal Behavior under Different Tariff and Tax Rates. *The Journal of Political Economy*, *79*(5),1059-1072.

Kanbur, R. & Keen, M. (1993). Jeux Sans Frontieres: Tax Competition and Tax Coor-dination When Countries Differ in Size. *The American Economic Review*, *83*(4), 877-892.

Kant, C. (1988). Endogenous transfer pricing and the effects of uncertain regulation. *Journal of International Economics*, *24*, 147- 157.

Kant, C. (1990). Multinational firms and government revenues. *Journal of Public Economics*, *42*, 135-147.

Liu, L. et al. (2017). International Transfer Pricing and Tax Avoidance: Evidence from Linked Trade-Tax Statistics in the UK. *International Finance Discussion Papers*, Board of Governors of the Federal Reserve System, No.1214.

Nielsen, S.B., Raimondos-Møller, P., & Schjelderup, G. (2003). Formula Apportionment and Transfer Pricing under Oligopolistic Competition. *Journal of Public Economics*, *5* (2), 419-437.

Organisation for Economic Co-operation and Development (1995), *Transfer Pricing Guidelines for Multinaitonal Enterprises and Tax Administrations*, Paris, OECD.

Raff, H. (2004). Preferential trade agreements and tax competition for foreign direct investment. *Journal of Public Economics*, *88*, 2745- 2763.

Raimondos-Møller, P. & Scharf, K. (2002). Transfer pricing rules and competing governments. *Oxford Economic Papers*, *54*, 230-246.

Samuelson, L. (1982). The multinational firm with arm's length transfer price limits. *Journal of International Economics*, *13*, 365-374.

Tiebout, C. M. (1956). A Pure Theory of Local Expenditures. *The Journal of Political Economy*, *64*(5), 416- 424.

Vicard, V. (2014). Profit Shifting through transfer pricing: evidence from French firm level trade data, *Banque de France Working Paper*, No. 555.

Wilson, J. D. & Wildasin, D. E. (2004). Capital tax competition: bane or boon. *Journal of Public Economics*, *88*, 1065-1091.

Wilson, J. D. (1986). A Theory of Interreginal Tax Competition. *Journal of Urban Economics*, *19*, 296-315.

Zodrow, G. R. & Mieszkowski, P. (1986). Pigou, Tiebout, Property Taxation, and the Under provision of Local Public Goods. *Journal of Urban Economics*, *19*, 356-370.

The appendices for this article is available for free on the journal website at www.tresp.econ.tu.ac.th.

Appendix

A1 Optimal cooperative tax rates given penalty rates

ζ_a	ζ_b	(t_a, t_b)	A	B	q_a	q_b	T_a	T_b	T	Π_g
0.05	0.18	(0.795, 0.770)	0.211	0.383	0.108	0.891	-1, 944, 026	2, 205, 580	261, 554	50, 461
0.10	0.18	(0.789, 0.740)	0.211	0.511	0.182	0.818	−1, 651, 241	1, 877, 046	225, 804	46, 646
0.15	0.18	(0.900, 0.827)	0.206	0.878	0.233	0.766	−1, 881, 994	2, 092, 144	210, 149	21, 077
0.18	0.18	(0.800, 0.8858)	0.891	0.208	0.738	0.262	1, 897, 916	−1, 691, 363	206, 553	23, 692
0.18	0.18	(0.8858, 0.800)	0.208	0.891	0.262	0.738	−1, 691, 363	1, 897, 916	206, 553	23, 692
0.202	0.18	(0.90912, 0.9967)	1.741	0.198	0.758	0.242	2, 524, 332	−2, 313, 002	211, 329	929
0.25	0.18	(0.811, 0.900)	0.956	0.205	0.788	0.212	2, 147, 184	−1, 940, 785	206, 399	21, 106

ζ_a	ζ_b	(t_a, t_b)	A	B	q_a	q_b	T_a	T_b	T	Π_g
0.05	0.202	(0.795, 0.770)	0.212	0.385	0.099	0.900	−1, 938, 389	2, 199, 662	261, 272	49, 983
0.10	0.202	(0.800, 0.751)	0.216	0.527	0.169	0.831	−1, 609, 800	1, 834, 981	225, 118	42, 463
0.15	0.202	(0.8023, 0.730)	0.214	0.638	0.221	0.779	−1, 496, 592	1, 705, 782	209, 190	40, 889
0.18	0.202	(0.900, 0.813)	0.207	0.948	0.243	0.756	−1, 785, 278	1, 992, 044	206, 765	20, 713
0.202	0.202	(0.897, 0.800)	0.201	0.976	0.259	0.740	−1, 900, 707	2, 105, 154	204, 446	22, 588
0.202	0.202	(0.800, 0.897)	0.976	0.201	0.740	0.259	2, 105, 154	−1, 900, 707	204, 446	22, 588
0.22	0.202	(0.8025, 0.900)	0.993	0.206	0.752	0.247	1, 994, 722	−1, 789, 797	204, 924	20, 902
0.25	0.202	(0.801, 0.900)	0.997	0.203	0.772	0.228	2, 139, 189	−1, 9346, 616	204, 572	21, 460

ζ_a	ζ_b	(t_a, t_b)	A	B	q_a	q_b	T_a	T_b	T	Π_g
0.05	0.22	(0.794, 0.769)	0.213	0.385	0.092	0.907	−1, 933, 674	2, 194, 773	261, 099	49, 965
0.10	0.22	(0.795, 0.745)	0.211	0.522	0.156	0.844	−1, 767, 375	1, 992, 245	224, 870	45, 496
0.15	0.22	(0.800, 0.727)	0.213	0.637	0.208	0.792	−1, 541, 339	1, 750, 174	208, 834	41, 660
0.20	0.22	(0.900, 0.8034)	0.207	0.989	0.246	0.754	−1, 784, 118	1, 989, 184	205, 065	20, 829
0.202	0.22	(0.900, 0.8025)	0.206	0.993	0.248	0.752	−1, 789, 797	1, 994, 722	204, 924	20, 902
0.22	0.22	(0.701, 0.600)	0.220	0.619	0.270	0.729	−1, 011, 211	1, 202, 406	191, 194	59, 103
0.22	0.22	(0.600, 0.701)	0.619	0.220	0.729	0.270	1, 202, 406	−1, 011, 211	191, 194	59, 103

A2 Optimal competitive tax rates given penalty rates

ζ_a	ζ_b	(t_a, t_b)	A	B	q_a	q_b	T_a	T_b	Π_g
0.02	0.18	(0.005, 0.043)	0.272	0.211	0.290	0.710	24,910	61,718	285,872
0.03	0.18	(0.009, 0.044)	0.273	0.217	0.309	0.690	33,174	62,344	273,805
0.04	0.18	(0.013, 0.045)	0.275	0.224	0.327	0.672	39,749	62,997	262,947
0.05	0.18	(0.017, 0.046)	0.276	0.230	0.343	0.656	45,015	63,639	253,108
0.10	0.18	(0.033, 0.049)	0.283	0.258	0.414	0.585	59,490	65,274	215,616
0.15	0.18	(0.045, 0.050)	0.290	0.282	0.469	0.530	64,356	65,567	190,504
0.18	0.18	(0.051, 0.051)	0.295	0.295	0.500	0.500	65,431	65,431	178,864
0.20	0.18	(0.055, 0.052)	0.298	0.302	0.518	0.481	65,789	65,281	172,069
0.202	0.18	(0.055, 0.052)	0.298	0.303	0.521	0.479	65,800	65,237	171,511
0.25	0.18	(0.064, 0.052)	0.303	0.322	0.553	0.446	65,641	64,676	158,160
0.30	0.18	(0.072, 0.052)	0.308	0.339	0.583	0.416	64,925	63,870	147,092
0.35	0.18	(0.079, 0.052)	0.313	0.356	0.609	0.390	64,003	62,962	138,082
0.40	0.18	(0.086, 0.052)	0.317	0.371	0.631	0.369	63,035	61,992	130,427
0.45	0.18	(0.092, 0.052)	0.322	0.385	0.651	0.349	62,090	61,017	123,997
0.50	0.18	(0.099, 0.052)	0.326	0.399	0.666	0.334	61,203	59,978	118,143

ζ_a	ζ_b	(t_a, t_b)	A	B	q_a	q_b	T_a	T_b	Π_g
0.02	0.202	(0.004, 0.046)	0.278	0.211	0.279	0.720	25, 209	63, 267	279, 634
0.03	0.202	(0.009, 0.047)	0.279	0.218	0.293	0.707	33, 532	64, 197	267, 620
0.04	0.202	(0.013, 0.048)	0.280	0.225	0.310	0.690	40, 141	64, 197	267, 620
0.05	0.202	(0.017, 0.050)	0.283	0.231	0.329	0.670	45, 331	65, 177	246, 299
0.10	0.202	(0.032, 0.053)	0.292	0.259	0.401	0.599	59, 724	65, 966	208, 623
0.15	0.202	(0.045, 0.055)	0.299	0.284	0.454	0.545	64, 402	66, 044	183, 122
0.20	0.202	(0.055, 0.056)	0.307	0.306	0.498	0.501	65, 454	65, 485	164, 739
0.202	0.202	(0.056, 0.056)	0.307	0.307	0.500	0.500	65, 456	65, 456	164, 111
0.25	0.202	(0.065, 0.057)	0.313	0.326	0.535	0.464	65, 116	64, 639	150, 662
0.30	0.202	(0.073, 0.057)	0.319	0.344	0.565	0.434	64, 147	63, 625	139, 660
0.35	0.202	(0.081, 0.058)	0.325	0.361	0.592	0.407	63, 103	62, 548	130, 474
0.40	0.202	(0.088, 0.058)	0.330	0.377	0.615	0.385	61, 932	61, 436	122, 929
0.45	0.202	(0.095, 0.058)	0.334	0.392	0.633	0.366	60, 809	60, 310	116, 413
0.50	0.202	(0.101, 0.058)	0.339	0.406	0.651	0.349	59, 759	59, 214	110, 882

A2 Optimal competitive tax rates given penalty rates (continued)

ζ_a	ζ_b	(t_a, t_b)	A	B	q_a	q_b	T_a	T_b	Π_g
0.02	0.22	(0.004, 0.048)	0.282	0.212	0.266	0.733	25, 478	64, 701	275, 256
0.03	0.22	(0.008, 0.049)	0.284	0.219	0.284	0.716	33, 825	65, 061	263, 022
0.04	0.22	(0.012, 0.050)	0.286	0.225	0.300	0.700	40, 440	65, 461	252, 008
0.05	0.22	(0.016, 0.051)	0.287	0.232	0.315	0.685	45, 705	65, 868	242, 031
0.10	0.22	(0.032, 0.055)	0.297	0.260	0.384	0.615	59, 865	66, 516	203, 698
0.15	0.22	(0.045, 0.057)	0.305	0.286	0.438	0.562	64, 290	66, 236	178, 054
0.18	0.22	(0.052, 0.058)	0.310	0.300	0.465	0.535	65, 035	65, 832	166, 229
0.20	0.22	(0.055, 0.059)	0.314	0.308	0.486	0.514	65, 143	65, 375	159, 525
0.202	0.22	(0.056, 0.059)	0.314	0.309	0.486	0.514	65, 141	65, 386	158, 816
0.22	0.22	(0.056, 0.059)	0.317	0.317	0.500	0.500	64, 995	64, 995	153, 523
0.25	0.22	(0.065, 0.060)	0.321	0.329	0.521	0.478	64, 586	64, 389	145, 388
0.30	0.22	(0.074, 0.061)	0.327	0.348	0.552	0.448	63, 513	63, 251	134, 171
0.35	0.22	(0.081, 0.062)	0.334	0.364	0.581	0.419	62, 288	62, 045	125, 234
0.40	0.22	(0.089, 0.062)	0.339	0.381	0.601	0.398	60, 972	60, 827	117, 595
0.45	0.22	(0.096, 0.062)	0.344	0.397	0.621	0.379	59, 719	59, 618	111, 170
0.50	0.22	(0.103, 0.062)	0.349	0.412	0.637	0.362	58, 557	58, 417	105, 546

A3 Optimal Cooperative transfer pricing penalty rates given tax rates

t_a	t_b	(ζ_a, ζ_b)	A	B	q_a	q_b	T_a	T_b	T	Π_g
0.010	0.056	(0.08, 0.76)	0.345	0.274	0.15	0.85	64,881	58,720	123,602	170,651
		(0.09, 0.549)	0.345	0.274	0.212	0.787	63,988	59,613	123,602	170,704
		(0.095, 0.491)	0.345	0.274	0.240	0.759	63,466	60,134	123,602	170,682
		(0.10, 0.447)	0.345	0.274	0.267	0.733	62,880	60,721	123,602	170,733
		(0.113, 0.374)	0.345	0.274	0.326	0.673	61,304	62,297	123,602	170,664
		(0.12, 0.347)	0.345	0.274	0.355	0.644	60,381	63,220	123,602	170,777
		(0.125, 0.332)	0.345	0.274	0.374	0.626	59,746	63,855	123,602	170,751
		(0.13, 0.319)	0.345	0.274	0.392	0.608	59,104	64,497	123,602	170,756
		(0.135, 0.308)	0.345	0.274	0.408	0.591	58,477	65,124	123,602	170,713
		(0.20, 0.235)	0.345	0.274	0.565	0.434	51,034	72,567	123,602	170,909
		(0.26, 0.21)	0.345	0.274	0.651	0.349	45,853	77,748	123,601	171,039
		(0.28, 0.205)	0.345	0.274	0.672	0.327	44,442	79,159	123,602	170,920
		(0.30, 0.201)	0.345	0.274	0.690	0.309	43,159	80,442	123,602	170,715
		(0.32, 0.197)	0.345	0.274	0.707	0.292	41,950	81,651	123,602	170,892
		(0.34, 0.194)	0.345	0.274	0.722	0.277	40,861	82,740	123,602	170,793

A3 Optimal Cooperative transfer pricing penalty rates given tax rates (continued)

t_a	t_b	(ζ_a, ζ_b)	A	B	q_a	q_b	T_a	T_b	T	Π_g
0.056	0.056	(0.10, 0.651)	0.292	0.292	0.133	0.867	53, 678	78, 167	131, 845	181, 610
		(0.11, 0.409)	0.292	0.292	0.211	0.788	56, 308	75, 536	131, 845	181, 608
		(0.112, 0.384)	0.292	0.292	0.225	0.774	56, 782	75, 063	131, 845	181, 577
		(0.12, 0.312)	0.292	0.292	0.277	0.722	58, 498	73, 346	131, 845	181, 634
		(0.13, 0.260)	0.292	0.292	0.333	0.666	60, 354	71, 490	131, 845	181, 634
		(0.14, 0.227)	0.292	0.292	0.381	0.618	61, 948	69, 897	131, 845	181, 730
		(0.15, 0.21)	0.292	0.292	0.416	0.583	63, 252	68, 589	131, 842	180, 540
		(0.155, 0.196)	0.292	0.292	0.441	0.558	63, 960	67, 885	131, 845	181, 784
		(0.16, 0.19)	0.292	0.292	0.457	0.542	64, 504	67, 340	131, 845	181, 383
		(0.165, 0.182)	0.292	0.292	0.475	0.524	65, 099	66, 746	131, 845	181, 799
		(0.170, 0.176)	0.292	0.292	0.491	0.508	65, 630	66, 215	131, 845	181, 888
		(0.172, 0.175)	0.292	0.292	0.495	0.504	65, 778	66, 066	131, 845	181, 532

t_a	t_b	(ζ_a, ζ_b)	A	B	q_a	q_b	T_a	T_b	T	Π_g
0.100	0.056	(0.155, 0.705)	0.268	0.339	0.129	0.871	37, 684	94, 000	131, 685	169, 435
		(0.16, 0.54)	0.268	0.339	0.165	0.834	39, 088	92, 596	131, 685	169, 303
		(0.17, 0.371)	0.268	0.339	0.232	0.767	41, 779	89, 905	131, 685	169, 458
		(0.176, 0.32)	0.268	0.339	0.266	0.733	43, 499	88, 185	131, 685	169, 184
		(0.18, 0.290)	0.268	0.339	0.289	0.710	44, 515	87, 169	131, 685	169, 468
		(0.193, 0.231)	0.268	0.339	0.351	0.648	47, 934	83, 751	131, 685	169, 478
		(0.194, 0.228)	0.268	0.339	0.355	0.644	48, 194	83, 490	131, 685	169, 423
		(0.195, 0.225)	0.268	0.339	0.359	0.640	48, 451	83, 234	131, 685	169, 386
		(0.20, 0.210)	0.268	0.339	0.380	0.619	49, 688	81, 997	131, 685	169, 472
		(0.212, 0.184)	0.268	0.339	0.424	0.575	52, 534	79, 151	131, 685	169, 366
		(0.22, 0.170)	0.268	0.339	0.451	0.548	54, 323	77, 361	131, 685	169, 560

A4 Optimal competitive transfer pricing penalty rates given tax rates

t_a	t_b	(ζ_a, ζ_b)	A	B	q_a	q_b	T_a	T_b	Π_g
0.01	0.01	(0.08, 0.08)	0.240	0.240	0.500	0.500	49, 062	49, 062	280, 654
0.02	0.01	(0.107, 0.09)	0.242	0.258	0.492	0.507	58, 144	49, 758	259, 004
0.03	0.01	(0.135, 0.10)	0.244	0.275	0.489	0.511	63, 419	50, 587	240, 289
0.04	0.01	(0.165, 0.109)	0.246	0.293	0.493	0.507	66, 174	51, 553	223, 796
0.05	0.01	(0.195, 0.116)	0.248	0.311	0.498	0.502	67, 268	52, 325	210, 301
0.06	0.01	(0.23, 0.122)	0.251	0.329	0.511	0.489	67, 417	53, 316	197, 026
0.07	0.01	(0.267, 0.125)	0.254	0.347	0.528	0.472	66, 891	54, 124	185, 909
0.08	0.01	(0.31, 0.129)	0.257	0.366	0.546	0.453	66, 197	54, 863	174, 158
0.09	0.01	(0.352, 0.131)	0.260	0.385	0.563	0.437	65, 339	55, 256	164, 876
0.10	0.01	(0.4, 0.132)	0.264	0.403	0.583	0.417	64, 483	55, 486	155, 836

t_a	t_b	(ζ_a, ζ_b)	A	B	q_a	q_b	T_a	T_b	Π_g
0.01	0.056	(0.119, 0.215)	0.321	0.249	0.494	0.506	52, 881	67, 385	202, 273
0.02	0.056	(0.131, 0.218)	0.318	0.262	0.478	0.521	58, 740	66, 093	192, 138
0.03	0.056	(0.145, 0.218)	0.315	0.274	0.471	0.529	62, 251	65, 552	183, 415
0.04	0.056	(0.163, 0.214)	0.311	0.286	0.475	0.525	64, 219	65, 451	175, 697
0.05	0.056	(0.185, 0.207)	0.308	0.299	0.487	0.513	65, 195	65, 495	168, 658
0.056	0.056	(0.202, 0.202)	0.307	0.307	0.500	0.500	65, 456	65, 456	164, 111
0.06	0.056	(0.214, 0.199)	0.306	0.313	0.508	0.491	65, 511	65, 405	161, 091
0.07	0.056	(0.247, 0.190)	0.305	0.327	0.533	0.467	65, 436	65, 155	154, 228
0.08	0.056	(0.287, 0.182)	0.305	0.343	0.561	0.439	65, 603	64, 603	147, 023
0.09	0.056	(0.334, 0.174)	0.305	0.359	0.590	0.409	64, 670	63, 753	140, 112
0.10	0.056	(0.385, 0.168)	0.306	0.376	0.617	0.383	64, 127	62, 746	133, 433

t_a	t_b	(ζ_a, ζ_b)	A	B	q_a	q_b	T_a	T_b	Π_g
0.01	0.10	(0.132, 0.4)	0.403	0.264	0.417	0.583	55, 486	64, 483	155, 836
0.02	0.10	(0.135, 0.418)	0.399	0.275	0.389	0.611	58, 648	65, 567	147, 889
0.03	0.10	(0.14, 0.416)	0.392	0.283	0.378	0.622	60, 607	63, 379	143, 660
0.04	0.10	(0.148, 0.411)	0.386	0.292	0.372	0.628	61, 749	63, 586	139, 368
0.05	0.10	(0.159, 0.398)	0.379	0.301	0.375	0.625	62, 421	63, 967	135, 591
0.06	0.10	(0.174, 0.378)	0.373	0.310	0.388	0.612	62, 824	64, 280	131, 916
0.07	0.10	(0.192, 0.354)	0.367	0.319	0.406	0.593	63, 051	64, 525	128, 555
0.08	0.10	(0.215, 0.328)	0.362	0.330	0.433	0.567	63, 188	64, 471	124, 991
0.09	0.10	(0.242, 0.301)	0.357	0.341	0.464	0.536	63, 358	64, 213	121, 770
0.10	0.10	(0.276, 0.276)	0.353	0.353	0.500	0.500	63, 512	63, 512	118, 111

A5 Comparative statics analysis when governments are symmetric

When α changes, assuming $p = 10; w = 0.1; r = 0.5; \beta = 0.4$

α	Cooperative equilibrium	Competitive equilibrium
	(t, ζ)	(t, ζ)
0.3	$(1, 0)$	$(0.108, 0.340)$
0.4	"	$(0.056, 0.202)$
0.5	"	$(0.023, 0.094)$

When β changes, assuming $p = 10; w = 0.1; r = 0.5; \alpha = 0.4$

β	Cooperative equilibrium	Competitive equilibrium
	(t, ζ)	(t, ζ)
0.3	$(1, 0)$	$(0.216, 0.536)$
0.4	"	$(0.056, 0.202)$
0.5	"	$(0.018, 0.075)$

When w changes, assuming $p = 10; r = 0.5; \alpha = 0.4; \beta = 0.4$

w	Cooperative equilibrium	Competitive equilibrium
	(t, ζ)	(t, ζ)
0.05	$(1, 0)$	$(0.019, 0.083)$
0.1	"	$(0.056, 0.202)$
0.2	"	$(0.246, 0.529)$
0.3	"	$(0.445, 0.660)$
0.4	"	$(0.494, 0.712)$
0.5	"	$(0.482, 0.776)$
0.6	"	$(0.452, 0.844)$
0.7	"	$(0.417, 0.907)$
0.8	"	$(0.384, 0.961)$
0.9	"	$(0.355, 1.008)$
1.0	"	$(0.329, 1.048)$

A5 Comparative statics analysis when governments are symmetric (continued)

When r changes, assuming $p = 10; w = 0.1; \alpha = 0.4; \beta = 0.4$

r	Cooperative equilibrium	Competitive equilibrium
	(t, ζ)	(t, ζ)
0.1	$(1, 0)$	$(0.056, 0.202)$
0.2	"	"
0.3	"	"
0.4	"	"
0.5	"	"
0.6	"	"
0.7	"	"

When p changes, assuming $r = 0.5; w = 0.1; \alpha = 0.4; \beta = 0.4$

p	Cooperative equilibrium	Competitive equilibrium
	(t, ζ)	(t, ζ)
8	$(1, 0)$	$(0.056, 0.202)$
9	"	"
10	"	"
11	"	"
12	"	"
13	"	"
14	"	"