International Tax Competition:

Theory and Evidence

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Abstract

The aim of this thesis is to analyse how the international mobility of productive capital creates strategic tax setting behaviour in corporate taxation and to investigate whether the central propositions of tax competition theory conform with empirical evidence. The analysis starts from a symmetric two countries model in which countries compete to attract each other's capital by manipulating corporation tax rate. This thesis shows that tax competition leads to a unique and stable Nash equilibrium. Numerical calibration suggests that non-cooperative tax rates are 40-50% below the optimal level.

The basic model is extended to analyse three asymmetric forms of tax competition: different country size, different per capita capital endowment, and different preference for public goods. This thesis suggests that smaller countries and countries with a weak preference for public goods tend to undercut larger countries and countries with a strong preference for public goods. However, difference in per capita capital endowment does not make any difference between countries not only in the level of tax rates but also in the size of tax cutting.

The structure of the tax competition game is modified into a two-stage game. Firstly, when countries use not only tax rates but also tax rules as a strategic variable, a source-based tax (the exemption rule) is not compatible with the subgame perfect Nash equilibrium, and therefore, tax competition does not take place. Secondly, when tax competition is followed by subsidy competition, tax cutting happens even with a residence-based tax (the credit rule and the deduction rule).

The assumption of perfect capital mobility is then replaced by the assumption of imperfect capital mobility. The introduction of imperfect capital mobility leads to the non-existence of pure strategy Nash equilibrium. Both countries randomly select their tax rates from among those below the optimal level. As transaction costs decrease, tax rates decrease and the expected tax differential between them also decreases.

Testable propositions are derived and tested with the marginal effective corporate tax rates of OECD member countries for the period 1960-1998. The four propositions tested are: (1) corporation tax rates should show a decreasing trend; (2) more-open countries should decrease tax rates more than less-open countries; (3) smaller countries should decrease tax rates more than larger countries; (4) countries with a strong preference for public goods should decrease tax rates more than those with a weak preference. The data supports all four of those propositions and thus suggests that tax competition has led to lower corporate tax rates.

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Chapter 1

Introduction

1.1 Motivation

One of the most remarkable changes in the world economy during this century is worldwide economic integration[1]. The speed and the degree of economic integration are rarely recognized within a single generation. However, if we compare the economic life of the current generation with that of three generations ago, the change is remarkable. Two snap shots taken between different generations may be a more appropriate means of illustrating these changes than a motion picture covering these generations. The following are fictitious descriptions of an eight year old school boy from different generations:

[1]The term 'international economic integration' has been used to refer to the integration of different nations into a regional block and implies specific forms of integration such as free trade, customs union, economic union, etc. I do not confine 'worldwide economic integration' to these specific forms.

> A country boy in York in 1900 would go to school by a carter drawn by horses bred in Naburn, a small village in the south of York. He would have worn clothes made of domestic wool and might have put on school shoes made by 'Churches', whose factory was in Leeds. His big lunch box would probably have been made of tin processed in Liverpool and would be full of vegetables and fruits cultivated in his village. After school, he might have played with a kite which his father had made for him. The dinner menu was probably his favourite, 'Yorkshire Pudding', made of beef and flour purchased at his local butchers in the village. After dinner, he probably listened to the radio made by a manufacturer in Bristol.
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> Suppose his counterpart was a boy living in 1999. He goes to school in a 'Rover' car made in the UK but financed by German capital. His shoes are 'Nike', made in China and his bag bears an American 'Disney' logo but is made in Indonesia. His lunch box bears a picture of 'Star Wars' and is made in Turkey. It contains fish fingers, which are processed in Birmingham but made of cod imported from Norway, and yogurt, which is a product of the Swiss chocolate giant 'Nestle', but is produced by its UK branch in York. After school, he plays with a 'Sony Playstation' which his father bought on their last summer holiday in the USA. He is taken out for dinner to 'McDonalds'. Returning home, he watches the European Cup Final between 'Real Madrid' and 'Chelsea'. Over half of the players of both teams are from other countries such as Brazil, France, Italy and Nigeria.

How could a school boy of three generations ago have imagined what the life of his great grandson would be? It is difficult to deny that the current level of affluence of material life is sustained by products and services which are provided worldwide.[2] The trend of economic integration cannot be reversed and, just like our great grandparents, we cannot imagine how the economic life of the next generations will change.[3]

[2]In 1997 in OECD countries, traded goods and services totalled on average 41% of the GDP. This contrasts with a rate of only 22% in 1960. The volumes of imports and exports in 1997 are 8.8 and 9.1 times those of 1960 respectively while the volume of GDP in 1997 is 3.4 times that of 1960.

[3]Kevin H. O'Rourke claims that globalization was further advanced along some dimensions in the late nineteenth century than it is today and that globalization was reversed by losers of globalization if they were not adequately compensated but were sufficiently powerful politically. He interpretes the First World War in this context. For detail, see *Globalization in Historical Perspective*(1999).

Worldwide economic integration has provided many issues for the discipline of Economics. Trade, exchange rates, foreign direct investment, economic union and international capital markets are just a few of these issues. Public Finance, however, has been influenced relatively little by economic integration. Until recently, it was believed that taxation could be used to solve domestic problems, independently of international considerations. Of course there have been considerations of international issues in the realm of Public Economics. Trade has been the major mode of economic integration in this century and thus export and import tax have been in the centre of economic debates. However, the tax system, as a whole, does not seem to be affected by such international considerations.

However, economic integration itself has become much more diversified. Recently, due to the rapid technological development of telecommunication and transportation industries, consumers and firms are able to move more easily. Eventually, these are likely to erode the base of the tax system. Even if the movement of tax bases does not constitute a real threat to the existence of tax system as a whole at present, a specific tax may be much more distorted than other forms of taxation.

Within the deeply integrated world economy, some production factors appear to move across borders easily whilst others do not. The asymmetry in the international mobility of production factors provides motivation for governments to attract mobile factors by taxing them slightly, whereas immobile factors are taxed heavily to make up for this loss of revenue. This strategic taxation behaviour leads to lower tax rates on mobile factors and thus lower levels in the supply of public goods than the optimal level[4]. Typically, the higher mobility of capital and the lower mobility of labour implies that labour income tends to be more heavily taxed than capital income. This is an unwanted result which is generally thought to be unfair.

From the economists' point of view, tax competition implies an inefficient allocation of resources. From the politicians' point of view, tax competition implies an unequal burden of tax for immobile factors, mostly for labours. From the governments' point of view, tax competition implies limits in using taxation to finance expenditure. These concerns tend to increase as the world economy becomes more integrated and thus the tax base moves by huge amounts.

The abundant theoretical literature on tax competition reflects the magnitude of the concerns shared by economists and policy makers alike. The main outcome of this theoretical literature is the belief that tax competition will result in lower tax on capital income and the under-supply of public goods. This also implies that international tax coordination is beneficial to worldwide welfare. International tax harmonization is one of policies suggested by this school of thought.[5] OECD, EU, and US-Canada have all been taking the issue seriously.

On the other hand, there are many economists and policy makers who are suspicious of the harmful effect of tax competition. McLure (1986) is a typical example of

[4]If there are unlimited alternative taxes, public goods is not necessarily under-provided.

[5]Tax harmonization is not always feasible. Instead, minimum tax rate, enforcement of residence-based tax, restricting capital mobility, infromation sharing among tax authoritie, etc. are other policies recommeded by various studies.

those who believe that the harmful effect of tax competition is exaggerated:

> In the extreme case this amounts to asking whether spending on school lunches in Gloucester, Massachusetts, would be optimal if financed by a property tax on the fishing fleet docked there. ..... one would expect that boats would be docked elsewhere, little revenue would be collected by Gloucester, the burden of the tax would be borne by owners of the least mobile factors in Gloucester, and school lunches would be supplied at suboptimal levels in Gloucester. ...... Most of us would not, however, conclude from this simple example that tax competition was the basic cause of suboptimal spending ......Rather we would conclude that policies such as this would, at best, be second-best responses forced on us by the adoption of a patently idiotic scheme for the finance of school lunches.

There are three possible explanations for why some economists are suspicious of the claims of tax competition theory. The first comes from not recognizing the difference between international tax competition and regional tax competition. The existence of central government as a final coordinator makes a considerable difference between them. The distortion caused by tax competition among regional governments can be lessened by the intervention of central government while there is no international organization which is able to cope with the distortion from international tax competition. Secondly, tax competition theories have focused on analysing the direction of change in welfare between pre- and post-tax competition. However, what is important in the real world is not only the direction but also the magnitude of change. Tax competition theory still needs to provide an answer to those who say "Well, I agree with you that there might be a distortion caused by tax competition. But, is that distortion serious enough to make a difference in my life?". Thirdly, it is not conclusive whether the main propositions of tax competition are consistent with the empirical data. Some empirical studies have found some signs which support tax competition theory but they are not strong.

The aim of this thesis is to deepen our understanding in the three areas mentioned above. I have sought to do this in three ways. Firstly, I construct a microfounded model which shows how much tax cutting will result from tax competition. For this purpose stylized model is adopted. Numerical calibration is carried out to show the size of tax cutting in various cases. Secondly, tax competition game is set up in a more international context. The standard model is modified to consider three asymmetrical tax competition cases, relationship between tax rules and tax competition, interdependence between tax competition and subsidy competition, and imperfection in the international capital mobility. Thirdly, empirical evidence is investigated by testing main propositions of tax competition theory against empirical data. Testable propositions are drawn in a close connection with theoretical analyses and then tested against the data.

1.2 Contribution

The basic idea of the model built up in this thesis is that countries, like players in a game, compete to attract foreign capital by manipulating source-based corporation tax rates. Capital is modelled to contribute to an increase in social welfare via higher productivity of immobile factors (labour) and via a larger tax revenue. Countries are assumed to have fixed endowment of labour and capital. Capital is internationally mobile as in MacDougall-Kemp model (see Ruffin [1988]). One goods is produced by use of labour and capital, under the conditions of perfect competition. Each government maximises social welfare, which is a function of both private and public consumption. Private consumption is equal to the national income net of corporation tax revenue, and public consumption is equal to corporation tax revenue. Using a symmetric-two-countries model and Cobb-Douglas specification for both production and social welfare functions, it is shown that tax competition leads to a unique and stable non-cooperative Nash equilibrium, where tax rates are 40-50% below the optimal level.

Although symmetric tax competition has an advantage in showing the distortion which arises purely from strategic tax setting behaviour, it is less realistic in the sense that it does not allow for movement of capital at the equilibrium. Therefore, the basic tax competition model is extended to three asymmetric cases: different country size, different per capita capital endowment and different preference for public goods. At the non-cooperative Nash equilibrium, the smaller country (the country with a weak preference for public goods) is found to undercut the larger country (the country with a strong preference for public goods). However, the asymmetry of per capita capital endowment is found to lead to the same size of tax cutting in both countries.

This thesis investigates a simple form of tax coordination such that both countries raise their tax rates by the same amount.[6] In contrast to popular coordinations

[6]This tax coordination is suggested by Crombrugghe and Tulkens (1990).

such as tax harmonization and the imposition of minimum tax rate[7], this simple tax coordination does not change the allocation of capital because the tax differential at the non-cooperative equilibrium is maintained.[8] The smaller country (the country with smaller per capita capital endowment and the country with a weak preference for public goods) always prefers this cooperative outcome to the non-cooperative equilibrium. However, the larger country (the country with larger per capita capital endowment and the country with a strong preference for public goods) consents to this coordination only when the positive effect of an increase in public goods outweighs the negative effect of a decrease in the income from foreign investment. Numerical calibration shows that this tax coordination is feasible in all three cases.

In an international context, governments can cope with the pressure from tax competition by changing their tax rules. This thesis modifies the basic model into a dynamic tax competition game in which governments decide tax rules at the first stage of the game and tax rates at the second stage of the game. The structure of the game is an extension of Janeba (1995) but my model differs from his in three ways. Firstly, in his model, one country is assumed to be potential exporter of capital and the other an importer of capital. In contrast, I present a game between two identical economies, which produces a variety of strategic behaviour. Either country can be a capital exporter and the tax rules of both countries are therefore relevant to the result.

[7]Tax harmonization and the imposition of minimum tax rate are irrelevant in the case of tax competition between countries with different per capita capital endowments because tax rates at the non-cooperative equilibrium are the same.

[8]This tax coordination, however, does not improve efficiency in worldwide capital allocation. It only reduces the distortion of the under-supply of public goods in both countries.

Secondly, in this study, each government is assumed to maximize its social welfare as a function of private consumption and of public consumption. This social welfare function contrasts with Janeba (1995) who assumes that governments optimize their national income as the sum of domestic output and net factor payments to the other country. Lastly, Janeba (1995) analyses only the game in which governments choose their method of double taxation relief among exemption, credit, and deduction. In addition to these, I also analyse the game in which governments choose between the residence principle[9] and the source principle.

This thesis shows that both countries adopt one of four variations of the residence principle: no adjustment, deduction, credit with limitation and exemption (deduction and credit method under the world income taxation) at the subgame perfect Nash equilibrium. A simple intuitive explanation for the result is that these tax rules never treat the income from capital located abroad preferentially to that from capital at home and can protect the country from capital flight. Because both countries do not choose the exemption method (the source principle), tax competition does not occur at all. This implies that international tax coordination (harmonization) is not

[9]When one country applies the residence principle and the other applies the source principle, the income from the capital invested abroad is taxed not only by the host country but also by the home country. The home country which applies the residence principle has five options through which to relieve the burden from double taxation. Firstly, the government ignores the problem of double taxation (No adjustment). Secondly, the government can tax the income net of tax paid to the foreign government (Deduction). Thirdly, the government can give full credit for the tax paid to the foreign government (Full credit). If the tax credit is greater than the tax payable to the government, the government may repay the money. Fourthly, the government can give the credit with limitation up to the amount of the tax payable to the government (Credit with limitation). Finally, the government may tax only the income earned domestically, exempting the income earned abroad from calculating the tax base income (Exemption).

necessary when countries are free to choose their tax rules.

Tax competition is also analysed in relation to subsidy competition. There are three reasons why subsidies are not incorporated into effective tax rates and are analysed separately from tax rates. Firstly, while tax rates are applied equally to all the capital income in a country, subsidies tend to be granted either to all investors or exclusively to foreign investors. Secondly, subsidies are usually granted according to the source principle, even when taxation follows the residence principle. Thirdly, the decisions made in relation to subsidies are different from those made on tax rates, in the sense that tax rates fall under the stricter control of the assembly and are changed less frequently than subsidies.

The modified structure of the game is that governments decide tax rates at the first stage and then the amounts of subsidies at the second stage. Two different subsidies are explored: a preferential subsidy (granted exclusively to foreign capital) and a universal subsidy (granted to all capital in its territory). The availability of subsidy is found to cause strategic behaviour with regard to tax rates in the first stage even when both countries apply the credit method (the residence principle). Regardless of the method of double taxation relief (the taxation principle), the effective tax rates are the same at the subgame perfect Nash equilibrium.

The result has implications for the validity of those anti-tax competition policies suggested by previous studies. International tax harmonization and the imposition of minimum tax rate fail to achieve their objectives of enhancing efficiency in worldwide capital allocation and of alleviating the distortion of the under-supply of public goods if governments use subsidies to attract foreign capital. Rather, they may lead to bigger governments which lavish subsidies and tax heavily.

The assumption of perfect capital mobility is replaced by that of imperfect capital mobility. In this thesis, the marginal transaction cost for the first unit of capital movement is specified not to be zero. Therefore, tax differential does not necessarily cause movement of capital. This specification of transaction costs differs from previous studies (Persson and Tabellini [1992] and Haufler [1996b]). With a symmetric two countries model, it is found that the pure strategy Nash equilibrium no longer exists under imperfect capital mobility. If the mixed strategy Nash equilibrium exists, both countries randomly select their tax rates from those below the optimal level. As a result of randomization, the tax rates differ between the identical countries. As transaction costs decrease, the tax rates and the expected tax differential also decrease. With a small-open-economy model, it is found that a small country always sets its tax rate below the world tax rate under imperfect capital mobility. Furthermore, as transaction costs become smaller, tax undercutting of the small open country becomes greater.

Compared to abundant theoretical studies on tax competition, the number of empirical studies is relatively small due to difficulties in collecting data and in defining testable propositions. This thesis suggests five testable propositions. (1) Corporation tax rates should show a decreasing trend. (2) More-open countries should decrease tax rates more than less-open countries. (3) Smaller countries should decrease tax rates more than larger countries. (4) Countries with a strong preference for public goods should decrease tax rates more than those with a weak preference for public goods. (5) Tax competition theory is significant in explaining tax differentials across countries. These propositions are then tested with the marginal effective corporate tax rates of 24 OECD member countries between 1960-1998. In addition to the analysis using cross section data, I use time series data in testing these propositions. The result of the tests suggests evidence in favour of tax competition theory.

1.3 Composition of chapters

Chapter 2 provides a literature survey on the subject of tax competition. This chapter is categorized into four sections: (1) regional tax competition, (2) international tax competition, (3) empirical tests of tax competition theory, and (4) new approaches. It is intended to draw a line between regional tax competition and international tax competition. This is in order to emphasize that the accumulated literature on regional tax competition contributes greatly to a basic understanding of international tax competition but, on the other hand, results in international tax competition theory missing several important features in an international context.

Chapter 3 provides a model which is stylized for the analysis of international tax competition on corporation tax. The model is used repeatedly in later chapters with appropriate modifications where necessary. With a symmetric-two-countries model, the Nash equilibrium is shown to be unique and stable with Cobb-Douglas specification for both production and social welfare functions. The model is explored to find the Nash equilibrium when the objective function of governments is modified in various ways. Numerical calibrations show the size of tax cutting caused by tax competition.

Chapter 4 analyses three asymmetric cases of tax competition: different size of countries, different per capita capital endowments and difference in preference for public goods. Numerical calibrations show tax rates at the Nash equilibrium. Furthermore, a simple and feasible tax coordination is discussed.

Chapter 5 analyses the relationship between tax competition and tax rule by a two-stage game. Firstly, it is assumed that each government choose tax principle between the residence principle and the source principle. Secondly, each government is assumed to choose the method of double taxation relief under the world income taxation: deduction, credit and exemption method. The subgame perfect Nash equilibrium is sought as a solution to the game.

Chapter 6 analyses a game where subsidies are manipulated to attract foreign capital along with tax cutting. The game is dynamic in the sense that tax rate is decided and announced at the first stage, and then subsidy is decided at the second stage. Preferential subsidies and universal subsidies are analysed separately. The subgame perfect Nash equilibrium is sought by backward induction.

Chapter 7 analyses tax competition when the mobility of capital is imperfect.

The imperfection of capital mobility is assumed to derive from transaction costs. The analysis is carried out not only with a symmetric two countries model but also with a small-open-economy model. The analysis is focused on the existence of the Nash equilibrium and the relationship between the size of transaction costs and the degree of tax cutting.

Chapter 8 defines testable propositions which are generated by tax competition models. This is necessary for the empirical tests which are carried out in chapter 9. The propositions are derived in a close connection with theoretical analyses and their testing is discussed.

Chapter 9 presents the results of empirical analysis. I define five main propositions and test them separately with the marginal effective corporate tax rates of 24 OECD member countries between 1960-1998, which are computed by the method suggested by King and Fullerton (1984). The five propositions are as follows. (1) Corporation tax rates should show a decreasing trend; (2) More-open countries should decrease tax rates more than less-open countries. (3) Smaller countries should decrease tax rates more than larger countries. (4) Countries with a strong preference for public goods should decrease tax rates more than those with a weak preference for public goods (5) Tax competition theory is significant in explaining tax differentials across countries.

The last chapter summarizes the results of previous chapters, synthesizes them into a conclusion, makes the limitations of the analysis explicit, and finally suggests future work.

Chapter 2

Literature survey

2.1 Regional tax competition in a federal government

Fiscal federalism has long been one of the controversial issues in Public Economics because it creates interdependency among local governments. In earlier works, fiscal federalism is thought to contribute to increasing economic efficiency. Tiebout (1956), for example, contends that fiscal federalism can solve the problem of the non-existence of market solution in determining the level of expenditure on public goods. Free migration implies that firms and individuals will locate themselves among different jurisdictions to obtain their most preferred 'tax-expenditure package', in the same way that individuals buy goods in the private market. The fundamental difference between his model and recent tax competition models is that he assumes that the revenue-expenditure pattern of each local government is fixed and set differently.

Oates (1972) reveals the idea that the process of tax competition will result in a tendency towards less than efficient output in local public services. Local officials, in an attempt to attract new investment to stimulate local employment and income, compete with neighbouring jurisdictions by holding down local tax rates. However, he acknowledges this to be an oversimplified view of the problem. The benefits, as well as the costs, are of importance in location decision of firms and the location decision, therefore, is likely to be insensitive to local fiscal programs.

Boskin (1973) argues that the Tiebout's conclusion does not apply to the situation in which local governments, by their tax rates and expenditure policies, compete each other. In contrast to Tiebout, the mobility of consumer is the cause of an inefficient allocation of resources. The redistributive services are under-provided and tax rates are too low.

Gordon (1983) provides a formal characterization of the reasons why decentralized decision-making can lead to a less efficient and equitable outcome. This arises because one community's decisions affect the utility of residents of other communities, but these effects are ignored when separate decisions are made.

Wilson (1986) shows that the use of distorting property tax on mobile capital can either increases or decreases the level of public service. However, he predicts that the over-supply of public goods is not likely to occur with high substitutability between capital and the immobile input, labour. His study is distinguished in that inefficiency in production of public goods by governments is analysed. He differentiates public goods with private goods and defines production technology for public goods. He finds that the public production techniques chosen by local governments differ from those which minimize costs at private producer prices. The chosen capital-labour ratios in public production are inefficiently high. This is different from subsequent studies which assume that single output is either used for private or public consumption.

Zodrow and Mieszkowski (1986) consider the case of a large number of identical jurisdictions and show that the use of distorting property tax on mobile capital decreases the level of public service. Wildasin (1988) compares the Nash equilibrium where the level of expenditure is the strategic variable with the standard Nash equilibrium where the tax rate is the strategic variable. He shows that the Nash equilibrium in expenditure competition is more intensive than that of tax competition.

Mintz and Tulkens (1986) set up a general model where two economies levy an origin-based commodity tax on private goods to finance a local public goods. They provide four main results which have been in the centre of disputes by subsequent studies. (1) A non-cooperative equilibrium may not always exist due to the occurrence of a jump in the tax reaction. (2) At a non-cooperative equilibrium, tax rates and sizes of public sector of identical regions differ due to strategic behaviour. (3) The inefficiency of a non-cooperative equilibrium arises from two types of externalities: private consumption effect and public consumption effect.[1] (4) Pareto improving tax

[1]The changes in tax rate of one region have two counterbalancing externalities for the other region. An increase in the tax rate of region i increases tax revenue of region j by increasing tax

changes are always tax increases for the tax importing region but are ambiguous for the tax exporting region.

Crombrugghe and Tulkens (1990) obtain a strong result that the public consumption effect always dominates the private consumption effect and that Pareto improving tax changes are always tax increases both for the tax importing region and for the tax exporting region. As Haufler (1996) argues, their result depends on the assumption that welfare in the tax importing country is concave with respect to the tax rate of the tax exporting country and this assumption cannot be met for elastic transaction cost schedule. Kanbur and Keen (1993) and Haufler (1996b) show that there exists a unique non-cooperative Nash equilibrium when transaction costs are identical for both countries and the marginal costs of purchasing the first unit abroad are zero.

It has been generally stressed that tax competition leads to inefficiently low tax rates and the under-supply of local public goods. The essential force of this distortion is that higher tax rates cause a flight of resources, which implies erosion of tax base. This pressure forces jurisdictions to set their tax rates below the optimal level and thus causes the under-supply of public services. These results are derived because most analyses have been focused on symmetric equilibrium. When asymmetries between

base (consumption) of region j. This is the 'public consumption effect'. On the other hand, an increase in the tax rate of region i reduces income of consumers of region j by taking away more tax from consumption in region i. This is the 'private consumption effect'. When these effects are evaluated for region i, they may be called as 'tax base effect' and 'terms of trade effect' (Haufler [1996]). As for capital income taxation, Persson and Tabellini (1992) call them as the 'tax-the-foreigner effect' and 'tax-competition effect'. 'Tax-competition effect' is usually termed as 'capital flight effect'.

countries are introduced, higher tax rates and over-supply of public goods are also predicted.

There have also been more complicated studies which accommodate more realistic assumptions. One of these is concerned with the fact that jurisdictions differ in size. Bucovetsky (1991) and Wilson (1991) show that a small jurisdiction will choose a lower tax than the large one because it faces a more elastic supply of tax base. As a result, the smaller jurisdiction will be better off than the large one and, if it is small enough, it will be better off than under Pareto efficient tax rate. This argument has been used as a theoretical explanation for why tax coordination is difficult to achieve between different jurisdictions.

Bucovetsky and Wilson (1991) analyse tax competition in which two tax instruments are used. With a two-period economy model in which decisions on labour supply and savings are endogenous, they show that tax competition does not lead to inefficiently low level of public goods when both a source-based tax and a residence-based tax are available. However, when a source-based tax and wage tax are available, tax competition leads to an inefficient outcome.

The analyses in the regional tax competition can be extended to the international ones. Most of earlier works on regional tax competition have been interpreted in the international context by subsequent studies. However, their policy recommendations are not applied to international coordinations. Boskin (1973), for example, suggests that a social optimum can be achieved by the provision of public goods directly by higher government and tax-subsidy scheme, which are irrelevant in an international context.

2.2 International tax competition

Direct foreign investment has been of increasing importance with regard to the economic growth and the issue of how to treat its income has been studied in International Economics. Hamada (1966) sets up a model where the international investment situation between two countries can be interpreted as bilateral monopoly and the 'prisoner's dilemma'. He shows that international tax treaties (the credit rule) which relieve double taxation can help to achieve joint-product-maximization.

Feldstein and Hartman (1979) derive the optimal tax rate for a capital-exporting country, like the USA, when other countries adjust their tax rates in response to its own. They conclude that the capital-exporting country should tax foreign source profits, net of foreign tax, at the same rate that it taxes domestic profits, provided that its tax rate does not cause a change in the tax rate of the host country and that foreign investment accounts for only a very small fraction of production in the host country. This is termed 'full taxation after deduction'. Otherwise, it is optimal for the home country to tax more heavily than the 'full taxation after deduction'.

In contrast to Hamada (1966), Bond and Samuelson (1989) compare tax rates and capital allocation under the credit rule and the deduction rule. Their analysis shows that tax credit, rather than deduction, produces an anti-trade bias and that capital exporters as well as importers prefer deduction to credit.

The earlier literature differs from current literature in two ways. Firstly, it was assumed that different tax rates could be applied to domestic capital and foreign capital. Therefore, the tax rate for foreign investment income could be manipulated, leaving the tax rate for domestic capital unchanged. This goes against casual observations. Equal treatment of capital income regardless of its nationality has been a common practice among developed countries. Moreover, the international investment convention agreed in the World Trade Organization (WTO) prohibits differential treatment. Secondly, and more importantly, the change in tax revenue was not considered in relation to the supply of public goods. The close connection between them was adopted from regional tax competition theory in Public Economics.

Razin and Sadka (1991) show that, with the deduction method for the relief of double taxation, each country employs the residence principle. This means that each country should not tax foreigners on their income from capital within its border and should tax its residents uniformly on their income from all sources, domestic as well as foreign. It is also claimed that there is no gain from tax harmonization in this instance.

Gordon (1992) starts from a question about why countries continue to tax capital income whereas optimal-tax theory forecasts that small-open economies should not tax capital income. He explains that this inconsistency results from the convention of double taxation, whereby governments credit taxes paid abroad against domestic taxes. Capital income is taxed if a dominant capital exporter acts as a Stackelberg leader when setting its tax rate. Due to this convention, other countries will then tax income from imported capital, making it attractive for the dominant capital exporter to tax capital income. Without a dominant capital exporter, however, the model still forecasts no capital income tax.

Kanbur and Keen (1993) show that differences in size exacerbate the inefficiency from non-cooperative behaviour, damaging both countries. At the non-cooperative equilibrium, the smaller country undercuts the larger country and capital moves from the latter to the former. The smaller country loses from harmonization to any tax rate between those set in the non-cooperative equilibrium. Both countries, however, gain from the imposition of a minimum tax anywhere in that range. However, Pareto-welfare improvement of the imposition of minimum tax rate derives from the assumption that governments behave as revenue-maximizers. It is not clear that their result continues to hold under more general government objectives (see Haufler [1996b]).

Janeba (1995) sets tax competition as multiple stage game. He models tax competition as a non-cooperative game with respect to both corporate tax rates and forms of double taxation relief. He concludes that the subgame perfect equilibrium is independent of tax rules because the capital exporting country prefers less capital outflow and thus set its tax rate at zero. When the tax rate of the capital exporting country is zero, double taxation does not happen at all and therefore the form of double taxation relief becomes irrelevant. He shows that the credit method requires neither compensatory payment nor fully harmonized tax rates. For this reason, he asserts that the credit method is widely adopted.

Yang (1996) models tax competition in capital income tax for individuals. He shows that tax distortions can result from the mere threat of capital flight and the ensuing tax competition, even though inefficient allocation of the world capital resources may no longer be a problem. Given the recognition that governments cannot enforce taxation on foreign source capital income owing to a lack of information, he assumes that each government is restricted to using the source-based principle only. Each government is assumed to optimize the utility of domestic individual through the taxation of income and provision of public goods. Under the threat of capital flight, each government chooses to tax capital income at a lower rate than the optimum. Furthermore, he claims that as the number of countries involved in tax competition increases, tax competition will be intensified. As the number of competing countries increases to the infinity, each country becomes a small-open economy and it is forced to choose a zero tax rate on capital income.

Most studies on international tax competition focus on one of two taxes, either capital income tax or consumption tax. This tendency derives from the higher mobility of capital and consumers. Recently, there have been some studies which have analysed these two taxes simultaneously in order to establish the optimal mix of both taxes. Gordon and Nielson (1997) analyse the use of income tax and VAT, given that cross-shopping undermines VAT and that shifting taxable income abroad undermines income tax. They conclude that a country would make use of both taxes in order to minimize the efficiency costs of evasion activity, relying relatively more on whichever tax is harder to evade.

It is important to note that there are differences between regional tax competition and international tax competition. First of all, regional tax competition occurs under the umbrella of central government. The extent to which regional governments change their tax bases and tax rates is restricted by central government. Therefore, tax competition occurs within a limited range. As far as international tax competition is concerned, there are no rules and no institutions which restrict the range of competition. The major taxes such as VAT and capital income tax are not damaged seriously by regional tax competition but they are vulnerable to international tax competition.

The lower level of tax rates caused by tax competition results in the under-supply of public goods below the optimal level. The distortion from the under-supply of public goods, however, can be mitigated by central government. Central government's tax transfer can weaken the incentive for regional governments to compete in order to attract mobile factors. At the same time, the central government's supply of public goods can alleviate the distortion from the under-supply of public goods. In this context, international tax competition is more harmful because there are no international bodies to put limits on tax competition by making money transfer or to cure the distortion by supplying public goods.

The higher mobility of resources across regions in a country may make regional tax competition more intensive than international tax competition. However, it is not the mobility itself which ignites the strategic tax setting behaviour of governments, but rather the asymmetry of mobility amongst resources. Within a country, labour can move across regions more easily than across countries. Therefore, regional governments become less concerned with unemployment because labours moves from the regions of high unemployment to regions of low unemployment. However, labour is less mobile internationally partly due to restrictive immigration policies and partly due to cultural differences such as different language, food, religion, etc. Therefore, much larger asymmetry in mobility between capital and labour may drive countries into more intensive tax competition.

International tax competition theory borrows much from regional tax competition theory. However, this borrowing also imposes unintentional restrictions on the development of international tax competition theory. For example, the production technology, the preference for public goods and productivity in producing public goods do not differ widely across regions in a federal country. Therefore, in regional tax competition theory, asymmetry is mostly assumed to stem from the different size of jurisdictions. However, in an international context, it is more likely that there are considerable differences between individual countries with respect to the factors cited above.

In addition, international tax competition is more multidimensional than regional tax competition. Several strategic variables other than tax rates are available to governments when they fight against capital flight and erosion of tax revenue. Tax rules, exchange rates, subsidies for foreign capital and restriction on capital movement are some of the many factors which governments can resort to under the pressure from tax competition. Imperfection in international capital mobility, which has been identified by large number of empirical works, is to be fully considered. Some of these are analysed in the following chapters but others must remain the subject of future study.

2.3 Empirical tests of tax competition theory

A balance between theoretical studies and empirical studies is essential for every economic theory because the latter enables the former to keep up with the experience of the real world. However, in tax competition theory, the number of empirical studies is relatively small compared with large number of theoretical studies.

Not being directly related with tax competition theory, many empirical works have examined the effect of capital income taxes on the distribution of foreign direct investment across countries or across regions in a federal country (see Ruding Committee [1992], Hines [1996] and Devereux and Griffith [1998]). Altshuler, Grubert and Newlon (1998), for example, provide evidence that the foreign investment of US manufacturing firms is sensitive to differences in host country tax rates and that the sensitivity has been increased between 1984 and 1992. One example of empirical research carried out with respect to income taxation is that of Kirchgassner and Pommerehne (1996). They seek empirical evidence of individual income tax competition among Cantons in Switzerland. They conclude that tax competition has some influence on the spread of people within a high income bracket over Cantons. However, they also note that tax competition leads neither to a collapse of the supply of public goods nor does it make redistribution by fiscal authorities impossible.

However, those empirical works mentioned above are not focused on the strategic tax setting behaviours of governments which tax competition theory suggests. Devereux (1995) is the first to try to find empirical evidence of the validity of tax competition theory. He is concerned with two propositions. (1) Have corporation tax reforms been induced by tax competition? (2) Are capital income tax rates higher in large and closed countries? For the first question, he reserves the judgement, referring to the fact that 1980s' corporation tax reforms of 'rate-cutting and base-broadening' may not necessarily be indicative of tax competition; rather, it may have been due to 'the fashion of the decade'. For the second question, he finds a mixed result. There is little difference on average between the marginal effective tax rates[2] (average effective tax rates) for large and small countries but open countries tend to have a lower marginal effective tax rates (average effective tax rates) than closed countries. He suggests an explanation for this inconsistency by referring to the inelastic response of

[2]He uses the marginal effective tax wedge.

investment to the tax reforms.

Chennells and Griffith (1997) measure three different effective tax rates on capital income in ten countries, the G7 countries, Australia, Ireland and Sweden, between 1979-1994. The first effective tax rate is the marginal effective tax rate (METR), which is applied to marginal investment projects. The second is the average effective tax rate (AETR), which is applied to investment projects that earn some economic rent.[3] The third is the average tax rate (ATR), which is constructed from firm-level accounting data. These three effective tax rates are calculated for three different types of investments: domestic investment, inward investment and outward investment.

They find that the effective tax rates, whichever effective tax rates are considered, have not fallen between 1979-1984. The only systematic change is a convergence in statutory tax rates and METR for domestic investment even if it is not strong. They seek to establish whether the data conform with the predictions of theoretical tax competition models: (1) smaller and more-open economies should have lower tax rates than larger and less-open economies; (2) capital importing countries should set their tax rates on inward investment at the same rate as the dominant exporting country.[4] No clear empirical evidence to support any of those predictions is found.

[3]Their AETR is different from average effective tax rates generally used in other studies. Average effective tax rates are generally calculated by the total tax revenue as a fraction of the total profits. The AETR in Chennells and Griffith (1997) is similar to marginal effective tax rates in the case of fixed pre-tax rate of return in King and Fullerton (1984).

[4]In addition to these two propositions, they discussed two more propositions. They are (1) whether imperfection in the product market leads to an increase in tax rates and (2) whether capital taxes are used as an anti-avoidance measure of labour taxes. They discuss these two propositions but do not test them with empirical data.

They conclude that tax competition is not driving tax rates to zero and that there has been no significant erosion of the capital tax base.

They attempt to reconcile this lack of empirical evidence through three speculative hypotheses: (1) if the degree of competition is not strong; (2) if effective tax rates do not reflect important changes in the tax treatment of capital income; (3) if international coordination is already achieved.

Grubert (1999) uses US Treasury corporate tax files of large US multinational companies. He computes the average effective tax rates of 60 countries using the data on reported amount of tax paid to foreign countries and their reported net income. This firm-level data have advantages over the METR because the METR reflects only a few basic features of business taxation, namely nominal tax rates, tax depreciation rates, investment incentives, stock valuation and because the METR is computed for a hypothetical investment project. However, one of the fundamental problems of the average effective tax rate calculated by firm-level data is that the change in the effective tax rates is derived not only by firms' tax sparing behaviour but also by governments' tax change. Therefore, we cannot tell how much of change is derived from which.

Grubert (1999) find inconsistent evidence of tax competition. Effective tax rates fell on average but there was a wide diversity of behaviour among different countries. More mobile manufacturing industries such as electronics did not enjoy greater tax reductions. Tax rates did not fall more in homogeneous areas with low trade barriers such as EU. However, he also has result which supports tax competition theory. The smaller, poorer and more open countries lowered their tax rates the most.[5] He suggests two possible explanations for these mixed evidence. Firstly, globalization has not been occurring as fast as supposed. Secondly and more importantly, governments have successfully responded with capital flight with new measures. He stressed recent introduction of controlled foreign corporation (CFC) rules and reinforcement of transfer price rules.

As Devereux (1995) recognizes, there seem to be two difficulties in undertaking empirical work. Firstly, most of the propositions which theoretical literature puts forward are difficult to test.[6] Secondly, collecting and interpreting the empirical tax data is far from straightforward. This is the case, for example, if one attempts to test the proposition that tax competition leads to lower tax on capital income than the optimal level. The fact that optimal tax rates are not empirically observable is problematic. At the same time, there are many alternatives to measure tax burden on capital income and they differ significantly. These problems must be discussed prior to carrying out tests if they are to be plausible and persuasive. It is therefore a starting point of empirical work to define testable propositions.

[5] I have not found studies which suggest that a poor country tends to undercut rich one. Instead, the analysis in chapter 4 implies that there is no difference in tax rates between poor and rich country at the non-cooperative Nash equilibrium.

[6] Devereux (1995) provides a table which summarizes the main propositions concerning tax rates and tax rules. This is reprinted in Chennells and Griffith (1997).

2.4 New approaches

The ultimate issue with which economists are concerned is not whether tax competition leads to lower or higher tax rates but whether tax competition is a good thing or a bad thing. The evaluation of tax competition mainly depends on which economic perspective is adopted. According to neo-classical economic analysis, tax competition leads to an inefficient outcome. This perspective is the main stream of research on tax competition as the preceding sections have revealed.

However, an alternative and radically different view also exists. This view regards tax competition as valuable force which imposes a limitation on policy-makers' expansionary tendency. Whereas neo-classical economists stress the economic distortions induced by differential taxation and therefore favour a policy of tax harmonization, political economists focus on the political distortions and therefore reject harmonization. For the political economists, competing governments are able to reduce political distortions and shift the possibility frontiers (see Brennan and Buchanan [1977]).

The political economists, however, do not deny the economic distortions which may arise through the mechanism of tax competition. Rather, they place more stress on political distortion. Political distortion arises because politicians pursue their own goals which often deviate from the preference of citizens. Frey and Eicenberger (1996) claim that policy choices on the possibility frontier between economic and political distortions tend to be biased in favour of harmonization because economic advisors, politicians and interest groups typically favour harmonization. They therefore recommend popular referenda and 'functional-overlapping-competing' jurisdictions.

From the perspective of neo-classical Public Finance, the appropriate forms of policy coordination are tax harmonization, the imposition of minimum tax rates, the use of corrective subsidies and the enforcement of resident-based taxation. Inman and Rubinfeld (1996), however, claim that these recommendations do not work from the perspective of Political Economics. They argue that the states will retain source-based taxation and central government grants will be over-used. Rather, they recommend institutional reforms such as strong political parties, veto rights of nationally elected executives, and constitutional strategies to assign only residence-based taxation to state governments and to limit the number of states in the federal hierarchy.

There have been a few trials which consider both views jointly. Persson and Tabellini (1992) is an excellent example of this type of study. They consider the taxation of capital in a two-country model, where a democratically-chosen government in each country chooses tax policy. They find that higher capital mobility changes the politico-economic equilibrium in two ways. On the one hand, it leads to greater tax competition and, as a result, to lower tax rates in both countries. On the other hand, it alters voters' preferences and makes them elect a more 'left-wing'[7] government. This political effect offsets the distortion caused by tax competition, although not completely. Their prediction that 'left-wing' parties would come into power in EU countries conforms with the present political situation where Labour parties dominate

[7]This refers the government who cares much more about the redistribution of income by heavier taxation.

in many EU members.

Edwards and Keen (1996) attempt to synthesise these two extremes: the view of government as a Leviathan and the view of government as a benevolent maximizer of citizens' welfare. They conclude that the issue of whether international tax coordination tends to increase or reduce the welfare of citizens depends on two counteracting effects. Some degree of coordination is desirable if the gain in efficiency is sufficient to outweigh the policy-maker's tendency to waste.

Chapter 3

International corporation tax competition model

3.1 Introduction

An increasing international mobility of capital means an increasing mobility of tax bases across countries. As countries attempt to attract tax base by offering more favourable tax rates than are available elsewhere, taxes on capital income appear vulnerable to fierce international tax competition. Abundant research on capital income taxation in open economies reflects academic and political concerns that capital income taxes cannot survive in an open economy.

Some theoretical studies have predicted that capital income tax rates would fall to zero (see Giovannini [1989], Gordon [1992], Tanzi [1995] and Yang [1996]). However, others have predicted that tax competition leads to lower tax rates than the optimal level, but still positive tax rates (see Boskin [1973] and Crombrugghe and Tulkens [1990]). Gordon (1992) suggests a number of simple explanations for why capital income tax rates have not fallen to zero: (1) if countries are not small; (2) if pure profits exist; (3) if countries close their borders to capital flows; (4) if governments' expenditure has an effect on firms' productivity. Haufler (1996b) asserts that tax rates drop to zero only when either there is no public goods in the model or there are more efficient taxes other than capital income tax in the model.

Even if whether tax competition leads to zero tax rate or not is no longer of great concern, we may still have questions; "Which capital income tax is vulnerable to tax competition?" and "How much do countries decrease tax rates lower than the efficient level?" The first question arises because in reality there is no 'the capital income tax' characterised in theoretical models. Instead, various different capital income taxes exist. Corporation tax seems to be close to 'the capital income tax' modelled in theoretical studies because it has two properties. The theoretic models assume that 'the capital income tax' is a source-based tax[1] and has an effect on the allocation of capital. Corporation tax can be manipulated to attract productive capital which can

[1]Corporation income is taxed in the host country as well as in the home country where it receives double taxation relief. There are four circumstances in which corporation tax can be considered as a source-based tax. Firstly, if a home country applies the exemption rule to relieve international double taxation, only host country's tax matters. Secondly, if tax authorities have a lack of information on foreign income, only domestic income of residents and non-residents is taxed. Third, if corporation income is not repatriated or repatriated after a long time later, the tax of home country matters little. Fourth, if the tax rate of the host country is higher than that of the home country, only the tax rate of the host country matters.

benefit the economy by increasing the marginal products of labour and by enlarging the capital income tax base.

In this chapter, a game-theoretic model is stylized to analyse international tax competition with source-based corporation tax. Countries are assumed to have fixed endowment of labour and capital. Capital is internationally mobile as in MacDougall-Kemp model (see Ruffin [1988]). One goods is produced by use of labour and capital, under the conditions of perfect competition. Each government maximises social welfare, which is a function of both private and public consumption. Private consumption is equal to the national income net of corporation tax revenue, and public consumption is equal to corporation tax revenue.

The result of the analysis finds that tax competition leads to lower tax rates (under-supply of public goods) below the optimum level even though misallocation of the world capital is no longer a problem. Using Cobb-Douglas specification for both production and social welfare functions, this chapter shows that tax competition leads to a unique and stable non-cooperative Nash equilibrium, where tax rates are 40-50% below the optimal level.

The basic model is extended in three ways by changing the objective function of the government. Firstly, when the government is assumed to be Leviathan, tax competition is shown to be a desirable pressure to place a limit on its expansion. Tax competition between Leviathan governments leads to either higher or lower tax rates than socially optimal tax rates. Secondly, when the government is to maximise domestic products rather than national products, tax competition is more intensive and tax rate is set at the lower level. Lastly, as more countries are involved in tax competition, tax cutting becomes larger. However, even if an infinite number of countries become involved in tax competition, their tax rates do not fall to zero but rather remain a positive value.

The rest of this chapter is structured as follows. In the next section, a game theoretical two-identical economy model is presented. In section 3, the Nash equilibrium is examined and the under-supply of public goods (the lower tax rate than the optimal level) is demonstrated. Three extensions are explored in section 4 and numerical results are given in section 5. Conclusions are drawn in the final section.

3.2 The model

3.2.1 Setting

We assume that there are two countries, domestic (country 1) and foreign (country 2). All domestic variables are indexed with subscript 1 and all foreign variables are indexed with subscript 2. In both countries, one goods is produced by use of two factors, capital, K, and labour, L, under the conditions of perfect competition in all markets. The production function, F, is homogeneous of degree one, is strictly quasi-concave and satisfies the standard Inada conditions[2]. Each country has strictly positive en-

[2]These conditions are $F_L(0, K) = F_K(L, 0) = \infty$ and $F_L(L, 0) = F_K(L, 0) = 0$.

dowment of capital and of labour, which are inelastically supplied. However, capital is internationally mobile whereas labour is not. Because labour is inelastically supplied and internationally immobile, it may be omitted in the production function for notational convenience. This makes it possible to write $F(K, L) = f(K)$.[3]

Each government maximises the social welfare, which is a function of consumption of private goods, C, and of public goods, G. The one goods, which is produced in both countries, is consumed either as private goods or as public goods. The social welfare function is denoted by $W(C, G)$; it is assumed to be strictly increasing in C and G, and to be strictly quasi-concave. National income, defined as the sum of domestic output and net of factors payments to the other country, is divided into private consumption and public consumption. Private consumption is equal to the national income net of corporation tax revenue and public consumption is equal to

[3]Derivatives of first-order and second-order are symbolized as $f(\cdot)'$ and $f(\cdot)''$ instead of $f'(\cdot)$ and $f''(\cdot)$.

corporation tax revenue.[4][5]

The owners of capital can locate their capital in their own country or abroad. It is assumed that only the after-tax rate of return is a criterion in deciding the location of capital and that corporation tax is the only tax which creates a wedge between after-tax rate of return and before-tax rate of return.[6] It is also assumed that when firms are indifferent to the location of capital, they invest their capital domestically.

Each country seeks to maximise its social welfare through corporation tax rate and through provision of public goods. Two governments set their corporation tax rates independently. Then, the owners of capital in the two countries decide how much

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[4]In a single goods economy model, it is impossible to differentiate the public goods from the private goods. At best, the public goods is thought to be publicly provided private goods. Therefore, it is not clear why individuals should benefit from the public provision of private goods over and above the private provision of private goods. There might be three ways by which public goods could be introduced into the existing model. Firstly, it is assumed that two different types of goods - one private goods and one public goods - are produced by exactly the same form of production technology. In this case, we can treat two different types of goods as a single goods. When, for example, the same car is used either for personal use (private goods) or for police patrol (public goods), we may treat them as a single product as presented in this thesis. Secondly, it is assumed that governments can improve income distribution by redistributing private goods and that individuals then benefit from this income redistribution. The introduction of governments' role as the redistributer of income, however, requires additional consideration in relation to the asymmetric distribution of capital and labour among residents. Lastly, governments are assumed to convert private goods (tax revenue) into public goods. The private goods allocated to the pubilc sector is presumed to be used to produce the public goods. The government has a production technology such that $G = g\{tKf(K)'\}$. In this case, the social welfare function is $W(C, G) = W[f(K) - Kf(K)', g\{tKf(K)'\}]$. The new social welfare function have an advantage in that each government can be assumed to have different levels of productivity in providing public goods. However, governments' production of public goods is exogenous to the model because we have assumed that there are two production resources and they are fully employed in producing private goods. We must further elaborate with the model in order to incorporate governments' role of producing public goods.

[5]My model is different from previous ones. Janeba (1995) assumes that governments maximize national income, defined as the sum of domestic output and net factor payments to the other country. He does not divide national income into private consumption and public consumption. Yang (1996) assumes that all rent, which is the income of labour, is taxed fully. Thus, an increase of foreign capital contributes only to an increase in tax revenue. In our model, it contributes both to pulic consumption and private consumption by increasing the marginal productivity of labour.

[6]The model is known as MacDougall-Kemp model (Ruffin [1988]), which is used for analysing international capital movements.

capital to locate at home and abroad, after taking into account the two corporation tax rates, domestic and foreign. The owners of capital in the two countries are given full information about the corporation tax rates of the two countries which are known and fixed.[7] Each government takes the other's corporation tax rate as given and fixed. A non-cooperative Nash equilibrium is reached when the owners of capital maximize their capital incomes, given the two corporation tax rates, and each government has no incentive to alter its corporation tax rate, given the tax rate of the other government. The equilibrium in this game can be sought by maximizing each government's objective function subject to the conditions which satisfy the maximization of capital income.

3.2.2 Effect of corporation tax

Who bears the burden of corporation tax has been a long-lasting dispute. When markets for goods and production inputs are perfectly competitive and production function has property of constant returns to scale, firms have zero profit. In this setting, corporation tax, as a tax on the profits of firms, cannot collect tax revenue simply because there is no profit in the economy. Let π, P, K, L, r and w denote respectively profit, price of product, capital, labour, rental cost of capital and wage. The profit of a firm is defined as

$$\pi = PF(K, L) - rK - wL. \tag{3.1}$$

[7]It is assumed that there is no problem of time-inconsistency in committing tax rates.

When P is normalized to 1, a firm, maximizing its profit, produces at the quantity where the marginal productivity of capital is equal to rental cost of capital and marginal productivity of labour is equal to wage, i.e.

$$F_K(K, L) = r \tag{3.2}$$

and

$$F_L(K, L) = w. \tag{3.3}$$

By Euler's theorem, the total product of the firm is equal to the sum of the compensation for labour and capital when labour and capital are rewarded according to their marginal productivity. Therefore, there is no profit on which to impose corporation tax.

The result of non-profit of firms in the perfect competitive economy derives from the assumption that compensation for rented capital is deducted from the income of firms. If all capital of firms is not rented but owned by firms, the tax base of corporation tax is defined as $KF_K(K, L)$. Therefore, it is necessary to assume that individuals have shares of firms and that all capital is owned by firms if corporation tax is modelled to have an effect on firms' production decisions. If corporation tax is the only capital income tax in the economy, individuals are indifferent to whether the profits of firms are distributed as dividends or retained by firms. Individuals can receive increased income as a form of dividends if the firm's income is distributed, or as rising price of shares if the income is retained. In any case, the income of individuals rise by the same amount of capital income net of the corporation tax.

The incidence of the corporation tax depends on elasticities of demand and supply, the structure of markets, and the time period allowed for adjustments. If firms operate as retained monopolists, if sales rather than profits are maximized, or if other pricing rules apply, firms may well attempt to pass on the tax through higher prices. Therefore, consumers will bear the burden of the tax. Moreover, if labour markets are imperfect, higher taxes may be reflected in more limited demands in collective bargaining and thus be passed on to labour. With a model in which capital can move across frontiers but labour is immobile, the burden of the corporation tax can be partly passed to labour because the outflow of capital due to tax will lower wage. This is because less capital per worker results in lower marginal productivity. Capital will bear some part of burden in a two-country model whilst capital bears no burden when the economy is small.

3.2.3 Residence principle vs. source principle

There are two polar principles of capital income taxation; the residence and the source principle. According to the residence principle, residents are taxed on their worldwide income equally, regardless of whether the source of the income is domestic or foreign, but non-residents are not taxed on domestic income. According to the source principle, residents and non-residents are taxed on their domestic income equally but residents are not taxed on their income from foreign sources. These two principles result in different allocation of saving and investment worldwide. The residence principle results in efficient allocation of investment but inefficient allocation of saving while the source principle results in efficient allocation of saving but inefficient allocation of investment.

They also make difference in governments' tax revenue. According to the residence principle, the government of the home country (the country where the investor resides) can collect tax revenue from the capital income from abroad but the host country (the country where the investment is realized) cannot collect any tax revenue from the income of foreign capital. In contrast, according to the source principle, the home country cannot collect any tax revenue from capital income generated from investment abroad, but the host country can.

Let Z_1 be the amount of country 1's capital moving to country 2, and Z_2 be the amount of country 2's capital moving to country 1. The capital moved to the foreign country cannot exceed its endowment. Therefore, $Z_i \in [0, K_i], i = 1$ and 2. When the residence principle is applied, the budget constraints of private consumption and public consumption for country i are

$$\begin{aligned} C_i &= f(K_i - Z_i + Z_j) - f_i(K_i - Z_i + Z_j)'(K_i - Z_i + Z_j) \\ &\quad +(1 - t_i)f_i(K_i - Z_i + Z_j)'(K_i - Z_i) \\ &\quad +(1 - t_i)f_j(K_i + Z_i - Z_j)'Z_i \end{aligned} \tag{3.4}$$

and

$$G_i = t_i f_i(K_i - Z_i + Z_j)'(K_i - Z_i)$$

$$+t_i f_j(K_i + Z_i - Z_j)' Z_i. \tag{3.5}$$

In (3.4), the first line is the income of labour, the second line is the income of capital located in country i and the third line is the income of capital moved to country j. In (3.5), the first line is the tax revenue from the income of capital located in country i and the second line is the tax revenue from the income of capital moved to country j.

When the source principle is applied, the budget constraints of private consumption and public consumption for country i are

$$\begin{aligned} C_i &= f(K_i - Z_i + Z_j) - f_i(K_i - Z_i + Z_j)'(K_i - Z_i + Z_j) \\ &\quad + (1 - t_i) f_i(K_i - Z_i + Z_j)'(K_i - Z_i) \\ &\quad + (1 - t_j) f_j(K_i + Z_i - Z_j)' Z_i \end{aligned} \tag{3.6}$$

and

$$G_i = t_i f_i(K_i - Z_i + Z_j)'(K_i - Z_i + Z_j). \tag{3.7}$$

Lemma 1 *If both countries apply the residence principle, changes in the corporation tax rates of both countries have no effect on the allocation of capital between the two countries.*

Perfect international mobility of capital implies that capital earns an equal after-tax rate of return in the two countries. Therefore, with the residence principle, this gives the equilibrium condition in the capital market such that

$$(1 - t_i) f_i(K_i - Z_i + Z_j)' = (1 - t_i) f_j(K_j + Z_i - Z_j)'. \tag{3.8}$$

If the common factor, $(1 - t_i)$, in both sides of (3.8) is eliminated, it is clear that Z_i is influenced neither by domestic corporation tax rate nor by foreign corporation tax rate. Therefore, if both countries apply the residence principle, international capital mobility does not impose any influence on the tax decision of the each government. Each government's decision on the corporation tax has no effect on the other government's tax decision.

Lemma 2 *When both countries apply the source principle, an increase in the corporation tax rate of one country increases the outflow of its capital to the other country or decreases the inflow of foreign capital from the other country. Changes in the corporation tax of the other country have the opposite effect.*

With the source principle, the equilibrium condition in the capital market gives

$$(1 - t_i)f_i(K_i - Z_i + Z_j)' = (1 - t_j)f_j(K_j + Z_i - Z_j)'. \tag{3.9}$$

If we take total differentials of (3.9), we have

$$\frac{\partial Z_i}{\partial t_i} = \frac{-f_i(K_i - Z_i + Z_j)'}{(1 - t_i)f_i(K_i - Z_i + Z_j)'' + (1 - t_j)f_j(K_j + Z_i - Z_j)''} > 0, \tag{3.10}$$

$$\frac{\partial Z_j}{\partial t_i} = \frac{f_i(K_i - Z_i + Z_j)'}{(1 - t_i)f_i(K_i - Z_i + Z_j)'' + (1 - t_j)f_j(K_j + Z_i - Z_j)''} < 0, \tag{3.11}$$

$$\frac{\partial Z_i}{\partial t_j} = \frac{f_j(K_j + Z_i - Z_j)'}{(1 - t_i)f_i(K_i - Z_i + Z_j)'' + (1 - t_j)f_j(K_j + Z_i - Z_j)''} < 0 \tag{3.12}$$

and

$$\frac{\partial Z_j}{\partial t_j} = \frac{-f_j(K_i + Z_i - Z_j)'}{(1 - t_i)f_i(K_i - Z_i + Z_j)'' + (1 - t_j)f_j(K_j + Z_i - Z_j)''} > 0 \tag{3.13}$$

The signs of (3.10) - (3.13) are unambiguous because $t_i, t_j < 1$, $f(\cdot)' > 0$ and $f(\cdot)'' < 0$.

Currently, most countries are adopting world income principle, which is a mixture of the source principle and the residence principle. The income of an UK subsidiary established in the USA is taxed by USA corporation tax and, if it is repatriated to the UK, it is taxed by UK corporation tax, with credit for the tax paid in the USA. Whether the current corporation income taxation should be modelled as a residence-based tax or a source-based tax will not be analysed in the thesis. Rather, it is assumed that corporation tax follows the source principle.

3.3 Symmetric Nash equilibrium

The game of the tax competition between two identical economies has an advantage in that it shows the distortion arising purely from the manipulation of tax rates because there is no movement of capital at the equilibrium. Suppose that country 1 and country 2 are identical in that they have the same production function, $f_i = f_j = f$, the same endowment of capital and labour, $K_i = K_j = K$ and $L_i = L_j = L$, and the same social welfare function, $W_i = W_j = W$.

When each country is closed ($Z_i = 0$, $i = 1, 2$), country i is to maximize

$$\max_{t_i} W(C_i, G_i) \tag{3.14}$$

with subject to

$$C_i = f(K) - t_i f(K)' K,$$

$$
\begin{aligned}
G_i &\doteq t_i f(K)'K \\
0 &\leq t_i < 1.
\end{aligned}
\tag{3.15}
$$

The first-order conditions[8] give

$$\frac{W_{C_i}}{W_{G_i}} = \frac{f(K)'K}{f(K)'K} = 1. \tag{3.16}$$

Each country sets its tax rate at the level where the marginal rate of substitution between private consumption and public consumption is 1.[9] The tax rate is optimal not only for each country but also world-wide.

Definition 3 *When there is no international mobility of capital, each country is said to be in autarky.*

Definition 4 *The optimal tax rate is the tax rate at which world capital is efficiently allocated between countries and national income is divided efficiently between private and public consumption in each country.*

Proposition 5 *When capital can move internationally, at the non-cooperative Nash equilibrium in a two-identical economy model, each country sets its corporation tax*

[8]In the optimization problem with an inequality in the constraints, the classical first-order condition must be replaced by the Kuhn-Tucker conditions. Here, we restrict our analysis to the interior solution and the classical first-order condition is considered.

[9]The second-order condition is not investigated explicitly. Even if the assumption on the social welfare function such that $W(C, G)$ is strictly increasing in C and G, and strictly quasi-concave, $W(t)$ is not always strictly quasi-concave with respect to t. With given maximization problem,

$$\frac{\partial^2 W}{\partial t^2} = (W_{11} - 2W_{12} + W_{22})\{f(K)'K\}^2.$$

The sign of the second-order derivative is ambiguous even if $W_{11} < 0$, $W_{22} < 0$ and $W_{11}W_{22} - W_{12}^2 < 0$.

rate at a level which is lower than the optimal level. The inefficiency of non-corporative equilibrium is entirely incurred by strategic use of the corporation tax rate.

Suppose that the international capital market is introduced and capital can move across the borders. Country i maximizes

$$\max_{t_i} W(C_i, G_i) \tag{3.17}$$

subject to

$$\begin{aligned}
C_i &= f(K_i - Z_i + Z_j) - f_i(K_i - Z_i + Z_j)'(K_i - Z_i + Z_j) \\
&\quad +(1 - t_i) f_i(K_i - Z_i + Z_j)'(K_i - Z_i) \\
&\quad +(1 - t_j) f_j(K_i + Z_i - Z_j)' Z_i, \\
G_i &= t_i f(K - Z_i + Z_j)'(K - Z_i + Z_j), \\
0 &\leq t_i < 1, \\
0 &\leq Z_i \leq K.
\end{aligned} \tag{3.18}$$

The private consumption in (3.18) can be silplified using the equilibrium condition of (3.9) as

$$C_i = f(K - Z_i + Z_j) - f(K - Z_i + Z_j)'(t_i K - Z_i). \tag{3.19}$$

For notational simplification, let Z be country i's net export of capital, i.e. $Z = Z_i - Z_j$. When $t_i = t_j$, there is no incentive for capital of both countries to move to the other country and thus all capital is invested domestically. Therefore, $Z = Z_i =$

$Z_j = 0$. If $t_i > t_j$, capital of country i will move to country j until satisfying

$$(1 - t_i)f(K - Z_i)' = (1 - t_j)f(K + Z_i)'. \tag{3.20}$$

The capital of country j does not move at all. Therefore, $Z = Z_i > 0$ and $Z_j = 0$. If $t_i < t_j$, $Z = -Z_j < 0$ and $Z_i = 0$. Therefore, the following relationships stand:

1. When $Z > 0$, $Z_i > 0$ and $Z_j = 0$.

2. When $Z < 0$, $Z_i = 0$ and $Z_j > 0$.

3. When $Z = 0$, $Z_i = Z_j = 0$.

Definition 6 *When some amount of capital of country i is invested in country j and, at the same time, some amount of capital of country j is invested in country i, it is called cross-hauling of capital. Full cross-hauling implies that all capital of a country is invested in the other country and vice versa.*

Lemma 7 *When capital income is taxed by the source principle, cross-hauling of capital does not occur.*

The equilibrium condition in the international capital market for capital of country 1 is

$$(1 - t_1)f(K - Z)' = (1 - t_2)f(K + Z)'. \tag{3.21}$$

For capital of country 2, the equilibrium condition in the international capital market is

$$(1 - t_2)f(K - Z)' = (1 - t_1)f(K + Z)'. \tag{3.22}$$

In (3.21) Z is the net export of capital of country 1, i.e. $Z = Z_1 - Z_2$, while in (3.22) Z is the net export of capital of country 2, i.e. $Z = Z_2 - Z_1$. By assuming $Z = Z_1 - Z_2$,(3.21) and (3.22) are expressed as

$$(1-t_i)f(K+(-1)^iZ)' = (1-t_j)f(K+(-1)^jZ)', \quad i,j = 1,2 \text{ and } j \neq i. \tag{3.23}$$

Then, budget constraints of private consumption and public consumption in (3.18) can be rewritten as

$$\begin{aligned} C_i &= f(K+(-1)^iZ) - f(K+(-1)^iZ)'(t_iK+(-1)^iZ) \\ G_i &= t_if(K+(-1)^iZ)'(K+(-1)^iZ). \end{aligned} \tag{3.24}$$

The first-order conditions[10] give

$$\frac{W_{C_i}}{W_{G_i}} = \frac{f(K+(-1)^iZ)'(K+(-1)^iZ) + (-1)^it_if(K+(-1)^iZ)''(K+(-1)^iZ)\psi}{f(K+(-1)^iZ)'K + (-1)^if(K+(-1)^iZ)''(t_iK+(-1)^iZ)\psi + (-1)^it_if(K+(-1)^iZ)'\psi}, \tag{3.25}$$

where

$$\psi = \frac{\partial Z}{\partial t_i}.$$

We can define ψ from (3.23) as follows.

$$\psi = \frac{(-1)^if(K+(-1)^iZ)'}{(1-t_i)f(K+(-1)^iZ)'' + (1-t_j)f(K+(-1)^jZ)''} \tag{3.26}$$

By plugging (3.26) into (3.25), we get

$$\frac{W_{C_i}}{W_{G_i}} = \frac{f(K+(-1)^iZ)''(K+(-1)^iZ) + (1-t_j)f(K+(-1)^jZ)''(K+(-1)^iZ)}{f(K+(-1)^iZ)''(K+(-1)^iZ) + (1-t_j)f(K+(-1)^jZ)''K + t_if(K+(-1)^iZ)'}. \tag{3.27}$$

[10]The second-order condition is assumed to be satisfied.

By symmetry, $t^{*11} = t_1 = t_2$ at the equilibrium and it implies that $Z^* = 0$. Thereby, (3.27) is reduced to

$$\begin{aligned} \frac{W_C^*}{W_G^*} &= \frac{f(K)''K + (1-t^*)f(K)''K + t^*f(K)'}{f(K)''K + (1-t^*)f(K)''K} \\ &= 1 + \frac{t^*f(K)'}{(2-t^*)f(K)''K} < 1. \end{aligned} \tag{3.28}$$

(3.28) implies that the marginal utility from public consumption is greater than that from private consumption. Thus, it is welfare-increasing to consume more public goods and less private goods by increasing tax revenue with higher tax rate. This implies that tax rates are too low and public goods is under-provided at the non-cooperative equilibrium. This is the same for both countries. There is no distortion caused by capital allocation between the two countries. The distortion of the under-supply of public goods arises either because each government has an incentive to attract foreign capital or because it is concerned with the threat of tax base erosion caused by the lower tax rate of the foreign country.

(3.28) can also show the results of tax competition where the objectve function of governments are defined differently. If the social welfare function is reduced to maximizing total outcome, i.e. the sum of privete goods and public goods, then the marginal utility of private goods and public goods are always the same, i.e.$W_C = W_G$. This condition makes (3.28) produce that $t^* = 0$. This result implies that capital tax vanishs either if pubic goods is not included as a separate argument of the social welfare function or if the supply of public goods can be financed by efficcieant taxes

[11] Asterisk denotes values at the equilibrium. This is applied throughout the thesis.

other than capital taxes.

The tax rate in the case of tax competition between Leviathan governments is also derived from (3.28). Leviathan governemnts do not care about the private consumption so that $W_C = 0$. Therefore, (3.28) becomes

$$t^* = \frac{2f(K)''K}{f(K)''K - f(K)'}. \tag{3.29}$$

It should be stressed that the rusults presented above are based on the assumption that an equilibrium tax rate exists as defined in (3.28). However, (3.28) does not tell us much about the properties of this equilibrium. Is there indeed an equilibrium and, if so, is it one or a set of multiple equilibria? Is the equilibrium stable? To what extent will tax cutting be executed? Those questions can not be answered until the reaction functions are definded by additional assumptions of the social welfare and production function.

3.4 Extensions

3.4.1 Leviathan government

Some economists have questioned the assumption that the government is a benevolent maximizer of social welfare. Instead, they assume that governments seek to maximize their own interest. This form of selfish government has been called Leviathan. In our model, the objective of the Leviathan government is to maximize its own interest, R, which is proportional to the size of the tax revenue, $R = \kappa G$, where $\kappa \in (0, 1)$.

In autarky, the objective function of country i is

$$\max_{t_i} R_i \tag{3.30}$$

subject to

$$\begin{aligned} R_i &= \kappa\{t_i f(K)'K\} \\ 0 &\leq t_i < 1. \end{aligned} \tag{3.31}$$

The corporation tax rate of both countries must be close to 1[12] and all of capital income is appropriated to tax revenue.

Proposition 8 *Tax competition can restrict the expansion of Leviathan government effectively and tax harmonization can be viewed as a means to resist the restriction imposed by the international mobility of capital.*

With the introduction of mobility of capital, each government is restricted in collecting tax revenue from the capital income by increasing tax rate. This is because capital moves to the foreign country if the domestic tax rate is higher than that of the foreign country. The government is to maximize

$$\max_{t_i} R_i \tag{3.32}$$

subject to

$$R_i = \kappa\{t_i f(K + (-1)^i Z)'(K + (-1)^i Z)\}$$

[12]The objective function is monotonically increasing and there is no interior solution.

$$\begin{aligned} 0 &\leq t_i < 1, \\ -K &\leq Z \leq K. \end{aligned} \tag{3.33}$$

The first-order conditions give

$$\begin{aligned} 0 &= \kappa\{f(K+(-1)^i Z)'(K+(-1)^i Z) + (-1)^i t_i f(K+(-1)^i Z)''(K+(-1)^i Z)\psi \\ &\quad +(-1)^i t_i f(K+(-1)^i Z)'\psi\}, \end{aligned} \tag{3.34}$$

where

$$\psi = \frac{\partial Z}{\partial t_i}. \tag{3.35}$$

ψ is the same with (3.26). By plugging (3.26) into (3.34), we get

$$0 = \frac{f(K+(-1)^i Z)''(K+(-1)^i Z) + (1-t_j)f(K-(-1)^i Z)''(K+(-1)^i Z)}{(1-t_i)f(K+(-1)^i Z)'' + (1-t_j)f(K-(-1)^i Z)''} \frac{+t_i f(K+(-1)^i Z)'}{}. \tag{3.36}$$

At the symmetric equilibrium, $t^* = t_1 = t_2$ and $Z^* = 0$. Therefore (3.36) is simplified to

$$t^* = \frac{2f(K)''K}{f(K)''K - f(K)'} = \frac{2}{1+\varepsilon}, \tag{3.37}$$

where

$$\varepsilon = -\frac{f(K)'}{f(K)''K}. \tag{3.38}$$

ε is the elasticity of supply (demand) of exported (imported) capital. When $0 < \varepsilon \leq 1$, t^* is close to 1, as is the case in the closed economy. However, when $\varepsilon > 1$, t^* is less than 1. Therefore, under tax competition, Leviathan governments have to set their tax rates below those of the closed economy. In addition, (3.37) is the same with

(3.29) which has been derived directly from the general equilibrium condition by restricting $W_C = 0$.

This result implies that the introduction of international capital mobility places a restriction on the expansion of Leviathan governments. This also gives an explanation for why governments seek for harmonized capital taxation. With the perspective of Leviathan governments, the harmonization of world capital taxation is not desirable for the efficient allocation of goods between private consumption and public consumption. The hidden goal of the international harmonization of capital taxation might be seen as to avoid the pressure of international capital mobility and to pursue governments' selfish interest effectively.

However, it is worth stressing that tax competition does not force Leviathan governments to set tax rates at the optimal level from the citizens' point of view. The tax rates at the non-cooperative equilibrium can be either higher or lower than the socially optimal level.

3.4.2 GNP vs GDP

In the standard model presented in section 3, private consumption is defined as national product, net of tax. The income of foreign capital is not counted into private consumption but capital income earned abroad is counted into private consumption. With this definition, private consumption becomes Gross National Product (GNP). However, Gross Domestic Product (GDP) is more frequently cited as the economic policy target of governments. It is therefore reasonable to assume that governments regard domestic product net of tax for private consumption.[13] With the new definition, the income from foreign capital is counted into private consumption but, capital income earned abroad is not counted.

Proposition 9 *When governments care about domestic income rather than national income, tax competition is more intensive and as a result tax rates in both countries become lower.*

With the new definition of private consumption, the objective of the government of country i is

$$\max_{t_i} W(C_i, G_i) \tag{3.39}$$

subject to

$$\begin{aligned} C_i &= f(K+(-1)^i Z) - t_i f(K+(-1)^i Z)'(K+(-1)^i Z) \\ G_i &= t_i f(K+(-1)^i Z)'(K+(-1)^i Z) \\ 0 &\leq t_i < 1, \\ -K &\leq Z \leq K. \end{aligned} \tag{3.40}$$

The first-order conditions give

$$\frac{W_{C_i}}{W_{G_i}} = \frac{f(K+(-1)^i Z)'(K+(-1)^i Z)}{\begin{array}{c} f(K+(-1)^i Z)'(K-Z) - (-1)^i f(K+(-1)^i Z)'\psi \\ \hline +(-1)^i t_i f(K+(-1)^i Z)''(K+(-1)^i Z)\psi + (-1)^i t_i f(K+(-1)^i Z)'\psi \\ \hline +(-1)^i t_i f(K+(-1)^i Z)''(K+(-1)^i Z)\psi + (-1)^i t_i f(K+(-1)^i Z)'\psi \end{array}}, \tag{3.41}$$

[13]UK government is likely to count the profit of UK Toyota into GDP of the UK.

where

$$\psi = \frac{\partial Z}{\partial t_i}.$$

We can define ψ as (3.26). By plugging (3.26) into (3.41), we get

$$\begin{aligned}\frac{W_{C_i}}{W_{G_i}} &= \frac{f(K+(-1)^iZ)''(K+(-1)^iZ)}{f(K+(-1)^iZ)''(K+(-1)^iZ)} \\ &\quad \frac{+(1-t_j)f(K+(-1)^jZ)''(K+(-1)^iZ)+t_if(K+(-1)^iZ)'}{+(1-t_j)f(K+(-1)^jZ)''K-(1-t_i)f(K+(-1)^iZ)'}. \end{aligned} \quad (3.42)$$

By symmetry, $t^* = t_1 = t_2$ at an equilibrium and it implies that $Z^* = 0$. Thereby, (3.42) is reduced to

$$\begin{aligned}\frac{W^*_{C_i}}{W^*_{G_i}} &= \frac{f(K)''K+(1-t^*)f(K)''K+t^*f(K)'}{f(K)''K+(1-t^*)f(K)''K-(1-t^*)f(K)'} \\ &= 1+\frac{f(K)'}{(2-t^*)f(K)''K-(1-t^*)f(K)'}<1. \end{aligned} \quad (3.43)$$

The above result implies that public goods is under-provided in both countries.

Is the under-supply of public goods more serious than in previous case where GNP is used? Suppose that t^*_N is the tax rate which is defined in (3.28). t^*_N can not satisfy (3.43).

$$\begin{aligned}\frac{W_{C_i}}{W_{G_i}} &= \frac{(2-t^*_N)f(K)''K+t^*_Nf(K)'}{(2-t^*_N)f(K)''K} \\ &> \frac{(2-t^*_N)f(K)''K+t^*_Nf(K)'+(1-t^*_N)f(K)'}{(2-t^*_N)f(K)''K-(1-t^*_N)f(K)'} \end{aligned} \quad (3.44)$$

Tax rates greater than t^*_N cannot satisfy (3.43) because any tax rate greater than t^*_N increases the left-hand side of (3.43) while decreasing the right-hand side. Only a tax rate below t^*_N can satisfy (3.43) by decreasing the left-hand side and, at the same time, by increasing the right-hand side. The tax rate which satisfies (3.43) should be lower than t_N^*. Therefore, the problem of the under-supply of public goods is more serious.

3.4.3 Large number of countries

Here, the model is modified to reflect the situation where a large number of identical countries are involved in tax competition. The additional assumption is that when the tax rates of foreign countries are the same, the amount of capital movement from/to each foreign country is the same. Let us assume there exist $n+1$ identical economies, where country 1 is the domestic country, and country 2, country 3, ...and country $n+1$ are foreign countries.

Let Z_k be the amount of capital export from country 1 to country k. Then the total quantity of the capital located in the foreign countries are $\sum_{k=2}^{n+1} Z_k \equiv nZ$. The private consumption and public consumption of country 1 are defined as

$$\begin{aligned} C_1 &= f(K-nZ) - f(K-nZ)'(K-nZ) + (1-t_2)f(K+Z_2)'Z_2 \\ &\quad +(1-t_3)f(K+Z_3)'Z_3 \\ &\quad +\dots\dots\dots\dots\dots\dots & (3.45) \\ &\quad +(1-t_{n+1})f(K+Z_{n+1})'Z_{n+1} & (3.46) \end{aligned}$$

and

$$G_1 = t_1 f(K-nZ)'(K-nZ). \tag{3.47}$$

The equilibrium condition in the international capital market is

$$
\begin{aligned}
(1-t_1)f(K-nZ)' &= (1-t_2)f(K+Z_2)' \\
(1-t_1)f(K-nZ)' &= (1-t_3)f(K+Z_3)' \\
&= \\
&= \\
(1-t_1)f(K-nZ)' &= (1-t_{n+1})f(K+Z_{n+1})'. \qquad (3.48)
\end{aligned}
$$

By substituting (3.48) into (3.46), the private consumption is defined as

$$C_1 = f(K-nZ) - f(K-nZ)'(t_1K - nZ). \qquad (3.49)$$

Therefore, the objective function of country 1 is

$$\max W(C_1, G_1) \qquad (3.50)$$

subject to

$$
\begin{aligned}
C_1 &= f(K-nZ) - f(K-nZ)'(t_1K-nZ) \\
G_1 &= t_1 f(K-nZ)'(K-nZ) \\
0 &\leq t_i < 1, \\
-nK &\leq nZ \leq K
\end{aligned}
$$

The first-order conditions give

$$\frac{W_{C_1}}{W_{G_1}} = \frac{f(K-nZ)'(K-nZ) - nt_1 f(K-nZ)''(K-nZ)\phi - nt_1 f(K-nZ)'\phi}{f(K-nZ)'K - nf(K-nZ)''(t_1K-nZ)\phi}, \qquad (3.51)$$

where

$$\phi = \frac{\partial Z}{\partial t_1}. \tag{3.52}$$

We can define ϕ using the equilibrium condition in the international capital market as follows.

$$\phi = \frac{-f(K-nZ)'}{n(1-t_1)f(K-nZ)'' + (1-t_2)f(K+Z_2)''}. \tag{3.53}$$

By plugging (3.53) into (3.51), we get

$$\frac{W_{C_1}}{W_{G_1}} = \frac{nf(K-nZ)''(K-nZ) + (1-t_2)f(K+Z_2)''(K-nZ) + nt_1 f(K-nZ)'}{nf(K-nZ)''(K-nZ) + (1-t_2)f(K+Z_2)''K} \tag{3.54}$$

By symmetry, $t^* = t_1 = t_2$ at equilibrium and it implies that $Z^* = 0$. Thereby, (3.54) is reduced to

$$\begin{aligned} \frac{W^*_{C_1}}{W^*_{G_1}} &= \frac{(n+1-t^*)f(K)''K + nt^* f(K)'}{(n+1-t^*)f(K)''K} \\ &= 1 + \frac{nt^* f(K)'}{(n+1-t^*)f(K)''K} < 1. \end{aligned} \tag{3.55}$$

With two identical economies, $n+1=2$, (3.55) becomes (3.28).

Proposition 10 *As the number of countries involved in tax competition increases, the tax rate at the Nash equilibrium becomes lowered. However, even if an infinite number of countries are involved in tax competition, the tax rate does not fall to zero.*

Suppose that $n_1 < n_2$ and $t^*_{n_1}$ and $t^*_{n_2}$ are tax rate at the equilibrium when $n = n_1$

and $n = n_2$ respectively, satisfying (3.55). If $t^*_{n_1} \leq t^*_{n_2}$, then

$$\begin{aligned} 1+\frac{n_1 t^*_{n1} f(K)'}{(n_1+1-t^*_{n_1})f(K)''K} &= \frac{W_{C_1}(t^*_{n_1})}{W_{G_1}(t^*_{n_1})} \\ &< \frac{W_{C_1}(t^*_{n2})}{W_{G_1}(t^*_{n_2})} = 1+\frac{n_2 t^*_{n2} f(K)'}{(n_2+1-t^*_{n_2})f(K)''K}. \end{aligned} \tag{3.56}$$

However, for every $n > 1$,

$$1+\frac{n_1 t^*_{n_1} f(K)'}{(n_1+1-t^*_{n_1})f(K)''K} > 1+\frac{n_2 t^*_{n_2} f(K)'}{(n_2+1-t^*_{n_2})f(K)''K}.^{14} \tag{3.57}$$

Therefore, $t^*_{n_1} \leq t^*_{n_2}$ is contradictory to $n_1 < n_2$. Therefore, $t^*_{n_1}$ should be higher than $t^*_{n_2}$.

When n goes to ∞, (3.55) becomes

$$\frac{W_{C_1}}{W_{G_1}} = 1+\frac{t^* f(K)'}{f(K)''K} > 0. \tag{3.58}$$

(3.58) implies that, even if the number of countries increases to infinity, the tax on capital income never drops to zero.

The result is different from Yang (1996), who predicts a zero tax rate under tax competition among an infinite number of countries. The different result is due to difference in assumptions. His model differs from mine in two ways: firstly, there is an efficient tax other than capital income tax, and secondly, the inflow of foreign capital is modelled to increase public consumption only.[15] Therefore, tax cutting in

[14]The following is the proof for (3.53).
$[1+\frac{n_1 t^*_{n_1} f(K)'}{(n_1+1-t^*_{n_1})f(K)''K}] - [1+\frac{n_2 t^*_{n_2} f(K)'}{(n_2+1-t^*_{n_2})f(K)''K}]$
$= \frac{f(K)'}{f(K)''K}[\frac{n_1 n_2(t^*_{n_1}-t^*_{n_2})+n_1 t^*_{n_1}(1-t^*_{n_2})-n_2 t^*_{n_2}(1-t^*_{n_1})}{(n_1+1-t^*_{n_1})(n_2+1-t^*_{n_2})}]$
> 0 because $\frac{f(K)'}{f(K)''K} < 0$ and $n_1 t^*_{n_1}(1-t^*_{n_2}) - n_2 t^*_{n_2}(1-t^*_{n_1}) < 0$.

[15]Yang (1996) assumes that labour income is fully taxed. Labour income is all ecomomic rent because the supply of labour is fixed. Labour income tax is an efficient tax.

his model causes a less serious distortion of the under-supply of public goods and there is still supply of public goods even with zero corporation tax rate.

In contrast, in my model, the same degree of decrease in tax rate causes a more serious distortion of the under-supply of public goods because the inflow of foreign capital increases tax revenue only via enlarged tax base. Furthermore, a zero capital tax rate implies no supply of public goods because other tax than capital tax is not available. Therefore, there is a certain level of tax rate below which the inflow of capital motivated by lower tax rate does not result in an increase in the level of social welfare. Below this tax rate, the positive effect of an increase in consumption of private goods is dominated by the negative effect of the under-supply of public goods.

In reality, public goods is financed by other taxes than capital income tax but with some limitations. The limitations derives from not only consideration of economic inefficiency but also from political consideration. For example, even after all other factors are taxed, the marginal social value of public goods is still high so that governments inevitably tax capital income. Moreover, governments cannot substitute labour tax for capital tax above a certain level because of tax evasion in labour tax. This limitations make capital income tax rate be a positive value.[16]

[16] It will be discussed in section 3.6 how to incorporate this limitation into the current model.

3.5 Numerical results

Even if the pressure of tax competition leads to a lower tax rate on capital income, two questions still remain: "Is tax rate cutting significant?" and "Is the Nash equilibrium unique and stable?". To obtain specific values of tax rates, it is necessary to assume tractable forms of social welfare and production functions. They are assumed as

$$W(C_i, G_i) = \beta \ln C_i + \ln G_i, \qquad \beta \in (0, \infty) \tag{3.59}$$

and

$$f(K) = K^\alpha, \qquad \alpha \in (0, 1). \tag{3.60}$$

β represents the relative preference for the private consumption and α represents the income share of capital.[17]

Firstly, the tax rates in autarky can be obtained by using the result of $\frac{W_{C_1}}{W_{G_1}} = 1$. The tax rates under specific values of α and β is defined as

$$t_i = \frac{1}{\alpha(\beta + 1)}. \tag{3.61}$$

Table 3.1 shows the tax rates in autarky under specific values of α and β. The higher the value of β, the lower the tax rate. This result is to be expected because the higher value of β implies that people prefer private consumption and oppose a higher tax rate. The higher the value of α, the lower the tax rate is. This is because the higher

[17]These production function and social welfare function satisfy all the assumptions made in section 3.2 and make the second-order condition for maximization satisfied.

	$\alpha = 1/3$	$\alpha = 1/2$	$\alpha = 2/3$	$\alpha = 3/4$	$\alpha = 4/5$
$\beta = 1$	close to 1(1.5)	close to 1	0.75	0.67	0.625
$\beta = 2$	close to 1	0.67	0.5	0.44	0.42
$\beta = 3$	0.75	0.5	0.38	0.33	0.31

Table 3.1: Tax rates in the autarchy

	$\alpha = 1/3$	$\alpha = 1/2$	$\alpha = 2/3$	$\alpha = 3/4$	$\alpha = 4/5$
$\beta = 1$	0.65	0.50	0.37	0.30	0.26
$\beta = 2$	0.54	0.40	0.29	0.24	0.21
$\beta = 3$	0.46	0.33	0.24	0.20	0.18

Table 3.2: Tax rates in tax competition between symmetric two countries

value of α enlarges the tax base and a lower tax rate can therefore collect certain amount of tax revenue.

Tax rates under tax competition can be calculated by the equilibrium tax rate expressed in (3.28). Substituting (3.59) and (3.60) into (3.28) and rearranging give

$$t^2\{\alpha + \alpha(1+\beta)(1-\alpha)\} - t\{(2-\alpha) + 2\alpha(1-\alpha)(1+\beta)\} + 2(1-\alpha) = 0. \quad (3.62)$$

Table 3.2 shows the tax rates given values of β and α. Compared with tax rates in autarky, tax rates are lowered in all values of β and α. The lower values of β and α, the more serious the tax undercutting, measured by absolute amount. For most of the values of β and α, tax under-cutting ranges around 40-50% of tax rates in autarky.

When two identical Leviathan governments are involved with tax competition, the

	$\alpha = 1/3$	$\alpha = 1/2$	$\alpha = 2/3$	$\alpha = 3/4$	$\alpha = 4/5$
$\beta = 1$	0.8	0.67	0.50	0.40	0.34
$\beta = 2$	0.8	0.67	0.50	0.40	0.34
$\beta = 3$	0.8	0.67	0.50	0.40	0.34

Table 3.3: Tax rates in tax competition between two Leviathan governments

tax rates are

$$t_i = \frac{2(1-\alpha)}{2-\alpha}. \tag{3.63}$$

Table 3.3 shows that each government always sets its tax rate lower than 1 because

$$\varepsilon = -\frac{f(K)'}{f(K)''K} = \frac{1}{1-\alpha} > 1. \tag{3.64}$$

Tax competition always places a restriction on the Leviathan government. Table 3.3 also shows that β is not relevant in deciding the tax rate in tax competition between Leviathan governments. This is because Leviathan governments are not concerned with private consumption. It is noteworthy that tax competition between Leviathan governments can lead to either higher or lower tax rates than the socially optimal level.

Table 3.4 shows the tax rates when GDP (net of tax) is assumed to represent the private consumption. The tax rates at the non-cooperative equilibrium are defined as

$$t^2\{\alpha(1+\beta)(2-\alpha)\} - t\{2(1-\alpha) + \alpha(3-2\alpha)(1+\beta)\} + 2(1-\alpha) = 0. \tag{3.65}$$

The tax rates here are always lower than the tax rate when GNP (net of tax) is

	$\alpha = 1/3$	$\alpha = 1/2$	$\alpha = 2/3$	$\alpha = 3/4$	$\alpha = 4/5$
$\beta = 1$	0.60	0.42	0.28	0.21	0.17
$\beta = 2$	0.46	0.30	0.19	0.14	0.12
$\beta = 3$	0.37	0.23	0.15	0.11	0.09

Table 3.4: Tax rates in tax competition with GDP optimization

assumed to represent the private consumption (Proposition 9). The degree of tax undercutting is around 60-70% of the optimal level.

Table 3.5 - 3.7 show the relationship between the number of competing countries and the tax rates. The tax rates at the non-cooperative equilibrium are defined as

$$\begin{aligned} 0 &= t^2\{n\alpha + \alpha(1+\beta)(1-\alpha)\} - t\{(1+n-\alpha) \\ &\quad +(n+1)\alpha(1-\alpha)(1+\beta)\} + (n+1)(1-\alpha). \end{aligned} \tag{3.66}$$

When n goes to the ∞, (3.66) becomes

$$\alpha t^2 - t\{1 + \alpha(1-\alpha)(1+\beta)\} + (1-\alpha) = 0. \tag{3.67}$$

Table 3.5 - 3.7 confirm that as more countries are involved in tax competition, the tax rates become lower. However, even if the number of countries goes to the infinity, the tax rates do not drop to zero (Proposition 10). They also indicate that an increase in the number of countries results in a small decrease in tax rates. When the number of countries increases from two to an infinity, tax rates fall by 3-7% point for most values of α and β.

Up to this point, using the condition of a symmetric equilibrium, we have obtained the tax rates at the Nash equilibrium. However, an important question still remains:

	$\alpha = 1/3$	$\alpha = 1/2$	$\alpha = 2/3$	$\alpha = 3/4$	$\alpha = 4/5$
$\beta = 1$	0.60	0.45	0.32	0.26	0.22
$\beta = 2$	0.50	0.36	0.26	0.21	0.18
$\beta = 3$	0.43	0.31	0.22	0.18	0.16

Table 3.5: Tax rates in tax competition when n=2

	$\alpha = 1/3$	$\alpha = 1/2$	$\alpha = 2/3$	$\alpha = 3/4$	$\alpha = 4/5$
$\beta = 1$	0.58	0.43	0.31	0.24	0.20
$\beta = 2$	0.48	0.35	0.25	0.20	0.17
$\beta = 3$	0.41	0.30	0.21	0.17	0.15

Table 3.6: Tax rates in tax competition when n=3

	$\alpha = 1/3$	$\alpha = 1/2$	$\alpha = 2/3$	$\alpha = 3/4$	$\alpha = 4/5$
$\beta = 1$	0.53	0.38	0.26	0.20	0.17
$\beta = 2$	0.44	0.31	0.22	0.17	0.15
$\beta = 3$	0.38	0.27	0.19	0.15	0.13

Table 3.7: Tax rates in tax competition when n=∞

"Is the equilibrium unique and stable?" We can answer this question by drawing reaction functions.

Proposition 11 *The non-cooperative Nash equilibrium is unique and stable in a two-identical economy model.*

The case of $\alpha = 0.5$ and $\beta = 2$ is analysed. By substituting $\frac{W^*_{C_i}}{W^*_{G_i}} = \frac{2G_i}{C_i}$, $f(K) = K^{0.5}$, $f(K)' = 0.5K^{-0.5}$, $f(K)'' = -0.25K^{-1.5}$ and $Z = \{\frac{(1-t_1)^{-2}-(1-t_2)^{-2}}{(1-t_1)^{-2}+(1-t_2)^{-2}}\}K$, (3.28) gives reaction functions as

$$(1-2t_i)(1-t_j)^4 + (5t_i^2 - 16t_i + 4)(1-t_i)(1-t_j)^2 + (1-t_i)^5 = 0. \tag{3.68}$$

Figure 3.1 shows that the symmetric equilibrium tax rate ($t_i^* = t_j^* = 0.4$) is unique and stable[18]. $E_1(0.67, 0.67)$ is the equilibrium in autarky. As capital can move across countries, each country can attract capital by manipulating its tax rate. $t_1^*(t_2)$ is the trace of tax rates maximizing the social welfare of country 1, given country 2's tax rate. $t_2^*(t_1)$ is the best tax rates for country 2. The reaction functions intersect ($t_i = t_j = 0.4$) and ($t_i = t_j = 1$). By the assumption of $t_i < 1$, ($t_i = t_j = 1$) is not an equilibrium.[19]

It should be stressed that the derivation of the reaction functions and the properties of the equilibrium depend on the specification of the social welfare and production

[18]Stability refers to the situation that the simple dynamic adjustment process in which two countries take turns myopically playing best response to each other's current tax rates converges to the Nash equilibrium from any tax rate pair in a neighborhood of the equilibrium.

[19]If we define $t \in [0, 1]$, ($t_i = t_j = 1$) is an unstable Nash equilibrium in that each country can attract all foreign capital by decreasing its tax rate by arbitrarily small amount.

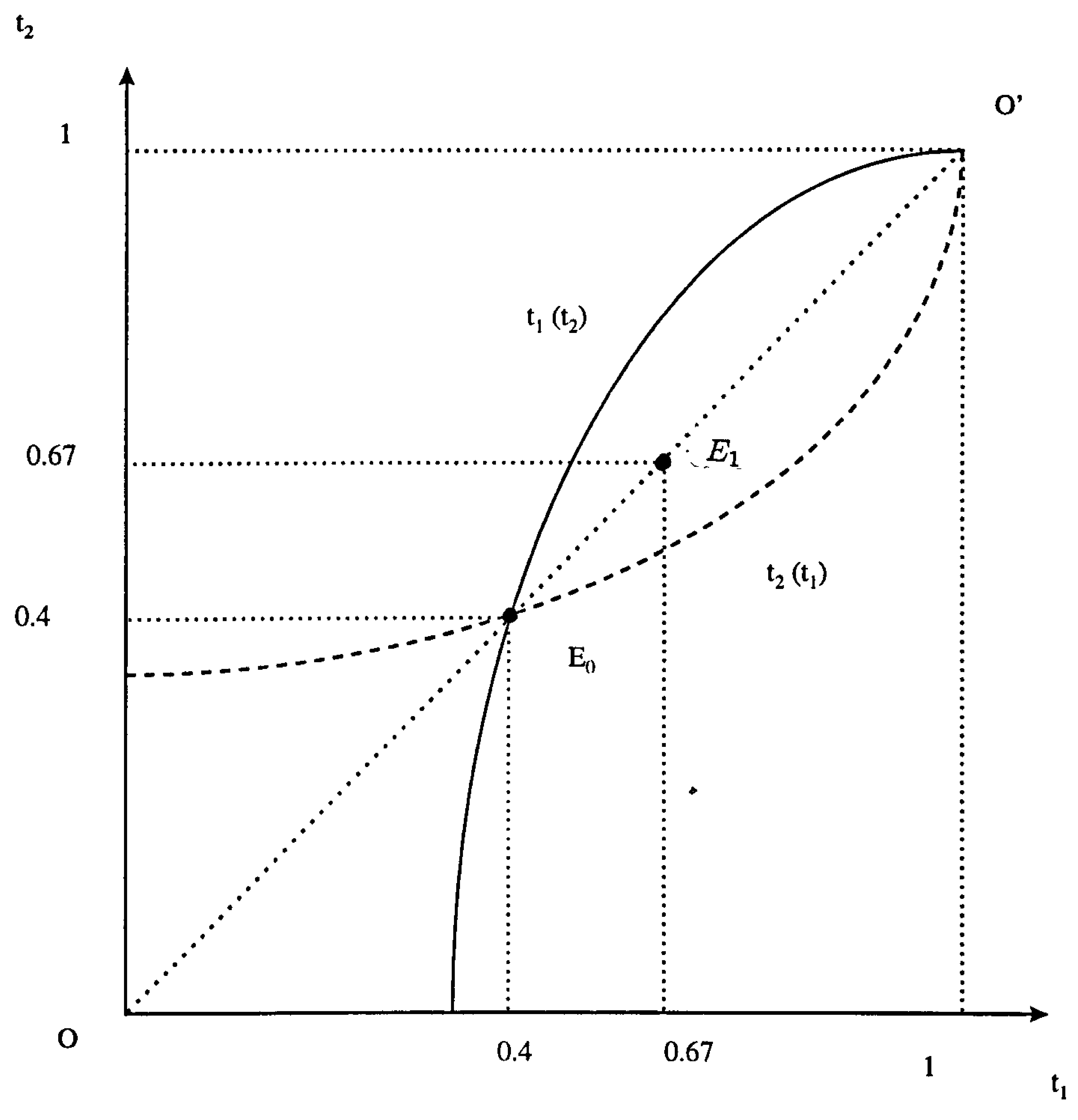

Figure 3.1: Equilibrium of symmetric tax competition

function. In addition, the degree of tax cutting depends on the values of α, the income share of capital, and β, the relative preference for the private consumption.

3.6 Conclusion

This chapter has built up a model which is microfounded in analysing international corporation tax competition. Using the model, two fundamental questions are answered: "Is tax undercutting serious?" and "Is the Nash equilibrium unique and stable?" The answers depend on the functional forms of production and social welfare functions. Even if the exact size of tax undercutting depends on α, the share of income of capital, and β, preference for private consumption, numerical calibration suggests that tax undercutting generally ranges from 40-50% below the optimal level. The answer to the second question is yes as far as these specific functional forms are assumed.

It is noteworthy that the model predicts $t \to t^* > 0$ even if as $n \to \infty$. This is different from previous studies which predicts zero tax rate in a small-open economy model. This is related with the assumption that supply of public goods is solely financed by corporation tax revenue. However, the availability of other taxes than capital income tax can be incorporated into the model presented in this thesis. β has been interpreted as the magnitude of marginal substitution between private goods and public goods. Alternatively, β can be interpreted as the relationship between supply of public goods and capital income tax revenue. The higher β is, the less restricted supply of public goods is by capital income tax revenue. As far as there are limitations in financing supply of public good by other taxes than capital income tax (β is positive), tax rates at the non-cooperative equilibrium do not drop to zero.

The basic model is extended in three cases. Firstly, benevolent governments are replaced by Leviathan governments. It is demonstrated that international capital mobility places an effective restriction on the expansionary tendency of Leviathan governments. In this context, the current movement towards international tax harmonization is undesirable. The movement can be viewed as designed to avoid the restrictions imposed by the international mobility of capital.

Secondly, when each government evaluates its economic performance with GDP rather than GNP, tax competition leads to a much lower tax rate. This is because the income of foreign capital invested in its territory is counted into private consumption and thus foreign capital is more attractive under the maximization of GDP.

Thirdly, the analysis is extended to the case in which more than two countries compete to attract foreign capital. It is demonstrated that as more countries are involved in tax competition, tax rates become lower. However, even when the number of countries becomes close to the infinity, the tax rate is still positive. Numerical calibration reveals that the effect of an increase in number of countries on the level of tax rates is not large.

It is, however, dangerous to simply apply the results presented here to the real world. Firstly, countries are never identical. There are asymmetries in their size, capital endowment, production function, and preference for public goods. Secondly, international mobility of capital is far from perfect. Theoretical developments which incorporate imperfection in capital mobility are necessary for deeper understanding of tax competition. Thirdly, firms' decision on location is a complicated process, and there are influential variables other than tax, such as financing, marketing, and restructuring, which must be taken into account. These three factors must be considered in order to generate more realistic results.

Chapter 4

Three asymmetric tax competitions

4.1 Introduction

Although symmetric tax competition analysis has an advantage in showing the distortion which arises purely from strategic tax setting behaviour, it is less realistic in the sense that it does not allow for movement of capital at the equilibrium. Compared with large number of research carried out on symmetrical tax competition, the study of asymmetric analysis is relatively rare. Among the limited number of studies are Bucovestsky (1991), Wilson (1991), Kanbur and Keen (1993), Eggert and Haufler (1996) and Haufler (1996b).

With the exception of Haufler (1996b), all assume that asymmetry derives from differences in country (jurisdiction) size. The first two analyse tax competition with capital income tax in a federal country, while the third and fourth deal with tax competition with consumption tax in an international context.

The aim of this chapter is to analyse three asymmetric tax competition cases which is significant in an international context. Three asymmetric cases of tax competition are: (1) countries differ in their sizes, (2) countries differ in their per capita capital endowments, and (3) countries differ in their preferences for public goods. Difference both in preference for public goods and in per capita capital endowment is more significant in the international context than in a federal country.

In this chapter, not only the different level of tax rates but also the different size of tax cutting at the non-cooperative equilibrium will be investigated. The size of tax cutting is important because even if the country with a strong preference for public goods have a higher tax rate than the country with a weak preference, the former decreases tax rate more than the latter at the non-cooperative equilibrium. With the results of analyses of three cases, I will discuss an international tax coordination which is feasible in all three cases and is simple to implement.

Firstly, when countries are different in their sizes, the smaller country is shown to undercut the larger country. This is consistent with the results of previous studies mentioned above. In this thesis, the non-cooperative equilibrium is demonstrated to be unique and stable. Numerical calibration shows that the tax differential between two countries is relatively small compared with the size of tax cutting in both countries.

The second asymmetry derives from differences in per capita capital endowment among countries. This case has not been fully investigated by previous studies. This is because previous studies assume that residents in each jurisdiction own an identical share of total capital stock. This assumption eliminates the possibility of different per capita capital endowment. The asymmetry in country size can be applied properly to tax competition between France, a larger one, and Belgium, a smaller one. The asymmetry in per capita capital endowment can be applied to the tax competition between Sweden, a country with higher per capita capital endowment, and Portugal, a country with lower per capita capital endowment.

The analysis finds that tax competition leads to the same size of tax cutting in both lower and higher per capita capital endowment countries. At the non-cooperative equilibrium, capital moves from the country with higher per capita capital endowment to the country with the lower one, resulting in the same amount capital in both countries. Therefore, there is no distortion in capital allocation between two countries. The distortion stems from too low tax rate (the under-supply of public goods) in both countries. Numerical calibration shows that the degree of tax cutting is the same regardless of the degree of asymmetry.

The third asymmetry derives from differences in preference for public goods. It is found that the country with a weak preference for public goods undercuts the country with a strong preference for public goods. As a result, capital moves from the latter to the former. This result parallels the results presented by Haufler (1996b). However, this should not surprise us because the country with a strong preference for public goods is expected to have higher tax rate without strategic tax setting behaviours. Being different from Haufler (1996b) which concludes that the country with a strong preference for public goods will have a lower tax rate than the country with a weak preference, my thesis stresses that the former will cut its tax rate to a greater degree than the latter.

Existing research suggests that international tax harmonization is not feasible in asymmetric cases because small countries are opposed to it if they are better off at the non-cooperative equilibrium than at the coordinated outcome. Therefore, Kanbur and Keen (1993) propose the imposition of a minimum tax rate which is strictly Pareto-improving. However, their result is not applied to three cases presented here. As Haufler (1996b) pointed out, the imposition of minimum tax rate is not always welfare-improving for both countries if governments care about private consumption and public consumption.[1] In addition, the imposition of minimum tax rate is technically impossible in the case of tax competition between countries of different per capita capital endowment because tax rates at the non-cooperative equilibrium are the same.

This thesis considers a simple form of tax coordination. It is found to be welfare-improving for both countries to raise their tax rates by the same amount.[2] The small country (the country with smaller per capita capital endowment and the country

[1]In Kanbur and Keen (1993), governments are assumed to behave as revenue-maximizers.
[2]This tax coordination is suggested in Crombrugghe and Tulkens (1990).

with a weak preference for public goods) always prefers this cooperative equilibrium to the non-cooperative equilibrium because the tax differential at the non-cooperative equilibrium is maintained and thus the amount of capital inflow is the same. The large country (the country with larger per capita capital endowment and the country with a strong preference for public goods) prefers this cooperative equilibrium to the non-cooperative equilibrium only when the positive effect of an increase in public goods outweighs the negative effect of a decrease in the income from foreign investment. Numerical calibration shows that this is the case in all three asymmetric cases presented here.

This chapter is organized as follows. Section 2 analyses the asymmetric tax competition between two countries of different sizes. Section 3 analyses the asymmetric tax competition between two countries of different per capita capital endowments. The asymmetric tax competition between countries of different preferences for public goods is analysed in section 4. Policy considerations are presented in section 5, and a summary is drawn in the final section.

4.2 Different size of country

Suppose that country 1 is endowed with capital and labour amounting (nK, nL) and country 2 (K, L). The assumption that $n > 1$ makes country 1 larger country and country 2 smaller country. Then, with the production function defined in (3.60), total production and marginal product of capital of country 1 are expressed as follows.

$$F(nK, nL) = nF(K, L) = nf(K) \tag{4.1}$$

and

$$F_1(nK, nL) = F_1(K, L) = f(K)'. \tag{4.2}$$

In autarky, the objective of country 1 is

$$\max_{t_1} W(C_1, G_1) \tag{4.3}$$

subject to

$$\begin{aligned} C_1 &= nf(K) - t_1 nKf(K)', \\ G_1 &= t_1 nKf(K)', \\ 0 &\leq t_1 < 1. \end{aligned} \tag{4.4}$$

The first-order conditions give

$$\frac{W_{C_1}}{W_{G_1}} = \frac{nKf(K)'}{nKf(K)'} = 1. \tag{4.5}$$

With the same procedure, the condition for maximizing country 2's social welfare is

$$\frac{W_{C_2}}{W_{G_2}} = \frac{Kf(K)'}{Kf(K)'} = 1. \tag{4.6}$$

With the social welfare function and the production function, defined in (3.59) and (3.60), the tax rates in both countries are the same at the level of

$$t_i^A = \frac{1}{\alpha(1+\beta)}, \qquad i = 1, 2. \tag{4.7}$$

Now, assume that capital can move across the borders. When Z is net outflow of capital from country 1, the equilibrium condition in the international capital market is

$$(1-t_1)f(K-\frac{Z}{n})' = (1-t_2)f(K+Z)'. \tag{4.8}$$

(4.8) implies that capital moves from the high-tax country to the low-tax country and that the amount of the movement of capital, given constant tax differential, increases as the difference in sizes of two countries increases.

The private consumption and the public consumption of country 1 are

$$C_1 = nf(K-\frac{Z}{n}) - f(K-\frac{Z}{n})'(t_1 nK - Z) \tag{4.9}$$

and

$$G_1 = t_1 f(K-\frac{Z}{n})'(nK-Z). \tag{4.10}$$

The objective of country 1 is

$$\max_{t_1} W(C_1, G_1) \tag{4.11}$$

subject to

$$\begin{aligned} C_1 &= nf(K-\frac{Z}{n}) - f(K-\frac{Z}{n})'(t_1 nK - Z), \\ G_1 &= t_1 f(K-\frac{Z}{n})'(nK-Z), \\ 0 &\leq t_1 < 1, \\ -K &\leq Z \leq nK. \end{aligned} \tag{4.12}$$

The first-order conditions give

$$\frac{W_{C_1}}{W_{G_1}} = \frac{f(K-\frac{Z}{n})'(nK-Z) - t_1 f(K-\frac{Z}{n})''(nK-Z)\frac{1}{n}\psi}{f(K-\frac{Z}{n})'nK - f(K-\frac{Z}{n})''(t_1 nK - Z)\frac{1}{n}\psi} \qquad \frac{-t_1 f(K-\frac{Z}{n})'\psi}{}, \tag{4.13}$$

where

$$\psi = \frac{\partial Z}{\partial t_1}.$$

We can define ψ from (4.8) as follows.

$$\psi = \frac{-f(K-\frac{Z}{n})'}{(1-t_1)\frac{1}{n}f(K-\frac{Z}{n})'' + (1-t_2)f(K+Z)''}. \tag{4.14}$$

By plugging (4.14) into (4.13), we get

$$\begin{aligned} \frac{W^*_{C_1}}{W^*_{G_1}} &= \frac{f(K-\frac{Z^*}{n})''(K-\frac{Z^*}{n}) + (1-t_2^*)f(K+Z^*)''(nK-Z^*) + t_1^* f(K-\frac{Z^*}{n})'}{f(K-\frac{Z^*}{n})''(K-\frac{Z^*}{n}) + (1-t_2^*)f(K+Z^*)''nK} \\ &= 1 + \frac{-(1-t_2^*)f(K+Z^*)''Z^* + t_1^* f(K-\frac{Z^*}{n})'}{f(K-\frac{Z^*}{n})''(K-\frac{Z^*}{n}) + (1-t_2^*)f(K+Z^*)''nK}. \end{aligned} \tag{4.15}$$

Whether (4.15) is greater than 1 or not depends on the sign of Z^*. If Z^* is positive, (4.15) is always less than 1. This implies the under-supply of public goods in the large country.

The objective of country 2 is

$$\max_{t_2} W(C_2, G_2) \tag{4.16}$$

subject to

$$C_2 = f(K+Z) - f(K+Z)'(t_2 K + Z),$$

$$\begin{aligned}G_2 &= t_2 f(K+Z)'(K+Z), \\ 0 &\leq t_2 < 1, \\ -K &\leq Z \leq nK.\end{aligned}$$

The first-order conditions give

$$\frac{W_{C_2}}{W_{G_2}} = \frac{f(K+Z)'(K+Z) + t_2 f(K+Z)''(K+Z)\varphi}{f(K+Z))'K + f(K+Z)''(t_2 K + Z)\varphi + t_2 f(K+Z)'\varphi}, \tag{4.17}$$

where

$$\varphi = \frac{\partial Z}{\partial t_2}.$$

We can define ψ from (4.8) as

$$\varphi = \frac{nf(K+Z)'}{(1-t_1)f(K-\frac{Z}{n})'' + n(1-t_2)f(K+Z)''}. \tag{4.18}$$

By plugging (4.18) into (4.17), we get

$$\begin{aligned}\frac{W^*_{C_2}}{W^*_{G_2}} &= \frac{(1-t_1^*)f(K-\frac{Z^*}{n})''(K+Z^*) + nf(K+Z^*)''(K+Z^*) + t_2^* nf(K+Z^*)'}{(1-t_1^*)f(K-\frac{Z^*}{n})''(K+Z^*) + nf(K+Z^*)''(K+Z^*)} \\ &= 1 + \frac{t_2^* nf(K+Z^*)'}{(1-t_1^*)f(K-\frac{Z^*}{n})''(K+Z^*) + nf(K+Z^*)''(K+Z^*)} < 1. \qquad (4.19)\end{aligned}$$

Therefore, there is an under-supply of public goods in the small country regardless of the sign of Z^*. However, this implies neither that the new tax rate at the non-cooperative equilibrium is lower than that in autarky, nor that absolute amount of public goods is less than that in autarky.

The equilibrium is no more symmetrical. With complicated (4.15) and (4.19), it is difficult to ascertain the economic implications. With the assumption that $\alpha = 0.5$

and $\beta = 1$, the reaction functions of country 1 and country 2 are

$$\begin{aligned}
& -2n(n+1)(1-t_1)(1-t_2)^2 + 5n(n+1)t_1(1-t_1)(1-t_2)^2 \\
& -2n^2(n+1)(1-t_1)^4 + n^2(1-t_1)^2(2t_1-1)(1-t_2)^2 \\
& +n^2(1-t_1)^4(2nt_1+1) + n(2t_1-1)(1-t_2)^4 \\
& -n(2t_1-1)(nt_1+1)(1-t_1)(1-t_2)^2 \\
= \; & 0 \qquad (4.20)
\end{aligned}$$

and

$$\begin{aligned}
& n(n+1)(5t_2-2)(1-t_1)^2(1-t_2) + (n+2t_2)(1-t_2)^4 \\
& +n(1-t_2)^2(2t_2-1)(1-t_1)^2 - 2(n+1)(1-t_2)^4 \\
& -n(2t_2-1)(t_2+n)^2(1-t_1)^2(1-t_2) + n^2(2t_2-1)(1-t_1)^4 \\
= \; & 0 \qquad (4.21)
\end{aligned}$$

By plugging $n = 1$ into (4.20) and (4.21), we can get the reaction functions which are symmetric for $t_1 = t_2$ such as

$$(1-2t_i)(1-t_j)^4 + 4(t_i^2 - 3t_i + 1)(1-t_i)(1-t_j)^2 + (3-2t_i)(1-t_i)^4 = 0. \quad (4.22)$$

At the equilibrium, tax rates are $(t_1^* = t_2^* = 0.5)$.[3]

When $n = 2$, we have

$$-12(1-t_1)(1-t_2)^2 + 30t_1(1-t_1)(1-t_2)^2 - 24(1-t_1)^4$$

[3]The reaction functions are different from those in chapter 3 because here $\beta = 1$.

$$
\begin{aligned}
&+4(1-t_1)^2(2t_1-1)(1-t)^2+4(1-t_1)^4(4t_1+1)+2(2t_1-1)(1-t_2)^4 \\
&-2(2t_1-1)(2t_1+1)(1-t_1)(1-t_2)^2 \\
=\ & 0 \qquad (4.23)
\end{aligned}
$$

and

$$
\begin{aligned}
&6(5t_2-2)(1-t_1)^2(1-t_2)+(2+2t_2)(1-t_2)^4 \\
&+2(1-t_2)^2(2t_2-1)(1-t_1)^2-6(1-t_2)^4 \\
&-2(2t_2-1)(t_2+2)^2(1-t_1)^2(1-t_2)+4(2t_2-1)(1-t_1)^4 \\
=\ & 0 \qquad (4.24)
\end{aligned}
$$

The reaction functions are no longer symmetrical as shown in Figure 4.1. At the equilibrium, tax rates are $(t_1^* = 0.54, t_2^* = 0.47)$. Both countries lower their tax rates below the tax rates in autarky. Furthermore, the small country sets its tax rate below that of the large country. Therefore, capital moves from the large country to the small country. The large country is worse off than in autarky because of the capital flight and the under-supply of public goods. Country 2 is also worse off if the negative effect of the under-supply of public goods outweighs the positive effect of the inflow of capital.

With the same way with the above, when $n = 3$, the tax rates are $(t_1^* = 0.44, t_2^* = 0.31)$ at the non-cooperative Nash equilibrium.

Proposition 12 *At the non-cooperative equilibrium, the smaller country undercut the larger country and attracts foreign capital. The larger country is worse off than*

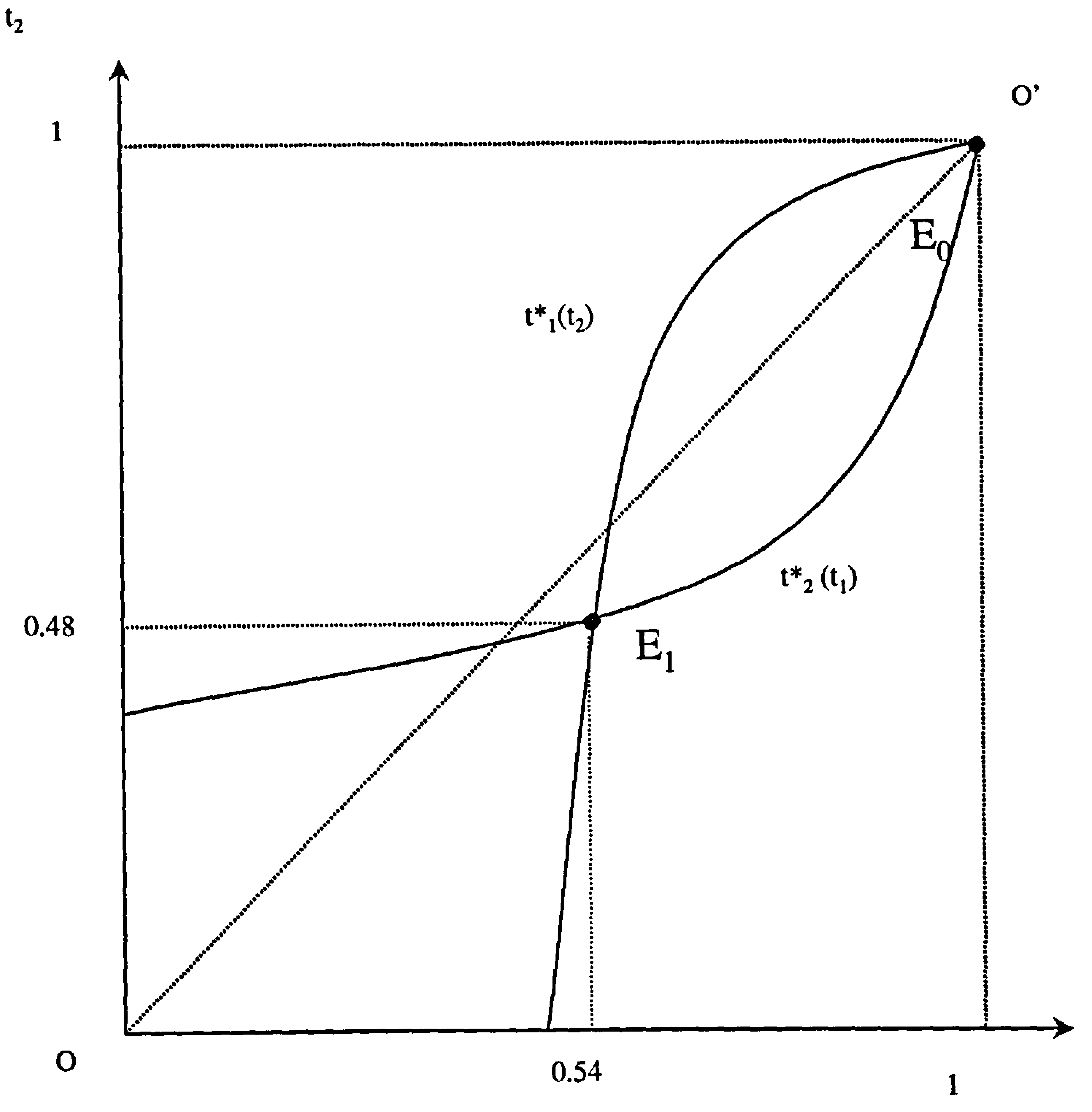

Figure 4.1: Asymmetric tax competition of different sizes

in autarky due to the capital flight and the under-supply of pubic goods, while the smaller country is either worse off or better off.

Why does the larger country choose the higher tax rate than that of the smaller country? Suppose that the tax rates of the two countries are the same, i.e. $t_1 = t_2$. Then, there is no movement of capital between two countries, $Z = 0$. A tax cutting causes the same amont of capital inflow in both countries. This result can be confirmed by the identity between (4.14) and (4.18) with $Z = 0$. The inflow of capital increases the same amount of private consumption and public consumption in both countries. A tax cutting, however, causes the distortion by reallocating more products from public consumption to private consumption. The larger the size of country (the amount of capital endowment), the graeter the distortion is. The tax cutting decision of the governemtns rest on the relative size between the positive effect of capital inflow and the negative effect of the distortion. [4] Tax cutting gives the same

[4]The first-order derivatives of private consumption and public consumption with respect to tax change are

$$\frac{\partial C_1}{\partial t_1} = -f(K - \frac{Z}{n})' nK - f(K - \frac{Z}{n})''(t_1 nK - Z)\frac{1}{n}\psi,$$

$$\frac{\partial G_1}{\partial t_1} = f(K - \frac{Z}{n})' nK - t_1 f(K - \frac{Z}{n})''(nK - Z)\frac{1}{n}\psi - t_1 f(K - \frac{Z}{n})'\psi,$$

$$\frac{\partial C_2}{\partial t_2} = -f(K - Z)'K + f(K + Z)''(t_2 K + Z)\varphi$$

and

$$\frac{\partial G_2}{\partial t_2} = f(K - Z)'K + t_2 f(K + Z)''(K + Z)\varphi + t_2 f(K + Z)'\varphi.$$

From $t_1 = t_2$, $Z = 0$ and $\psi = -\varphi$, we have

$$\frac{\partial C_1}{\partial t_1} = -\frac{\partial G_1}{\partial t_1} < \frac{\partial C_2}{\partial t_2} = -\frac{\partial G_2}{\partial t_2}.$$

Therefore, a tax cutting of country 1 (the larger country) transfers public consumption to private consumption more than that of country 2 (the smaller country).

positive effect to both countries but causes greater distortion to the larger country than the smaller country. Therefore, the smaller country always has an incentive to lower its tax rate further below the tax rate at the level of which the larger country has no incentive for tax cutting.

The result that the smaller country tends to undercut the larger country has also been shown by Bucovetsky (1991), where a quadratic production function is assumed. It should be stressed that the proposition 12 in this section also holds for the specific functional forms defined in (3.60) and may not hold in the more general case.

4.3 Different endowment of capital

Suppose that two countries are identical except that country 1 is endowed with capital of nK while country 2 is endowed with K. Even if their capital endowments are different, the two countries are assumed to have the same population. Then, with the production function defined in (3.60), total production and marginal product of capital of country 1 are expressed as follows.

$$F(nK, L) = f(nK) \tag{4.25}$$

and

$$F_1(nK, L) = f_1(nK, L) = f(nK)'. \tag{4.26}$$

In autarky, the objective of country 1 is

$$\max_{t_1} W(C_1, G_1) \tag{4.27}$$

subject to

$$\begin{aligned} C_1 &= f(nK) - t_1 nKf(nK)', \\ G_1 &= t_1 nKf(nK)', \\ 0 &\leq t_1 < 1. \end{aligned} \tag{4.28}$$

The first-order conditions give

$$\frac{W_{C_1}}{W_{G_1}} = \frac{nKf(nK)'}{nKf(nK)'} = 1. \tag{4.29}$$

With the same procedure, the condition maximizing country 2's social welfare is

$$\frac{W_{C_2}}{W_{G_2}} = \frac{Kf(K)'}{Kf(K)'} = 1. \tag{4.30}$$

With the assumed social welfare function and production function, the tax rates in both countries are the same at the level of

$$t_i^A = \frac{1}{\alpha(1+\beta)}. \tag{4.31}$$

Now, assume that capital can move across the borders. When Z is net outflow of capital from country 1, the equilibrium condition of capital market is

$$(1 - t_1)f(nK - Z)' = (1 - t_2)f(K + Z)'. \tag{4.32}$$

(4.32) implies that capital does not always move from the high-tax country to the low-tax country. When tax rates are the same in two countries, capital moves from the country with larger per capita capital endowment to the country with smaller endowment. As the difference in capital endowments increases, the amount of the movement of capital also increases.

The private consumption and the public consumption of country 1 are

$$C_1 = f(nK - Z) - f(nK - Z)'(t_1 nK - Z) \tag{4.33}$$

and

$$G_1 = t_1 f(nK - Z)'(nK - Z). \tag{4.34}$$

The objective of country 1 is

$$\max_{t_1} W(C_1, G_1) \tag{4.35}$$

subject to

$$\begin{aligned} C_1 &= f(nK - Z) - f(nK - Z)'(t_1 nK - Z), \qquad (4.36) \\ G_1 &= t_1 f(nK - Z)'(nK - Z), \\ 0 &\leq t_1 < 1, \\ -K &\leq Z \leq nK. \end{aligned}$$

The first-order conditions give

$$\frac{W_{C_1}}{W_{G_1}} = \frac{f(nK - Z)'(nK - Z) - t_1 f(nK - Z)''(nK - Z)\psi}{f(nK - Z)'nK + f(nK - Z)''(t_1 nK - Z)\psi - t_1 f(nK - Z)'\psi}, \tag{4.37}$$

where

$$\psi = \frac{\partial Z}{\partial t_1}. \tag{4.38}$$

We can define ψ from (4.32) as

$$\psi = \frac{-f(nK - Z)'}{(1-t_1)f(nK - Z)'' + (1-t_2)f(K+Z)''}. \tag{4.39}$$

By plugging (4.39) into (4.37), we get

$$\begin{aligned} \frac{W^*_{C_1}}{W^*_{G_1}} &= \frac{f(nK-Z^*)''(nK-Z^*) + (1-t_2^*)f(K+Z^*)''(nK-Z^*) + t_1^* f(nK-Z^*)'}{f(nK-Z^*)''(nK-Z^*) + (1-t_2^*)f(K+Z^*)''nK} \\ &= 1 + \frac{-(1-t_2^*)f(K+Z^*)''Z^* + t_1^* f(nK-Z^*)'}{f(nK-Z^*)''(nK-Z^*) + (1-t_2^*)f(K+Z^*)''nK}. \end{aligned} \tag{4.40}$$

Whether (4.40) is greater than 1 or not depends on the sign of Z^*. If Z^* is positive, (4.15) is always less than 1. This implies the under-supply of public goods in the country with larger per capita capital endowment.

The objective of country 2 is

$$\max_{t_2} W(C_2, G_2) \tag{4.41}$$

subject to

$$\begin{aligned} C_2 &= f(K+Z) - f(K+Z)'(t_2K + Z), \\ G_2 &= t_2 f(K+Z)'(K+Z), \\ 0 &\leq t_2 < 1, \\ -K &\leq Z \leq nK. \end{aligned} \tag{4.42}$$

The first-order conditions give

$$\frac{W_{C_1}}{W_{G_1}} = \frac{f(K+Z)'(K+Z) + t_2 f(K+Z)''(K+Z)\psi}{f(K+Z))'K + f(K+Z)''(t_2K+Z)\psi} \\ \frac{+t_2 f(K+Z)'\psi}{}, \tag{4.43}$$

where

$$\psi = \frac{\partial Z}{\partial t_2}. \tag{4.44}$$

We can define ψ from (4.32) as follows.

$$\psi = \frac{f(K+Z)'}{(1-t_1)f(nK-Z)'' + (1-t_2)f(K+Z)''}. \tag{4.45}$$

By plugging (4.45) into (4.43), we get

$$\begin{aligned} \frac{W^*_{C_2}}{W^*_{G_2}} &= \frac{(1-t_1^*)f(nK-Z^*)''(K+Z^*) + f(K+Z^*)''(K+Z^*) + t_2^* f(K+Z^*)'}{(1-t_1^*)f(nK-Z^*)''K + f(K+Z^*)''(K+Z^*)} \\ &= 1 + \frac{(1-t_1^*)f(nK-Z^*)''Z^* + t_2^* f(K+Z^*)'}{(1-t_1^*)f(nK-Z^*)''K + f(K+Z^*)''(K+Z^*)}. \end{aligned} \tag{4.46}$$

Whether (4.46) is less than 1 is ambiguous when Z^* is positive. This implies that public goods is either under-provided or over-provided in the country with smaller per capita capital endowment.[5]

With given $\alpha = 0.5$ and $\beta = 1$, the reaction functions of country 1 and country 2 are respectively

$$n(1-2t_1)(1-t_2)^4 + (2n+1-2nt_1)(1-t_1)^4$$

[5]With given example, at the non-cooperative equilibrium, the private and public consumption of country 2 are

$$C_2 = \frac{1}{2}\{\frac{(n+1)K}{2}\}^{0.5} + \frac{1}{4}\{\frac{(n+1)K}{2}\}^{-0.5}K$$

and

$$G_2 = \frac{1}{4}\{\frac{(n+1)K}{2}\}^{0.5}.$$

Here, public goods is under-provided.

$$
\begin{aligned}
&+(1-t_1)(1-t_2)^2\{4nt_1{}^2-3(3n+1)t_1+3n+1\} \\
&= 0, \qquad (4.47)
\end{aligned}
$$

and

$$
\begin{aligned}
&(1-2t_2)(1-t_1)^4+(n+2-2nt_2)(1-t_2)^4 \\
&+(1-t_2)(1-t_1)^2\{4t_2{}^2-3(n+3)t_2+n+3\} \\
&= 0. \qquad (4.48)
\end{aligned}
$$

With $n=1$, the reaction functions are the same with (4.22) and symmetric for $t_1=t_2$. When $n=2$, the reaction functions are

$$
\begin{aligned}
&2(1-2t_1)(1-t_2)^4+(5-4t_1)(1-t_1)^4 \\
&+(1-t_1)(1-t_2)^2(8t_1{}^2-21t_1+7) \\
&= 0 \qquad (4.49)
\end{aligned}
$$

and

$$
\begin{aligned}
&(1-2t_2)(1-t_1)^4+2(2-t_2)(1-t_2)^4 \\
&+(1-t_2)(1-t_1)^2(4t_2{}^2-15t_2+5) \\
&= 0. \qquad (4.50)
\end{aligned}
$$

The reaction functions are not symmetric for $t_1=t_2$ as shown in Figure 4.2. At the equilibrium, however, the tax rates are ($t_1^*=t_2^*=0.5$).[6] Both countries set their

[6]We have the same result regardless of the value of n.

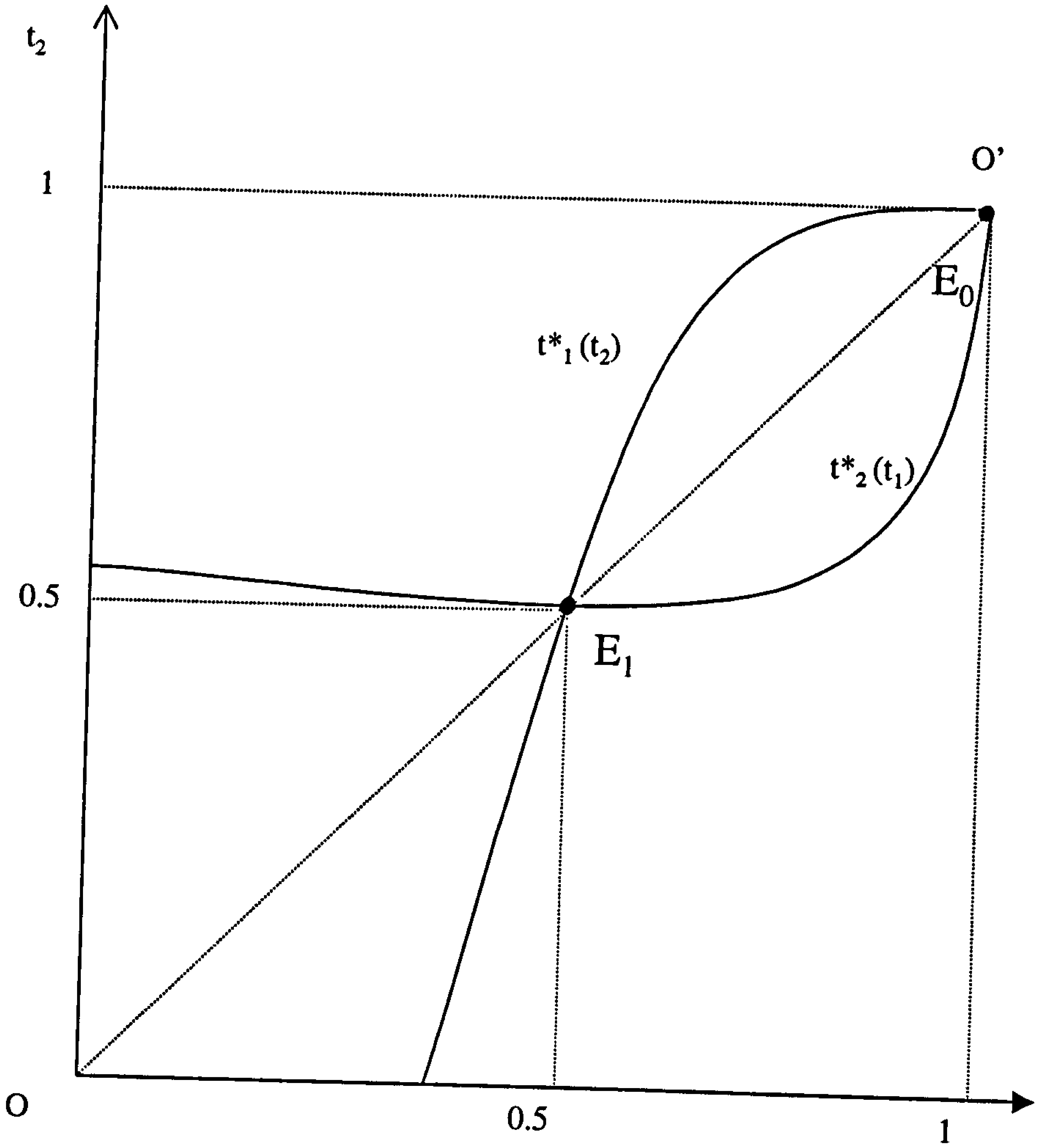

Figure 4.2: Asymmetric tax competition of different capital endowment

tax rates lower than those in autarky. However, as long as the new tax rates are the same in both countries, the capital allocation is efficient worldwide. Total capital in the world, $(1+n)K$, is divided to the same amount to the each country, $\frac{(1+n)K}{2}$.[7]

Proposition 13 *At the non-cooperative equilibrium, both countries set their tax rates at the same level regardless of difference in their per capita capital endowments. Each country attracts a half of the world capital, which is an efficient allocation of capital. The country with larger per capita capital endowment is worse off than in autarky due to the capital flight and the under-supply of public goods, while the country with smaller endowment is either worse off or better off.*

4.4 Different preference for public consumption

Suppose now that countries are different, in that country 1 has a relatively strong preference for public goods and country 2 has a relatively weak preference for public goods. Without losing generality, suppose that country 1 has a preference for public goods twice as strong as that of country 2. Then, using the welfare function defined in (3.59), we can define welfare function of two countries as

$$W(C_1, G_1) = \ln C_1 + \ln G_1 \tag{4.51}$$

[7]Country 1, which have higher per capita capital endowment, is regarded as rich country and country 2 as poor country. In this context, Proposition 13 is interpreted as that tax competition does not create tax differential between rich countries and poor countries at the non-cooperative equilibrium.

and

$$W(C_2, G_2) = 2 \ln C_2 + \ln G_2. \tag{4.52}$$

In autarky, the objective of country i is

$$\max_{t_i} W(C_i, G_i) \tag{4.53}$$

subject to

$$\begin{aligned} C_i &= f(K) - t_i K f(K)', \\ G_i &= t_i K f(K)', \\ 0 &\leq t_i < 1. \end{aligned} \tag{4.54}$$

The first-order conditions give

$$\frac{W_{C_i}}{W_{G_i}} = \frac{Kf(K)'}{Kf(K)'} = 1. \tag{4.55}$$

With the production function given as (3.60), the tax rates in country 1 and country 2 are

$$t_1^A = \frac{1}{2\alpha} \tag{4.56}$$

and

$$t_2^A = \frac{1}{3\alpha}. \tag{4.57}$$

With $\alpha = 0.5$, the optimal tax rates in two countries can be calculated. As shown in Table 3.1, country 1, which has a relatively strong preference for public goods, sets its tax rate higher than that of country 2 in autarky.

Now, assume that capital can move across the borders. When Z is net outflow of capital from country 1, the market equilibrium condition of capital is

$$(1-t_1)f(K-Z)' = (1-t_2)f(K+Z)'. \tag{4.58}$$

The private consumption and the public consumption of country 1 are

$$C_1 = f(K-Z) - f(K-Z)'(t_1K - Z) \tag{4.59}$$

and

$$G_1 = t_1 f(K-Z)'(K-Z). \tag{4.60}$$

The objective of country 1 is

$$\max_{t_1} W(C_1, G_1) \tag{4.61}$$

subject to

$$\begin{aligned} C_1 &= f(K-Z) - f(K-Z)'(t_1K - Z), \\ G_1 &= t_1 f(K-Z)'(K-Z), \\ 0 &\leq t_1 < 1, \\ -K &\leq Z \leq K. \end{aligned} \tag{4.62}$$

The first-order conditions give

$$\frac{W_{C_1}}{W_{G_1}} = \frac{f(K-Z)'(K-Z) - t_1 f(K-Z)''(K-Z)\psi}{f(K-Z)'K + f(K-Z)''(t_1K-Z)\psi} \\ \frac{-t_1 f(K-Z)'\psi}{\qquad\qquad}, \tag{4.63}$$

where

$$\psi = \frac{\partial Z}{\partial t_1}.$$

We can define ψ from (4.58) as

$$\psi = \frac{-f(K-Z)'}{(1-t_1)f(K-Z)'' + (1-t_2)f(K+Z)''}. \tag{4.64}$$

By plugging (4.64) into (4.63), we get

$$\begin{aligned}\frac{W^*_{C_1}}{W^*_{G_1}} &= \frac{f(K-Z^*)''(K-Z^*) + (1-t_2^*)f(K+Z^*)''(K-Z^*) + t_1^* f(K-Z^*)'}{f(K-Z^*)''(K-Z^*) + (1-t_2^*)f(K+Z^*)''K} \\ &= 1 + \frac{-(1-t_2^*)f(K+Z^*)''Z^* + t_1^* f(K-Z^*)'}{f(K-Z^*)''(K-Z^*) + (1-t_2^*)f(K+Z^*)''K}.\end{aligned} \tag{4.65}$$

Whether (4.65) is greater than 1 or not depends on the sign of Z^*. If Z^* is positive, (4.65) is always less than 1. This implies the under-supply of public goods in the country with a strong preference for public goods.

The objective of country 2 is

$$\max_{t_2} W(C_2, G_2) \tag{4.66}$$

subject to

$$\begin{aligned} C_2 &= f(K+Z) - f(K+Z)'(t_2K+Z), \\ G_2 &= t_2 f(K+Z)'(K+Z), \\ 0 &\leq t_2 < 1, \\ -K &\leq Z \leq K. \end{aligned} \tag{4.67}$$

The first-order conditions give

$$\frac{W_{C_1}}{W_{G_1}} = \frac{f(K+Z)'(K+Z) + t_2 f(K+Z)''(K+Z)\psi + t_2 f(K+Z)'\psi}{f(K+Z))'K + f(K+Z)''(t_2K+Z)\psi}, \tag{4.68}$$

where

$$\psi = \frac{\partial Z}{\partial t_2}.$$

We can define ψ from (4.58) as follows.

$$\psi = \frac{f(K+Z)'}{(1-t_1)f(K-Z)'' + (1-t_2)f(K+Z)''}. \tag{4.69}$$

By plugging (4.69) into (4.68), we get

$$\begin{aligned} \frac{W^*_{C_2}}{W^*_{G_2}} &= \frac{(1-t^*_1)f(K-Z^*)''(K+Z^*) + f(K+Z^*)''(K+Z^*) + t^*_2 f(K+Z^*)'}{(1-t^*_1)f(K-Z^*)''K + f(K+Z^*)''(K+Z^*)} \\ &= 1 + \frac{(1-t^*_1)f(K-Z^*)''Z^* + t^*_2 f(K+Z^*)'}{(1-t^*_1)f(K-Z^*)''K + f(K+Z^*)''(K+Z^*)}. \end{aligned} \tag{4.70}$$

Whether (4.70) is less than 1 is ambiguous when Z^* is positive. This implies that public goods is either under-provided or over-provided in the country with a weak preference for public goods[8].

With given social welfare function in (4.51) and (4.52) and $\alpha = 0.5$, the reaction function of country 1 and country 2 are respectively

$$(1-2t_1)(1-t_2)^4 + (3-2t_1)(1-t_1)^4$$

[8]With given example, at the non-cooperative equilibrium, the amount of capital moving from country 1 to country 2 is

$$Z = \{\frac{(1-t_1)^{-2} - (1-t_2)^{-2}}{(1-t_1)^{-2} + (1-t_2)^{-2}}\}K = 0.1256K.$$

The marginal substitution between private and public consumption is

$$\frac{W^*_{C_2}}{W^*_{G_2}} = \frac{0.4350K^{0.5}}{0.8085K^{0.5}} < 1.$$

Here, public goods is under-provided.

$$
\begin{aligned}
& +4(1-t_1)(1-t_2)^2(4{t_1}^2-3t_1+1) \\
= \; & 0 \qquad (4.71)
\end{aligned}
$$

and

$$
\begin{aligned}
& (1-2t_2)(1-t_1)^4+(1-t_2)^5 \\
& +(1-t_2)(1-t_1)^2(5{t_2}^2-16t_2+4) \\
= \; & 0. \qquad (4.72)
\end{aligned}
$$

The reaction functions are drawn in Figure 4.3. At the equilibrium, the tax rates are $(t_1 = 0.48, t_2 = 0.41)$. Both countries set their tax rates below the level in autarky. Country 2, which has a weak preference for public goods set its tax rate below that of country 1, which has a strong preference for public goods. Capital moves from country 1 to country 2. Country 1 is worse off than in autarky because of the under-supply of public goods and capital flight. Country 2 is also worse off if the negative effect of the under-supply of public goods outweighs the positive effect of inflow of capital. Compared with the autarkic equilibrium ($t_1 \simeq 1.00$, $t_2 = 0.67$), the country with a strong preference for public goods reduces its tax rate to a greater degree than the country with a weak preference for public goods at the non-cooperative equilibrium. As a result, the tax differential between two countries becomes smaller.

Proposition 14 *At the non-cooperative equilibrium, the country with a weak preference for public goods has a lower tax rate than the country with a strong preference and attracts foreign capital. However, the latter cuts tax rate to a greater degree than*

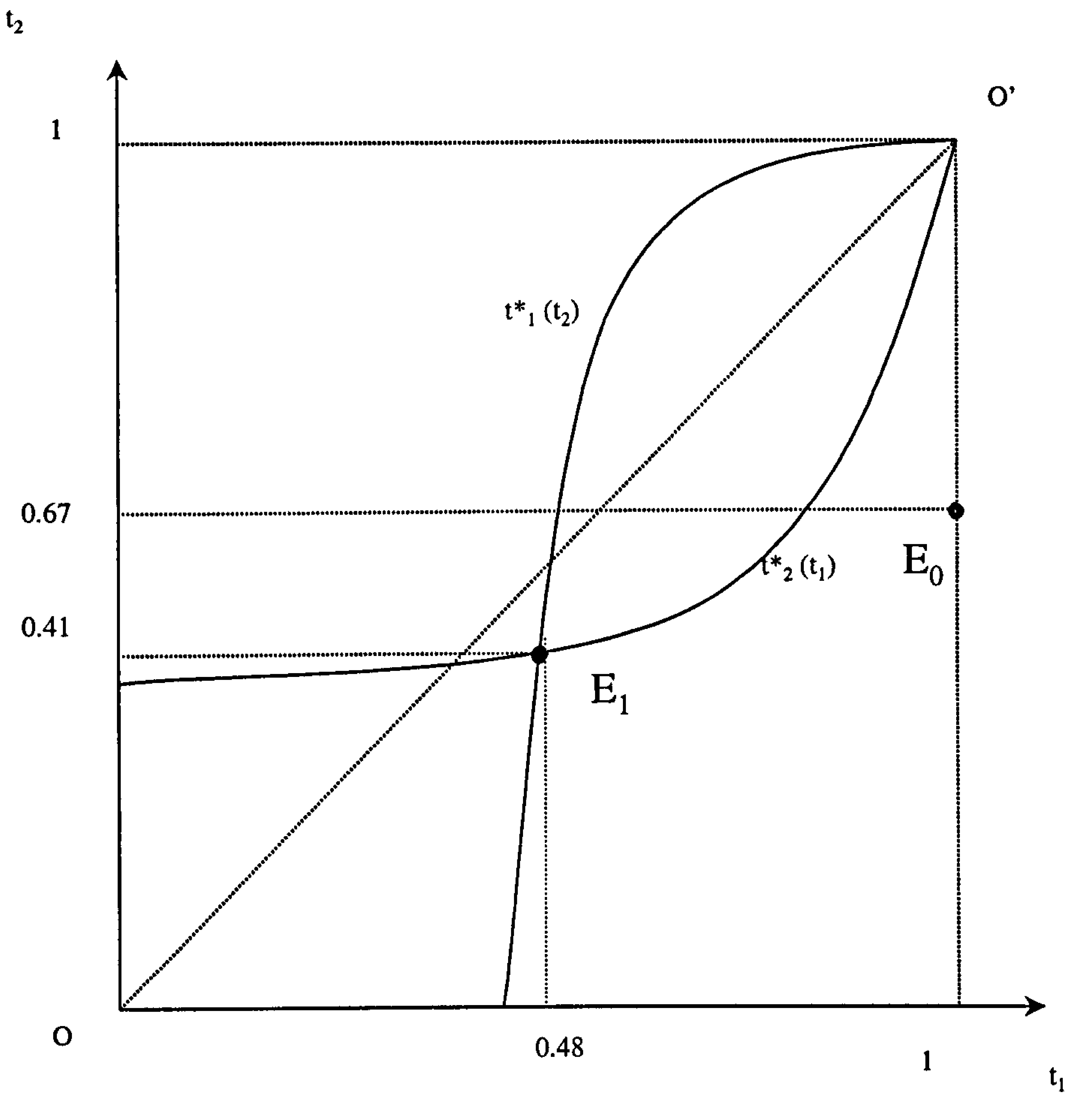

Figure 4.3: Asymmetric tax competition of different preference for public goods

the former. The country with a strong preference for public goods is worse off than in autarky due to the capital flight and the under-supply of public goods, while the country with a weak preference is either worse off or better off.

4.5 International coordinations

Existing research suggests that international tax harmonization is not feasible when there are asymmetries between countries. When two countries are different in size, the small country is opposed to it if it is better off at the non-cooperative equilibrium than at the coordinated outcome (see Bucovetsky [1991] and Wilson [1991]). Kanbur and Keen (1993) propose the imposition of a minimum tax rate which is strictly Pareto-improving. However, this is not applied to three cases presented here. As Haufler (1996b) pointed out, the imposition of minimum tax rate is not always welfare-improving for both countries if governments care about private consumption and public consumption.[9] In addition, the imposition of minimum tax rate is technically impossible in the asymmetrical case of different per capita capital endowments because tax rates at the non-cooperative equilibrium are the same.

We consider an alternative form of tax coordination where both countries increase tax rates by the same amount. The smaller country (the country with smaller per capita capital endowment and the country with a weak preference for public goods) always prefers this cooperative equilibrium to the non-cooperative equilibrium be-

[9]In Kanbur and Keen (1993), governments are assumed to behave as revenue-maximizers.

cause it can increase supply of public goods, keeping the amount of capital inflow the same. However, the larger country (the country with larger per capita capital endowment and the country with a strong preference for public goods) may oppose this tax coordination because the income from capital located abroad is decreased by the higher tax rate of foreign country. The larger country (the country with larger per capita capital endowment and the country with a strong preference for public goods) consents to this tax coordination only when the positive effect of increase in public goods outweighs the negative effect of decrease in the income from foreign investment.

Firstly, let's investigate the effect of this tax coordination in the case of tax competition between countries of different sizes. Given the social welfare function in (3.59), the production function in (3.60), $\beta = 1$, $\alpha = 0.5$ and $n = 2$, the amount of capital moving from country 1 to country 2 at the non-cooperative equilibrium, $(t_1^* = 0.54, t_2^* = 0.47)$, is

$$Z^* = \{\frac{(1-t_1^*)^{-2} - (1-t_2^*)^{-2}}{0.5(1-t_1^*)^{-2} + (1-t_2^*)^{-2}}\}K = 0.17K. \tag{4.73}$$

At the non-cooperative equilibrium, the social welfare of country 1 is

$$W_1^*(C_1^*, G_1^*) \tag{4.74}$$

where

$$C_1^* = nf(K - \frac{Z^*}{n}) - f(K - \frac{Z^*}{n})'(t_1^* nK - Z^*) \tag{4.75}$$

and

$$G_1^* = t_1^* f(K - \frac{Z^*}{n})'(nK - Z^*). \tag{4.76}$$

The effect of an arbitrarily small increase of t_1 on the social welfare is

$$\begin{aligned}
\frac{\partial W_1}{\partial t_1} &= (\frac{\partial W_1^*}{\partial C_1})\{-f(K-\frac{Z^*}{n})'nK\} + (\frac{\partial W_1^*}{\partial G_1})\{f(K-\frac{Z^*}{n})'(nK-Z^*)\} \\
&= \frac{\{-f(K-\frac{Z^*}{n})'nK\}}{C_1^*} + \frac{\{f(K-\frac{Z^*}{n})'(nK-Z^*)\}}{G_1^*} \\
&= \frac{-1.0454K^{0.5}}{1.43734K^{0.5}} + \frac{\{f(K-\frac{Z^*}{n})'(nK-Z^*)\}}{t_1^* f(K-\frac{Z^*}{n})'(nK-Z^*)} \\
&= -0.727 + 1.852 > 0 \qquad (4.77)
\end{aligned}$$

Therefore, country 1 is in favour of the coordination of arbitrarily small increase in tax rates of both countries maintaining the gap in tax rates at the non-cooperative equilibrium.

Secondly, when asymmetry derives from the differences in per capita capital endowment, the tax rate at the non-cooperative equilibrium is the same in both countries. Given $n = 2$, the amount of capital moving from country 1 to country 2 at the non-cooperative equilibrium, $(t_1^* = t_2^* = 0.5)$, is

$$Z^* = \frac{K}{2}. \qquad (4.78)$$

At the non-cooperative equilibrium, the social welfare of country 1 is

$$W_1^*(C_1^*, G_1^*) \qquad (4.79)$$

where

$$C_1^* = f(nK - Z^*) - f(nK - Z^*)'(t_1^* nK - Z^*) \qquad (4.80)$$

and

$$G_1^* = t_1^* f(nK - Z^*)'(nK - Z^*). \qquad (4.81)$$

The effect of an arbitrarily small increase of t_1 on the social welfare is

$$\begin{aligned}
\frac{\partial W_1^*}{\partial t_1} &= (\frac{\partial W_1^*}{\partial C_1})\{-f(nK - Z^*)'nK\} + (\frac{\partial W_1^*}{\partial G_1})\{f(nK - Z^*)'(nK - Z^*)\} \\
&= \frac{\{-f(nK - Z^*)'nK\}}{C_1^*} + \frac{\{f(nK - Z^*)'(nK - Z^*)\}}{G_1^*} \\
&= \frac{-0.8165K^{0.5}}{1.02062K^{0.5}} + \frac{\{f(nK - Z^*)'(nK - Z^*)\}}{t_1^*\{f(nK - Z^*)'(nK - Z^*)\}} \\
&= -0.800 + 2 > 0
\end{aligned} \tag{4.82}$$

Therefore, country 1 is in favour of the coordination of arbitrarily small increase in tax rates of both countries maintaining the gap in tax rates at the non-cooperative equilibrium.

Lastly, when the asymmetry comes from the difference in the preference for public goods, the amount of capital moving from country 1 to country 2 at the non-cooperative equilibrium, $(t_1 = 0.48, t_2 = 0.41)$, is

$$Z = \{\frac{(1-t_1)^{-2} - (1-t_2)^{-2}}{(1-t_1)^{-2} + (1-t_2)^{-2}}\}K = 0.1256K. \tag{4.83}$$

At the non-cooperative equilibrium, the social welfare of country 1 is

$$W_1^*(C_1^*, G_1^*) \tag{4.84}$$

where

$$C_1^* = f(K - Z^*) - f(K - Z^*)'(t_1^*K - Z^*) \tag{4.85}$$

and

$$G_1^* = t_1^* f(K - Z^*)'(K - Z^*). \tag{4.86}$$

The effect of an arbitrarily small increase in t_1 on the social welfare is

$$\begin{aligned}
\frac{\partial W_1^*}{\partial t_1} &= (\frac{\partial W_1^*}{\partial C_1})\{-f(K-Z^*)'K\} + (\frac{\partial W_1^*}{\partial G_1})\{f(K-Z^*)'(K-Z^*)\} \\
&= \frac{\{-f(K-Z^*)'K\}}{C_1^*} + \frac{\{f(K-Z^*)'(K-Z^*)\}}{G_1^*} \\
&= \frac{-0.5348K^{0.5}}{0.6849K^{0.5}} + \frac{\{f(K-Z^*)'(K-Z^*)\}}{t_1^* f(K-Z^*)'(K-Z^*)} \\
&= -0.781 + 2.083 > 0 \qquad (4.87)
\end{aligned}$$

Therefore, the country with a strong preference for pubic goods is in favour of arbitrarily small increase in tax rates of both countries.

Proposition 15 *A Pareto improving tax coordination is for both the smaller country (the country with smaller per capita capital endowment and the country with a weak preference for public goods) and for the larger country (the country with larger per capita capital endowment and the country with a strong preference for public goods) to increase their tax rates by equal amount.*

Therefore, the proposed tax coordination is feasible in all three cases because it is welfare-improving for both countries. Two points, however, need to be mentioned. Firstly, the above result is applied to an arbitrarily small increase in tax rates. In practice, the change in social welfare of the larger country (the country with larger per capita capital endowment and the country with a strong preference for public goods) depends on the size tax increase. Secondly, the feasibility of the tax coordination depends on two parameters. From the first line of (4.77), we can say that capital exporting country might be better off by this coordination when the net out flow of capital, Z^*, is small and the substitution between private goods and public goods, $(\frac{\partial W^*}{\partial C_1})/(\frac{\partial W^*}{\partial G_1})$, is small. These are self-explanatory; if the amount of exported capital is small, an increase in the tax rate of the foreign country causes small reduction in the income from foreign investment; if the substitution between private goods and public goods is small, an increase in public consumption by higher tax rate is more effective in increasing the social welfare.

4.6 Conclusion

Three cases of asymmetric tax competition are analysed in this chapter. When asymmetry derives from differences in the size of countries, the smaller country sets its tax rate below that of the larger country at the non-cooperative equilibrium. Therefore, capital moves from the larger country to the smaller country. The larger country is always worse off than in autarky due to the capital flight and the under-supply of public goods. The smaller country can be better off if the positive effect of capital inflow outweighs the negative effect of the under-supply of capital.

The second asymmetry derives from different initial endowments of capital per capita. At the non-cooperative equilibrium, both countries set their tax rates below those in autarky. However, because the new tax rates of two countries are the same, there is no distortion from the misallocation of the world capital. The country with larger per capita capital endowment is always worse off than in autarky due to the capital flight and the under-supply of public goods. The country with smaller per capita capital endowment can be better off if the positive effect of capital inflow outweighs the negative effect of the under-supply of capital.

The third asymmetry derives from different preferences for public goods. At the non-cooperative equilibrium, the country with a relatively weak preference for public goods sets its tax rate below that of the country with a relatively strong preference for public goods. Therefore, capital moves from the latter to the former. The latter becomes worse off due to the capital flight and the under-supply of public goods. The former can be better off if the positive effect of capital inflow outweighs the negative effect of the under-supply of capital.

It is found to be welfare-improving for both countries to raise their tax rates by the same amount in all three cases. The smaller country (the country with smaller per capital and the country with a weak preference for public goods) always prefers this cooperative outcome to the non-cooperative one because the differential at the non-cooperative equilibrium is maintained and thus the amount of capital inflow is the same. The larger country (the country with larger per capita capital and the country with a strong preference for public goods) consents to this tax coordination only when the positive effect of an increase in public goods outweighs the negative effect of a decrease in the income from foreign investment. Numerical calibrations show that this is the case in any asymmetric tax competition.

One of advantages[10] of this tax coordination is that the benefit and cost of the

[10]The disadvantage of this tax coordination is that it dose not improve efficiency in capital allocation caused by tax differentials. This might be a reason why it has not been fully considered in

coordination is easily calculated by each country because it does not change the allocation of capital. Only the amount of increased tax revenue by higher tax rate of its own and the amount of reduced foreign income due to higher tax rate of foreign country are taken into account by the larger country (the country with large per capita capital endowment and the country with a strong preference for public goods). Tax harmonization and the imposition of minimum tax rate create uncertainty on capital allocation and on change in welfare. The other advantage is that this is feasible in all asymmetric cases discussed in this chapter. In realty, tax differentials among countries reflect compound effect of various different asymmetries and we cannot differentiate the sources of tax differentials. In this situation, this tax coordination is feasible irrespective of the source of asymmetry.

In addition to the three elements of asymmetry analysed in this chapter, there are a variety of sources of asymmetry. Countries differ in the extent of their budget constraints, in the productivity of immobile factors, in the productivity of public sector, etc. The analysis carried out in this chapter can be extended to those cases.

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subsequent studies after Crombrugghe and Tulkens (1990).

Chapter 5

Tax rule and tax competition

5.1 Introduction

Tax competition is closely related with the tax principle. Most of theoretical models of tax competition assume that capital income is taxed by a source-based tax. If countries employ a residence-based tax, tax competition is no longer a problem. In an international context, tax rule is a decision variable for a country which fight against capital flight. A country can strategically choose its tax between a source-based tax and a residence-based tax.

Earlier studies have recognized the effect of tax rules on the capital allocation between countries. One issue is which double taxation relief method yields more efficient allocation of capital. While Hamada (1969), for example, advocates the credit rule, Bond and Samuelson (1989) favour the deduction rule. On the other hand, Mintz and Tulkens (1996) find that the residence principle is not compatible with the non-cooperative equilibrium while Razin and Sadka (1991) assert that it can be sustained as the non-cooperative equilibrium.

Even if tax rules are recognized to have an influence on tax competition by those studies, they are not treated as a strategic decision element as tax rates are. Janeba (1995) presents a model in which the decision on tax rules can also be a strategic element used by governments in a similar way to the decision on tax rates. Given that the decision on a tax rule is a long-term decision and remains fixed for a long time, while tax rates changes annually, he assumes that, at the first stage, both governments decide their tax rules simultaneously and, then, with knowledge of each other's tax rules, also decide their tax rates simultaneously.

His analysis shows that the decision on tax rules has no influence on national income and capital flow. The capital-exporting country prefers less capital outflow when the host country taxes foreign investment income. Therefore, the capital exporting country sets its tax rate to zero. With zero tax rate, the form of double taxation relief becomes irrelevant. However, his model cannot fully exploit the strategic characteristics of tax rules because tax rules are decided only by the capital-exporting country. His results also imply that the tax rate of the capital-importing country will be increased than the optimal level. This result runs counter to the prediction of tax competition theory that tax competition leads to lower tax rates.[1]

[1]Lower tax rates are not unanimously predicted. Ghosh (1991) predicts that public goods can be either over-supplied or under-supplied by tax competition.

In this chapter, the structure of the game is similar to that in Janeba (1995). There are, however, three major differences between his model and that presented here. Firstly, in his model, one country is assumed to be a potential exporter of capital and the other an importer of capital. This assumption limits the analysis in that tax rules are decided by only one country, capital-exporting country. In contrast, I present a game between two identical economies, which produces a variety of strategic behaviours. Either country can be a capital-exporting country and the tax rule of both countries is relevant to the result.

Secondly, in this thesis, each government is assumed to maximize its social welfare as a function of private consumption and of public consumption. Janeba (1995) assumes that governments optimize their national income as the sum of domestic output and net factor payments to the other country. His striking conclusion such that the tax rate in the capital-exporting country tends to drop to zero and the decision on forms of double taxation relief is irrelevant derives from this objective function. When the supply of public goods is financed by other taxes than capital income tax, the international mobility of capital forces capital income tax to vanish.

Lastly, Janeba (1995) analyses only the game in which the decisions on tax rules are among methods of double taxation relief: exemption, credit, and deduction. In addition to these, I also analyse the situation in which the decisions on tax rules are among the residence principle and the source principle. This is informative because many tax competition models employ the assumption that the capital tax is a source-based tax.

In section 3, each government is assumed to select one tax rule from five variations of the residence principle and the source principle.[2] When one country applies the residence principle and the other applies the source principle, the income from the capital invested abroad is taxed not only by the host country but also by the home country. The home country which applies the residence principle has five options through which it can relieve the burden of double taxation.[3] Therefore, altogether there are six options for each government in selecting its tax rule. These strategies for each government make thirty six subgames, which reduce to twenty one different subgames due to the symmetry. For each subgame, tax rates at the Nash equilibrium are sought and then the social welfare of both countries can be defined. By comparing these social welfare at the equilibrium in each subgame, I will find the subgame perfect Nash equilibrium.

[2]According to the residence principle, residents are taxed on their worldwide income equally, regardless of whether the source of the income is domestic or foreign and foreigners are not taxed at all. According to the source principle, residents of a country are not taxed on their income from foreign sources and foreigners are taxed equally as residents on income from domestic sources.

[3]The home country which applies the residence principle has five options through which to relieve the burden from double taxation. First, the government ignores the problem of double taxation (No adjustment). By ignoring, it can discriminate the outgoing investment. Second, the government can tax the income net of tax paid to the foreign government (Deduction). Third, the government can give full credit for the tax paid to the foreign government from the tax calculated on the total income of domestic investment and investment abroad (Full credit). If the tax credit is greater than the tax payable to the government, the government may repay the money back. Fourth, the government can give the credit with limitation up to the amount of the tax payable to the government (Credit with limitation). With this system, the money is not given to the taxpayer even if the tax paid to the foreign government is greater than the tax payable to the domestic government. The double taxation problem is relieved partially. Finally, the government may tax only the income earned domestically exempting the income earned abroad from calculating tax base income (Exemption). In this case, the owner of capital can benefit from this exemption by allocating investment abroad if the domestic tax rate is higher than the foreign tax rate or the domestic tax rule adopts progressivity even if the domestic tax rate is the same with the foreign tax rate.

It is found that the game has multiple subgame perfect Nash equilibria. Each country adopts one of four variations of the residence principle: no adjustment, deduction, credit with limitation and exemption. However, tax rates under one of four tax rules are the same with optimal tax rate and thus there is no distortion from tax competition. The simple intuitive explanation for this result is that these four tax rules never treat the income from capital located abroad preferentially to that from capital at home. Therefore, these four tax rules perfectly protect the country from capital flight.

In section 4, each government is assumed to select the double taxation relief method under the world income taxation. Currently, most countries adopt the principle of world income taxation, which is a mixture of the source principle and the residence principle.[4] Under the principle of world income taxation, foreign investment is always subject to international double taxation because the income of capital invested abroad is subject to both the host country's tax and the home country's tax. Each government is assumed to select one of three methods: deduction, credit with limitation and exemption.

The equilibrium under the world income taxation is similar to that of the case in

[4]For example, suppose that 'A-Company', established in the UK and entirely owned by UK nationals, sets up a subsidiary in the US. The income of the subsidiary is subject to the US corporation tax but it is not subject to the UK corporation tax if the income is not repatriated to 'A-Company'. The above shows that the UK is applying source principle in the corporation tax. However, when the income of the subsidiary is sent to 'A-Company', 'A-Company' has to pay the corporation tax on the sum of its own income in the UK and the income received from the subsidiary. This looks as though the UK is applying the residence principle. There are many complications in corporation tax and applications are different across countries and across the form of investment abroad.

which the source principle and the residence principle are decision variables. Both countries always adopt the credit method or the deduction method which never treats investments abroad preferentially to domestic investments. Once these rules are employed, tax competition does not occur at all. The tax rates in both countries are optimal for each country and world-wide and international tax coordination (harmonization) is therefore not necessary.

The paper is organized as follows. The model is described in the next section. In section 3, I analyse the situation in which the decision on tax rules is between the residence principle and the source principle. In section 4, the decision is on the method of double taxation relief under the world income taxation. Concluding remarks are presented in the final section, together with limitations and suggestions of extension.

5.2 The model

The basic assumptions made concerning the social welfare function, the production function, the objective function of governments and firms' decision on location of capital are the same as those made in chapter 3. The structure of the game, however, requires one change. At first, each government decides its tax rule simultaneously. In the second stage, the two governments set their corporation tax rates knowing the tax rule of the other country. Firms in both countries decide how much capital to locate at home and how much abroad, after knowing tax rules and tax rates, domestic and foreign. Firms are given full information about the corporation tax

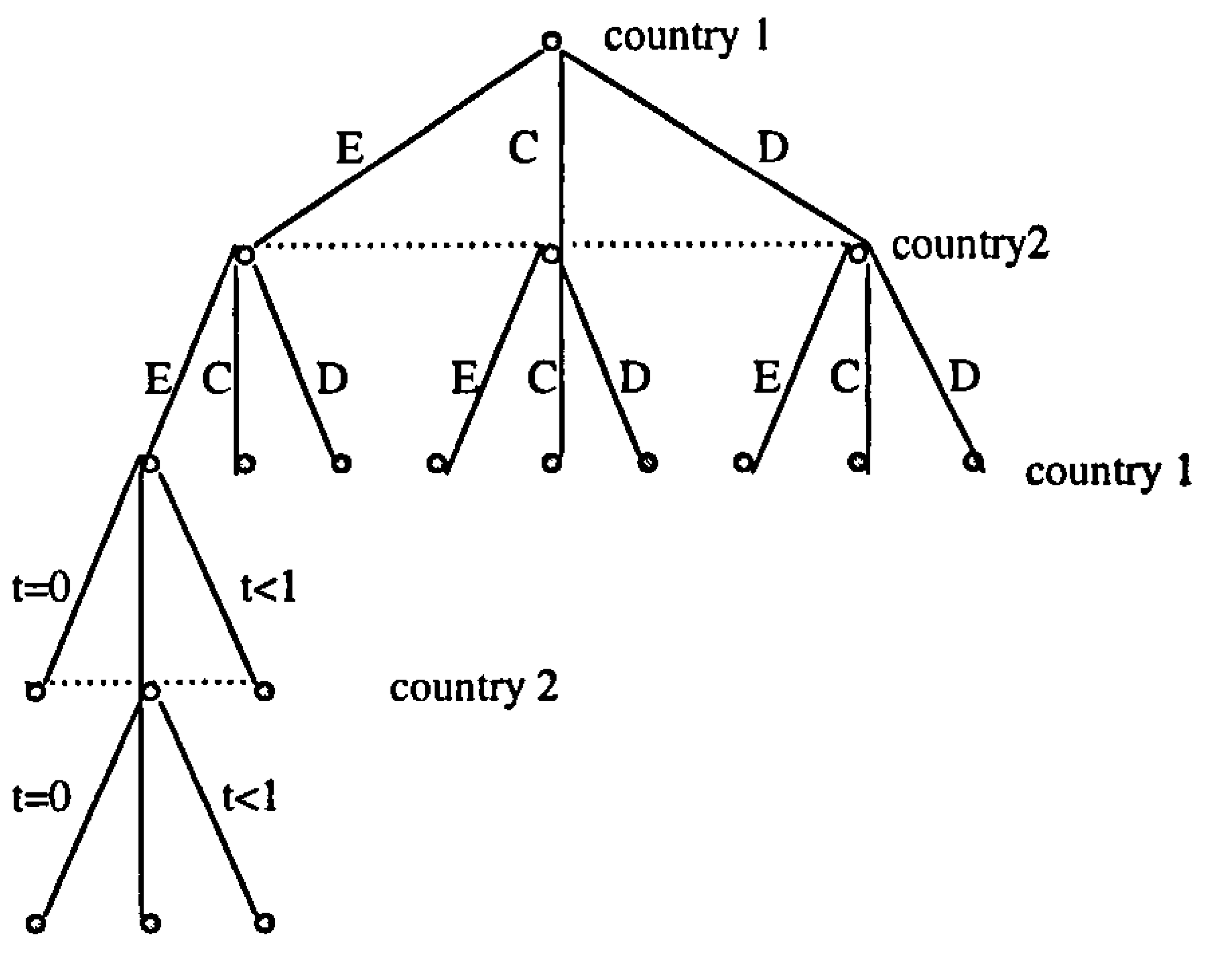

Figure 5.1: Structure of the game of tax rules and tax rates

rules and rates of the two countries which are known and fixed. Each government takes other government's corporation tax rule and rate as given and fixed. A non-cooperative Nash equilibrium is reached when the owners of capital maximize their capital incomes, given tax rates and tax rules, and each government has no incentive to alter its corporation tax rule and rate, given the tax rule and rate of the other government.

Figure 5.1 illustrates the structure of the game in which world income taxation is applied. Both countries decide their tax rule - exemption (E), credit(C) or deduction(D) - simultaneously and then, knowing each other's decision on tax rule, decide their tax rates simultaneously. Therefore, in Figure 5.1, the first decision nodes of country 2 are joined into an information set because country 2 does not know the tax rule of country 1 when it decides its tax rule. However, the second decision nodes of country 1 are not joined and every node is a single information set because country 1 knows its own tax rule and that of the other country. Again, the second decision nodes of country 2 are joined into an information set because country 2 does not know the tax rate of country 1.

The equilibrium in this game can be sought by a backward induction method. The whole game is divided into several subgames according to the tax rules two countries select. Tax rates at Nash equilibrium in each subgame are sought. With a reduced game where the following subgame is replaced with the Nash equilibrium outcome, the Nash equilibrium of the whole game can be defined. The equilibrium sought here is the subgame perfect Nash equilibrium.

5.3 Source principle vs residence principle

5.3.1 When both countries apply residence principles

When both countries apply the residence principle, the income from capital, irrespective of its location, is subject to the corporation tax of the home country. Therefore, the market equilibrium condition for country i's capital is

$$(1 - t_i)f(K + (-1)^i Z)' = (1 - t_i)f(K + (-1)^j Z)', \quad i = 1, 2. \tag{5.1}$$

Given the strict concavity of the production function, Z is always 0. Therefore, there is no movement of capital between two countries when both countries apply the residence principle. Movement of capital is not influenced not only by domestic corporation tax but also by foreign corporation tax. Neither government's decision on corporation tax has an effect on the allocation of capital between countries and thus has an effect on the tax decision of the other government. In this situation, the tax rate is set at a level to maintain the optimal level of social welfare. The allocation of capital is also optimal worldwide.

These results are the same whichever tax rule of double taxation relief both countries employ. As far as the foreign country employs the residence principle, the income from the capital located in the foreign country is not subject to the foreign tax and thus the tax rule of the double taxation relief becomes irrelevant.

5.3.2 When both countries apply source principles

When the source principle is applied in both countries, the income from capital located in the home country is subject to the domestic tax rate and the income from the capital located in foreign country is subject to the tax rate of the foreign country. Therefore, the market equilibrium condition for country i's capital is

$$(1-t_i)f(K+(-1)^iZ)' = (1-t_j)f(K+(-1)^jZ)', \ i=1,2. \tag{5.2}$$

In this situation, an increase in the domestic tax rate increases the amount of capital moving from the domestic country to the foreign country. In contrast, an increase in the foreign tax rate diminishes the amount of capital moving from the domestic country to the foreign country. When setting its tax rate, each government considers the movement of capital which depends on the difference between two tax rates.

The objective of country i is

$$\max_{t_i} W(C_i, G_i) \tag{5.3}$$

subject to

$$\begin{aligned}
C_i &= f(K+(-1)^i Z) - f(K+(-1)^i Z)'(t_i K + (-1)^i Z), \\
G_i &= t_i f(K+(-1)^i Z)'(K+(-1)^i Z), \\
0 &\le t_i < 1, \\
-K &\le Z \le K.
\end{aligned}$$

The first-order conditions give

$$\frac{W_{C_i}}{W_{G_i}} = \frac{f(K+(-1)^i Z)'(K+(-1)^i Z) + (-1)^i t_i f(K+(-1)^i Z)''(K+(-1)^i Z)\psi}{f(K+(-1)^i Z)'K + (-1)^i f(K+(-1)^i Z)''(t_i K + (-1)^i Z)\psi + (-1)^i t_i f(K+(-1)^i Z)'\psi}, \tag{5.4}$$

where

$$\psi = \frac{\partial Z}{\partial t_i}.$$

We can define ψ from (5.2) as follows.

$$\psi = \frac{(-1)^i f(K+(-1)^i Z)'}{(1-t_i)f(K+(-1)^i Z)'' + (1-t_j)f(K+(-1)^j Z)''} \tag{5.5}$$

By plugging (5.5) into (5.4), we get

$$\frac{W_{C_i}}{W_{G_i}} = \frac{f(K+(-1)^i Z)''(K+(-1)^i Z)}{f(K+(-1)^i Z)''(K+(-1)^i Z)} \frac{(1-t_j)f(K+(-1)^j Z)''(K+(-1)^i Z) + t_i f(K+(-1)^i Z)'}{+(1-t_j)f(K+(-1)^j Z)''K}. \tag{5.6}$$

By symmetry, $t^* = t_1 = t_2$ at the equilibrium and it implies that $Z^* = 0$. Thereby, (5.6) is reduced to

$$\begin{aligned}\frac{W_C^*}{W_G^*} &= \frac{f(K)''K + (1-t^*)f(K)''K + t^*f(K)'}{f(K)''K + (1-t^*)f(K)''K} \\ &= 1 + \frac{t^*f(K)'}{(2-t^*)f(K)''K} < 1.\end{aligned} \tag{5.7}$$

(5.7) implies that the marginal utility from public consumption is greater than that from private consumption. Thus, it is welfare-increasing to consume more public goods and less private goods by increasing tax revenue with higher tax rate. This result implies under-supply of public goods and, at the same time, lower tax rate than the optimum. The tax rate at the non-cooperative equilibrium is the same for both countries. At the equilibrium, there is no distortion caused by capital allocation between two countries. The distortion of the under-supply of public goods arises either because of each government's incentive to attract foreign capital or because of the threat of tax base erosion caused by the lower tax rate of the foreign country (see chapter 3 for detailed analysis of the equilibrium).

5.3.3 When one country applies the residence principle and the other the source principle

No adjustment

When two countries apply the same tax principle - either the residence principle or the source principle - the world capital is allocated between the two countries according to one single equilibrium condition, respectively defined in (5.1) and (5.2). However, when two countries apply different tax principles, there is no single condition according to which the world capital is allocated. The condition which produces the same rate of return irrespective of location of capital differs between the capital of country 1 and the capital of country 2. There are three possibilities: both conditions are satisfied;[5] only one of them is satisfied; or neither of them is satisfied.

Suppose country 1 applies the residence principle without any double taxation relief and country 2 applies the source principle (throughout this subsection, country 2 is assumed to apply the source principle). For the capital of country 1, the income from the capital invested domestically is subject to the tax rate of country 1 and the income from the capital which is moved to country 2 is subject not only to the tax of country 1 but also to the tax of country 2. Therefore, the market equilibrium condition for country 1's capital[6] is

$$(1 - t_1)f(K - Z)' = (1 - t_1 - t_2)f(K + Z)'. \tag{5.8}$$

For the capital of country 2, the income from the capital invested domestically is subject to the tax of country 2 and the income from the capital moved to country 1 is not subject to any tax. Therefore, the market equilibrium condition for country

[5]More accurately, two conditions become the same in this case.

[6]The term 'the market equilibrium condition' is misleading because it may not stand at the equilibrium. This condition means that capital of country 1 should be allocated in order to earn an equal rate of return in the two countries. Therefore, the term 'the arbitrage condition of the allocation of country 1's capital' is technically more appropriate. However, for the sake of consistency, the first term is used throughout the thesis.

2's capital is

$$(1-t_2)f(K+Z)' = f(K-Z)'. \tag{5.9}$$

Only when $t_2 = 0$, (5.8) and (5.9) are satisfied at the same time with $Z = 0$. Then, country 1 can choose the optimal tax rate. The tax rate will be the same in autarky because its tax rate does not have an influence on the movement of capital. Therefore, the social welfare of country 1 is the same as that in autarky but that of country 2 deteriorates due to a lack of supply of public goods.

What if t_2 is not equal to zero? The capital of country 2 moves to country 1 up to the amount satisfying (5.9). However, for the owners of the capital in country 1, it is always profitable to locate all capital in the country 1 at any tax rates of two countries.[7] Therefore, country 1 sets its rate at the optimum with given amount of inflow of capital from country 2. However, country 2 must set the tax rate, considering the movement of capital which satisfies (5.9).

The objective of country 2 is to

$$\max_{t_2} W(C_2, G_2) \tag{5.10}$$

subject to

$$\begin{aligned} C_2 &= f(K+Z) - f(K+Z)'(t_2K+Z), \\ G_2 &= t_2 f(K+Z)'(K+Z), \end{aligned}$$

[7] In the case of large inflow of country 2's capital into country 1, the right-hand side of (5.8) can be greater than the left-hand side of (5.8). This result implies that country 1's capital earns the higher after-tax rate of return in country 2 than in country 1. However, the above case does not occur because the amount of capital inflow from country 2 is restricted by (5.9). This restriction always makes the left-hand side of (5.8) greater than the right-hand side.

$$
\begin{aligned}
(1-t_2)f(K+Z)' &= f(K+Z)', \\
0 &\leq t_2 < 1, \\
-K &\leq Z \leq 0.
\end{aligned} \tag{5.11}
$$

The first-order conditions give

$$\frac{W_{C_2}}{W_{G_2}} = \frac{f(K+Z)'(K+Z) - t_2 f(K+Z)''(K+Z)\psi - t_2 f(K+Z)'\psi}{f(K+Z)'K + f(K+Z)' - f(K+Z)''(t_2K+Z)\psi}, \tag{5.12}$$

where

$$\psi = \frac{\partial Z}{\partial t_2}. \tag{5.13}$$

We can define ψ from (5.9) as follows.

$$\psi = \frac{f(K+Z)'}{f(K-Z)'' + (1-t_2)f(K+Z)''}. \tag{5.14}$$

By plugging (5.14) into (5.12), we get

$$\frac{W^*_{C_2}}{W^*_{G_2}} = 1 + \frac{f(K-Z)''Z + t_2^* f(K+Z)'}{f(K-Z)''K + f(K+Z)''(K+Z)} < 1. \tag{5.15}$$

Because $Z^* < 0$, (5.15) is always less than 1. This result implies that public goods are under-supplied in country 2.[8]

Which of the two, $t_2 = 0$ or $t_2 \neq 0$, is the better for country 2? If country 2 chooses $t_2 = 0$, there is no loss of welfare caused by the capital flight but there is a serious loss of welfare caused by a lack of provision of public goods. On the contrary,

[8]This does not necessarily imply that the tax rate of country 2 in this subgame is lower than the tax rate in the autarky. It is impossible to compare these two tax rates because there is a change in the amount of capital in country 2. The under-supply of pubic goods should be evaluated with the changed amount of capital, $K + Z$, not with the original endowment of capital, K.

with $t_2 \neq 0$, the loss of welfare from the inefficient allocation between private goods and public goods is less serious than in the case of $t_2 = 0$ but there is another loss of welfare caused by the capital flight. It is obvious that country 2 is worse off than in autarky in both cases.

However, is country 1 better off due to the inflow of the capital? If $t_2 = 0$, there is no inflow of capital from country 2 and the tax rate and the social welfare of country 1 is the same as in autarky. If $t_2 \neq 0$, the total output of country 1 will increase due to the increased capital. Country 1 can allocate this increased output into the private consumption and the public consumption by setting its tax rate to get

$$\frac{W_{C_1}}{W_{G_1}} = 1. \tag{5.16}$$

Therefore, the social welfare of country 1 is greater than that in autarky. The new tax rate also be higher than t_A.[9]

Lemma 16 *When one country applies a source-based tax and the other applies a residence-based tax without adjustment, capital never moves from the latter to the former. The former is worse off but the latter is not worse off than in autarky.*

Deduction method

Suppose that country 1 taxes the capital income from abroad, net of tax paid to the foreign country. For the capital of country 1, the income from the capital which

[9]The inflow of capital increases the total income of labour but decreases the total income of domestic capital. Therefore, capital income tax rate must be increased in order to divide total income into equal private and public consumption.

is moved to country 2 is subject to country 2's tax rate and country 1's tax rate with deduction. Therefore, the market equilibrium condition for country 1's capital is

$$(1-t_1)f(K-Z)' = (1-t_1)(1-t_2)f(K+Z)'. \tag{5.17}$$

For the capital of country 2, the market equilibrium condition is (5.9).

(5.9) and (5.17) are the same. For any value of t_1, $Z \leq 0$ and only t_2 matters. This result is the same with the previous case where country 1 applies the residence principle without adjustment. The method of double taxation relief, either no adjustment or deduction, does not matter because capital never moves abroad from the country which applies one of these methods.

Lemma 17 *When one country applies a source-based tax and the other applies a residence-based tax with deduction rule, capital never moves from the latter to the former. The former is worse off but the latter is not worse off than in autarky.*

Full credit method

Suppose that country 1 gives full credit for the tax paid to the foreign country. When t_2 is higher than t_1, country 1 subsidises the difference between the tax paid to country 2 and the tax payable to country 1. For the capital of country 1, the capital income is subject to t_1, regardless of the location in which the capital is invested. Therefore, the market equilibrium condition for country 1's capital is

$$(1-t_1)f(K-Z)' = (1-t_1)f(K+Z)' \tag{5.18}$$

For the capital of country 2, the market equilibrium condition is (5.9).

When $t_2 = 0$, Z must be 0 satisfying (5.9) and (5.18). When $t_2 \neq 0$, Z must have a negative sign, which means that the capital of country 2 moves to country 1. By plugging (5.9) into (5.18) we get

$$(1 - t_1)f(K - Z)' < (1 - t_1)f(K + Z)'. \tag{5.19}$$

(5.19) implies that, for the owners of the capital in country 1, it is more profitable to move some of its capital to country 2 than to locate it in country 1 because the inflow of capital from country 2 lowers the marginal productivity of capital located in country 1. Country 1's capital moves to country 2 until (5.18) is fulfilled. In this situation, (5.9) is not satisfied.

$$(1 - t_2)f(K + Z)' < f(K - Z)'. \tag{5.20}$$

(5.20) implies that it is profitable for country 2's capital to move to country 1. This process will continue until all of the capital in country 2 moves to country 1 and all of the capital of country 1 moves to country 2.

The full cross-hauling of capital gives pure gains of tax revenue to country 2 because all tax revenue is entirely born by foreigners who locate capital in its territory. Therefore, country 2 sets its tax rate close to 1.

Because the capital tax is the only source of tax revenue of country 1, t_1 must not be lower than t_2 if full credit is to be given. This makes country 1 set its tax rate close to 1. At the equilibrium, ($t_1 = t_2 \simeq 1$), the welfare of country 1 and country 2 are respectively

$$W_1 = W_1[f(K) - f(K)'K,\ 0] \tag{5.21}$$

and

$$W_2 = W_2[f(K) + f(K)'K,\ f(K)'K] \tag{5.22}$$

Country 2 is better off than in autarky and than the case $t_2 = 0$. But country 1 is worse off than in autarky because most of the capital income goes to the tax revenue of country 2 and there is no tax revenue.

Lemma 18 *When one country applies a source-based tax and the other applies a residence-based tax with the full credit method, the tax rates of both countries are close to* 1. *The former is better off while the latter is worse off than in autarky.*

Credit-cum-limitation method

Suppose that country 1 gives credit for the tax paid to country 2. Contrary to the full credit method, the credit is limited to the tax payable to country 1. When the tax rate in country 2 is higher than that of country 1, the government of country 1 does not give money back to make up for the payment of tax to country 2. For the capital of country 1, the income from capital moved to country 2 is subject to the higher of the tax rates of country 1 and country 2. Therefore, the market equilibrium condition for the capital of country 1 is

$$(1 - t_1)f(K - Z)' = \{1 - \max(t_1, t_2)\}f(K + Z)'. \tag{5.23}$$

For the capital of country 2, the market equilibrium condition is (5.9).

When $t_2 = 0$, Z must be 0 satisfying (5.9) and (5.23). Country 1 can maintain the same welfare level by setting $t_1 = t_A$ while country 2 is worse off than in autarky due to no supply of public goods. When $t_2 \neq 0$, there are two cases; Case 1 ($t_1 = 0$) and Case 2 ($t_1 \neq 0$). With Case 1, (5.23) becomes

$$f(K - Z)' = (1 - t_2)f(K + Z)'. \tag{5.24}$$

This equilibrium condition is the same as (5.9). Country 2's capital moves to country 1 up to the amount satisfying (5.9). Country 2 is worse off because of the capital flight and because of the under-supply of public goods. Country 1 can be worse off or better off than in autarky. It is better off if the positive effect of the inflow of foreign capital outweighs the negative effect of the lack of supply of public goods.

With Case 2, regardless of the values of t_1 and t_2, full cross-hauling of capital occurs. This result is confirmed because when (5.9) is satisfied, the right hand side of (5.23) is less than the right hand side regardless of which is the higher of t_1 and t_2. Country 2 will set its tax rate close to 1. t_1 is irrelevant because there is no capital income on which to impose tax because country 2 takes all capital income as tax revenue. Country 1 does not necessarily set its tax rate as close to 1 as country 2 because country 1 has no obligation to give money back if its tax rate is lower than that of country 2.

If t_1 is expected to be positive, country 2 sets its tax rate close to 1. However, if t_1 is expected to be 0, then country 2 sets its tax rate at $t_2^*(t_1 = 0)$ which is defined in

(5.15). In contrast, country 1 sets its tax rate at 0 if country 2 is expected to set its tax rate close to 1. If country 2 is expected to set its tax rate at $t_2^*(t_1 = 0)$, country 1 will set its tax rate at $t_1^*(t_2 = t_2^*(t_1 = 0))$.

A pure-strategy Nash equilibrium will exist when $t_2^*(t_1 = 0) \neq 0$ and $t_1^*(t_2 = t_2^*(t_1 = 0)) = 0$. Otherwise, only the mixed strategy Nash equilibrium may exist.[10] At $(t_1 = 0, t_2 = t_2^*(t_1 = 0))$, country 2 is worse off, not only due to the capital flight but also due to the under-supply of public goods. Country 1 can be better off if the positive effect of the inflow of foreign capital outweighs the negative effect of the lack of supply of public goods. Otherwise, it is worse off.

Lemma 19 *When one country applies a source-based tax and the other applies a residence-based tax with the credit-cum limitation rule, the existence of a pure strategy Nash equilibrium is not guaranteed. If it does, the former is worse off while the latter is either better off or worse off than in autarky.*

Exemption method

Suppose that country 1 does not impose tax on the income from the capital located in the foreign country. For the capital of country 1, the income from capital moved to country 2 is subject to country 2's tax rate. Therefore, the market equilibrium condition for country 1's capital is

$$(1 - t_1)f(K - Z)' = (1 - t_2)f(K + Z)'. \tag{5.25}$$

[10]For the conditions for existence of mixed strategy Nash equilibrium, see Dasgupta and Maskin (1986).

For the capital of country 2, the market equilibrium condition is (5.9).

This equilibrium condition is the same with Case 2 in which country 1 applies the residence principle with credit-cum-limitation and t_2 is not lower than t_1. The equilibrium in the previous case does not depend on the assumption that t_2 is not lower than t_1. Therefore, the equilibrium is the same. When $t_2^*(t_1 = 0) \neq 0$ and $t_1^*(t_2 = t_2^*(t_1 = 0)) = 0$, the unique pure strategy Nash equilibrium is $\{(t_1^* = 0), (t_2^* = t_2(t_1 = 0))\}$. Country 2 is worse off, not only due to the capital flight but also due to the under-supply of public goods. Country 1 is better off if the positive effect of the inflow of foreign capital dominates the negative effect of the lack of supply of public goods. Otherwise, it is worse off.

Lemma 20 *When one country applies a source-based tax and the other applies a residence-based tax with the exemption rule, the existence of pure strategy Nash equilibrium is not guaranteed. If it does, the former is worse off while the latter is either better off or worse off than in autarky.*

5.3.4 Summary

The analysis presented above can be summarized as follows. Here t_A and t_C denote the tax rate in autarky and in tax competition respectively where both countries apply the source principle. W_A and W_C denote the social welfare under $(t_1 = t_2 = t_A)$ and $(t_1 = t_2 = t_C)$.

1. Both countries apply the residence principle : Each country maintains tax rate

the same with that in autarky and the level of social welfare is the same as in autarky. This outcome is optimal with respect to each country and worldwide. $(t_1^* = t_2^* = t_A)$ is the Nash equilibrium tax rate and the payoff corresponding to this is $(W_1^* = W_2^* = W_A)$. This result is the same regardless of the method of double taxation relief.

2. Both countries apply the source principle : The threat of capital flight (the incentive of attracting foreign capital) makes each country set its tax rate below that in autarky. Given the same tax rates in both countries, there is no movement of capital but there is an allocative distortion of products between private consumption and public consumption in both countries. $(t_1^* = t_2^* = t_C < t_A)$ is the Nash equilibrium tax rate and the payoff corresponding to this is $(W_1^* = W_2^* = W_C < W_A)$.

3. One country (country 1) applies the residence principle and the other (country 2) applies the source principle:

(1) No adjustment and deduction method : t_1 has no influence on the movement of capital and is thus decided at the level to maximize its social welfare. At the equilibrium $(t_1^* \geq t_A, t_2^* \lesseqgtr t_A)$[11]. If $t_2^* \neq 0$, capital moves from country 2 to country 1. Country 1 is better off than in autarky due to the inflow of foreign capital, while country 2 is worse off due to the under-supply of public goods and the capital flight.

[11] The inflow of foreign capital reduces the income of capital whilst increasing the income of labour. Therefore, the optimal t_1^* must be higher than t_A to secure tax revenue.

	Source principle	Full credit	No adjust / Deduction	Exemption / Credit
Source principle	W_C, W_C	W_{++}, W_{--}	W_-, W_+,	W_-, W_{-+}
Full Credit	W_{--}, W_{++}	W_A, W_A	W_A, W_A,	W_A, W_A
No adjust / Deduction	W_+, W_-,	W_A, W_A,	W_A, W_A,	W_A, W_A,
Exemption / Credit	W_{-+}, W_-	W_A, W_A	W_A, W_A,	W_A, W_A

Table 5.1: Reduced payoff table (1)

If $t_2^* = 0$, there is no movement of capital. Country 2 is worse off due to the lack of supply of public goods while country 1 has the same level of social welfare as that in autarky. Therefore, $(W_1^* \geq W_A, W_2^* < W_A)$.

(2) Full credit method : Full cross-hauling of capital makes country 2 set its tax rate close to 1. $(t_1^* = t_2^* \simeq 1)$ is the equilibrium tax rates and the payoff corresponding to this is $(W_1^* < W_A, W_2^* > W_A)$.

(3) Credit-cum-limitation method and exemption method : $(t_1^* = 0, t_2^* = t_2(t_1 = 0))$ is the pure strategy equilibrium if it exists. Country 1 is better off if the positive effect of the net inflow of capital outweighs the negative effect of the lack of supply of capital. Country 2 is worse off due to the capital flight and the under-supply of public goods. Thus, $(W_1^* \lesseqgtr W_A, W_2^* < W_A)$.

Table 5.1 summarizes the above result with a reduced payoff table. The first value of a payoff is for the country which applies the tax rule shown in the first column and the second is for the country which applies the tax rule shown in the first row. The payoff in the subgame in which one country adopts 'no adjustment' and 'deduction' is exactly the same and thus they are merged into one. This merger is applied to the subgames in which one country adopts 'credit-cum-limitation' and 'exemption'. Here, we can say $W_{++} > W_{+} \geq W_A > W_{-}$, $W_C > W_{--}$, and $W_{+} > W_{-+}$. We do not know the superiority of preference between W_A and W_{-+}, and between W_C and W_{-+}. This ambiguity does not change the following result.

There are four multiple Nash equilibria in the whole game. Each country choose either the residence principle with 'no adjustment / deduction' or 'credit-cum-limitation / exemption'. When one country applies the residence principle with 'full credit', the other country has an incentive to change its tax principle to the source principle from the residence principle. Therefore, the residence principle with 'full credit' is not a Nash equilibrium. At these four Nash equilibria, the tax rates and social welfare are $(t_1^* = t_2^* = t_A)$ and $(W_1^* = W_2^* = W_A)$.

Proposition 21 *The subgame perfect Nash equilibria are* (Re*residence principle with No-adjustment, Deduction, Credit-cum-limitation or Exemption,* $t_i = t_A$)*. Therefore, the international allocation of capital between two countries and the allocation of products between private and public consumption are optimal for each country and worldwide.*

Two points need to be mentioned. The Nash equilibrium concept does not preclude the use of weakly dominated strategies in randomizing its strategies. However, weakly dominated strategies are unappealing because they are dominated unless a player is absolutely sure of what other players will play. In the above game, the residence principle with 'no adjustment/deduction' weakly dominates the residence principle with 'credit-cum-limitation/exemption'. This result derives from that $W_{+} > W_{-+}$. In the equilibrium in both subgames, country 1 has the same amount of the inflow of foreign capital. However, the tax rate of country 1 is optimal in the subgame of the residence principle with 'no adjustment/deduction' while the tax rate is zero in the subgame of the residence principle with 'credit-cum-limitation/exemption'. Therefore, only the residence principle with 'no adjustment/deduction' is the trembling-hand perfect Nash equilibrium.[12]

What if only mixed strategy Nash equilibrium exists in the subgame in which one country adopts the residence principle with 'credit-cum-limitation/exemption' and the other country adopts the source principle? The equilibrium of the whole game depends on the expected payoff of the mixed strategy for both countries. The expected payoff for the country which adopts the residence principle is less than W_{+}. The payoff for the other country can be either greater than W_A or less than W_A. If it is not greater than W_A, the result is the same as analysed above. Otherwise, only the residence principle with 'no adjustment/deduction' is employed at the subgame perfect Nash equilibrium.

[12]The trembling-hand perfect Nash equilibrium is robust to the possibility that, with some very small probability, players make mistakes. See Mas-colell, Whinston and Green (1995) for the formal definition.

5.4 World income tax principle

5.4.1 When the same methods are applied

Deduction method

Suppose that both countries apply deduction methods. For the capital of country 1, the income from capital invested domestically is subject to the tax rate of country 1 while the income from capital invested in country 2 is subject to the tax rate of country 2 and of country 1 with deduction. Therefore, the market equilibrium condition for capital of country 1 is

$$(1-t_1)f(K-Z)' = (1-t_1)(1-t_2)f(K+Z)'. \tag{5.26}$$

Z must be negative with any value of (t_1, t_2). This result implies that the net inflow of capital for country 2 cannot be positive and thus country 2 cannot change the allocation of capital between two countries when country 1 does not attract capital from country 2.

For the capital of country 2, the income from capital invested domestically is subject to the tax rate of country 2 while the income from the capital invested in country 1 is subject to the tax rate of country 2 and of country 1 with deduction. Therefore, the market equilibrium condition for the capital of country 2 is

$$(1-t_2)f(K+Z)' = (1-t_1)(1-t_2)f(K-Z)'. \tag{5.27}$$

Z must be positive with any value of (t_1, t_2). This result implies that country 1 cannot attract capital from country 2 even with a lower tax. Therefore, each country cannot attract capital from the other. Tax is not useful in attracting foreign capital and tax competition does not occur. Therefore, tax rates in both countries are the same as those in autarky. The allocation of products between private consumption and public consumption is optimal and the allocation of capital is also optimal worldwide.

Lemma 22 *When both countries apply the deduction method under the world income taxation, both countries cannot attract capital from each other. Therefore, tax competition does not occur.*

Credit method

With the credit-cum-limitation method, for the capital of country 1, the income from the capital invested domestically is subject to the tax rate of country 1 while the income from the capital invested in country 2 is subject to the higher one between the tax rate of country 1 and that of country 2. Therefore, the market equilibrium condition for the capital of country 1 is

$$(1 - t_1)f(K - Z)' = \{1 - \max(t_1, t_2)\}f(K + Z)'. \tag{5.28}$$

Z cannot be positive with any value of (t_1, t_2). This result implies that country 2 cannot attract capital from country 1 even with a lower tax rate.

For the capital of country 2, the income from the capital invested domestically is subject to the tax rate of country 2 while the income from the capital invested in country 1 is subject to the higher one between the tax rate of country 2 and that of country 1. Therefore, the market equilibrium condition for the capital of country 2 is

$$(1-t_2)f(K+Z)' = \{1-\max(t_1,t_2)\}f(K-Z)'. \tag{5.29}$$

Z cannot be negative with any value of (t_1, t_2). This result implies that country 1 cannot attract capital from country 2 even with a lower tax rate. Therefore, each country cannot attract capital from the other. Tax is useless in attracting foreign capital and tax competition does not occur.

Lemma 23 *When both countries apply the credit method under the world income taxation, both countries cannot attract capital from each other. Therefore, tax competition does not occur.*

Exemption method

With the exemption method, for the capital of country i, the income from the capital invested domestically is subject to the tax rate of country i while the income from the capital invested in country j is subject to the tax rate of country j. Therefore, the market equilibrium condition for the capital of country i is

$$(1-t_i)f(K+(-1)^iZ)' = (1-t_j)f(K+(-1)^jZ)'. \tag{5.30}$$

This condition is exactly the same situation where both countries apply the source principle. The analysis under the source principle has demonstrated that both countries are involved with tax competition, which leads to lower tax rates in both countries. There is no distortion from the allocation of capital between countries but there is a distortion in the allocation of products between private consumption and public consumption.

Lemma 24 *The world income taxation with the exemption rule for the relief of double taxation is exactly equivalent to the source principle. Therefore, tax competition leads to lower tax rates in both countries.*

5.4.2 When different methods are applied

Deduction method and credit method

Suppose that country 1 applies the deduction method and country 2 applies the credit method. The market equilibrium condition for the capital of country 1 is (5.26) and the market equilibrium condition for the capital of country 2 is (5.29). Neither country can attract capital from the other. Tax is not a useful mechanism for attracting foreign capital and tax competition does not occur. Tax rates in both countries are the same with those in autarky.

Lemma 25 *When both countries apply one of deduction rule and credit rule, the difference of tax rates does not cause movement of capital at all. Therefore, tax competition does not occur.*

Deduction method and exemption method

Suppose that country 1 applies the deduction method and country 2 applies the exemption method. The market equilibrium condition for the capital of country 1 is (5.26) and the market equilibrium condition for the capital of country 2 is (5.30). Z cannot be positive with any value of (t_1, t_2). This result implies that country 2 cannot attract capital from country 1 even with a lower tax. Country 1 can attract capital from country 2 by setting its tax rate below that of country 2. Therefore, country 1 can maintain its level of social welfare, at least, at the level of W_A by fixing its tax rate at t_A. If it manipulates its tax rate, the expected social welfare must be greater than W_A. However, for country 2, the maximum level of its social welfare is W_A when $t_1^* = t_2^* = t_A$. Otherwise, $W_2^* < W_A$.

Lemma 26 *When one country applies the exemption rule and the other country applies the deduction rule, the former is not better off than in autarky and the latter is not worse off than in autarky.*

How do both countries make their mixed strategies? Country 1 is better off when setting the lower tax rate than that of country 2 and thus attracting capital. For country 2, it is best to set its tax rate at the same level as that of country 1. Even a lower tax rate is not able to attract capital from country 1. If the expected utility of a mixed strategy, randomizing its tax rates, is less than W_A for country 1, $(t_1^* = t_2^* = t_A)$ is a Nash equilibrium tax rate and the social welfare is $(W_1^* = W_2^* = W_A)$. Otherwise, both countries will randomize their tax rates at the mixed strategy Nash equilibrium.

Credit method and exemption method

Suppose that country 1 applies the credit method and country 2 applies the exemption method. The market equilibrium condition for the capital of country 1 is (5.29) and the market equilibrium condition for the capital of country 2 is (5.30). Z cannot be positive with any value of (t_1, t_2). This result implies that country 2 cannot attract capital from country 1 even with a lower tax rate. Country 1, however, can attract capital from country 2 by setting its tax rate below that of country 2. Therefore, country 1 can maintain its social welfare, at least, at the level of W_A by fixing its tax rate at t_A. If it manipulates its tax rate, the expected social welfare must be greater than W_A. However, for country 2, the maximum of its social welfare is W_A when $t_1^* = t_2^* = t_A$. Otherwise, $W_2^* < W_A$.

Lemma 27 *When one country applies the exemption rule and the other country applies the credit rule, the former is not better off than in autarky and the latter is not worse off than in autarky.*

5.4.3 Summary

The equilibrium in each subgame can be summarized as follows.

1. Subgame of Deduction-Deduction, Credit-Credit and Deduction-Credit : Tax competition does not occur and thus $\{(t_1^* = t_2^* = t_A), (W_1^* = W_2^* = W_A)\}$ is a

Nash equilibrium.

2. Subgame of Exemption-Exemption : Tax competition leads to a lower tax in both countries and thus the under-supply of public goods. Therefore, both countries are worse off than in autarky. $\{(t_1^* = t_2^* = t_C), (W_1^* = W_2^* = W_C)\}$ is a Nash equilibrium.

3. Subgame of Deduction-Exemption and Credit-Exemption : Regardless of tax rates at the equilibrium, the country applying the Deduction or Credit method is not worse off than in autarky while the country applying the Exemption method is not better off than in autarky. $W_1^* \geq W_A \geq W_2^*$ at the Nash equilibrium.

From the above analysis, we can get a reduced payoff table. The payoff for the deduction rule is exactly the same as those for the credit rule. Therefore, these two subgames are merged into one. Table 5.2 summarizes the results. It is obvious that $W_+ \geq W_A > W_C$ and W_-. However, the ordering of preference between W_C and W_- is not obvious. The subgame perfect Nash equilibrium is $\{$(Deduction or Credit, Deduction or Credit), $(t_1^* = t_2^* = t_A)$, $(W_1^* = W_2^* = W_A)\}$. The result is not changed according to the ordering of preference between W_C and W_-.

The implication of the result is the same as in the previous section where two countries select one of two polar tax principles with double taxation relief. Each country can protect capital flight by not treating the income of the capital located abroad more favourably than the income from the capital located domestically. The

	Deduction / Credit	Exemption
Deduction / Credit	W_A, W_A	W_+, W_-
Exemption	W_-, W_+	W_C, W_C

Table 5.2: Reduced payoff table (2)

deduction method and the credit method are these schemes.

Proposition 28 *Under the world income taxation, the subgame perfect Nash equilibrium is* $\{\{$*(Deduction/Credit, Deduction/Credit)*, $(t_1^* = t_2^* = t_A)$, $(W_1^* = W_2^* = W_A)\}$. *Therefore, the international allocation of capital and the allocation of products between private consumption and public consumption is optimal for each country and worldwide.*

5.5 Concluding remarks

In this chapter, tax rule is treated as a decision variable of governments in the same way as tax rate. In this modified dynamic game, neither countries apply the source principle (the exemption method under the world income taxation) and thus international capital mobility does not provoke strategic tax setting behaviour of governments. The result is perhaps surprising in that current concerns about the distortional effects of tax competition appear to be irrelevant only if countries are free to choose their own tax rules as well as tax rates.

However, although in a legal sense corporation tax is a residence-based tax, there are many cases in practice in which it functions as a source-based tax. Firstly, the government is likely to have incomplete information about the foreign income of domestic firms. While domestic income can be thoroughly monitored by tax authorities, foreign income cannot be completely monitored because of the national boundaries of the jurisdiction of tax authorities. Of course, foreign income can be monitored by the sharing of information among tax authorities. However, it has been argued that self-interested tax authorities do not share information fully with foreign tax authorities (see Bacchetta and Espinosa [1993]). Therefore, given limitations of available information about foreign income, corporation tax becomes a source-based tax in practice (the exemption method under the world income taxation).

Secondly, the financial behaviour of firms seeking to minimize tax burden effectively transforms a residence-based tax as a legal form into a source-based tax in fact. When subsidiaries defer the repatriation of profits to the holding company, only the tax of the host country is applied. Given that the profits of subsidiaries are commonly retained or used for reinvestment in themselves and in other subsidiaries, the tax of the home country does not matter.

Thirdly, when subsidies are used for attracting foreign capital along with tax rate cutting, tax rules are irrelevant in the context of tax competition. Tax competition occurs with both a source-based and residence-based tax (this will be analysed in chapter 6).

The analysis can be extended to asymmetric cases. The potential losers of tax competition (the larger country and the country with a strong preference for public goods) are more likely to select the tax rules by which they can prohibit their capital from moving abroad. However, the country with larger per capita capital endowment cannot prohibit its capital from moving abroad by employing these tax rules because domestic capital moves to the foreign country seeking for the higher marginal productivity of capital even if there is no tax differential. Therefore, this country may prefer tax rule which causes tax competition. The asymmetric cases provide another strategic aspects of governments' decisions on tax rules and tax rates.

Chapter 6

International tax and subsidy game

6.1 Introduction

The standard model of tax competition has not considered subsidies for foreign and/or domestic investment separately from tax competition. It seems to me that they assume that all subsidies can be converted into effective tax rates and therefore, there is no need for the separate treatment. This explanation is supported by the fact that empirical tests on tax competition have been carried out with using not nominal tax rates but rather effective tax rates (see Devereux [1995], and Chennells and Griffith [1997]).

However, there are three reasons why subsidies cannot be incorporated into effective tax rates and might be analysed separately with tax rates. Firstly, the same tax rates are applied to all the capital income in a country, regardless of the nationality of investors. However, subsidies are usually granted either to all investors or exclusively to foreign investors. Preferential subsidy creates a difference in effective tax rates between the income from domestic capital and the income generated by domestically invested foreign capital. Secondly, subsidy is always granted according to the source principle, even when taxation follows the residence principle. Thirdly, the decisions on subsidies are different from those on tax rates, in that tax rates are under a stricter control of the assembly and are changed less frequently than subsidies.

On the other hand, the introduction of subsidies into the model is significant in that, without it, the analysis of tax competition games appears to be trivial when tax rules are decided strategically along with tax rates. This result has been demonstrated in chapter 5. According to the result of that chapter, a source-based tax (the exemption method under the world income taxation) is never used and thus tax competition does not occur at all. Table 6.1[1] shows that, of 24 OECD countries, 12 countries adopt the credit rule for foreign source dividends while the same number of countries adopt the exemption rule. Credit(1) and Credit(2) imply 'world-wide credit' and 'country by country credit' respectively. This situation contradicts the prediction of the previous chapter. At the same time, a related question is whether tax competition is really irrelevant in the countries which adopt the credit rule.

This chapter will consider these two issues. The basic model, described in section

[1]The data are from Griffith and Chennels' tax data base and *Corporate taxes-1998 Worldwide Summaries* by PriceWaterHouse. Those are the methods which are applied in general. Different methods can be applied according to the income-source country and categories of income. OECD (1991) provides the tax rules applicable as of 1991.

Country	Dividends	Interests
Australia	Exemption	Credit (1)
Austria	Exemption	Credit (2)
Belgium	Exemption (up to 95%)	Credit (1)
Canada	Exemption	Credit (2)
Denmark	Exemption	Credit (2)
Finland	Exemption	Credit (2)
France	Exemption (up to 95%)	Credit (2)
Germany	Exemption	Credit (2)
Greece	Credit (2)	Credit (2)
Iceland	Credit(1)	Credit(1)
Ireland	Credit (2)[2]	Credit (2)
Italy	Credit (2)	Credit (2)
Japan	Credit (1)	Credit (1)
Luxembourg	Exemption	Credit (2)
Netherland	Exemption	Credit (2)
New Zealand	Exemption	Credit (2)
Norway	Credit (2)	Credit (2)
Portugal	Credit (2)	Credit (2)
Spain	Credit (2)	Credit (2)
Sweden	Credit (2)	Credit (2)
Switzerland	Exemption	Credit (2)
Turkey	Credit(2)	Credit(2)
UK	Credit (2) or Deduction	Credit (2)
USA	Credit (1)	Credit (1)

Table 6.1: Treatment of foreign source income

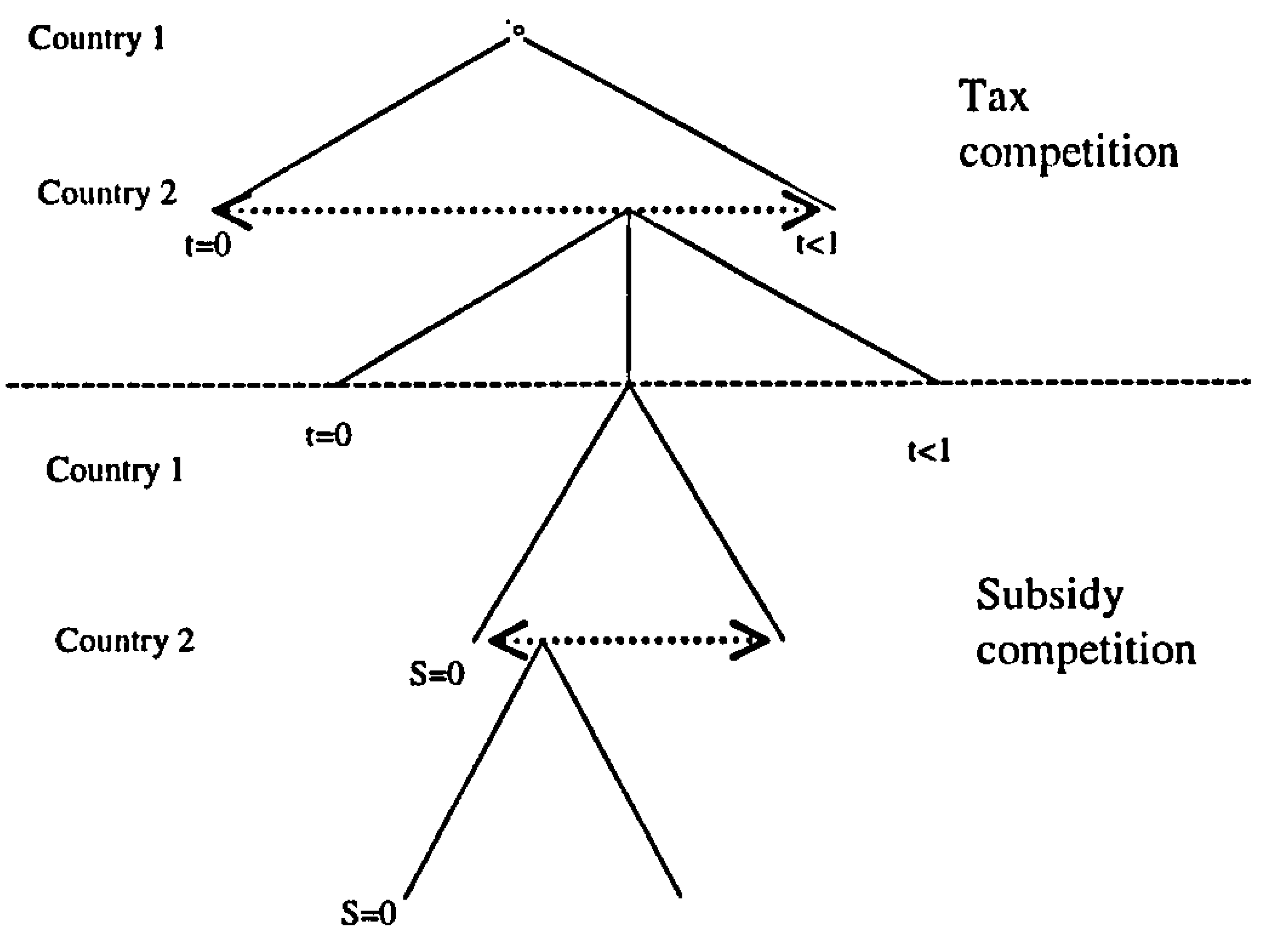

Figure 6.1: Structure of the game of tax rates and subsidies

3.2, is used for the analysis here. The necessary modification is the change in the structure of the game. Both countries decide their tax rates simultaneously and, with knowledge of each other's tax rates, then decide their subsidies simultaneously. Capital is allocated according to the marginal rate of return, net of taxes and gross of subsidies. I will investigate the subgame perfect Nash equilibria, which can be pure or mixed strategies, by the method of backward induction.

The outline of the game is illustrated in Figure 6.1. At the first stage of the game, both countries decide their tax rates simultaneously and, at the second stage, they decide their subsidies simultaneously, with the knowledge of each other's tax rate. In Figure 6.1, the first decision nodes of country 2 are joined to a single information set because country 2 is not aware of the tax rate of country 1 when it decides its tax rate. However, the second decision nodes of country 1 are not joined and every node appears as a single information set because country 1 knows its own tax rate as well as that of country 2. Again, the second decision nodes of country 2 are joined to an single information set because country 2 does not know the amount of subsidy of country 1.

The form of subsidy is significant to the result of the tax and subsidy game. I therefore analyse separately the preferential subsidy granted exclusively to foreign capital and the universal subsidy granted to both domestic capital and foreign capital. Contrary to the common belief that preferential subsidies are more effective than universal ones in attracting foreign capital, it is found that they are less effective under the assumption of perfect capital mobility.

When both countries apply the exemption method, preferential subsidies are useless in attracting more capital. They only replace domestic capital with foreign capital, leaving total capital in the territory of the country constant. This non-effectiveness of subsidies makes the two-stage game into a one-stage game of tax rates. Therefore, the introduction of subsidies into the model does not change the equilibrium of the game analysed in section 5.4.

However, when both countries apply the credit method, preferential subsidies can be used to attract foreign capital by the country which has set the lower tax rate at the previous stage. When the country with the higher tax rate grants subsidies, full cross-hauling of capital occurs. The country with the higher tax rate is always worse off by granting preferential subsidies because there is no net inflow of capital and it must grant subsidy to all foreign capital invested in its territory. Therefore, it never grants preferential subsidies.[3] This asymmetric effect of granting subsidies causes strategic decisions on tax rates in the previous stage. Each country reduces its tax rate in order to create the situation in which it can attract foreign capital by granting subsidies at the second stage. At the subgame perfect Nash equilibrium, both countries set their tax rates lower than the optimal level but subsidies are not granted by both countries.

Universal subsidies are shown to be a perfect substitute for tax undercutting when both countries apply the exemption method. There are an infinite number of subgame perfect Nash equilibria where tax undercutting and granting of subsidy are used together. Taking the additional assumption that the smaller subsidy is preferred, a unique subgame perfect Nash equilibrium exists. At this subgame perfect equilibrium, the tax rates of both countries are the same with those in pure tax competition game and subsidies are not used.

Under the credit rule, tax undercutting is not used but subsidies are, at the subgame perfect Nash equilibrium because subsidies are more effective than tax undercutting. Subsidies can either attract foreign capital or protect a flight of domestic capital while tax undercutting is effective only in protecting a flight of domestic capital. Granting subsidies leads to the under-supply of public goods just as tax

[3]This is true when the foreign country does not grant subsidies. Otherwise, the country with the higher tax rate can be better off by granting preferential subsidies and by causing a cross-hauling of capital. This is because domestic capital located in the foreign country can get foreign subsidies and net outflow of capital is reduced. This is demonstrated in section 6.3.

undercutting does, thereby lowering the effective tax rates.

The result of the analysis has clear implications for the anti-tax competition policies. International coordination to adopt the residence principle does not work when subsidies are available to each government. Under the residence principle, tax competition is replaced by subsidy competition. Effective tax rates are the same as those at the non-cooperative equilibrium and the distortion from the under-supply of public goods occurs. International tax coordination (tax harmonization or the imposition of minimum tax rate) can change effective tax rates only if governments are forbidden from using subsidies. Otherwise, increases in tax rates are followed by increases in the level of subsidies. Therefore, these tax coordinations are likely to increase the size of governments.

The next section of this chapter discusses the forms of subsidy which are adopted here. One of the difficulties in modelling subsidies is that there are many different forms of subsidy and the result of the analysis depends on their forms. It is therefore necessary to be explicit about which subsidies are considered in the analysis. Preferential subsidies are analysed in section 3 and universal subsidies in section 4. The conclusion of this chapter provides a summary along with shortcomings and possible extensions of the analysis.

6.2 Which subsidies?

There are various specific forms of subsidies. Firstly, subsidy can be given either to all capital located in its territory or to exclusively foreign capital. Suppose that subsidy is given only to foreign capital invested within its territory. When an amount of capital of the other country moves into the territory seeking for the subsidy, the inflow of foreign capital lowers the marginal productivity of domestic capital and thus, the same amount of domestic capital will leave the territory seeking the higher marginal productivity of capital abroad. Therefore, preferential subsidy substitutes domestic capital with foreign capital.[4] In contrast, when subsidy is given to all capital invested in its territory regardless of its nationality, it can attract more capital into its territory just like tax undercutting.

The effectiveness of subsidy contradicts a simple conjecture that a preferential subsidy is more effective in attracting foreign capital than a universal subsidy. If two countries are assumed to compete to attract multinational enterprise's capital, preferential subsidy is more effective. With the same total amount of subsidies, preferential subsidies can increase the rate of return for multinational capital more than universal subsidies because the former is given exclusively to multinational capital while the latter is given to multinational and domestic capital.

Definition 29 *A preferential subsidy is a subsidy which is granted exclusively to*

[4]This is true only when capital has the perfect mobility and the source-based tax (the exemption rule under the world income taxation) is used. Otherwise, this does not stand.

foreign capital. If a subsidy is granted to domestic and foreign capital, it is a universal subsidy.

Secondly, the amount of subsidy may be determined according to marginal productivity of capital (proportional subsidy) or fixed per unit (unit subsidy). The sequence of the game is that the government announces the amount of subsidy for the capital and then marginal productivity of capital is determined as a result of capital movement. Investors are less impressed by a subsidy the amount of which will be decided after their investment. A 'unit subsidy' is more realistic than a 'proportional subsidy'.

When a 'proportional subsidy' is granted and taxed, the marginal rate of the return of capital is

$$(1 - t_i)(1 + s_i)f(K - Z)' \equiv (1 - w_i)f(K - Z)' \tag{6.1}$$

where $w_i = t_i - s_i + t_i s_i$. w_i is an effective tax rate. When $s_i \geq 0$[5], $w_i \leq t_i$.

When a 'unit subsidy' is granted and taxed, the marginal rate of the return of capital is

$$(1 - t_i)f(K - Z)' + (1 - t_i)s_i. \tag{6.2}$$

A single effective tax rate does not capture the effect of tax and subsidy at the same time. Even if a unit subsidy looks to be more appropriate in highlighting the role of subsidies, a proportional subsidy is adopted in the following sections for the purpose of the analytical simplicity. This issue will be discussed in section 3 and 4.

[5] A negative subsidy is not considered here.

Third, subsidies for capital can be taxed, being added to the marginal productivity of capital, or not. If a 'proportional subsidy' is taxed by the government, the effective tax rate is $w_i = t_i - s_i + t_i s_i$. If not, $w_i = t_i - s_i$. There is no difference between them in converting the total effect of tax rate and subsidy into a single effective tax rate. The only difference derives from the fact that when subsidy is taxed, budget constraints does not impose a restriction such that $t_i \geq s_i$, which is inevitable otherwise.

The selection between the two relies on current practice. If subsidies are cash grants, subsidies are taxed via increasing the profit of firms. If subsidies are not cash grants but rather free provision of land, simplified licensing procedure, low interest loans and guarantee, granting monopoly, etc., it is less obvious whether those subsidies are taxed or not. However, those subsidies will be eventually reflected in profits of firms and then be taxed. Therefore, we assume that subsidies are taxed.

Regardless of the form of subsidy, granting subsidy always increases private consumption[6] and decreases the same amount of public consumption. Therefore, tax undercutting and granting subsidy have a similar effect. Higher tax rate and greater subsidy can have the same allocation of products between private and public consumption as lower tax rate and smaller subsidy. Infinite number of combination of tax rates and subsidies can maximize the social welfare. In order to define tax rates and subsidies in autarky, we need an assumption that lower tax rate and lower subsidy are preferred.

[6]A preferential subsidy increases private consumption of non-residents while a universal subsidy increases that of residents and non-residents.

This assumption can be attributed to the needs of politicians. Politicians need to maintain tax rates at their lowest level because tax rates are regarded by voters to indicate the effectiveness of monitoring government. Lower tax rates are helpful to their being re-elected. The simpler explanation is that democratic principle requires to restrict government's arbitrary power of granting subsidy at a minimum.

6.3 Preferential subsidy

6.3.1 Exemption rule

When both countries compete to attract capital only through tax undercutting, both countries lower their tax rates at the non-cooperative Nash equilibrium. How does the subsequent subsidy competition change the result? Suppose that tax rates are the same for two countries. If one country tries to attract capital from the other by giving subsidy to foreign capital, some foreign capital will move into the territory. The inflow of foreign capital must lower the marginal productivity of domestic capital and, thus the same amount of domestic capital will leave the territory seeking higher marginal productivity of capital abroad. This process continues up to the point where the marginal productivity of capital is the same in the home country and abroad. Therefore, the subsidy cannot successfully attract more capital. It only substitutes domestic capital with foreign capital.

Let Z_i be defined as the amount of capital of country i invested in country j and

Z_j as the amount of capital of country j invested in country i.[7] Here, $0 \leq Z_i$ and $Z_j \leq K$. The capital of country i invested in country i earns marginal productivity net of the tax paid to country i while the capital of country i invested country j earns marginal productivity of capital net of the tax paid to country j, and the subsidy of country j. Therefore, the equilibrium condition is

$$(1-t_i)f(K+(-1)^i(Z_i-Z_j))' = (1-t_j)(1+s_j)f(K+(-1)^j(Z_i-Z_j))'. \qquad (6.3)$$

The capital of country j invested in country j earns marginal productivity net of the tax paid to country j while the capital of country j invested country i earns marginal productivity of capital net of the tax paid to country i, and the subsidy of country i. Therefore, the equilibrium condition is

$$(1-t_j)f(K+(-1)^j(Z_i-Z_j))' = (1-t_i)(1+s_i)f(K+(-1)^i(Z_i-Z_j))'. \qquad (6.4)$$

Suppose that the tax rates are the same in two countries and neither country grants subsidies. (6.3) and (6.4) are the same as

$$f(K+(-1)^i(Z_i-Z_j))' = f(K+(-1)^j(Z_i-Z_j))'. \qquad (6.5)$$

(6.5) gives $Z_i = Z_j$. The relationship is drawn in Figure 6.2 (a). The dotted line represents the relationship satisfying (6.4) and the solid line represents the relationship of (6.3). With the assumption that firms locate their capital domestically when they are indifferent to the location of their capital, $Z_i = Z_j = 0$ at the equilibrium.

[7]In chapter 3, we denote $Z = Z_i - Z_j$. It is not possible to use this expression here because there is cross-hauling of capital.

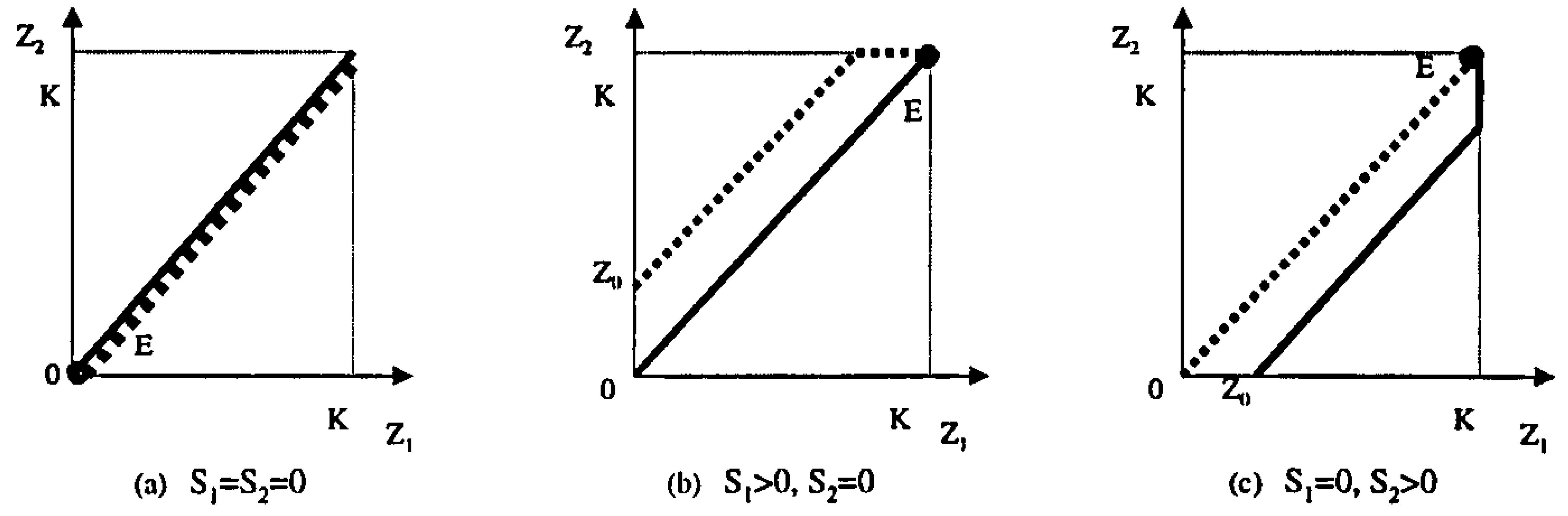

Figure 6.2: Movement of capital when $t_1 = t_2$ under the exemption or credit rule

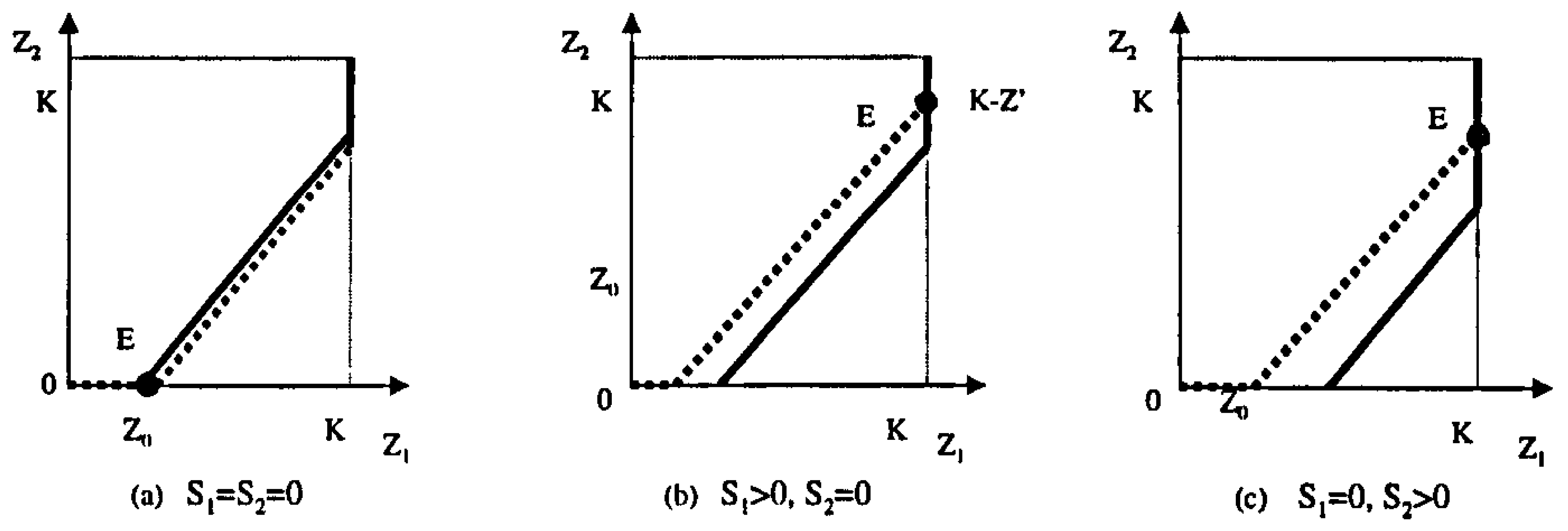

Figure 6.3: Movement of capital when $t_1 > t_2$ under the exemption rule

Suppose that country j tries to attract capital from country i by granting subsidy to foreign capital while country i does not. In this setting, we have

$$f(K+(-1)^i(Z_i-Z_j))' = (1+s_j)f(K+(-1)^j(Z_i-Z_j))' \tag{6.6}$$

and

$$f(K+(-1)^j(Z_i-Z_j))' = f(K+(-1)^i(Z_i-Z_j))'. \tag{6.7}$$

From (6.6), for any positive subsidy of country j, the difference between Z_i and Z_j, must be positive; $Z_i - Z_j > 0$, for any $s_j > 0$. Z_i and Z_j are in a linear relation. When $Z_j = 0$, $Z_i = Z_0 > 0$, where Z_0 denotes the amount of capital of country i which satisfies (6.6). When $0 < Z_j < K - Z_0$, $Z_i = Z_j + Z_0$. When $Z_j > K - Z_0$, $Z_i = K$ because Z_i can not be greater than K. From (6.7), $Z_i = Z_j$.

The relationship is drawn in Figure 6.2 (b) and (c). When either country gives subsidy, at the equilibrium $Z_i = Z_j = K$. This results in a full cross-hauling of capital. Neither country can attract more capital into its territory by providing subsidy. The country which grants subsidies is worse off because it pays subsidies for all capital of foreign country, failing to increase capital invested in its territory. Neither country has an incentive to grant preferential subsidies when tax rates of both countries are the same.

When tax rates in the two countries are different, the country with lower tax rate can attract capital from the country with higher tax rate (see Figure 6.3 (a)). Suppose that the country with the lower tax rate grants subsidies in order to attract more capital from the foreign country. This will move the dotted line leaving the solid line unchanged. The new equilibrium is E, in which all capital of foreign capital moves into its territory and some capital of its own moves to the foreign country, not changing the net inflow of capital. Any amount of subsidy of the country causes a cross-hauling of capital, leaving the net inflow of capital unchanged (see Figure 6.3 (c)). Therefore, the country with the lower tax rate does not need to provide subsidy in order to increase the net inflow of capital.

In contrary, suppose that the country with the higher tax rate grants subsidies in order to reduce the net outflow of capital. In the new equilibrium, all of its capital moves to the foreign country and some amount of capital of the foreign country moves into its territory, reducing the net outflow of capital (see Figure 6.3 (b)). When the subsidy is large enough, the net outflow of the capital can be zero. However, the country with the higher tax rate cannot make a positive net inflow of capital even with an extremely large subsidy.

Proposition 30 *Preferential subsidy for foreign capital always causes a cross-hauling of capital between two countries when both countries apply exemption method. The effect of preferential subsidy is asymmetric in that it is not useful in increasing the net inflow of capital but is useful in reducing the net outflow of capital.*

Is it beneficial to the country with the higher tax rate to reduce the net outflow of capital even if this causes a cross-hauling of capital? The answer depends not only on the magnitude of the parameters which characterise the social welfare function and the production function but also the tax rates in two countries. By reducing the net outflow of the capital, the country with the higher tax rate can increase private consumption and tax revenue. However, it has to provide the subsidy to all foreign capital invested in its territory. The increase in subsidies might result in a sharp decrease in public consumption and thus also lead to a lower social welfare.

Suppose that $t_1 > t_2$ and thus, without subsidy, the net outflow of capital of country 1, $Z = Z_1 - Z_2 > 0$ because $Z_1 > 0$ and $Z_2 = 0$. The private and public consumption of country 1 are respectively

$$C_1 = f(K-Z) - f(K-Z)'(t_1 K - Z) \tag{6.8}$$

and

$$G_1 = t_1 f(K-Z)'(K-Z). \tag{6.9}$$

Suppose that country 1 gives any small amount of subsidy. Then, the changes in private consumption and public consumption are

$$\begin{aligned} \frac{\partial C_1}{\partial s_1} &= -f(K-Z)'(\frac{\partial Z}{\partial s_1}) + f(K-Z)''(t_1 K - Z)(\frac{\partial Z}{\partial s_1}) + f(K-Z)'(\frac{\partial Z}{\partial s_1}) \\ &= f(K-Z)''(t_1 K - Z)(\frac{\partial Z}{\partial s_1}) \end{aligned} \tag{6.10}$$

and

$$\frac{\partial G_1}{\partial s_1} = -t_1 f(K-Z)''(K-Z)(\frac{\partial Z}{\partial s_1}) - t_1 f(K-Z)'(\frac{\partial Z}{\partial s_1}) + (\frac{\partial Z}{\partial s_1}) - (K-Z). \tag{6.11}$$

The last two terms of the right hand side of (6.11) denote the effect of increased subsidies due to a cross-hauling of capital.

Here, we can define $(\frac{\partial Z}{\partial s_1})$ from (6.6) as

$$\frac{\partial Z}{\partial s_1} = \frac{(1-t_1)f(K-Z)'}{(1-t_1)(1+s_1)f(K-Z)''+(1-t_2)f(K+Z)''} < 0. \tag{6.12}$$

Substituting $\frac{\partial Z}{\partial s_2}$ into (6.10) and (6.11), we get

$$\frac{\partial C_1}{\partial s_1} = \frac{f(K-Z)''(t_1K-Z)(1-t_1)f(K-Z)'}{(1-t_1)(1+s_1)f(K-Z)''+(1-t_2)f(K+Z)''} \tag{6.13}$$

and

$$\begin{aligned}\frac{\partial G_1}{\partial s_1} &= \frac{-t_1f(K-Z)''(K-Z)(1-t_1)f(K-Z)' - t_1f(K-Z)'(1-t_1)f(K-Z)'}{(1-t_1)(1+s_1)f(K-Z)''+(1-t_2)f(K+Z)''} \\ &\quad \underline{+(1-t_1)f(K-Z)'} - (K-Z). \end{aligned} \tag{6.14}$$

The sum of changes in private consumption and in public consumption is

$$\begin{aligned}\frac{\partial C_1}{\partial s_1}+\frac{\partial G_1}{\partial s_1} &= \frac{-f(K-Z)''f(K-Z)'(1-t_1)^2Z - t_1(1-t_1)\{f(K-Z)'\}^2}{(1-t_1)(1+s_1)f(K-Z)''+(1-t_2)f(K+Z)''} \\ &\quad \underline{+(1-t_1)f(K-Z)'} - (K-Z). \end{aligned} \tag{6.15}$$

The sign of (6.15) can be positive or negative. Here, I make an assumption that (6.15) is negative for all combination of t_1 and t_2. This assumption means that the country with the higher tax rate has no incentive to reduce the net outflow of capital by manipulating the subsidy. This assumption makes the solution of the game simple. With the above assumption, both countries have no incentive to manipulate subsidy and thus they do not need to consider what effect their tax rates will have on the next stage of the game. They may think that the whole game is over when tax rates are decided. Therefore, the unique perfect subgame Nash equilibrium is $\{(t_1^* = t_C, s_1^* = 0), (t_2^* = t_C, s_2^* = 0)\}$.

Proposition 31 *With the assumption that a cross-hauling of capital is not beneficial at any case, preferential subsidy is not used under the exemption rule. Therefore, the availability of subsidy as a means of attracting foreign capital has no effect on the tax competition. At the subgame perfect Nash equilibrium,* $\{(t_1^* = t_C, s_1^* = 0), (t_2^* = t_C, s_2^* = 0)\}$.

6.3.2 Credit rule

When subsidy is not available, tax competition does not occur under the credit rule. Even if one government lowers its tax rate, foreign capital does not come into the territory because the final tax burden for foreign capital is the tax rate of its residence. When both countries grants preferential subsidies, the capital market equilibrium condition is

$$(1-t_i)f(K+(-1)^i(Z_i-Z_j))' = \{1-\max(t_i,t_j)\}(1+s_j)f(K+(-1)^j(Z_i-Z_j))'. \quad (6.16)$$

When $t_1 = t_2$, a subsidy of both countries cannot attract more capital (see Figure 6.2 (b) and (c)). A subsidy of either country causes a full cross-hauling of capital, leaving the net inflow of capital zero. Therefore, when the tax rates in two countries are the same, neither country manipulates the subsidy.

Suppose that $t_1 > t_2$. Without subsidy, there is no movement of capital between the two countries even if there is a difference in tax rates (see Figure 6.4 (a)). Suppose that the country with the higher tax rate, country 1, tries to attract capital by giving

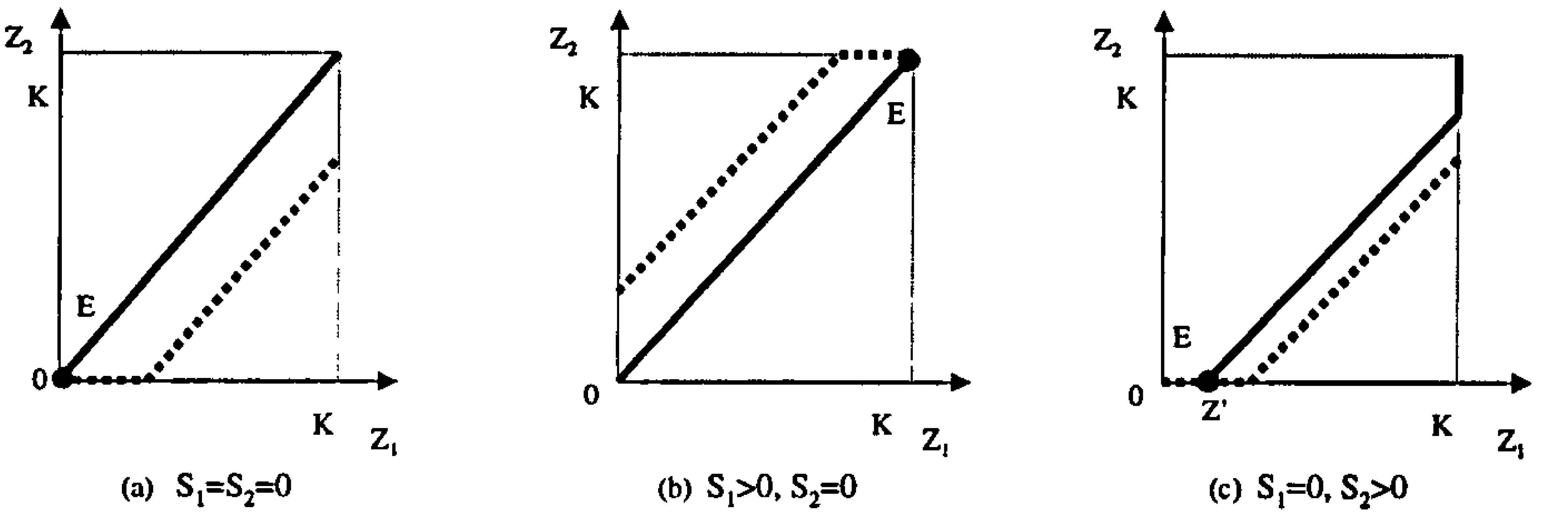

Figure 6.4: Movement of capital when $t_1 > t_2$ under the credit rule

a subsidy while country 2 does not. The capital market equilibrium conditions are

$$f(K - Z_1 + Z_2)' = f(K + Z_1 - Z_2)' \tag{6.17}$$

and

$$(1 - t_1)(1 + s_1)f(K - Z_1 + Z_2)' = (1 - t_2)f(K + Z_1 - Z_2)'. \tag{6.18}$$

(6.17) and (6.18) are for the capital of country 1 and country 2 respectively.

Country 1's subsidy makes the dotted line approach to the solid line. However, when $0 \leq s_1 \leq \frac{1-t_2}{1-t_1} - 1$, the equilibrium is still E is Figure 6.4 (a), where there is no movement of capital between two countries. When $s_1 > \frac{1-t_2}{1-t_1} - 1$, the new equilibrium is E in Figure 6.4(b), where all capital of country 1 locate in country 2 and vice versa. Country 1 fails to attract more capital into its territory, resulting in the waste of subsidy.

Now suppose that country 2, which sets the lower tax rate, tries to attract capital from country 1 by providing subsidy. The capital market equilibrium conditions are

$$f(K - Z_1 + Z_2)' = (1 + s_2)f(K + Z_1 - Z_2)' \qquad (6.19)$$

and

$$(1 - t_1)f(K - Z_1 + Z_2)' = (1 - t_2)f(K + Z_1 - Z_2)'. \qquad (6.20)$$

The amount of capital movement is decided solely by the subsidy of country 2 which has set the lower tax rate. Country 2 can attract capital from country 1 by manipulating the amount of subsidy such that $0 \leq s_2 \leq \frac{1-t_1}{1-t_2} - 1$. If $s_2 > \frac{1-t_1}{1-t_2} - 1$, a cross-hauling of capital occurs. Thus, the maximum amount of the subsidy of country 2 is $s_2 = \frac{1-t_1}{1-t_2} - 1$.

Proposition 32 *Under the credit rule, preferential subsidy is useful in attracting foreign capital only when the tax rate of the country is lower than that of the other country. Any subsidy of the country with higher tax rate results in a full cross-hauling of capital, leaving the net inflow of capital unchanged.*

Can country 2 increase subsidy up to $s_2 = \frac{1-t_1}{1-t_2} - 1$? The answer is yes only when country 2 is certain that country 1 will not grant any subsidy.[8] What happens if country 1 provides a small amount of subsidy, say ϵ? This subsidy reduces the net inflow of capital from country 1 to country 2, causing a cross-hauling of capital. Country 1 can benefit from the cross-hauling because all domestic capital is entitled to

[8]The other precondition is that granting subsidies will increase the social welfare of country 2. This condition is not explicitly considered in the analysis here.

a foreign subsidy, while it provides a small subsidy to foreign capital. Even if granting subsidies increases the distortion of resource allocation between private consumption and public consumption, it may be beneficial to country 1. The social welfare of country 2 deteriorates because the public consumption of country 2 must be reduced sharply due to increased subsidies to all capital of country 1. Therefore, country 2 must increase subsidy up to the point where a cross-hauling of capital is not beneficial to country 1.

Is it beneficial for the country with the lower tax rate to grant subsidy? The private consumption and public consumption of country 2 are respectively

$$\begin{aligned} C_2 &= f(K+Z) - f(K+Z)'(K+Z) + (1-t_2)f(K+Z)'K \\ &= f(K+Z) - f(K+Z)'(t_2K+Z) \end{aligned} \tag{6.21}$$

and

$$G_2 = t_2 f(K+Z)'K + (t_2 - s_2 + t_2 s_2) f(K+Z)'Z. \tag{6.22}$$

The effect of subsidy on the private consumption and the public consumption are

$$\begin{aligned} \frac{\partial C_2}{\partial s_2} &= f(K+Z)'(\frac{\partial Z}{\partial s_2}) - f(K+Z)''(t_2K+Z)(\frac{\partial Z}{\partial s_2}) - f(K+Z)'(\frac{\partial Z}{\partial s_2}) \\ &= -f(K+Z)''(t_2K+Z)(\frac{\partial Z}{\partial s_2}) > 0 \end{aligned} \tag{6.23}$$

and

$$\begin{aligned} \frac{\partial G_2}{\partial s_2} &= t_2 f(K+Z)''K(\frac{\partial Z}{\partial s_2}) + (t_2 - s_2 + t_2 s_2) f(K+Z)''Z(\frac{\partial Z}{\partial s_2}) \\ &\quad + (t_2 - s_2 + t_2 s_2) f(K+Z)'(\frac{\partial Z}{\partial s_2}) - (1-t_2) f(K+Z)'Z \lesseqgtr 0. \end{aligned} \tag{6.24}$$

Even if $t_1 > t_2$, $Z^* = 0$ without subsidy. Then, the sum of (6.23) and (6.24) is

$$\frac{\partial C_2}{\partial s_2} + \frac{\partial G_2}{\partial s_2} = (t_2 - s_2 + t_2 s_2) f(K)' (\frac{\partial Z}{\partial s_2}) > 0. \tag{6.25}$$

(6.25) implies that an arbitrarily small subsidy increases the sum of private consumption and public consumption at any value of t_2. However, it does not necessarily mean that granting subsidy is welfare-improving at any tax rate. The distortion of the under-supply of public goods dominates the positive effect of the increase in the sum of private consumption and public consumption at the lower value of $t_2 = t_L$. As long as $t_2 > t_L$, subsidy can increase the level of social welfare.

The objective of the government of country 2 is

$$\max_{s_2} W(C_2, G_2). \tag{6.26}$$

The first order condition gives

$$\begin{aligned} \frac{W_{C_2}}{W_{G_2}} &= \frac{t_2 f(K+Z)'' K\psi + (t_2 - s_2 + t_2 s_2) f(K+Z)'' Z\psi}{f(K+Z)''(t_2 K + Z)\psi} \\ &\quad \underline{+(t_2 - s_2 + t_2 s_2) f(K+Z)'\psi - (1 - t_2) f(K+Z)' Z} \\ &= 0 \end{aligned} \tag{6.27}$$

where

$$\psi = \frac{\partial Z}{\partial s_2} = \frac{-f(K+Z)'}{f(K-Z)'' + (1+s_2) f(K+Z)''}. \tag{6.28}$$

By substituting ψ, we have

$$\frac{W_{C_2}}{W_{G_2}} = \frac{f(K+Z)''(t_2 K + Z) + (t_2 - s_2 + t_2 s_2) f(K+Z)' + f(K-Z)''(1-t_2) Z}{f(K+Z)''(t_2 K + Z)}. \tag{6.29}$$

With the same welfare function and production function, we have

$$\frac{W_{C_2}}{W_{G_2}} = \frac{G_2}{C_2} = \frac{t_2 f(K+Z)'K + (t_2 - s_2 + t_2 s_2) f(K+Z)'Z}{f(K+Z) - f(K+Z)'(t_2 K + Z)}. \tag{6.30}$$

Therefore, we have

$$s_2^* = s_2(t_2).^9 \tag{6.31}$$

We assume that t_2 exists such that

$$s_2^*(t_2 = t_s) = 0.^{10} \tag{6.32}$$

Each country sets its tax rate below that of the other country in the first stage of game so that it can attract capital by granting subsidy at the second stage. The process of tax undercutting will continue until the positive effect of attracting foreign capital dominates the negative effect of the under-supply of public goods. Subsidy competition does not occur when the tax rates in both countries are below certain level, say t_s. Both countries will lower their tax rate to t_s at the first stage, and none of countries have an incentive to grant a subsidy at the second stage. Therefore, $\{(t_i^* = t_s, s_i^* = 0), (t_j^* = t_s, s_j^* = 0)\}$ is the unique subgame perfect Nash equilibrium.

Why do both countries not deviate from this equilibrium by increasing their tax rates even if it does not cause the capital flight? If one increases its tax rate above t_s, it will make the other country to utilize a subsidy at the second stage of the game. As a result, it suffers from the capital flight.

[9] The amount of capital movement is a function of subsidy of country 2 (see (6.19)). Therefore, the tax rate of country 1 dose not have an effect on the optimal value of subsidy of country 2.

[10] The existence and uniqueness of t_s is not demonstrated.

Proposition 33 *Under the credit rule, preferential subsidy is not used. However, the availability of subsidy as a means of attracting foreign capital makes both countries set their tax rates to the lower level. At the subgame perfect Nash equilibrium,* $t_i^* = t_j^* = t_S < t_A$ *and* $s_i^* = s_j^* = 0$.

6.4 Universal subsidy

Here, subsidy is granted to the capital in its territory, both domestic and foreign. When each country is in autarky, capital can not move across countries at all. Therefore, Z_i is always 0. The objective of country i is

$$\max_{t_i, s_i} W(C_i, G_i) \tag{6.33}$$

with subject to

$$\begin{aligned} C_i &= f(K) - t_i(1+s_i)f(K)'K + s_i f(K)'K, \\ G_i &= t_i(1+s_i)f(K)'K - s_i f(K)'K \\ 0 &\leq t_i < 1. \end{aligned} \tag{6.34}$$

The first-order conditions are

$$\frac{\partial W}{\partial t_i} = W_{C_i}\{-(1+s_i)f(K)'K\} + W_{G_i}\{(1+s_i)f(K)'K\} = 0 \tag{6.35}$$

and

$$\frac{\partial W}{\partial s_i} = W_{C_i}\{-t_i f(K)'K + f(K)'K\} + W_{G_i}\{t_i f(K)'K - f(K)'K\} = 0. \tag{6.36}$$

Therefore, $\frac{W_{C_i}}{W_{G_i}} = 1$. The marginal rate of substitution between private consumption and public consumption is 1.

With the social welfare function defined in (3.59) with $\beta = 1$ and the production function defined in (3.60), the optimal condition, $\frac{W_{C_i}}{W_{G_i}} = 1$, gives $C_i = G_i$. Therefore, we get

$$t_i = 1 - \frac{2\alpha - 1}{2\alpha(1 + s_i)}. \tag{6.37}$$

Now, the optimal tax rate is a non-linear function of subsidy. Table 6.2 shows the relationship between tax rates and subsidies when $\alpha = 3/4$. As the government increases subsidies, the optimal tax rate must also be increased. Subsidies transfer income from public consumption to private consumption and thus the tax rate must be increased to make up for this income transfer effect. On the assumption that the government prefers the least subsidy, the solution is

$$t_i = \frac{1}{2\alpha} \tag{6.38}$$

and

$$s_i = 0. \tag{6.39}$$

6.4.1 Exemption rule

When the exemption rule is applied, for capital of country i, the income from capital invested domestically is subject to the tax of country i and eligible for the subsidy of country i while the income from the capital invested in country j is subject

subsidies (s_i)	tax rates (t_i)
0	0.67
0.10	0.70
0.25	0.73
0.50	0.78
1.00	0.835
goes to ∞	gose to 1

Table 6.2: Tax rates and subsidies in autarky

to the tax rate of country j and eligible for the subsidy of country j. Therefore the equilibrium condition is

$$(1-t_i)(1+s_i)f(K+(-1)^i Z)' = (1-t_j)(1+s_j)f(K+(-1)^j Z)'. \qquad (6.40)$$

(6.40) is the same for the capital of country j. If we take total differentials with (6.40) with regard to one policy variable, given that other policy variables are fixed, we have

$$\begin{aligned}
\frac{dZ}{dt_i} &= \frac{-(1+s_i)f(K-Z)'}{(1-t_i)(1+s_i)f(K-Z)''+(1-t_j)(1+s_j)f(K+Z)''} > 0,\\
\frac{dZ}{dt_j} &= \frac{(1+s_j)f(K+Z)'}{(1-t_i)(1+s_i)f(K-Z)''+(1-t_j)(1+s_j)f(K+Z)''} < 0,\\
\frac{dZ}{ds_i} &= \frac{(1-t_i)f(K-Z)'}{(1-t_i)(1+s_i)f(K-Z)''+(1-t_j)(1+s_j)f(K+Z)''} < 0
\end{aligned}$$

and

$$\frac{dZ}{ds_j} = \frac{-(1-t_j)f(K+Z)'}{(1-t_i)(1+s_i)f(K-Z)''+(1-t_j)(1+s_j)f(K+Z)''} > 0. \qquad (6.41)$$

(6.41) implies that an increase in its own tax rate makes more domestic capital leave its territory but that an increase in its own subsidy makes more foreign capital move into its territory. Therefore, the government can attract capital either by lowering its tax rate or by increasing its subsidy.

Lemma 34 *An increase (A decrease) in its own universal subsidy leads to an increase (a decrease) in net inflow of capital. The change in the other country's subsidy has the opposite effect.*

The private consumption and the public consumption for country i are

$$\begin{aligned} C_i &= f(K-Z) - f(K-Z)'(K-Z) + \{(1-t_i)(1+s_i)f(K-Z)'\}(K-Z) \\ &\quad + \{(1-t_j)(1+s_j)f(K+Z)'\}Z \\ &= f(K-Z) - f(K-Z)'(t_i - s_i + t_i s_i)K + f(K-Z)'Z. \end{aligned} \tag{6.42}$$

and

$$\begin{aligned} G_i &= t_i(1+s_i)f(K-Z)'(K-Z) - s_i f(K-Z)'(K-Z) \qquad (6.43) \\ &= (t_i - s_i + t_i s_i)f(K-Z)'(K-Z). \end{aligned}$$

Let $(1-t_i)(1+s_i)$ be $(1-w_i)$. Then, the maximization with respect to t_i and s_i is the same with the maximization with respect to w_i. The solution is

$$\frac{W_{C_i}}{W_{G_i}} = 1 + \frac{w_i^* f(K)'}{(2-w_i^*)f(K)''K}. \tag{6.44}$$

With the social welfare function and the production function defined in chapter 3, we have, assuming $\alpha = 0.5$,

$$w_i^* = t_i - s_i + t_i s_i = 0.5. \tag{6.45}$$

There are infinite combinations of t_i and s_i which produce the same effective tax rate. The relationship between t_i and s_i is

$$s_i = \frac{t_i - 0.5}{1 - t_i}. \tag{6.46}$$

tax rate (t_i)	subsidy (s_i)
close to 1	goes to ∞
0.9	4
0.8	1.5
0.7	0.67
0.6	0.25
0.5	0

Table 6.3: Tax rates and subsidies under the exemption rule

Table 6.3 gives values of t_i and s_i which give the same social welfare.

All of these combination of tax rates and subsidies are subgame perfect Nash equilibria. However, by the assumption that the least subsidy is preferred, $\{(t_i = 0.5, s_i = 0), (t_j = 0.5, s_j = 0)\}$ is the unique subgame perfect Nash equilibrium. Only tax cutting is used at the equilibrium.

Proposition 35 *Under the exemption rule, there are an infinite number of subgame perfect Nash equilibria, in which both countries use tax cutting, granting subsidies or both of them. Every equilibrium results in the same effective tax rate, which is lower than the optimal level.*

The result of this analysis will be different if a 'unit subsidy' is used instead of 'proportional subsidy'. With a 'unit subsidy', the total effect of tax rate and subsidy cannot be denoted by a single value of effective tax rate. If tax undercutting is more effective than subsidy in attracting foreign capital, only tax undercutting is used. Contrarily, if subsidy is more effective than tax undercutting, tax rate will be increased to the maximum and subsidy will be granted at the maximum value.

However, as has been shown in (6.41), the relative effectiveness of tax cutting and granting subsidies depends on all four policy variables and changes according to these values. Therefore, tax cutting and granting subsidies are likely to be used together.

6.4.2 Credit rule

With the credit with limitation rule, for the capital of country i, the income from the capital invested domestically is subject to the tax rate of country i and eligible for the subsidy of country i while the income from the capital invested in country j is subject to the higher one between the tax rate of country i and that of country j and eligible for the subsidy of country j. The equilibrium condition is

$$(1-t_i)(1+s_i)f(K+(-1)^i Z)' = \{1-max(t_i,t_j)\}(1+s_j)f(K+(-1)^j Z)'. \quad (6.47)$$

Country i cannot attract capital from country j solely by lowering its tax rate but it can attract foreign capital by increasing its subsidy. Therefore, granting subsidy and tax cutting are not perfect substitutes for each other under the credit rule. The difference between them is in contrast to the case under the exemption rule. Tax cutting is not useful in attracting foreign capital but is useful in reducing the outflow of domestic capital. In contrary, subsidies are useful in both purposes.

Can $\{(t_i = t_C, s_i = 0), (t_j = t_C, s_j = 0)\}$ be a Nash equilibrium? When $t_i = t_C$, country j will raise its tax rate to the optimal level, t_A, because tax difference does not cause the capital flight only if $s_i = 0$. For the country with higher tax rate, it is not beneficial to reverse tax differential by granting subsidy. It is also not beneficial for country with the lower tax rate of t_C because the effect of distortion in the allocation of products between private and public consumption outweighs the positive effect of attracting foreign capital for both countries. Therefore, $\{(s_i = 0), (s_j = 0)\}$ is an equilibrium when $\{(t_i = t_C), (t_j = t_A)\}$ is the result in the first stage. However, this outcome cannot be an equilibrium in the whole game because country i will increase its tax rate to t_A and grant a positive subsidy.

Suppose the result of the stage of tax competition is $\{(t_i = t_A), (t_j = t_A)\}$. Subsidy competition at the second stage leads to $\{(s_i = s_C), (s_j = s_C)\}$. There is no movement of capital between two countries but both countries are worse off because of distortion between private and public consumption. Subsidies transfer tax revenue to private consumption from public consumption. The effective tax rate is the same with when only tax rate is available to manipulate.

The problem arises from the assumption that both countries prefer the least level of subsidy if other things are equal. Each country prefers $\{(t = t_C), (s = 0)\}$ to $\{(t = t_A), (s = s_C)\}$. We return to the starting point. There is no pure-strategy subgame perfect Nash equilibrium if we stick to the assumption. If both countries are concerned with the effective tax rates regardless of composition of tax rates and subsidies, the unique subgame perfect Nash equilibrium is $(t = t_A, s = s_C)$ for both countries. Both country prefer $(t = t_A, s = s_C)$ to $(t = t_C, s = 0)$ because the former can attract capital when the other country chooses the strategy of $(t = t_A, s < s_C)$

while the latter cannot.[11] In any case, pure strategy equilibrium and mixed strategy equilibrium, the effective tax rates of both countries will be lower than those in autarky.

Proposition 36 *Under the credit rule, each country does not lower its tax rate but grants subsidies at the subgame perfect Nash equilibrium. The effective tax rate will be the same with that under the exemption rule. With the assumption that the least subsidy is preferred, only mixed subgame perfect Nash equilibrium exists. Each country mixed tax cutting and granting subsidies, which leads to lower effective tax rate.*

6.5 Conclusion

The aim of this chapter was to set up a game in which both tax cutting and subsidies are manipulated by governments in order to attract foreign capital. The game was sought to emphasize that the outcomes of international tax competition depend both upon the strategies available to each government and the structure of the game. The availability of subsidies has an effect on tax competition and its effect depends on the nature of subsidy. When subsidy competition follows tax competition, strategic tax setting behaviours occur even under the credit method.

Under the exemption rule, preferential subsidies might not be used because they result in a cross-hauling of capital, leaving net inflow of capital unchanged. Universal

[11]$(t = t_A, s = s_C)$ weakly dominates $(t = t_C, s = 0)$. However, the concept of Nash equilibrium does not exclude the use of the weakly dominated strategy.

subsidies can be used to attract foreign capital along with tax undercutting, leaving effective tax rates identical to those of the game where only tax undercutting is available. On the assumption that a lower tax rate with a lower level of subsidy is preferred to a higher tax rate with a higher level of subsidy, providing they result in the same level of social welfare, it can be concluded that only tax undercutting is used at the equilibrium.

The more surprising results are provided when the credit rule is applied. Under the credit rule, the availability of preferential subsidies at the second stage of the game forces both countries to set lower tax rates at the first stage. Preferential subsidies can be used to attract foreign capital only by the country with the lower tax rate. At the equilibrium, both countries lower their tax rates to a level where there is no incentive for both countries to grant subsidies at all. Universal subsidies are more powerful than tax undercutting if they lead to the same effective tax rates. Tax undercutting cannot make the net inflow of capital positive whilst subsidy, in contrast, can. Therefore, only universal subsidies are used to lower effective tax rates, leaving tax rates at the optimal level. However, when the least subsidy is preferred, tax cutting and granting subsidy is used together to get the lower effective tax rate.

The result has significant implications for anti-tax competition policies. Unless countries are forbidden from granting subsidies for the purpose of attracting foreign capital, anti-tax competition policies cannot work as expected in previous studies. If the residence principle is enforced by the international coordination, tax competition is replaced by subsidy competition. Effective tax rates are the same as those at the non-cooperative equilibrium and the distortion from the under-supply of public goods occurs. In this sense, international tax coordinations (tax harmonization or the imposition of minimum tax rate) are likely to lead to higher tax rates and higher levels of subsidy. Therefore, the under-supply of public goods is not eased but the total tax revenue, before granting subsidies, becomes greater than that when only tax undercutting is available.

The original questions raised in the introduction of this chapter can be answered. The analysis has demonstrated that the difference between the exemption rule (a source-based tax) and the credit rule (a residence-based tax) disappears[12] when subsidies are available in attracting foreign capital. The effective tax rates will be lowered under any tax rule and public goods is under-supplied. Therefore, countries are indifferent to the tax rules. Tax competition, in terms of effective tax rates, occurs not only under the exemption rule but also under the credit rule.

It is not my intention to argue that subsidies will effectively nullify the expected effect of international tax coordinations. In reality, subsidies are regulated by the international rules. In this thesis, I suggest the possibility of that the outcome of tax coordinations can be altered by other factors which governments can manipulate.

One direction of extending the model presented in this chapter would be to explore a variety of forms of subsidy. The results in this chapter rest on the assumption that

[12]This is not strictly applied to preferential subsidies because t_C^* (equilibrium tax rate under the exemption rule) is not necessarily equal to t_s^* (equilibrium tax rate under the credit rule).

the amount of subsidy is determined according to the marginal productivity of capital, and subsidy is subject to capital income taxation. However, a 'unit subsidy' appears to be a more appealing option because the marginal productivity of capital is rarely known when a decision on the location of capital is made. In addition, some subsidies which are given as form of granting cash are likely to be subject to capital income taxation, but there are many other subsidies which are not subject to taxation at all.

Chapter 7

Tax competition with imperfect capital mobility

7.1 Introduction

Standard tax competition models have adopted the assumption of perfect capital mobility. The assumption of perfect capital mobility, however, runs counter to the established results of empirical research on the international capital mobility. Most empirical studies indicate a higher positive correlation between domestic saving and investment, which is believed to indicate imperfect capital mobility. In addition, real interest rates have not been equalized across major countries. Imperfection in the international capital market is an accepted phenomenon (among many, see Feldstein and Horioka [1980] and Feldstein [1996]).

The imperfection of capital mobility in the context of tax competition has been studied by Persson and Tabellini (1992) and Eggert and Haufler (1996). Imperfection in capital mobility is incorporated into the standard model by transaction costs. Those two models have focused on the welfare effects of changes in the size of transaction costs. A decrease in transaction costs is predicted to intensify tax competition between identical countries and thus pushes the non-cooperative Nash equilibrium away from the optimal level. However, this result depends on the assumption that the non-cooperative Nash equilibrium exists under imperfect capital mobility as is the case under perfect capital mobility.

They can go round away from the problem of the existence of Nash equilibrium by assuming a specific form of transaction costs. The crucial assumption is that the marginal costs of locating the first unit of capital abroad are zero. Any tax differential will then lead to the movement of capital between two countries. The introduction of transaction costs does not change the result of the existence of the Nash equilibrium in the perfect capital mobility model.

These models, however, fail to explain the situation in which capital does not necessarily move across countries even if there is tax differential. The objective of this chapter is to explore the effect of imperfect capital mobility on tax competition. In this thesis, the imperfection of capital mobility is assumed to originate from transaction costs. When capital moves internationally, investors may bear extra costs which do not occur in domestic movement of capital. These extra costs include long-distance transportation costs, learing costs which are paid by foreign investors doing business in an unfamiliar climate, the risk of non-repatriation of the product by host countries, etc.. More importantly, transaction costs are specified different from the previous studies. The marginal transaction costs for the first unit of capital movement are not zero. Therefore, a tax differential does not necessarily cause the movement of capital.

When transaction costs are large, international capital mobility does not change tax rate in both countries. As transaction costs become smaller, international capital mobility triggers tax competition between the two countries. While there must be the pure strategy Nash equilibrium at which tax rate is lower than the optimal tax rate under perfect capital mobility, there is no pure strategy Nash equilibrium under imperfect capital mobility.

The non-existence of pure strategy Nash equilibrium is due to a change in the strategy of each country and thus a discontinuity in its reaction function. When the tax rate of the foreign country is high, the country is willing to undercut its own tax rate to attract capital from the foreign country. However, as the tax rate of the foreign country is lowered, the country gives up undercutting because the distortion from tax undercutting is greater than the benefit derived from attracting foreign capital. In this situation, the best strategy is to set its tax rate at a level above that of the foreign country but below the tax rate at which domestic capital moves abroad.

When this strategy is used by both countries, there is no pure strategy Nash equilibrium. If a mixed strategy Nash equilibrium exists, each country randomly selects its tax rate from tax rates below the optimal level. These tax rates are within the range of twice the size of transaction costs.[1] Due to randomization of tax rates, the realized tax rates in the two identical countries may be different. As transaction costs decrease, the tax rates of both countries decrease and the expected tax differential between them also becomes smaller. Finally, as transaction costs tend to zero, the tax rates converge to the tax rate which is the Nash equilibrium under tax competition with perfect capital mobility.

The analysis is also carried out with a small-open economy model. The result shows that there is always a unique equilibrium tax rate even under imperfect capital mobility, as is the case under perfect capital mobility. The degree of tax undercutting of a small-open country depends on the size of transaction costs. Under imperfect capital mobility, tax undercutting is less intensive than under perfect capital mobility. The rationale for this result is that transaction costs counteract the tax differential and thus the movement of capital is less sensitive to the tax differential than under perfect capital mobility.

The paper is organized as follows. In the next section, the equilibrium tax rate in perfect capital mobility and imperfect capital mobility is compared with a two-identical economy model. A small-open economy case is analysed in section 3. Concluding remarks are presented in section 4, together with limitations of the analysis and suggestions for future research.

[1]When θ denotes the size of transaction costs, the range of tax rates is $\frac{2\theta}{f(K)'}$.

7.2 Symmetric two countries case

7.2.1 Perfect capital mobility

The analysis of this model is provided in chapter 3. At the symmetric equilibrium, the marginal utility from public goods is greater than that from private goods. Thus, it is welfare-increasing to consume more public goods and less private goods by increasing tax revenue with a higher tax rate. This result implies that public goods is provided below the optimal level and the tax rate is also below the optimal. At the non-cooperative equilibrium, there is no distortion caused by capital allocation between the two countries. The distortion of the under-supply of public goods arises either because of each government's incentive to attract foreign capital or because of the threat of tax base erosion caused by the lower tax rate of foreign country.

Numerical calibrations show that the Nash equilibrium is unique and stable by drawing the reaction function of both countries. The reaction functions of both countries are continuous and monotonic ones with regard to the tax rates of the foreign country as shown in Figure 3.1.

7.2.2 Imperfect capital mobility

When firms invest their capital abroad, they must bear extra transaction costs, θ, which do not occur when capital is invested domestically. If a domestic investor sends an amount of capital Z abroad, transaction costs, $T = \theta Z$, be paid in the transaction process. The marginal transaction costs are constant and, more importantly, the marginal transaction costs for the first unit of capital movement are not zero.[2] The costs are assumed to be identical for capital moving from country 1 to country 2 and for the capital moving from country 2 to country 1.

Now, we have two different capital market equilibrium conditions, one for the capital of country 1 and the other for that of country 2. These conditions are

$$(1 - t_1)f(K - Z_1 + Z_2)' = (1 - t_2)f(K + Z_1 - Z_2)' - \theta \tag{7.1}$$

and

$$(1 - t_2)f(K + Z_1 - Z_2)' = (1 - t_1)f(K - Z_1 + Z_2)' - \theta.^3 \tag{7.2}$$

Suppose that country 2 lowers its tax rate enough to attract the capital of country 1 to the level to satisfy (7.1). In this situation, it is profitable to locate all the capital of country 2 domestically because the left-hand side of (7.2) is strictly greater than the right-hand side. If the tax rate of country 1 is lowered enough to attract capital from country 2, the capital of country 1 never moves to country 2 at the same time. As a result, cross-hauling of capital never occurs and thus we can write $Z = Z_1 - Z_2$.

[2]It is not critical to the result of analysis whether transaction costs are linear or convex. The critical assumption is that the marginal transaction costs for the first unit of capital movement is not zero. Therefore, instead of the linear transaction costs, we may assume the general transaction costs function as

$$T = T(Z),$$

where $T(Z = 0) = 0$, $T(Z)' > 0$ and $T(Z)'' > 0$.

[3]Here, transaction costs are assumed not to be deducted from the tax base income. If it is deducted, (7.1) and (7.2) should be changed as follows. $(1 - t_1)f(K - Z_1 + Z_2)' = (1 - t_2)\{f(K + Z_1 - Z_2)' - \theta\}$ and $(1 - t_2)f(K + Z_1 - Z_2)' = (1 - t_1)\{f(K - Z_1 + Z_2)' - \theta\}$.

$Z > 0$ implies $Z_1 > 0$ and $Z_2 = 0$ and $Z < 0$ implies $Z_1 = 0$ and $Z_2 > 0$. When $Z = 0$, $Z_1 = Z_2 = 0$.

Due to the two different equilibrium conditions (both of which cannot be satisfied at the same time), we have to divide (t_1, t_2) space with three mutually exclusive regions and derive reaction function for each region. The three regions are as follows.

1. $t_2 < t_1 - \frac{\theta}{f(K)'}$: $Z > 0$ and (7.1) is satisfied while (7.2) is not satisfied.

2. $t_2 > t_1 + \frac{\theta}{f(K)'}$: $Z < 0$ and (7.2) is satisfied while (7.1) is not satisfied.

3. $t_1 + \frac{\theta}{f(K)'} \geq t_2 \geq t_1 - \frac{\theta}{f(K)'}$: $Z = 0$ and both of (7.1) and (7.2) are not satisfied.[4]

Firstly, when $Z > 0$, the private consumption and public consumption of country 1 are

$$\begin{aligned} C_1 &= f(K-Z) - (K-Z)f(K-Z)' + (1-t_1)(K-Z)f(K-Z)' \\ &\quad + (1-t_2)f(K+Z)'Z - \theta Z \\ &= f(K-Z) - (t_1 K - Z)f(K-Z)'. \end{aligned} \tag{7.3}$$

and

$$G_1 = t_1 f(K-Z)'(K-Z) \tag{7.4}$$

The private consumption and public consumption of country 2 are

$$\begin{aligned} C_2 &= f(K+Z) - (K+Z)f(K+Z)' + (1-t_2)Kf(K+Z)' \\ &= f(K+Z) - f(K+Z)'(K+t_2 Z) \end{aligned} \tag{7.5}$$

[4]This region is equivalent to the 'double autarky' regime in Mintz and Tulkens (1986). This region does not exist with the assumption that the marginal transaction costs for the first unit of capital movement are zero.

and

$$G_2 = t_2 f(K+Z)'(K+Z) \tag{7.6}$$

The private consumption and the public consumption of both countries are the same with those in the model of perfect capital mobility. Therefore, the first order conditions are the same with those in (3.28). However, the reaction function is not the same because the amount of moving capital, Z, is differently defined. When Z_f and Z_{if} denote the amount of movement of capital under perfect and imperfect capital mobility given equal tax differential such that $t_1 - t_2 = dt > 0$, the equilibrium conditions defined in (3.23) and (7.1) give

$$\frac{f(K-Z_f)'}{f(K+Z_f)'} = \frac{(1-t_2)}{(1-t_1)} > \frac{(1-t_2)}{(1-t_1)} - \frac{\theta}{(1-t_2)f(K+Z_{if})'} = \frac{f(K-Z_{if})'}{f(K+Z_{if})'}. \tag{7.7}$$

(7.7) implies $Z_f > Z_{if}$ because the production function defined in (3.60) has a monotonically decreasing marginal product.

The reaction function can not be expressed explicitly because Z cannot be explicitly expressed with the function of t_1, t_2 and θ. Here we assume that the reaction function under imperfect capital mobility has a shape similar to that under perfect capital mobility as shown in Figure 3.1.

Secondly, when $Z < 0$, the private consumption and the public consumption of both countries are the same with those in (7.3)-(7.6). The reaction functions are symmetrical with $Z > 0$.

When $t_1 + \frac{\theta}{f(K)'} \geq t_2 \geq t_1 - \frac{\theta}{f(K)'}$, there is no movement of capital. Therefore, it is the best policy of country 1 to set its tax rate as close to the optimal tax rate as possible. The following is the best response for country 1.

1. If $t_2 + \frac{\theta}{f(K)'} \geq t_1^*(t_2) \geq t_2 - \frac{\theta}{f(K)'} \geq t_A$, $t_1^*(t_2) = t_2 - \frac{\theta}{f(K)'}$.

2. If $t_2 + \frac{\theta}{f(K)'} \geq t_A \gtreqless t_1^*(t_2) \geq t_2 - \frac{\theta}{f(K)'}$, $t_1^*(t_2) = t_A$.

3. If $t_A \geq t_2 + \frac{\theta}{f(K)'} \geq t_1^*(t_2) \geq t_2 - \frac{\theta}{f(K)'}$, $t_1^*(t_2) = t_2 + \frac{\theta}{f(K)'}$.

Figure 7.1 and 7.2 show different response functions depending on the size of transaction costs. As transaction costs become smaller, the response function changes from Figure 7.1 to Figure 7.2.[5] The discontinuity occurs because the strategy of the country changes from 'undercutting foreign tax rate' to 'approaching to the optimal tax rate'. As Figure 7.1 shows, with large transaction costs, each country sets its tax rate at the optimal level. As transaction costs become smaller, the reaction functions of both countries become as shown in Figure 7.2. In this case, the two reaction functions do not intersect, which implies that there is no pure-strategy Nash equilibrium. There might be mixed-strategy Nash equilibrium.[6]

Proposition 37 *A pure strategy Nash equilibrium does not exist for sufficiently small transaction costs. Instead, both countries randomize their tax rates.*

[5]Compared with Figure 7.1, Figure 7.2 has three different features. Firstly, two transaction cost lines are closer to the diagonal line, representing smaller tranaction costs. Secondly, the curved reaction function is far away from the diagonal line. Third, the position of E_1 is far away from E_0.

[6]The social welfare function is no longer continuous with respect to tax rates. However, discontinuities in the payoff function are not the real problem for the existence of mixed strategy Nash equilibrium (see Dasgupta and Maskin [1986]).

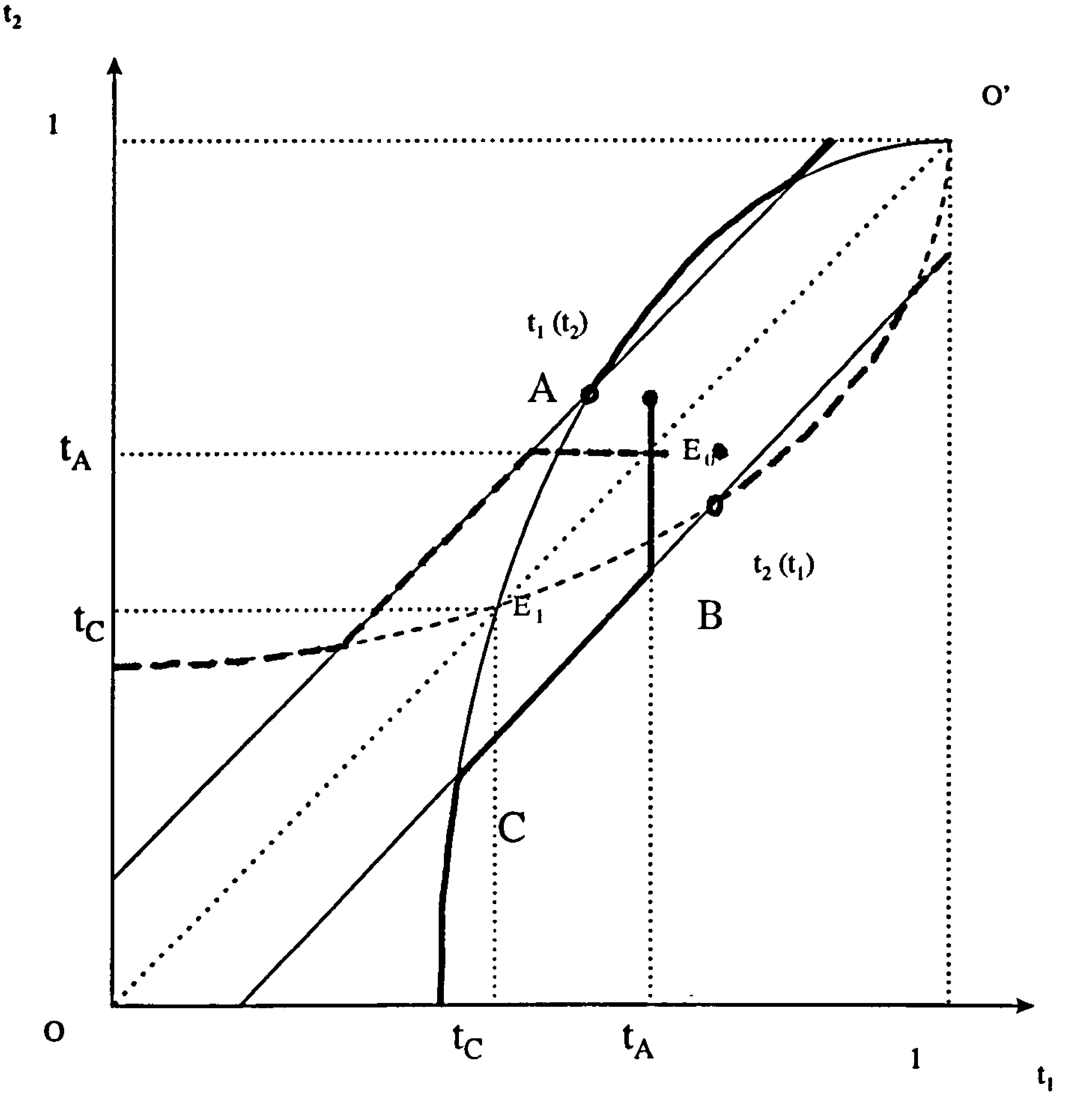

Figure 7.1: Reaction functions when transaction costs are large

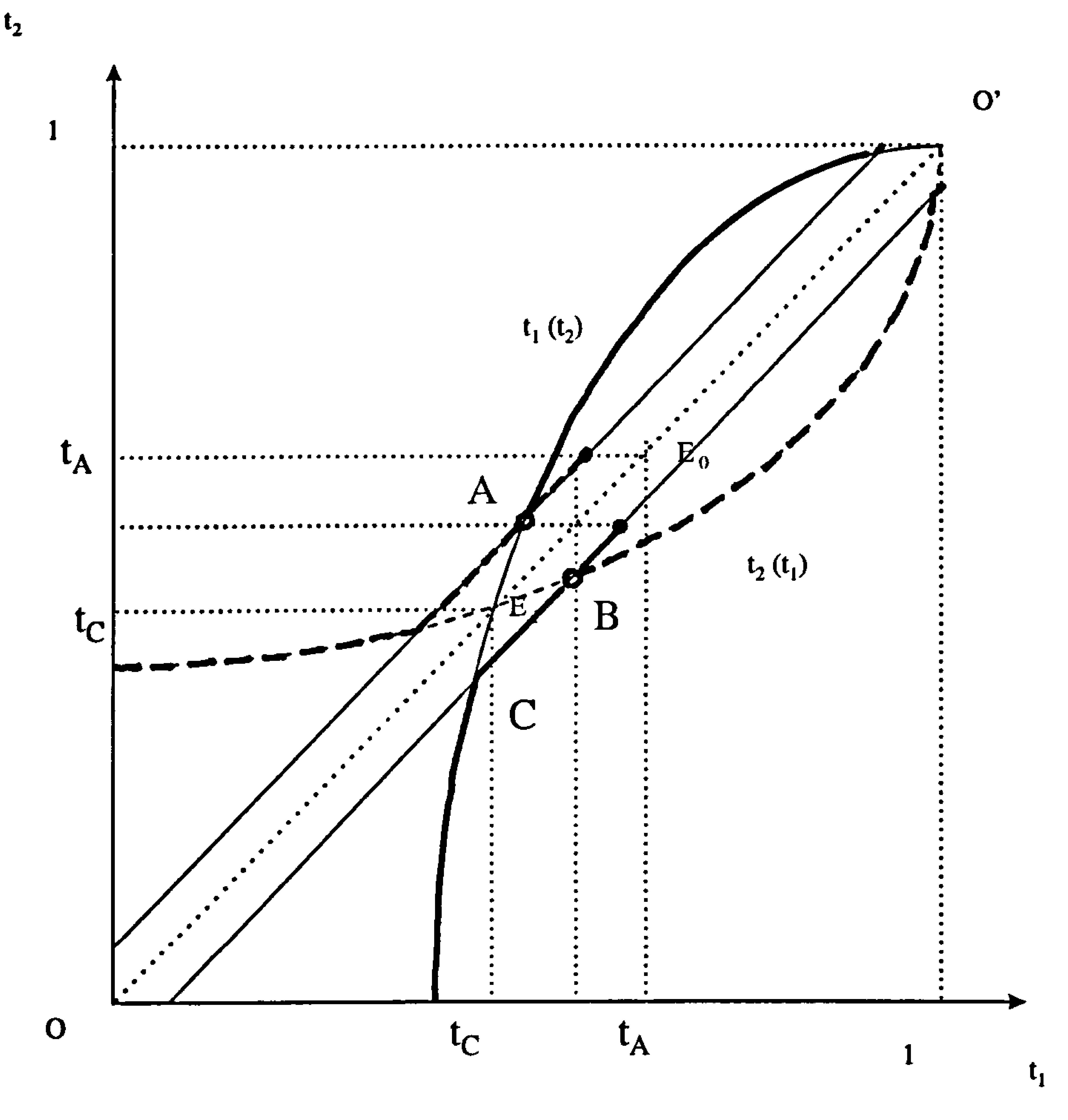

Figure 7.2: Reaction functions when transaction costs are small

How does each country create its mixed strategy? Do they randomize their tax rate over $t_i \in [0, 1)$? The strictly dominated strategies are not used in randomizing its strategy. The set remaining after iterative deletion of strictly dominated strategies is identical to the set of rationalizable strategies.[7] A rationalizable strategy consists of only the best responses[8]. The set of rationalizable strategies consists of those that may be played in a game where the structure of the game and the rationality of the players are common knowledge among the players. A player should not play a strategy that is never a best response. Moreover, common knowledge of rationality and the structure of the game implies that we can iterate the deletion of strategies that are never a best response. The set of strategies surviving this iterative deletion process can be the set of strategies that can be played by rational players.

We can exclude tax rates which are not best response. First, for t_1, the range of $[0, t_m)$ and $(t_n, 1)$ are excluded in Figure 7.2. Then, for t_2, we can exclude the tax rates except the tax rates corresponding $t_1 \in (t_m, t_n)$. This iterative process leads to a range of $t_i \in (t_L, t_H), i = 1, 2$. The concept of rationalizable strategy leads to the conclusion that only $t_i \in (t_L, t_H)$ constitutes a rationalizable strategy. Therefore, both countries randomize only with tax rates lower than the optimal level, t_A, but higher than the tax rate under tax competition with no transaction cost, t_C.

It is also expected that the tax rates are different from each other as a result

[7]This is true only in two players' game. Genarally, the set of rationalizable strategies is no larger than the set remaining after iterative deletion of strictly dominated strategies.

[8]Strategy σ_i is a best response for player i to his rival's strategies, σ_{-i} if $u_i(\sigma_i, \sigma_{-i}) \geq u_i(\sigma_i^*, \sigma_{-i})$ when σ_i^* is all possible responses of player i. Strategy σ_i is never a best response if there is no σ_{-i} for which σ_i is a best response (see Mas-colell, A., M. D. Whinston and J. R. Green [1995], 242-245).

of randomization. This result is striking because two identical countries can have different tax rates. However, the tax differential does not cause the movement of capital because the tax differential is smaller than transaction costs. As transaction costs become smaller, t_L and t_H become smaller and, at the same time, the interval between t_L and t_H becomes narrower. Finally, as transaction costs become close to zero, t_L and t_H converge to the tax rate under tax competition with perfect capital mobility, t_C.

7.3 Small economy case

7.3.1 Perfect capital mobility

The world rate of return of capital is assumed not to change due to the movement of capital from/to a small-open economy.[9] The world tax rate is also assumed to be fixed. Suppose that the gross rate of return of capital in the world is r_w and that the tax rate is t_w. When Z denotes the net inflow of capital into the small-open country, capital will be allocated satisfying the equilibrium condition

$$(1 - t_{so})f(K + Z)' = (1 - t_w)r_w, \tag{7.8}$$

[9]In this thesis, 'open' economy implies that there is no restriction to capital flow from/to the country.

where t_{so} denotes the tax rate of the small-open country. The objective of the small-open country is

$$\max_{t_{so}} W(C, G) \tag{7.9}$$

subject to

$$\begin{aligned} C &= f(K+Z) - f(K+Z)'(t_{so}K + Z), \\ G &= t_{so} f(K+Z)'(K+Z), \\ 0 &\leq t_{so} < 1, \\ -K &\leq Z. \end{aligned} \tag{7.10}$$

The first-order conditions give

$$\frac{W_C}{W_G} = \frac{f(K+Z)'(K+Z) - t_{so} f(K+Z)''(K+Z)\psi - t_{so} f(K+Z)'\psi}{f(K+Z)'K - f(K+Z)''(t_{so}K + Z)\psi}, \tag{7.11}$$

where

$$\psi = \frac{\partial Z}{\partial t_{so}}. \tag{7.12}$$

We can define ψ from (7.8) as follows.

$$\psi = \frac{f(K+Z)'}{(1 - t_{so}) f(K+Z)''}. \tag{7.13}$$

By plugging (7.13) into (7.11), we get

$$\begin{aligned} \frac{W_C^*}{W_G^*} &= \frac{f(K+Z^*)''(K+Z^*) + t_{so}^* f(K+Z^*)'}{f(K+Z^*)''(K+Z^*)} \\ &= 1 + \frac{t_{so}^* f(K+Z^*)'}{f(K+Z^*)''(K+Z^*)} < 1. \end{aligned} \tag{7.14}$$

(7.14) implies that the small economy sets its tax rate lower than the optimal tax rate and that public goods are under-provided. However, the under-provision of public goods does not necessarily mean that the quantity of public goods at this equilibrium is less than in autarky. Even if the tax rate is lower, the small-open economy can collect more tax revenue due to increased capital (tax base) and can provide more public goods. The under-supply of public goods only implies that, with given amount of capital inflow, it is welfare increasing to consume more public goods and less private goods by raising the tax rate. In addition, the under-supply of public goods also does not necessarily mean that a new tax rate is lower than in autarky.

We are not able to compare the level of tax rate after tax competition with that before tax competition by (7.14) because there is a change in the amount of capital due to the inflow of capital at the non-cooperative Nash equilibrium. In contrary, with a two identical economy model, the under-supply of public goods implies the lower tax rate because there is no movement of capital at the non-cooperative Nash equilibrium. The explicit way of comparison between ante- and post-tax competition is to calculate tax rates with the production function and social welfare function used in the previous chapters. (7.14) gives

$$\frac{\beta t_{so}^{*} f(K+Z)'(K+Z)}{f(K+Z) - f(K+Z)'(t_{so}^{*}K+Z)} = \frac{f(K+Z)''(K+Z) + t_{so}^{*} f(K+Z)'}{f(K+Z)''(K+Z)}, \quad (7.15)$$

where

$$Z = \{\frac{(1-t_w)^{-2} - (1-t_{so}^{*})^{-2}}{(1-t_{so}^{*})^{-2}}\}K. \quad (7.16)$$

Substituting (7.16) into (7.15) and rearranging it gives

$$(1-\alpha-t^*_{so})-\alpha(1-\alpha-t^*_{so})(1-t_w)^2\{(1-t_w)^{-2}-(1-t^*_{so})^{-2}\}=\beta t^*_{so}\alpha(1-\alpha). \quad (7.17)$$

Given that $\alpha = 0.5$ and $\beta = 2$, the tax rate of the small-open country before tax competition and the world tax rate are 0.67.[10] The tax rate of the small-open country after tax competition is 0.28 by (7.17). Tax competition makes the small-open country reduce its tax rate.

Proposition 38 *A small-open economy always sets its tax rate at a lower level than the world level and attracts capital from the rest of the world.*

Two points need to be mentioned. Firstly, a small-open economy does not have zero tax rate. This result is novel compared to previous works which predicted a zero tax rate (see Diamond and Mirrlees [1971], Gordon [1992] and Yang [1996]). This difference results from the assumption in this thesis that other taxes cannot substitute capital income tax completely in financing supply of public goods[11]. Even if a small-open country can attract more capital by lowering its tax rate, a decrease in tax rate causes a serious distortion between private consumption and public consumption and thus does not contribute to an increase in social welfare. Secondly, tax competition of a small-open economy is different from that among a infinite number of identical countries. At the non-cooperative equilibrium, the tax rate of the small-open country

[10] A small open economy and the rest of world are identical except the difference in their size.

[11] With a two-identical-economy model, it will be demonstrated that tax competition leads to the zero tax rate if there are unlimited alternative taxes for financing the supply of public goods (see chapter 8). This result can be applied to a small open economy model.

is lower than the tax rate of identical countries. They also differ in that tax competition amongst an infinite number of countries leads to no movement of capital (see chapter 3), while a small-open economy can attract capital from the rest of world.[12]

7.3.2 Imperfect capital mobility

With transaction costs, (7.8) becomes

$$(1 - t_{so})f(K + Z)' - \theta = (1 - t_w)r_w. \tag{7.18}$$

The objective of the small-open country and the constraints are the same as (7.9) and (7.10). The first-order condition is the same with (7.14). However, due to transaction costs, the same degree of tax undercutting leads to less inflow of capital under imperfect capital mobility than under perfect capital mobility. This is reflected in Z.

The tax rate of a small-open economy is influenced by the size of transaction costs. How do the tax rates change when transaction costs decrease? The amount of capital moving into the small economy is

$$Z = -K + (1 - t_{so}^*)^{\frac{1}{\alpha-1}}(\delta + \frac{\theta}{\alpha})^{\frac{1}{\alpha-1}}, \tag{7.19}$$

where

$$\delta = \{1 - \frac{1}{\alpha(1+\beta)}\}K^{\alpha-1}. \tag{7.20}$$

[12]Strictly speaking, a small open economy model is not a tax competition model in that there is no reciprocal reaction between more than one player. The small open country unilaterally choose its optimal tax rate with given tax rate and interest rate of the world.

By plugging (7.19) into (7.14), we get

$$(1-\alpha)(\alpha\beta t^*_{so} - 1 + \alpha + t^*_{so}) + \alpha K(1-t^*_{so})^{\frac{1}{\alpha-1}}(\delta + \frac{\theta}{\alpha})^{\frac{1}{1-\alpha}}(1-\alpha-t^*_{so}) = 0. \quad (7.21)$$

By taking a total differential of (7.21), we get

$$\frac{\partial t^*_{so}}{\partial \theta} = \frac{K(1-t^*_{so})^{\frac{1}{\alpha-1}}(\delta+\frac{\theta}{\alpha})^{\frac{\alpha}{1-\alpha}}(1-\alpha)^{-1}(-1+\alpha+t^*_{so})}{-(1-\alpha)-\alpha\beta(1-\alpha)-\alpha K(1-t^*_{so})^{\frac{1}{\alpha-1}}(\delta+\frac{\theta}{\alpha})^{\frac{1}{1-\alpha}}(1-\alpha)^{-1}(t^*_{so}\alpha)}. \quad (7.22)$$

Is (7.22) negative, positive, or indefinite? From (7.21), $\alpha\beta t^*_{so} - 1 + \alpha + t^*_{so}$ and $1-\alpha-t^*_{so}$ must have different signs if $t^*_{so} \in [0,1)$ exists. In addition, the former is always less than the latter.[13] This restricts the range of t^*_{so} as follows.

$$\frac{1-\alpha}{\alpha\beta+1} < t^*_{so} < 1-\alpha. \quad (7.23)$$

Therefore, (7.22) is always positive. This result implies that the tax rate at the equilibrium becomes lower as the size of transaction costs decreases.

Given that $\alpha = 0.5$ and $\beta = 2$, the amount of capital moving into the small economy is

$$Z = -K + 9(1-t^*_{so})^2(K^{-0.5} + 6\theta)^{-2}. \quad (7.24)$$

By plugging (7.24) into (7.14), we get

$$9(4t^*_{so} - 1) + (2t^*_{so} - 1)(1-t^*_{so})^{-1}K\{K^{-0.5} + 6\theta\}^2 = 0 \quad (7.25)$$

[13]Otherwise, $\frac{1-\alpha}{\alpha\beta+1} > t^*$ and $t^* > 1-\alpha$. In this case, t^* does not exist.

By taking total differential of (7.25), we get

$$\frac{\partial t^*_{so}}{\partial \theta} = \frac{12(2t^*_{so}-1)(1-t^*_{so})^{-1}K\{K^{-0.5}+6\theta\}}{36+2(1-t^*_{so})^{-1}K\{K^{-0.5}+6\theta\}^2-(2t^*_{so}-1)(1-t^*_{so})^{-2}K\{K^{-0.5}+6\theta\}^2}. \tag{7.26}$$

From (7.25), t^*_{so} must be between 0.25 and 0.5. And this makes the sign of (7.26) always positive. Therefore, the small open economy decreases its tax rate as transaction costs decrease.

Proposition 39 *The lower transaction costs, the greater the tax cutting by a small-open economy.*

7.4 Concluding remarks

By analysing tax competition under both perfect and imperfect capital mobility, we have found that the size of the transaction costs plays a significant role in deciding the level of tax rates at the non-cooperative Nash equilibrium. In general, as long as transaction costs are large, international capital mobility does not impose restrictions on tax rate decisions made by governments and thus there is no distortion from tax competition. As transaction costs become smaller, tax competition makes the non-cooperative Nash equilibrium diverge from the optimal level.

In contrast to the results of standard models which assume perfect capital mobility, the pure-strategy Nash equilibrium does not exist under the assumption of imperfect capital mobility. This result is also different from that of models which have considered transaction costs but still predict the pure-strategy Nash equilibrium. The difference results from the different definition of transaction costs. Although a tax differential always causes international capital movement in previous studies, tax differential, in my model, causes capital movement only when it is greater than the size of transaction costs.

If there exists mixed strategy Nash equilibrium, each country randomizes with tax rates below the optimal level. Therefore, tax competition leads not only to lower tax rates but also to variation of tax rates between two identical countries. As transaction costs become smaller, the tax rates are lowered and the expected variation becomes smaller. Finally, as transaction costs become close to zero, tax rates converge to the level identical to that under perfect capital mobility.

A small-open economy, however, always reduces its tax rate below the world tax rate. Tax undercutting becomes greater as transaction costs become smaller. Transaction costs reduce the intensity of tax competition because an equal degree of tax undercutting leads to less inflow of capital compared with that under perfect capital mobility.

Chapter 8

Testable propositions

8.1 Introduction

From the economists' point of view, tax competition implies an inefficient allocation of resources. From the politicians' point of view, tax competition results in an unequal burden of tax for immobile factors, mostly for labours. From the governments' point of view, tax competition entails limits on the utilization of taxation to finance expenditure. As the world economy becomes more integrated and thus tax bases move at a smaller cost and by a greater amount, these concerns become more pressing.

However, it is worth asking whether most countries really set their tax rates in the way tax competition theory predicts. Goodspeed (1999) suggests four reasons why the empirical measurement of the effects of tax competition, especially corporate tax competition, is so problematic. They are the complexity and opaqueness of tax systems, the existence of non-tax factors which have effects on the decision of location, the difficulty of measuring the benefit from public spending, and the difficulty of isolating effect of tax competition from other government's policies. Apart from those problems mentioned above, the initial difficulty in undertaking empirical study is to clarify the propositions of tax competition theory as testable ones.

The main propositions of tax competition theory were tested by Devereux (1995), Chennells and Griffith (1997) and Grubert (1999). Devereux (1995) finds mixed evidence in the sense that there is little difference on average between tax rates for large and small countries but open countries tend to have a lower tax rates than closed countries. Chennells and Griffith (1997) find no clear empirical evidence to support tax competition theory. They conclude that tax competition is not driving tax rates to zero and that there has been no significant erosion of the capital tax base. Grubert (1999) finds inconsistent evidence of tax competition. Effective tax rates fell on average but there was a wide diversity of behaviour among different countries. More mobile manufacturing industries such as electronics did not enjoy greater tax reductions. Tax rates did not fall more in homogeneous areas with low trade barriers such as EU. However, he also has results which imply tax competition. The smaller, poorer and more open countries lowered their tax rates the most.

There are three propositions which have been tested in common by previous studies. Firstly, they have investigated whether corporation tax rates of major countries have decreased. Secondly, it was investigated whether small and open countries have lower tax rates than large and closed countries. Thirdly, tax rates were investigated to see whether they were converged. A decline of corporation tax rates, lower tax rates of open and small countries, and convergence of tax rates are interpreted as evidence of tax competition.

However, theoretical analyses do not provide sufficient results to support these interpretation. Firstly, tax competition theory predicts one-shot downward jump in tax rates. Therefore, if this tax decrease happens before the sample period, tax rates are not expected to decrease. Secondly, tax differential between open-small and closed-large countries are expected only if other things are equal between two groups of countries. Thirdly, a divergence of tax rates are also predicted by tax competition. Tax competition creates tax differential between countries of different sizes. If the degree of openness among countries has a tendency of divergence rather than convergence, tax rates across countries are not likely to converge.[1]

The objective of this chapter is to draw empirically testable propositions and to discuss some problems arising in testing them. In the previous chapters, I have derived some predictions. (1) Tax competition leads to lower corporation tax rates but tax rates do not drop to zero. (2) As the international mobility of capital increases, corporate tax rates should decrease. (3) As the number of countries involved in the international capital market increases, corporation tax rates should decrease. (4)

[1] The convergence of tax rates will be discussed in chapter 9.

More-open countries decrease corporation tax rates more than less-open countries. (5) Smaller countries decrease corporation tax rates more than larger countries. (6) The countries with a strong preference for public goods decrease corporation tax rates more than the countries with a weak preference for public goods.

A realistic explanation for the gradual decrease in tax rates, instead of one-shot downward jump, may be a partial adjustment of tax rates due to political and economical constraints. I suggest two other reasons for a gradual decrease of corporation tax rates; increasing capital mobility and increasing number of countries in the international capital markets. The other thing to need clarification is whether tax competition leads to zero tax rate or not. The analysis in previous chapters have found that tax competition does not lead to zero tax rate but to a positive tax rate due to the limitations in financing supply of public goods by other taxes than capital income tax.

Devereux (1995) and Chennells and Griffith (1997) test the significance of tax differential between average tax rates of more-open countries and less-open countries (smaller countries and larger countries). The simple mean-comparison method (in this thesis, this is named as 'level-comparison test') is based on the assumption that other factors which may have an effect on the tax rates are equal between two groups. If there are other factors which have a significant effect on the level of tax rates and they differ between groups, the 'level-comparison test' is no longer valid.

If we can identify the effect of other factors, the effect of these factors must be excluded from the data. The validity of this process depends on how successfully we can identify the effects of those factors. Unless the exclusion of effects of other factors is possible, the alternative is to compare the difference in size of tax cutting between two groups (in this thesis, this is named as 'change-comparison test'). More-open countries (smaller countries and the countries with a strong preference for public goods) are expected to decrease corporation tax rates more than less-open countries (larger countries and the countries with a weak preference for public goods).[2]

It is the difference in the level of tax rates between different countries at the non-cooperative equilibrium that most of theoretic analyses have focused on. Smaller countries are predicted to tend to set their tax rates lower than those of larger countries under the pressure of tax competition. The size of tax cutting is not analysed because the tax rates at autarkic equilibrium are not defined. This thesis have taken different approach. This thesis has investigated the size of tax cutting between pre-tax competition and post-tax competition (between autarkic and non-cooperative equilibrium). Smaller countries are predicted to tend to cut tax rates to a greater degree than larger countries.

Therefore, the comparison of levels of tax rates between the groups ('level-comparison test') is the main interest in testing the validity of tax competition theory. However, reliability of the 'level-comparison test' depends on the satisfaction of the assumption that other things are equal between the groups. In this context, the comparison of

[2]It is implicitly assumed that the difference of those factors which have effects on tax rates between the two groups remains constant throughout the period.

the size of tax cutting between the groups ('change-comparison test') can be complementary to the 'level-comparison test'.

This chapter is organized as follows. In section 2, the effect of the degree of capital mobility and the number of countries in the international capital market is analysed with regard to the level of tax rates at the non-cooperative equilibrium. In section 3, asymmetric cases of different size and of different preference for public goods are analysed. The design of empirical tests is discussed in the final section.

8.2 Decreasing capital income tax

8.2.1 Is zero capital tax inevitable?

Chapter 3 shows that tax competition caused by international capital mobility does not lead to zero capital taxation but rather a positive tax rate which is lower than the optimal level. The result of non-zero lower tax rate is the same in the asymmetric cases analysed in chapter 4. The smaller country and the country with a weak preference for public goods are predicted to set its tax rate lower than that of the larger country and the country with a strong preference for public goods. Even if tax rates are different at the non-cooperative Nash equilibrium, they are all lower than the optimal level. Tax competition among an infinite number of identical countries also predicts none-zero tax rate.

However, there have been many theoretical models which predict zero tax rate.

Source-based capital income tax should be zero when capital has perfect capital mobility (see Diamond and Mirrlees [1971] and Bucovetsky and Wilson [1991]). In their setting, capital income tax should not be used because other efficient tax instruments are available. In other words, there is no obligation to finance the supply of public goods by capital income tax. Our model adopts the assumption that there is no tax to finance public goods other than capital income tax and thus predicts a positive tax rate.

The availability of other taxes can be accommodated into my model by assuming that governments are to maximize only the private consumption. The changed objective function of the government of country i $(i = 1, 2)$ is

$$\underset{t_i}{Max}\; C_i \tag{8.1}$$

subject to

$$\begin{aligned} C_i &= f(K + (-1)^i Z) - f(K + (-1)^i Z)'(t_1 K + (-1)^i Z) \\ 0 &\leq t_i < 1, \\ -K &\leq Z \leq K. \end{aligned} \tag{8.2}$$

The effect of an increase in the tax rate on the private consumption is

$$\frac{\partial C_i}{\partial t_i} = -(-1)^i f(K + (-1)^i Z)''(t_1 K + (-1)^i Z)\psi - f(K + (-1)^i Z)' K, \tag{8.3}$$

where

$$\psi = \frac{\partial Z}{\partial t_i} = \frac{(-1)^i f(K + (-1)^i Z)'}{(1 - t_i) f(K + (-1)^i Z)'' + (1 - t_j) f(K + (-1)^j Z)''}. \tag{8.4}$$

Plugging (8.4) into (8.3) and arranging it gives

$$\frac{\partial C_i}{\partial t_i} = \frac{-f(K+(-1)^i Z)''(t_1 K + (-1)^i Z) f(K+(-1)^i Z)'}{(1-t_i) f(K+(-1)^i Z)'' + (1-t_j) f(K+(-1)^j Z)''} - f(K+(-1)^i Z)' < 0. \tag{8.5}$$

(8.5) implies that the lower tax rate always makes each country better off. Therefore, both countries set their tax rates at zero.

The reality lies between these two extremes. Alternative taxes can be available only with limitations. Given the social welfare function such as $\beta \ln C + \ln G$, β is interpreted to represent the relative preference for the private goods. In other words, the higher the value of β is, the highly evaluated private goods is. β can have a different interpretation such that it represents the degree of the relationship between the revenue from corporation tax and the supply of public goods. The higher the value of β is, the weaker the relationship. When alternative taxes are available and thus the relationship is weak, the tax rate at the non-cooperative Nash equilibrium is lower (see Table 3.2).

If we assume that governments decrease tax rates step by step due to political restriction rather than a single shift, we expect time series data on tax rates to show a declining trend. There are two other factors which contribute to the prediction of a declining trend in tax rates. One is imperfection in capital mobility, which is analysed in chapter 7, and the other is the increase in the number of countries participating in the international capital market, which is analysed in chapter 3.

8.2.2 Imperfect capital mobility

Chapter 7 has changed the model of perfect capital mobility by introducing the idea of imperfect capital mobility. The analysis done in chapter 7 will not be reiterated here. Rather, the relationship between the size of transaction costs and the level of tax rates will be discussed in less formal ways. With a symmetric two countries model, there is no pure-strategy Nash equilibrium. There might be mixed-strategy Nash equilibrium. Both countries randomize only with tax rates which are lower than the optimal level. As transaction costs become smaller, t_L and t_H become lower. Finally, when transaction costs converge to zero, t_L and t_H converge to t_C, which is the tax rate under perfect capital mobility.

With a small-open economy model, the tax rate is found to be related to the size of transaction costs. In other words, as transaction costs become smaller, the tax rates of the small-open country become lower. The transaction costs mitigate the intensity of tax competition because the same degree of tax undercutting leads to a smaller inflow of capital compared with that in perfect capital mobility.

The imperfection of capital mobility is assumed to derive from transaction costs. These may include transportation costs, learning costs paid by foreigners in doing business in an unfamiliar climate, the risk of the non-repatriation of products by host countries, etc. Therefore, the model predicts a positive correlation coefficient between tax rates and transaction costs. In this context, tax competition theory can be tested by regressing tax rates as a dependent variable with respect to the size of transaction costs.

However, it is difficult to collect the data which measure transaction costs. International shipment tariffs, air travelling tariffs, international phone call tariffs, the ability of command to foreign language, access to the foreign currency, the transparency of legislation, etc. are a few of factors consisting of transaction costs. However, none of these is in isolation to measure transaction costs effectively. Given difficulty in getting the data on transaction costs, an alternative test would be to establish whether time series data of capital income tax show a declining trend assuming that transaction costs have been lowered for a long term period.

8.2.3 Number of countries

Chapter 3 has demonstrated that the tax rates under the pressure of tax competition will be lowered as more countries become involved in tax competition. As more countries participate in the international capital market, the elasticity of capital supply (capital demand) becomes greater. Therefore, the same degree of tax undercutting leads to a greater increase in capital and tax competition is more intensive. The relationship between tax rates and the number of countries are given in Table 3.5 to 3.7.

Even if an infinite number of countries are involved in tax competition, the tax rate does not drop to zero. There is a certain level of tax rate below which the inflow of capital motivated by a lower tax rate does not increase the level of social welfare.

Below this tax rate, the positive effect of an increase in the consumption of private goods is dominated by the negative effect of under-supply of public goods. Therefore, there is no incentive for each country to cut tax rates below this level in order to attract further capital.

The test will be to regress tax rates with respect to the number of countries in the international capital market. However, it is difficult to collect the data on the number of countries because the integration of a country into the international capital market is a gradual process. An alternative test would be to establish whether the time series data of capital income tax rates show a declining trend, assuming that more countries participate in the international capital market for a long term period.

8.3 Asymmetries in tax rates

8.3.1 Openness

The proposition that tax competition leads to lower tax rates implies that 'open countries' have lower tax rates than those of 'closed countries'. However, this proposition is difficult to test in the sense that the openness of a country is a problem of the degree, not a problem of the kind. The introduction of imperfection in capital mobility produces a testable prediction; 'more-open countries' have lower tax rates than those of 'less-open countries'.[3] The procedure of the test is to divide countries

[3]This result can be derived regardless of the functional forms of transaction costs (see Persson and Tabellini [1992], Eggert and Haufler [1996] and chapter 7).

into two groups - relatively more-open countries and relatively less-open countries and to establish whether the tax differential between two groups is significant.

If there are other factors which have an effect on the level of tax rates and they differ between more-open and less-open countries, tax competition may not necessarily lead to the tax differential predicted above. An alternative test is to see whether more-open countries decrease tax rates more than less-open countries. If the autarkic tax rates are the same for both groups, more-open countries cut their tax rate to a greater degree than less-open countries and, as a result, the tax rates of the former are lower than those of the latter. If not, a greater tax cutting does not necessarily results in lower level of tax rates.

There are various ways by which to measure the degree of openness of a country. One is the openness of product market which is measured by the sum of imports and exports divided by GDP. This criterion is used in Devereux (1995)[4] and Chennells and Griffith (1997). Grubert (1999) uses degree of restrictions based on World Bank listings. There are many alternative measures: (1) the import penetration rate[5], (2) the intensity of exposure of manufacturing industries to foreign competition[6] and (3) share of foreign affiliates in manufacturing production. As for the degree of

[4]He uses a criterion of the import divided by GDP.

[5]Import penetration is defined as the ratio of manufacturing imports to apparent consumption of manufactured goods (domestic production minus exports plus imports).

[6]The exposure to foreign competition (E) is a synthetic measure which takes into account both the export orientation of an industry and its import penetration. It is defined as

$$E = \frac{X}{Y} + (1 - \frac{X}{Y})\frac{M}{D},$$

where Y is output, M imports, X exports and D domestic demand.

openness of the capital market, it can be measured by the sum of inflow and outflow direct investment divided by GDP. Alternatively, the reservation of OECD Code of Liberalisation of Capital Movement can be used.

8.3.2 Size of a country

Chapter 4 has demonstrated that a smaller country sets its tax rate lower than that of a larger country. When there is no capital mobility, the tax rates of two countries are the same. Tax competition pressure makes the smaller country set its tax rate below that of the larger country. This is because the smaller country has a more elastic capital supply (capital demand). Therefore, the test is to establish whether the difference between the tax rates of two groups - larger countries and smaller countries - is significant. The argument about the relative validity between the 'level-comparison test' and the 'change-comparison test' can be applied to this case as well.

What are criteria for grouping larger countries and smaller countries? Devereux (1995) adopts a cut-off point of $160 billion GDP and Chennells and Griffith (1997) use the relative size of GDP instead of the cut-off point. Is population of a country more appropriate for grouping than GDP? This argument derives from the fact that, in theoretic models, the size of a country is defined by its population. With the assumption that the production technology and per capita capital endowment are the same across countries, the relative size[7] of GDP should be the same with that of population. In reality, these two differ and we are to choose between the two. I suggest that GDP is more appropriate than population because the standard model implies not simple population but quality-adjusted labour force. The latter might be related with the level of GDP.

8.3.3 Different preference for public consumption

Chapter 4 has demonstrated that the country with a weak preference for public goods sets its tax rate lower than that of the country with a strong preference. However, a test to establish whether the countries with a weak preference for public goods set their tax rates lower is misleading. The countries with a weak preference for public goods set their tax rates lower without strategic tax setting behaviour which tax competition theory assumes. Therefore, whether the countries with a weak preference for public goods set their tax rates lower than the countries with a strong preference is not relevant to the validity of tax competition theory.

Instead of the typical assumption of tax setting behaviour adopted by tax competition models, governments are assumed to set tax rates as if any change in their tax rates does not have an influence on the movement of capital between two countries. These governments are called '*myopic*'. They consider that the allocation of capital is fixed and that their tax rates have no effect on the allocation of capital. When

[7]As defined in chapter 4, what matters in tax competition is the relative size of a country, not the absolute size.

both countries maintain their optimal tax rates decided in autarky after the opening of the capital market, the amount of capital moving country 1, the country with a strong preference, to country 2, the country with a weak preference, is

$$\begin{aligned} Z &= \rho K, \\ \rho &= \{\frac{(\frac{2\alpha-1}{2})^{\frac{1}{\alpha-1}} - (\frac{\alpha\beta+\alpha-1}{\beta+1})^{\frac{1}{\alpha-1}}}{(\frac{2\alpha-1}{2})^{\frac{1}{\alpha-1}} + (\frac{\alpha\beta+\alpha-1}{\beta+1})^{\frac{1}{\alpha-1}}}\}, \\ 0 &\leq \rho \leq 1. \end{aligned} \tag{8.6}$$

The objective of country 1 is

$$\max_{t_1} W(C_1, G_1) \tag{8.7}$$

subject to

$$\begin{aligned} C_1 &= f(K-\rho K) - t_1 f(K-\rho K)'(K-\rho K) + (1-t_2) f(K+\rho K)'\rho K, \\ G_1 &= t_1 f(K-\rho K)'(K-\rho K), \\ 0 &\leq t_1 < 1. \end{aligned} \tag{8.8}$$

The first-order conditions give

$$\frac{W^*_{C_1}}{W^*_{G_1}} = 1. \tag{8.9}$$

Tax rate is

$$\begin{aligned} t_1^* &= \frac{1+\alpha(1-t_2)(1+\rho)^{-1}\rho}{2\alpha} \\ &> \frac{1}{2\alpha} = t_1^A. \end{aligned} \tag{8.10}$$

The objective of country 2 is

$$\max_{t_2} W(C_2, G_2) \tag{8.11}$$

subject to

$$\begin{aligned} C_2 &= f(K+\rho K) - f(K+\rho K)'(t_2 K + \rho K), \\ G_2 &= t_2 f(K+\rho K)'(K+\rho K), \\ 0 &\leq t_2 < 1. \end{aligned} \tag{8.12}$$

The first-order conditions give

$$\frac{W^*_{C_2}}{W^*_{G_2}} = \frac{K+\rho K}{K} > 1. \tag{8.13}$$

(8.13) implies that country 2 sets the tax rate at the level higher than the optimal and thus public goods are over-provided. This is because country 2 is willing to get more tax revenue from the income of foreign capital by means of a higher tax rate. The tax rate of country 2 is

$$\begin{aligned} t_2 &= \frac{1+\rho(1-\alpha)}{\alpha(\beta+1)} \\ &> \frac{1}{\alpha(\beta+1)} = t_2^A. \end{aligned} \tag{8.14}$$

(8.10) and (8.14) together imply that both countries set their tax rates at the higher level than those in autarky. This is opposite of the prediction that both countries set their tax rates at the lower level below the tax rates in autarky.

Table 8.1 shows that both countries have higher tax rates than those in autarky. It also shows that country 1 sets its tax rate higher than that of country 2 as is the case in autarky. Therefore, the fact that countries with a relatively strong preference for public goods set their tax rates higher than those of countries with a relatively

	$\alpha = 2/3$	$\alpha = 3/4$	$\alpha = 4/5$
t_1	0.83	0.77	0.74
t_2	0.63	0.53	0.48

Table 8.1: Tax rates with myopic governments

weak preference is not relevant to the validity of tax competition theory. Under any of three tax-setting behaviour of the government - tax competition, '*status quo*'[8] and '*myopic*' -, countries with a strong preference set their tax rates higher than countries with a weak preference.

In contrast with previous two asymmetric cases, the 'level-comparison test' cannot applied in this case. An appropriate test is to analyse whether countries with a strong preference have reduced their tax rates more than countries with a weak preference (the 'change-comparison test'). As I suggested in chapter 4, the country with a strong preference for public goods tends to cut its tax rate to a greater degree than the country with a weak preference for public goods, when they face the pressure of tax competition even if the former still sets its tax rate higher than that of the latter. When preference of country 1, for example, is twice that of country 2, the tax rates in autarky, ($t_1 = 1$[9]$, t_2 = 0.67$), becomes ($t_1^* = 0.48, t_2^* = 0.41$).[10]

If '*status quo*' tax setting behaviour is adopted, there should be no declining tendency in tax rates. On the contrary, if governments set their tax rate myopically,

[8]This refers to governments which do not change their tax rates even if capital becomes to be able to move internationally.

[9]The tax rate of country 1 will be close to 1.

[10]It is noteworthy that this is derived from specified production function and social welfare function.

the data of tax rates should show an increasing trend and the countries with a weak preference for public goods should increase their tax rates sharply than the countries with a strong preference.

Another problem is how to measure the preference for public goods. The relative size of government may represent the degree of preference for public goods. Probable measurement for the relative size of government are the total receipt of government divided by GDP, the total tax revenue divided by GDP and the final consumption of government divided by GDP. Traditionally, tax revenue as a proportion of GDP is the common measurement of government size (for example see Oates [1982]). Ferris and West (1996) term this measurement as nominal size of government and suggest the real size of government which is measured by the data not including transfer payment.

8.4 Concluding remarks

This section discusses how to test the propositions derived in the previous sections. Firstly, corporation tax rates are predicted to decrease as transaction costs of foreign investment are lowered or as more countries participate in the international capital market. If data on transaction costs and/or the number of countries involved in the international capital market are available, it is possible to test the proposition using a simple regression method for each or using a multiple regression model for both.

However, it is difficult to obtain data on transaction costs and/or the number of countries in the international capital market. An alternative is to establish whether the time series data of capital income tax reveals a declining trend, assuming decreasing transaction costs and increasing number of countries in the international capital market. The results of this test is only suggestive for the validity of tax competition theory because such a declining trend is caused by various factors other than tax competition.

A more informative test is to divide countries into two groups and to see whether tax differential between the two groups is consistent with the prediction of tax competition theory (the 'level-comparison test'). More-open countries and smaller countries are expected to have lower tax rates than less-open countries and smaller countries. However, it is misguided to test the validity of tax competition theory by establishing whether countries with a relatively weak preference for public goods undercut those with a relatively strong preference for public goods. The reason for the invalidity of the test is that the tax difference between these two groups can be expected to emerge when governments do not follow the strategic tax settings which tax competition theory generally assumes.

The validity of the 'level-comparison test' discussed above depends on the relevance of the assumption that other factors which have an effect on the level of tax rates are equal across the groups. Alternative test is to establish differences in degree of decrease in tax rates of two groups (the 'change-comparison test'). More-open countries, smaller countries and the countries with a strong preference for public goods are predicted to cut tax rates more than less-open countries, larger countries and the countries with a weak preference for public goods.

It is noteworthy that the level-comparison test and the change-comparison test are based on different assumption on the process of tax competition. The 'level-comparison test' implicitly assume that tax competition is effective and countries have already adjusted their tax rates accordingly at the specific sample year or throughout the sample period. In contrast, the 'change-comparison test' assumes that tax competition started to work at some point of the sample period. If tax competition started to work before the sample period, adjustments of tax rates are carried out gradually during the sample period. Without the assumption of gradual adjustment, there is no systematic change of tax rates because tax rates are already adjusted. The gradual adjustment is is an additional assumption which is not explicitly considered in theoretical models.

Chapter 9

Evidence of tax competition

9.1 Introduction

Contrasting with abundant theoretical literature and its emphatic claims, only a few empirical works on tax competition have been found. Devereux (1995), Chennells and Griffith (1997) and Grubert (1999) are the papers which have, to date, been directly concerned with empirical tests. There are three propositions which have been tested in common by these studies: (1) whether corporation tax rates have decreased; (2) whether small and open countries have lower tax rates than large and closed countries; (3) whether tax rates were converged. They have not found clear empirical evidence to support any of those predictions.

As Devereux (1995) acknowledges, there are two difficulties in undertaking empirical study. Firstly, many of the propositions put forward by theoretical studies are difficult to test empirically. Secondly, collecting and interpreting the relevant data is far from straightforward. For example, suppose that we try to test the proposition that tax competition should lead to a lower tax on capital income than the optimal level. A central problem stems from the fact that optimal tax rates are not directly observable. The other problem is the measurement of the level of capital income taxation. There are many alternative measurements of tax burdens and they differ significantly from each other. These problems must be discussed prior to the carrying out of tests.

This chapter seeks to draw main propositions and to test them with the marginal effective corporate tax rates (MECTRs) of 24 OECD member countries during 1960-1998. MECTRs are computed by the method suggested by King and Fullerton (1984). The propositions tested are as follows. (1) Corporation tax rates should show a decreasing trend.[1] (2) More-open countries should cut corporation tax rates more than less-open countries. (3) Smaller countries should cut corporation tax rates more than larger countries. (4) Countries with a strong preference for public goods should cut corporation tax rates more than those with a weak preference for public goods.

For detecting a decreasing trend of tax rates, this thesis fits the data with various statistical models: simple linear model, trend-stationary process model and difference-stationary process model. For detecting tax differential between different groups of countries, previous studies mainly carried out tests with cross section data. They

[1]This derives from three assumptions. (1) Mobility of capital has increased. (2) The number of competing countries has increased (3) Adjustment of tax rates occurs gradually.

compared the level of tax rate between open countries (smaller countries) and closed countries (larger countries). This thesis uses time series data to establish whether open countries (smaller countries and countries with a strong preference for public goods) have decreased tax rate more than closed countries (larger countries and countries with a weak preference for public goods). This comparison will be carried out not only with the average tax rates of groups but also with tax rates of individual countries.

The first proposition that corporation tax rates have decreased is consistently supported by the data. There is a remarkable drop, on average, from 54% in 1960 to 37% in 1998 across 24 OECD countries.[2] Out of these 24 countries, 19 countries have a negative trend when tax rates are fitted with a linear model. A decreasing trend is detected using different specifications of regression model such as simple linear model, trend-stationary process model and difference-stationary process model.

Proposition (2)-(4) are tested in two ways. Firstly, the countries are divided into two groups and the difference between the average tax rates of the two groups is placed under the significance test (here, this is named as 'level-comparison test'). This is the method employed in previous studies. When countries are grouped by the trade intensity ratio measured by the sum of import and export divided by GDP (here, this is named as product market openness)[3], more-open countries have, on average,

[2]The countries which have joined OECD recently are the Czech Republic, Hungary, Mexico, Poland and Republic of Korea. They are excluded form the analysis. This is because the availibility of the data is restricted and because the degree of capital mobility is likely to differ from that of the rest member countries.

[3]Devereux (1995) measures the openness of the market by the import divided by the output.

lower tax rates than less-open countries but the difference is not significant. However, when countries are grouped by the foreign capital flow intensity measured by sum of inflow and outflow of direct investment divided by GDP (here, this is named as capital market openness)[4], more-open countries have, on average, significantly lower tax rates than less-open countries.

When countries are grouped by size measured either by GDP or by population, larger countries have, on average, lower tax rates than smaller countries. This result contradicts the prediction of tax competition theory that smaller countries should have lower tax rates than larger countries (see Bucovestsky [1991], Wilson [1991], Kanbur and Keen [1993] and Eggert and Haufler [1996]). When countries are grouped by the scale of their preference for public goods, the countries with a strong preference for public goods have higher tax rates than those with a weak preference. As was discussed in chapter 8, this tax differential, by itself, is not a relevant evidence of tax competition theory.

Alternative method of test is to see the difference of the magnitude of decrease in tax rates of the two groups (here, this is named as 'change-comparison test'). The data consistently support proposition (2), (3) and (4) when the average tax rates of the two groups are linearly fitted with respect to time variable and the estimates of coefficient of time variable of two groups are compared. More-open countries have cut their tax rates more than less-open countries. This result is derived under the

[4]As Chennells and Griffith (1997) argue, this measurement may be problematic because these flows of foreign direct investment are volatile over time and because the definition of foreign direct investment is not consistent across countries.

grouping either by product or capital market openness. In addition, smaller countries are found to have cut their tax rates more than larger countries and the countries with a strong preference for public goods are also found to have cut their tax rates more than the countries with a weak preference for public goods. The difference in the degree of tax cutting is significant in all these cases.

Lastly, an econometric model is set up to consider explicitly other factors which may have an effect on corporate tax rates and to see the effect of the openness, the size of country and its preference for public goods at the same time. The MECTRs of 24 countries are regressed with respect to two 'non-tax competition' variables (the unemployment rate and total tax revenue proportional to GDP) and two 'tax competition' variables (the openness of a country and the size of a country) for each year.

The results of multiple regressions reveal that the 'tax competition' variables have significant joint power in explaining tax differences among countries only in recent years, 1988-1995. However, the pure effect of the size of country on tax rates is negligible throughout the period if the effect of the openness of the country on tax rates is excluded. This is because the size of a country is highly correlated with the openness of the country and therefore, it has little additional explanatory power. The total tax revenue proportional to GDP is insignificant except for the first two years as predicted by tax competition theory.

Overall, this thesis provides some positive evidence for validity of tax competition theory. This is different from the results of previous empirical studies which have found mixed evidence(see Devereux [1995], Chennells and Griffith [1997] and Grubert [1999]). However, the result of this thesis should not be interpreted to deny the results of previous works because this thesis adopts different assumptions and uses the data computed in different way. The validity of 'the change-comparison test' depends on whether process of tax adjustment is gradual. The marginal effective corporate tax rates in this thesis is computed with a simplified method in the sense that economic parameters are assumed to be the same across countries and across period. The tests in this thesis are suggestive for alterative approach to the previous studies and further study is needed.

Section 2 discusses technical problems in testing the propositions defined in chapter 8. Section 3 explains the methodology used in computing the MECTRs and the sources of the data. The results of the tests are presented in section 4. Section 5 evaluates overall effects of tax competition with an econometric model. Several limitations and possible extensions of the tests are discussed in the conclusion.

9.2 Testable propositions

In chapter 8, several testable propositions are derived and possible designs of tests are discussed. Here, I will discuss more technical problems arising in carrying out the tests. While the central claim of tax competition theory is that tax competition leads to a lower tax on the income from capital than the optimal level, the exact meaning of a lower tax rate differs across models. The level of tax rates at the non-cooperative equilibrium depends on not only the number of competing countries and but also on the availability of other taxes in financing supply of public goods. If the capital tax should finance the supply of public goods, tax competition even in a small-open economy model will not lead to zero tax rate.

However, it is difficult to compare the level of real tax rates with the level of optimal tax rates because optimal tax rates are not directly observable. Instead, we have established two reasons for a gradual decrease in tax rates; decreasing transaction costs and an increasing number of countries in the international capital market. Considering technological progress in the transportation, telecommunication and information industries, it is not unreasonable to assume that transaction costs have been decreasing in the long term. Neither does it seem unreasonable to assume that more countries have become involved in the international capital market. Given these assumptions, capital tax rates must have decreased if tax competition theory has been valid in the real world.

Data should be collected in the long term and for many countries in order to increase the reliability of tests. Chennells and Griffith (1997) use the data of ten countries - the G7 countries, Australia, Ireland and Australia - for 1979-1994. Their results do not show a decreasing trend in capital tax rates. In contrast, Grubert (1999) investigates 60 countries. However, it may not improve the reliability of tests to increase number of countries up to 60 if the degree of capital mobility may be considerably different among 60 countries. The time span of the data also matters. In detecting a downward trend, Devereux (1993) compares effective tax rates as of 1980 and 1991 and Grubert (1999), as of 1984 and 1992. Chennells and Griffith (1997) investigate changes throughout 1979-1994. The longer the data are collected, the stronger the test is. The data used in this chapter cover the period 1960-1998.

In this thesis, 24 OECD countries are divided into two groups according to the average product market openness between 1960-1996. (1) More-open countries : Austria, Belgium, Denmark, Iceland, Ireland, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Sweden, Switzerland. (2) Less-open countries : Australia, Canada, Finland, France, Germany, Greece, Italy, Japan, Spain, Turkey, UK, USA.[5] However, according to the average capital market openness between 1983-1996[6], two groups are rather defined as follows. (1) Open countries : Australia, Belgium, Canada, France, Ireland, Luxembourg, Netherlands, New Zealand, Norway, Sweden, Switzerland, UK. (2) Closed countries : Austria, Denmark, Finland, Germany, Greece, Iceland, Italy, Japan, Portugal, Spain, Turkey, USA[7].

GDP is used for grouping countries between small and large countries by Devereux (1995) and Chennells and Griffith (1997). (1) Smaller countries: Austria, Belgium,

[5]During the period, New Zealand and Finland have changed their groupings with each other. However, this does not change the results of the test.

[6]Before 1983, the data on the inflow and outflow of direct investment are available only for a few countries.

[7]Due to high volatility of the amount of foreign direct investment, this grouping is not applied for every year. If the criterion measured by the sum of inward and outward direct investment (these are stocks) is applied, the USA is grouped into the open countries instead of Norway and this grouping is correct for every year.

Denmark, Finland, Greece, Iceland, Ireland, Luxembourg, New Zealand, Norway, Portugal, Turkey. (2) Larger countries: Australia, Canada, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, Switzerland, UK, USA. Population is another criterion for grouping countries according to their size. The standard models assume that production technology and capital endowment per capita are the same across countries. Therefore, there must be no difference in grouping either by GDP or by population. However, with real data, the two are not related perfectly. According to population, Turkey and Belgium are grouped into larger countries instead of Sweden and Switzerland. We use the GDP criterion[8].

The grouping by the preference for public goods is more controversial than the two previous groupings. Several different criteria can be found: (1) final consumption by government divided by GDP; (2) tax revenue divided by GDP; (3) total government's revenue divided by GDP. The higher value of all these implies stronger preference for public goods. In this thesis, the second criterion is used. According to the data between 1965-1995, grouping is as follows. (1) Strong preference for public goods: Austria, Belgium, Canada, Denmark, Finland, France, Germany, Luxembourg, Netherlands, Norway, Sweden, UK. (2) Weak preference: Australia, Greece, Iceland, Ireland, Italy, Japan, New Zealand, Portugal, Spain, Switzerland, Turkey, USA.[9]

[8]The reason for choosing GDP instead of population in this thesis is that the standard model implies not simple population but quality-adjusted labour force. The latter might be related with the level of GDP.

[9]During 1983-1984 and 1987-1988, Ireland was grouped into the countries with a strong preference for public goods instead of the UK. In 1989, New Zealand was grouped into the countries with a

9.3 Methodology and sources of data

The marginal effective tax rate (METR) is a powerful tool in comparing the overall tax burden because it can evaluate the overall capital income taxes by summary statistics. It has been frequently used by economists in measuring allocational inefficiency of capital incurred by capital taxes. King and Fullerton (1984) use it to show the differences in the tax burdens between different assets, different financing methods and different investors. OECD (1991) further enlarges the application of the METR by calculating the METR for the cross-border investment for all OECD countries.

Devereux (1995) and Chennells and Griffith (1997) adopt the same concept for carrying out empirical tests of tax competition theory. I, however, modify the standard concept in two ways because my aim is not to analyse the tax-induced allocational distortion of capital but rather the historical changes in tax burdens in the context of tax competition. Firstly, only corporate taxes are included in computing the METR. When a firm decides between alternative locations for an investment, it is less relevant who provides the capital which it uses. Secondly, the values of all parameters except those of tax system are assumed to be fixed across countries and across periods. We can exclude the effect of non-tax variables by setting them being equal across countries and across period. This also makes the calculation of METR much simpler.

strong preference for public goods instead of the UK. Since 1990, Italy has been grouped into the countries with a strong preference for public goods instead of the UK.

Two points need mentioning in relation to the limit of the marginal effective corporate tax rates (MECTR). Firstly, the MECTR is valid only for the 'hypothetical investment'. The values of the MECTR vary greatly according to what is assumed as the 'hypothetical investment'. Aggregated values using the weights of assets, industries and methods of finance can be misleading in evaluating the burden of corporate tax for different investment projects. The comparison of the MECTR between countries is not likely to provide a good indication when you decide which country is the best for your investment because your investment is not the same as the 'hypothetical investment' used in calculating the MECTR. For example, according to Alworth and Castellucci (1994), the METR in Italy was around 20% in 1980s. However, the METR in the area of Mezzogiorno, southern Italy, was only 6%.

Secondly, the MECTR does not represent all provisions of corporate income taxes. Devereux and Pearsson (1994) surveys 176 firms in the UK with regard to which tax provisions are important in their decision on investment location. 'Loss carry-over' is reported to be as influential as 'capital allowances'. According to Ishi (1993), the Japanese government has depended heavily on 'free-tax reserves' as incentives for investments. However, the MECTR cannot represent tax provisions on loss carry-over, tax-free reserve, time lag of tax payment, tax appliance cost, etc. Therefore, the MECTR reflects only tax provisions on tax rates, capital allowances, stock valuation and general tax incentives.

Given these drawbacks, it is important to describe what is assumed to be the 'hypothetical investment' in computing the MECTR and how the conversion of complicated tax provisions into simple numerical values is carried out. The values of the MECTR should be read in a close connection with these two factors. The details on 'hypothetical investment', economic parameters and formulas for conversions are annexed.

The main sources for information about corporate tax system are *Income taxes outside the UK* by Inland Tax Revenue, *International tax summaries* and *Doing business Series* by Price Waterhouse. Due to the complicated tax systems of each country, it is inevitable to use only some parts of information of tax systems in calculating the MECTR. A summary of changes in the corporate tax systems of OECD countries is also annexed. This will help understand which information of tax systems is used in calculating the MECTR.

Macroeconomic data differ between different sources and even between different editions of the same source. Therefore, it is necessary to make clear all the sources and editions of the data used here. Data for inflow[10] and outflow direct investment[11],

[10]Code and Table: Inflows by country / Partner : World, International Direct Investment, Financial and Fiscal Affairs

[11]Code and Table: Outflows by country / Partner : World, International Direct Investment, Financial and Fiscal Affairs

GDP[12], import[13], export[14], tax revenue[15], population[16], labour force[17] and unemployment[18] are drawn from *OECD Statistical Compendium 1999.*

Table 9.1 provides time series data of all variables used in this chapter and their basic statistics. All values are caculated by a simple average of 24 countries. Table 9.2 provides cross-country data which are averaged for the period. OPEN (1) and (2) represent respectively the product market openness and the capital market openness.

The central proposition that tax rates should have decreased is based on the assumption of the increasing mobility of capital and an increasing number of countries involved. Therefore, tax rates are expected to have a negative correlation with product market openness and capital market openness, both of which might be used as proxy for capital mobility. The data reveal that tax rates have been decreased while the degree of openness, both of product market and of capital market, has been increased.

The data for each country are provided in appendix. Figure9.1 - 9.7 provides the overall summary of each variable for 24 countries. The simple average values are

[12]Code and Table: Gross Domestic Product (Expenditure) in billion US$ - current prices and exchange rates, National Accounts 1

[13]Code and Table: Imports of goods and services in billion US$ - current prices and exchange rates, National Accounts 1

[14]Code and Table: Exports of goods and services in billion US$ - current prices and exchange rates, National Accounts 1

[15]Code and Table : Total Tax Revenue / Tax as percentage of GDP, Revenue Statistics, Financial and Fiscal Affairs

[16]Code and Table : Population (Thousand, mid-year estimate), Annual Labour Force Statistics, Labour Force and Social Issues

[17]Code and Table : Total Labour Force (Thousand), Annual Labour Force Statistics, Labour Force and Social Issues

[18]Code and Table : Unemployment : Total, Annual Labour Force Statistics, Labour Force and Social Issues

Year	METRs	OPEN (1)	OPEN (2)	TAX /GDP	UNEM[1]	GDP[2]	POP[2]
1960	0.52	0.49	N/A	N/A	2.67	2.39	9.21
1965	0.50	0.49	N/A	0.26	2.19	2.83	9.27
1970	0.50	0.54	N/A	0.29	2.35	3.23	9.31
1975	0.48	0.58	N/A	0.32	3.66	4.07	9.36
1980	0.48	0.64	0.12	0.34	4.83	4.71	9.39
1985	0.45	0.71	0.17	0.36	7.60	4.62	9.42
1990	0.45	0.66	0.30	0.38	6.38	5.42	9.45
1995	0.41	0.69	0.31	0.38	8.44	5.66	9.50
1998	0.39	N/A	N/A	N/A	N/A	N/A	N/A
mean (*variance*)	0.47 (1.5×10^{-3})	0.59 (5.8×10^{-3})	0.28 (2.4×10^{-3})	0.34 (1.5×10^{-3})	5.01 (6.1)	4.16 (1.13)	9.37 (7.1×10^{-3})

Source : Tax data are from own caculation.
OECD Statistical Compendium, 1999
Note 1 : unemployment rate, Unit (%)
Note 2 : Unit [log(billionUS$), log(thousand population)]

Table 9.1: Summary of time series data

represented by bold round marks.

9.4 Empirical results

9.4.1 Test 1 : Are corporation tax rates decreasing?

Changes in the average tax rate of 24 OECD countries between 1960-1998 are shown in Figure 9.8, which reveals a decreasing trend. The average tax rate was 51% in 1960s, 49% in 1970s, 46% in 1980s and finally 41% in 1990s. Of the 24 countries, 19 countries have experienced a decrease in the corporation tax rates. The magnitude of a decrease is different across countries. In some countries such as

country	METRs	OPEN (1)	OPEN (2)	TAX / GDP	UNEM[1]	GDP[2]	POP[2]
Australia	0.465	0.33	0.34	0.28	5.34	4.52	9.57
Austria	0.591	0.65	0.11	0.39	2.52	3.74	8.93
Belgium	0.430	1.13	0.59	0.42	6.67	4.11	9.19
Canada	0.433	0.49	0.24	0.33	7.43	5.21	10.07
Denmark	0.439	0.63	0.24	0.44	5.22	3.65	8.52
Finland	0.591	0.53	0.20	0.37	5.00	3.40	8.47
France	0.524	0.38	0.27	0.39	5.81	5.88	10.88
Germany	0.604	0.46	0.13	0.40	3.96	6.21	11.06
Greece	0.450	0.34	0.11	0.31	5.41	3.29	9.15
Iceland	0.580	0.72	0.02	0.29	1.34	0.55	5.41
Ireland	0.316	0.97	0.19	0.33	9.69	2.43	8.08
Italy	0.412	0.39	0.86	0.32	7.77	5.56	10.91
Japan	0.601	0.21	0.81	0.25	1.93	6.44	11.63
Luxembourg	0.455	1.72	0.59	0.39	1.03	1.08	5.89
Netherlands	0.387	0.95	0.69	0.43	5.10	4.44	9.53
New Zealand	0.484	0.54	0.60	0.32	2.91	2.75	8.02
Norway	0.472	0.74	0.20	0.40	2.38	3.51	8.30
Portugal	0.474	0.58	0.22	0.25	4.89	2.87	9.15
Spain	0.307	0.32	0.23	0.25	10.02	4.67	10.49
Sweden	0.481	0.56	0.47	0.47	2.66	4.27	9.01
Switzerland	0.476	0.64	0.43	0.29	7.55	4.11	8.76
Turkey	0.469	0.22	0.04	0.17	8.18	3.79	10.67
UK	0.377	0.50	0.50	0.35	5.50	5.70	10.94
USA	0.427	0.16	0.16	0.26	6.04	7.64	12.31

Source : Tax data are from own caculation.
OECD Statistical Compendium, 1999
Note 1 : unemployment rate = (unemployment / total labour force)$\times$100
Note 2 : Unit [log(billionUS$), log(thousand population)]

Table 9.2: Summary of cross-country data

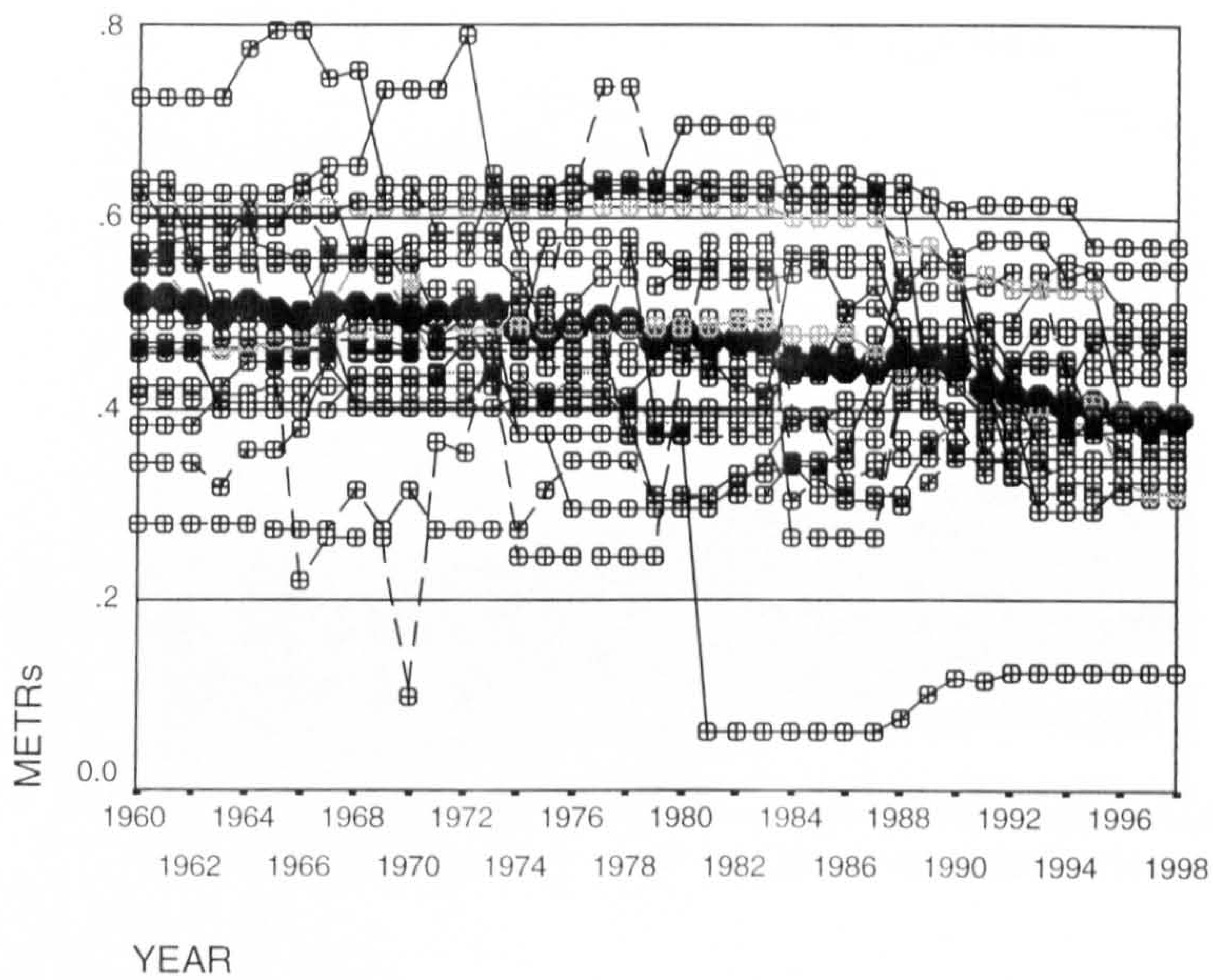

Figure 9.1: METRs of OECD countries, 1960-1998

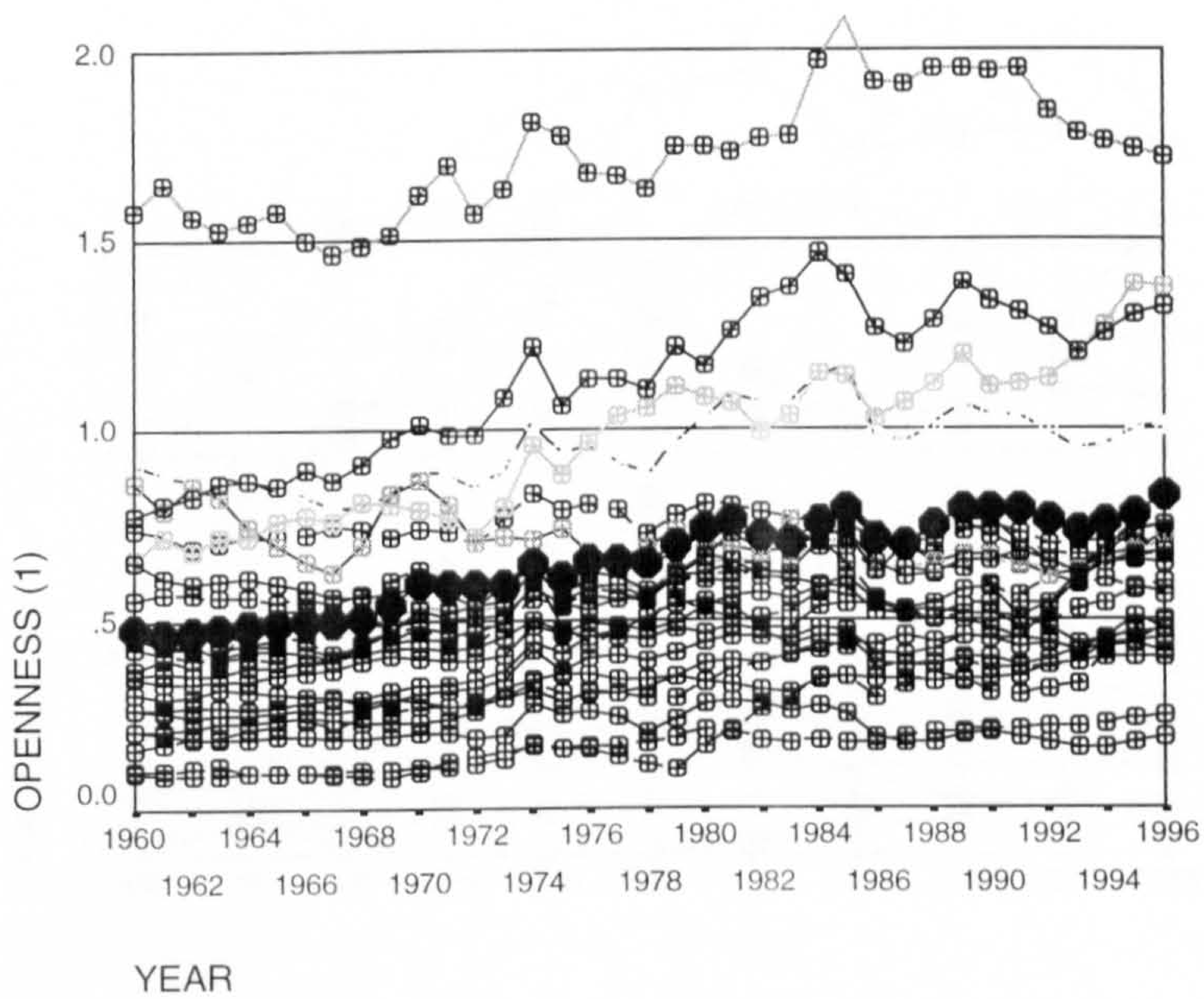

Figure 9.2: Openness of product market, 1960-1996

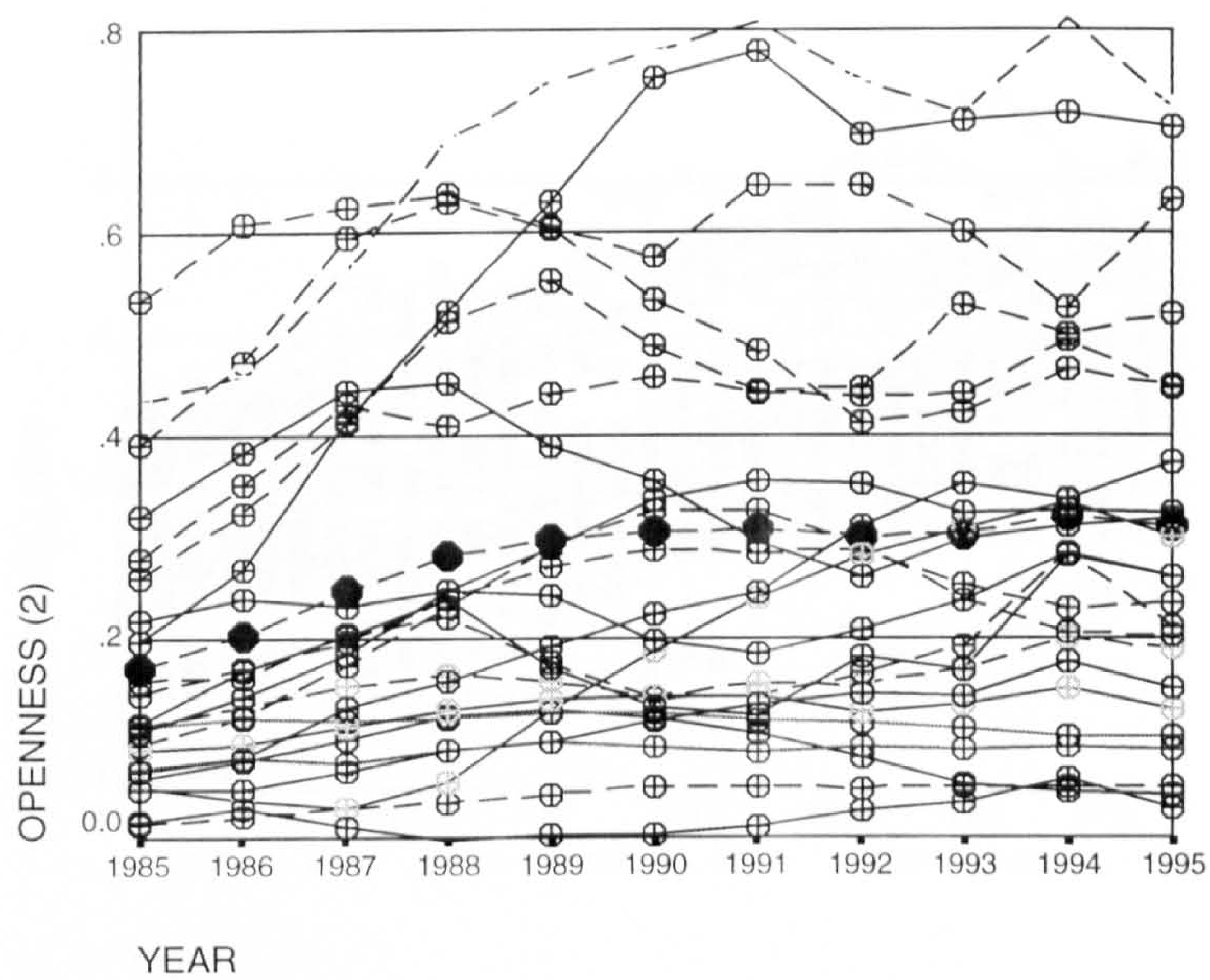

Figure 9.3: Openness of capital market, 1985-1996

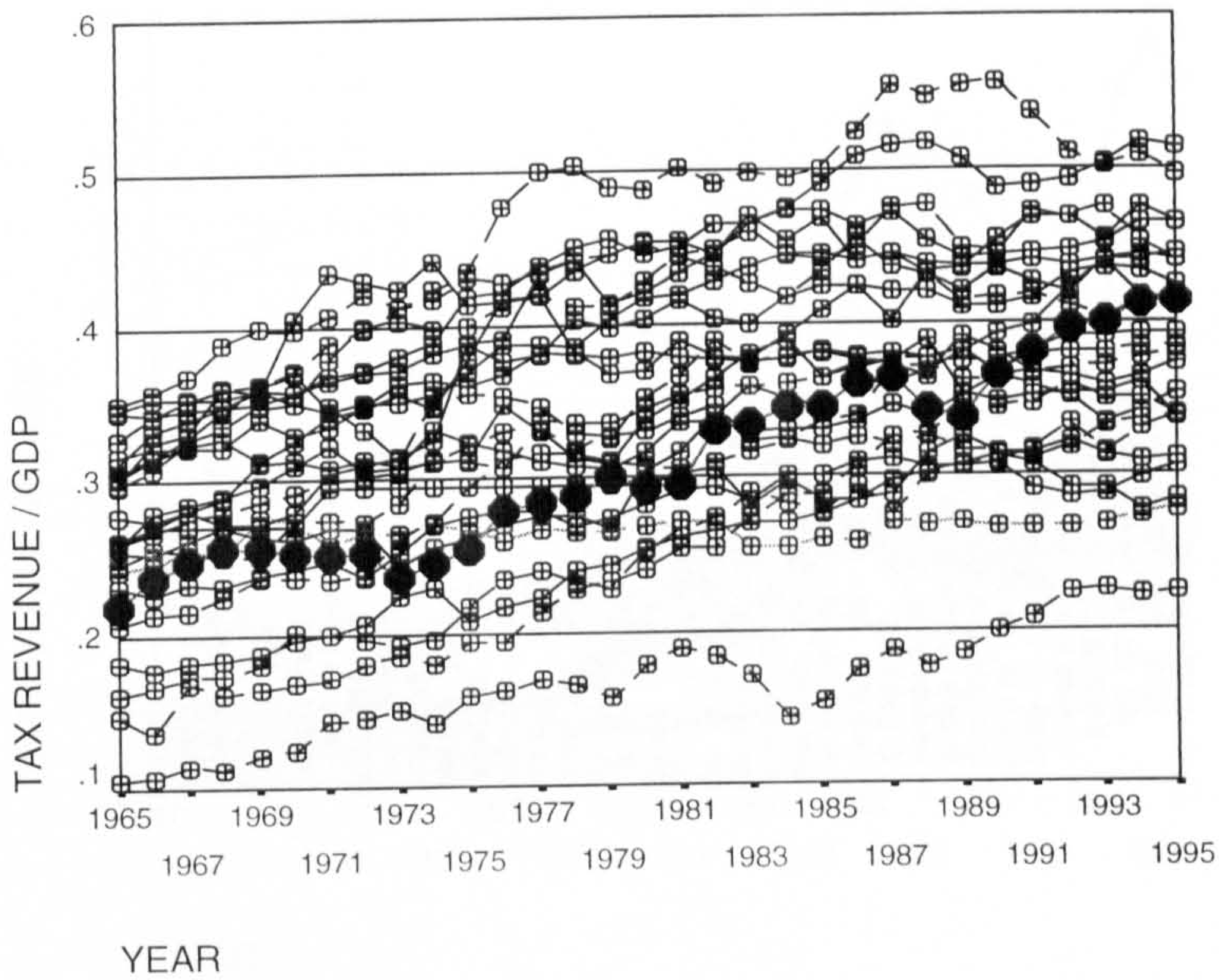

Figure 9.4: Tax revenue / GDP, 1965-1995

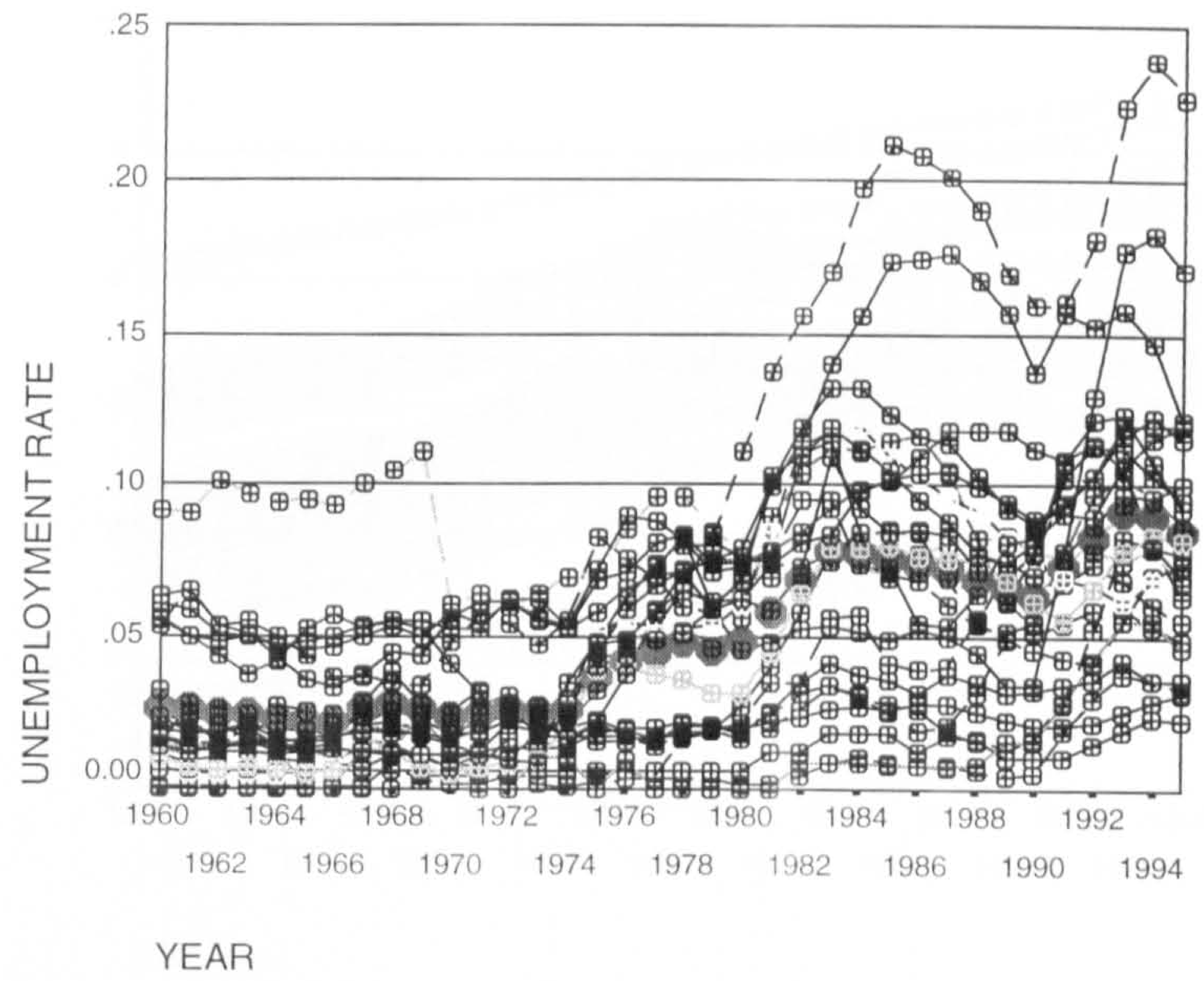

Figure 9.5: Unempolyment rate, 1960-1995

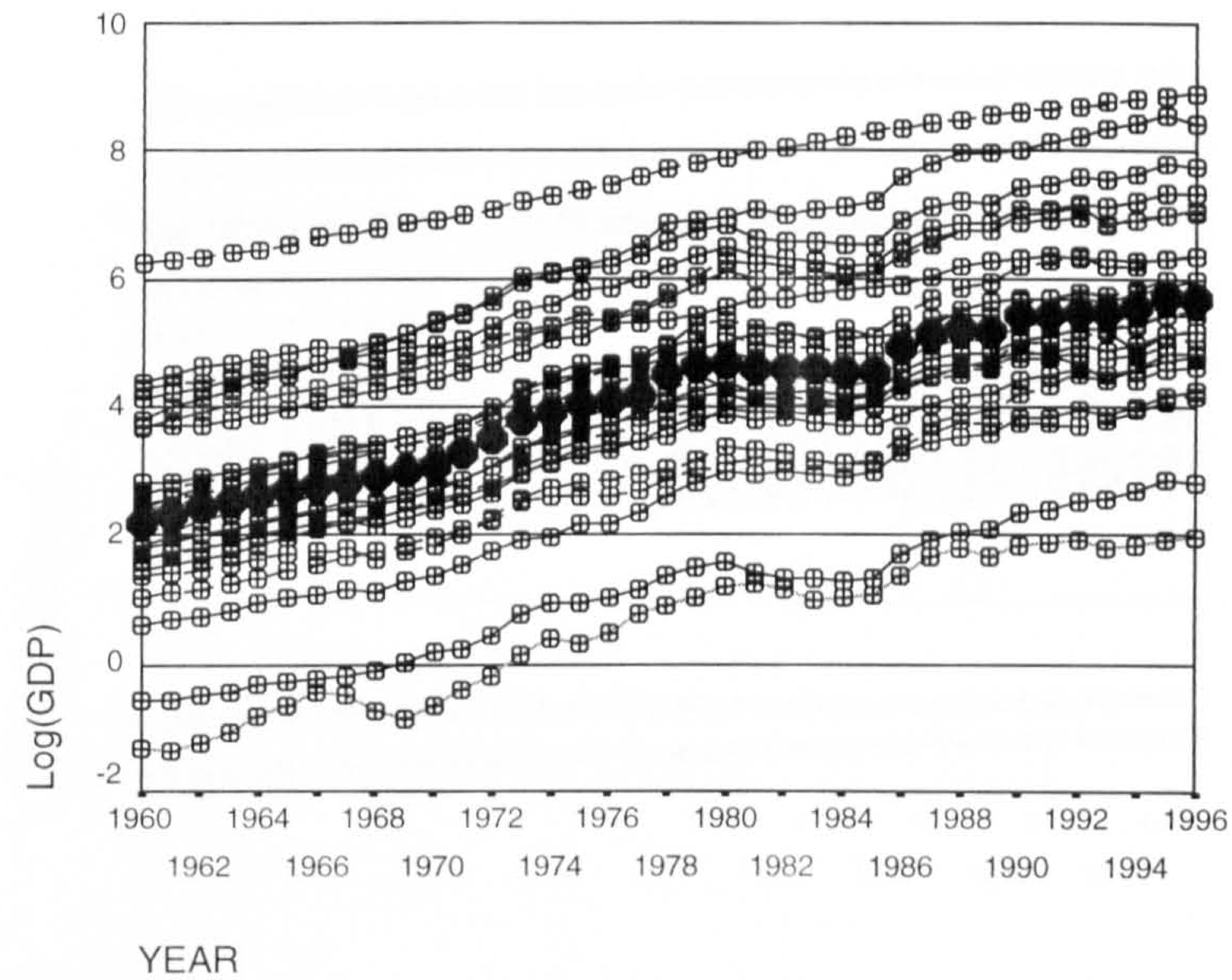

Figure 9.6: GDP, 1960-1996

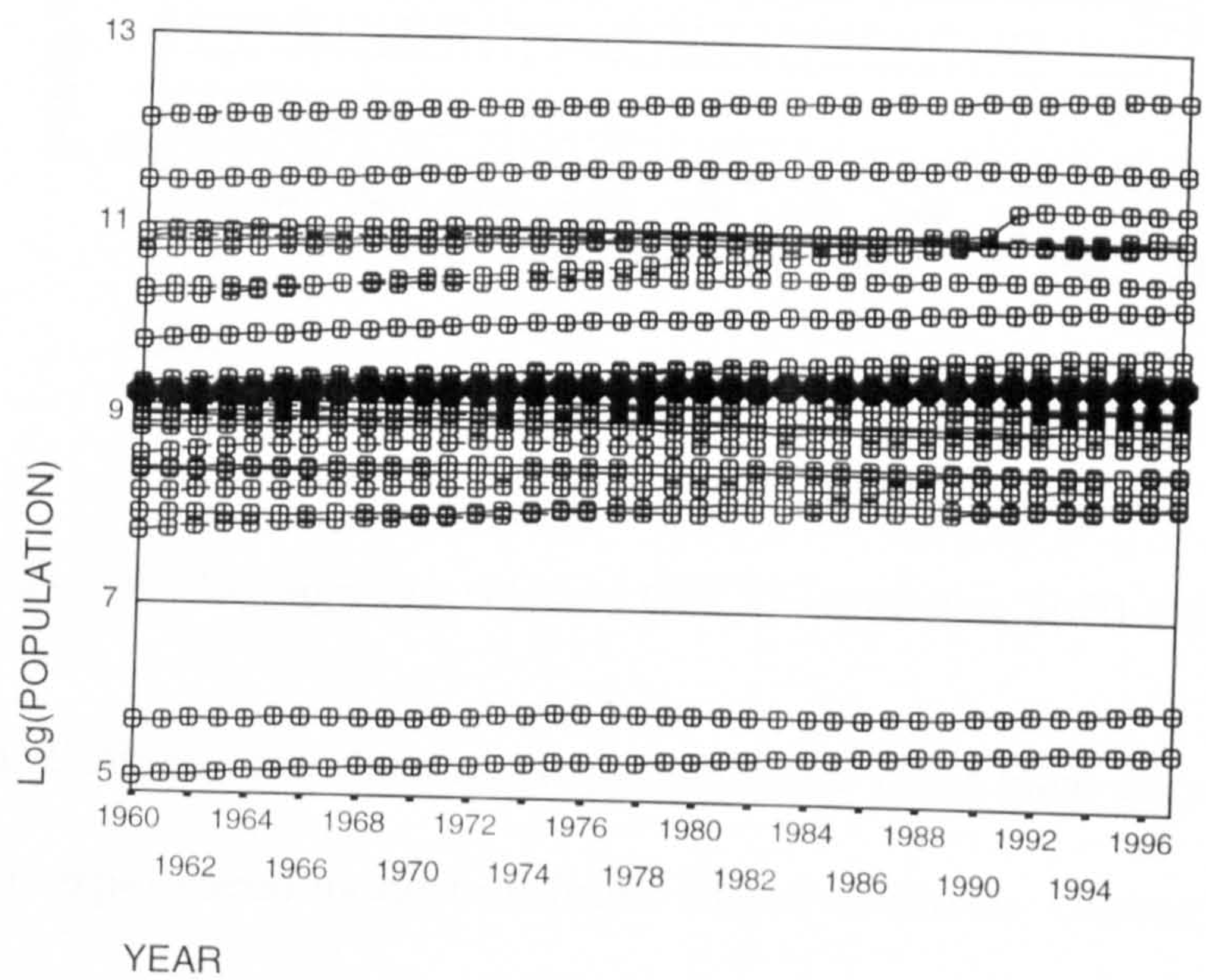

Figure 9.7: Population, 1960-1997

Figure 9.8: Average tax rates of OECD countries, 1960-1998

Austria, Ireland, Finland and Norway, corporation tax rates have decreased sharply while others have experienced modest declines. In five countries, Greece, Italy, Japan, Spain and Turkey, the corporation tax rates have been raised. Does this picture support, as a whole, the conjecture that the corporation tax rates of OECD countries have decreased?

A probable test is to regress the tax rates to time variables (t=1 for 1960, t=2 for 1962, ... , t=39 for 1998) for each country (i=1 for Australia, i=2 for Austria, ... , i =24 for USA) and to investigate the significance of the estimated coefficients of time variables. The regression model is

$$\tau_{it} = \alpha_i + \beta_i t + \varepsilon_{it}, \tag{9.1}$$

where $\varepsilon_{it} \sim iid\ N(0, \sigma_i^2)$. The results of estimation are provided in Table 9.3.[19] R^2 and DW denote the coefficient of determination and Durbin-Watson test statistic.

For the 19 countries, the value of estimate of β is negative. Compared with $t_{37,\alpha=0.025} < t_{30,\alpha=0.025} = 2.042$, the null hypothesis that $\beta_i = 0$ is rejected against the alternative hypothesis that $\beta_i < 0$ for 18 countries. For the UK, the null hypothesis is not rejected. For Greece, Italy, Japan, Spain and Turkey, the value of estimate of β is positive.

Instead of (9.1), one single regression equation is estimated using tax rates of all countries, on the assumption that α and β are the same across countries. The regression model is

$$\tau_{it} = \alpha + \beta t + \epsilon_{it}, \tag{9.2}$$

where $\varepsilon_{it} \sim iid\ N(0, \sigma^2)$. The null and the alternative hypothesis are

$$H_0 : \beta = 0 \tag{9.3}$$

and

$$H_1 : \beta < 0. \tag{9.4}$$

The result of estimation is

$$\tau_{it} = 0.533 - \underset{(-9.893)}{3.222E^{-3}}\, t,\ R^2 = 0.095, \tag{9.5}$$

[19]The OLS estimations in this thesis are carried out by SPSS.

country	$\hat{\alpha}_i$	$\hat{\beta}_i$	t value of $\hat{\beta}_i$	R^2	DW
Australia	0.509	$-2.195E^{-3}$	-2.952	0.191	0.320
Austria	0.737	$-7.336E^{-3}$	-6.224	0.511	0.401
Belgium	0.480	$-2.544E^{-3}$	-2.886	0.184	0.481
Canada	0.514	$-4.075E^{-3}$	-4.528	0.357	0.234
Denmark	0.473	$-1.669E^{-3}$	-2.476	0.142	0.442
Finland	0.816	$-11.240E^{-3}$	-11.286	0.775	0.290
France	0.601	$-3.846E^{-3}$	-6.608	0.541	0.402
Germany	0.631	$-1.353E^{-3}$	-3.952	0.297	0.320
Greece	0.400	$2.478E^{-3}$	3.885	0.290	0.605
Iceland	0.657	$-3.838E^{-3}$	-6.525	0.535	0.265
Ireland	0.668	$-17.600E^{-3}$	-13.108	0.823	0.365
Italy	0.353	$2.949E^{-3}$	3.156	0.212	0.136
Japan	0.577	$1.186E^{-3}$	2.939	0.189	0.229
Luxembourg	0.515	$-3.030E^{-3}$	-5.596	0.458	0.277
Netherlands	0.420	$-1.689E^{-3}$	-2.111	0.108	0.376
New Zealand	0.573	$-4.473E^{-3}$	-3.762	0.277	0.656
Norway	0.627	$-7.747E^{-3}$	-10.963	0.765	0.500
Portugal	0.558	$-4.201E^{-3}$	-2.755	0.170	0.248
Spain	0.278	$1.443E^{-3}$	4.284	0.332	1.020
Sweden	0.567	$-4.331E^{-3}$	-4.369	0.340	0.321
Switzerland	0.456	$-0.966E^{-3}$	-3.098	0.206	0.184
Turkey	0.457	$0.574E^{-3}$	1.433	0.053	0.538
UK	0.402	$-1.264E^{-3}$	-0.779	0.016	0.624
USA	0.517	$-4.493E^{-3}$	-10.088	0.733	0.529
Average	0.533	$-3.222E^{-3}$	-18.199	0.900	0.465

Table 9.3: Results of regression with standard disturbance term

where $t-$value is provided in the parenthesis. The null hypothesis is rejected at the 5% significance level.

The lower values of Durbin-Watson test statistic for all countries imply the existence of autocorrelation in the disturbance term. The values of Durbin-Watson test statistic for all countries, shown in Table 9.3, are below the lower bound (d_L =1.43 when $k = 2$, $n = 39$ and $\alpha = 0.05$). The existence of autocorrelation in the disturbance term makes the test based on OLS estimates invalid because the standard errors of estimates are underestimated.

Therefore, the disturbance term is assumed to follow a stationary AR(1) process. The regression model is

$$\begin{aligned} \tau_{it} &= \alpha_i + \beta_i t + u_{it}, \\ u_{it} &= \rho_i u_{it-1} + \varepsilon_{it}, \\ \varepsilon_{it} &\sim iid\ N(0, \sigma_i^2). \end{aligned} \tag{9.6}$$

The results of estimation are provided in Table 9.4. ρ_i's are estimated by the iterative Cochrane-Orcutt method.

For 10 countries, the null hypothesis that $\beta_i = 0$ is rejected against the alternative hypothesis that $\beta_i < 0$. For the rest of countries except Spain, the null hypothesis that $\beta_i = 0$ is not rejected.

Instead of (9.6), one single regression equation is estimated using tax rates of all countries, on the assumption that α and β are the same across countries.[20] The

[20]We can make three different assumptions on the covariance and the autocorrelation of the

country	$\hat{\alpha}_i$	$\hat{\beta}_i$	t value of $\hat{\beta}_i$	R^2	$\hat{\rho}_i$
Australia	0.576	-4.56E^{-3}	-2.0820	0.110	0.8103
Austria	0.820	-10.53E^{-3}	-3.0578	0.211	0.7846
Belgium	0.494	-3.22E^{-3}	-1.2618	0.044	0.7591
Canada	0.393	-0.12E^{-3}	-0.0464	0.000	0.8324
Denmark	0.467	-1.63E^{-3}	-0.8119	0.018	0.7745
Finland	0.912	-14.69E^{-3}	-4.2415	0.340	0.8440
France	0.618	-4.28E^{-3}	-2.5064	0.152	0.7827
Germany	0.679	-3.14E^{-3}	-2.2275	0.124	0.8754
Greece	0.380	3.14E^{-3}	2.1333	0.115	0.6734
Iceland	0.862	-10.93E^{-3}	-2.9814	0.202	0.9168
Ireland	0.631	-15.30E^{-3}	-3.2814	0.235	0.8213
Italy	0.226	6.73E^{-3}	1.2576	0.043	0.9327
Japan	0.653	-1.63E^{-3}	-0.6430	0.012	0.9209
Luxembourg	0.645	-7.79E^{-3}	-3.0596	0.211	0.8882
Netherlands	0.468	-3.30E^{-3}	-1.4432	0.056	0.7870
New Zealand	0.567	-4.05E^{-3}	-1.4192	0.054	0.6698
Norway	0.653	-8.51E^{-3}	-4.8711	0.404	0.7192
Portugal	0.675	-8.06E^{-3}	-1.3678	0.051	0.8680
Spain	0.280	1.33E^{-3}	2.2096	0.122	0.4770
Sweden	0.612	-6.40E^{-3}	-1.7107	0.077	0.8459
Switzerland	0.537	-1.80E^{-3}	-1.6157	0.069	0.8861
Turkey	0.464	0.15E^{-3}	0.1365	0.000	0.7230
UK	0.345	-0.78E^{-3}	-0.7790	0.001	0.6647
USA	0.492	-3.44E^{-3}	-3.0340	0.208	0.7188
Average	0.543	-3.65E^{-3}	-7.3839	0.609	0.7457

Table 9.4: Results of regression with AR(1) disturbance term

regression model is

$$\begin{aligned}\tau_{it} &= \alpha + \beta t + u_{it},\\ u_{it} &= \rho u_{it-1} + \varepsilon_{it},\\ \varepsilon_{it} &\sim iid\ N(0, \sigma^2).\end{aligned} \tag{9.7}$$

The null and the alternative hypothesis are

$$H_0 : \beta = 0 \tag{9.8}$$

and

$$H_1 : \beta < 0. \tag{9.9}$$

disturbance term respectively. This makes nine sets of results. S_0, S_1, and S_2 denote 'No correlation', 'Countrywise heteroscedasticity' and 'Cross country correlation and countrywise heteroscedasticity'. R_0, R_1 and R_2 denote 'No autocorrelation', 'AR(1) with the same ρ' and 'AR(1) with different ρ_i across countries'.

The estimated results are as follows with $z = \hat{\beta} / s.e.$

1. $S_0 - R_0$: $\hat{\tau}_{it} = 0.53 - 3.22E^{-3}t$, $z = -9.90$
2. $S_1 - R_0$: $\hat{\tau}_{it} = 0.51 - 2.46E^{-3}$, $z = -11.37$
3. $S_2 - R_0$: $\hat{\tau}_{it} = 0.51 - 2.45E^{-3}$, $z = -54.27$
4. $S_0 - R_1$: $\hat{\tau}_{it} = 0.53 - 3.24E^{-3}$, $z = -4.70$
5. $S_1 - R_1$: $\hat{\tau}_{it} = 0.51 - 1.75E^{-3}$, $z = -3.72$
6. $S_2 - R_1$: $\hat{\tau}_{it} = 0.51 - 1.14E^{-3}$, $z = -4.99$
7. $S_0 - R_2$: $\hat{\tau}_{it} = 0.53 - 3.47E^{-3}$, $z = -5.64$
8. $S_1 - R_2$: $\hat{\tau}_{it} = 0.51 - 2.41E^{-3}$, $z = -5.00$
9. $S_2 - R_2$: $\hat{\tau}_{it} = 0.51 - 2.38E^{-3}$, $z = -7.02$

The result of estimation[21] is

$$\tau_{it} = 0.528 - \underset{(-4.704)}{3.240E^{-3}}\, t, \quad \hat{\rho} = 0.91298, \tag{9.10}$$

where $z-$value is provided in the parenthesis. Therefore, the null hypothesis is rejected at the 5% significance level.

However, higher value of $\hat{\rho}$ suggests that the disturbance term may follow a random walk process instead of AR(1). By subtracting $\rho_i \tau_{it-1}$ from τ_{it}, the model defined in (9.7) can be rewritten as

$$\tau_{it} = [(1-\rho_i)\alpha_i + \rho_i \beta_i] + \rho_i \tau_{it-1} + \beta_i (1-\rho_i)t + \varepsilon_{it}. \tag{9.11}$$

The regression model is

$$\tau_{it} = \theta_i + \gamma_i \tau_{it-1} + \delta_i t + \varepsilon_{it}, \tag{9.12}$$

where $\theta_i = [(1-\rho_i)\alpha_i + \rho_i \beta_i]$, $\gamma_i = \rho_i \tau_{it-1}$ and $\delta_i = \beta_i(1-\rho_i)$. If $\gamma_i = 1$ and $\delta_i = 0$ (this is equivalent to $\rho_i = 1$ and $\beta_i(1-\rho_i) = 0$), random walk process is a more appropriate model in this case. Therefore, the null and the alternative hypothesis are

$$H_0 : \gamma_i = 1 \text{ and } \delta_i = 0 \tag{9.13}$$

and

$$H_1 : \gamma_i \neq 1 \text{ or } \delta_i \neq 0. \tag{9.14}$$

The F-test statistic for the null hypothesis is

$$F_i = \frac{(RSS_r - RSS_u)/2}{RSS_u/35}, \tag{9.15}$$

[21]LIMDEP produces two-step GLS estimates.

country	RSS_u	RSS_r	F *ratio*
Australia	0.02766	0.0333	3.57
Austria	0.08805	0.1036	3.09
Belgium	0.06031	0.0666	1.83
Canada	0.02797	0.0333	3.33
Denmark	0.03258	0.0370	2.37
Finland	0.04668	0.0518	1.92
France	0.02200	0.0259	3.10
Germany	0.00493	0.0055	2.02
Greece	0.03685	0.0444	3.59
Iceland	0.01478	0.0185	4.40
Ireland	0.11100	0.1184	1.17
Italy	0.02047	0.0222	0.15
Japan	0.00639	0.0074	2.77
Luxembourg	0.01295	0.0148	2.50
Netherlands	0.03800	0.0444	2.95
New Zealand	0.14200	0.1702	3.48
Norway	0.03844	0.0444	2.71
Portugal	0.09687	0.1073	1.88
Spain	0.01592	0.0211	5.69
Sweden	0.05313	0.0592	2.00
Switzerland	0.00258	0.0033	4.88
Turkey	0.01392	0.0148	1.11
UK	0.24300	0.2997	4.08
USA	0.01624	0.0185	2.44

Table 9.5: Unit root test statistics

where RSS_u is the residual sum of squares when (9.12) is estimated and RSS_r is the residual sum of squares when (9.12) is estimated with the restriction of $\gamma_i = 1$ and $\delta_i = 0$. The F ratio for each country is provided in Table 9.5.

According to Dickey-Fuller tables, the critical value is 7.24 when $n = 25$ (6.73 when $n = 50$) at the 5% significance level. The F ratios for all countries are not greater than this critical value. This result implies that 'difference-stationary process' represented by (9.16) is more appropriate than 'trend-stationary process' represented by (9.7) in modelling the movement of tax rates. However, given $\tau_{it} \in [0,1)$, 'difference-stationary process' is restricted to the current sample of observation (a finite period). It must not be extrapolated beyond the current sample.

Therefore, the regression model is

$$\tau_{it} = \tau_{it-1} + d_i + \epsilon_{it}, \tag{9.16}$$

where $\varepsilon_{it} \sim iid\ N(0, \sigma_i^2)$. The results of estimation are provided in Table 9.6

For 20 countries, the sign of the estimated drift is negative. However, the null hypothesis that $d_i = 0$ is not rejected for any country against the alternative hypothesis that $d_i < 0$ at the 5% significance level. Pooled data across countries are used to estimate one single equation with the assumption that the drift is the same across all countries. Then, the regression model is

$$\tau_{it} = \tau_{it-1} + d + \epsilon_{it}, \tag{9.17}$$

where $\varepsilon_{it} \sim iid\ N(0, \sigma^2)$. $\hat{d}$, estimate of d, is defined as

$$\hat{d} = \frac{\sum_{i=1}^{N} \sum_{t=2}^{T} \Delta\, \tau_{it}}{N(T-1)}. \tag{9.18}$$

$\Delta\, \tau_{it}$ is the first difference of tax rate. The null and the alternative hypothesis are

$$H_0 : d = 0 \tag{9.19}$$

and

$$H_1 : d < 0. \tag{9.20}$$

country	$\hat{d}_i$	t value of $\hat{d}_i$
Australia	$-0.08E^{-2}$	-0.176
Austria	$-0.65E^{-2}$	-0.765
Belgium	$-0.35E^{-2}$	-0.500
Canada	$-0.64E^{-2}$	-1.280
Denmark	$-0.29E^{-2}$	-0.569
Finland	$-1.05E^{-2}$	-1.721
France	$-0.26E^{-2}$	-0.634
Germany	$-0.15E^{-2}$	-0.750
Greece	$0.10E^{-2}$	0.167
Iceland	$-0.60E^{-2}$	-2.000
Ireland	$-1.30E^{-2}$	-1.444
Italy	$0.30E^{-2}$	0.750
Japan	$-0.00E^{-2}$	-0.000
Luxembourg	$-0.40E^{-2}$	-1.333
Netherlands	$-0.00E^{-2}$	-0.000
New Zealand	$-0.29E^{-2}$	-0.264
Norway	$-0.50E^{-2}$	-0.833
Portugal	$-0.30E^{-2}$	-0.750
Spain	$0.10E^{-2}$	0.250
Sweden	$-0.60E^{-2}$	-1.000
Switzerland	$0.10E^{-2}$	0.500
Turkey	$-0.10E^{-2}$	-0.500
UK	$-0.50E^{-2}$	-0.333
USA	$-0.40E^{-2}$	-1.000
Average	$-0.32E^{-2}$	-2.286

Table 9.6: Estimates of drift in random walk process

The result of estimation is

$$\hat{d} = -0.0031, \ \ s.e. = 0.0013. \tag{9.21}$$

Therefore, the test statistic is

$$\frac{\hat{d}}{s.e.} = -2.3846 < t_{0.05,912}. \tag{9.22}$$

The null hypothesis is rejected at the 5% significance level.

9.4.2 Test 2 : Do more-open countries cut tax rates more than less-open countries?

According to product market openness, 24 OECD countries are divided as follows. (1) More-open countries : Austria, Belgium, Denmark, Iceland, Ireland, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Sweden, Switzerland. (2) Less-open countries : Australia, Canada, Finland, France, Germany, Greece, Italy, Japan, Spain, Turkey, UK, USA. However, with capital market openness, two groups are as follows. (1) More-open countries : Australia, Belgium, Canada, France, Ireland, Luxembourg, Netherlands, New Zealand, Norway, Sweden, Switzerland, UK. (2) Less-open countries : Austria, Denmark, Finland, Germany, Greece, Iceland, Italy, Japan, Portugal, Spain, Turkey, USA.

The average tax rate of more-open countries and less-open countries for a specific year, τ_{ot} and τ_{ct}, are assumed to be a random sample respectively from the population with mean μ_o and μ_c. $\bar{d}$ and s_d^2 denote the sample mean and the sample variance for the differences $(\tau_{ot} - \tau_{ct})$. The null and the alternative hypothesis are

$$H_0 : \mu_o - \mu_c = 0 \tag{9.23}$$

and

$$H_1 : \mu_o - \mu_c < 0. \tag{9.24}$$

The decision rule is to reject H_0 if

$$t = \frac{\bar{d}}{\frac{s_d}{\sqrt{n}}} < -t_{n-1,\alpha}, \tag{9.25}$$

where α is significance level. When countries are grouped by product market openness, the test statistic is

$$t = \frac{-0.0063}{0.0081} = -0.78 > -t_{38,0.05}. \tag{9.26}$$

Therefore, the null hypothesis is accepted at the 5% significance level.

The same test is done with the grouping based on capital market openness. The test statistic is

$$t = \frac{-0.0539}{0.0053} = -10.17 < -t_{38,0.05}. \tag{9.27}$$

The null hypothesis is rejected at the 5% significance level. We reject the null hypothesis that there is no difference between the level of tax rates of more-open and less-open countries.

In addition to the 'level-comparison test', I compare the difference in changes in tax rates between two groups. In chapter 4, the tax rates of more-open countries are predicted to decrease tax rates more than less-open countries.

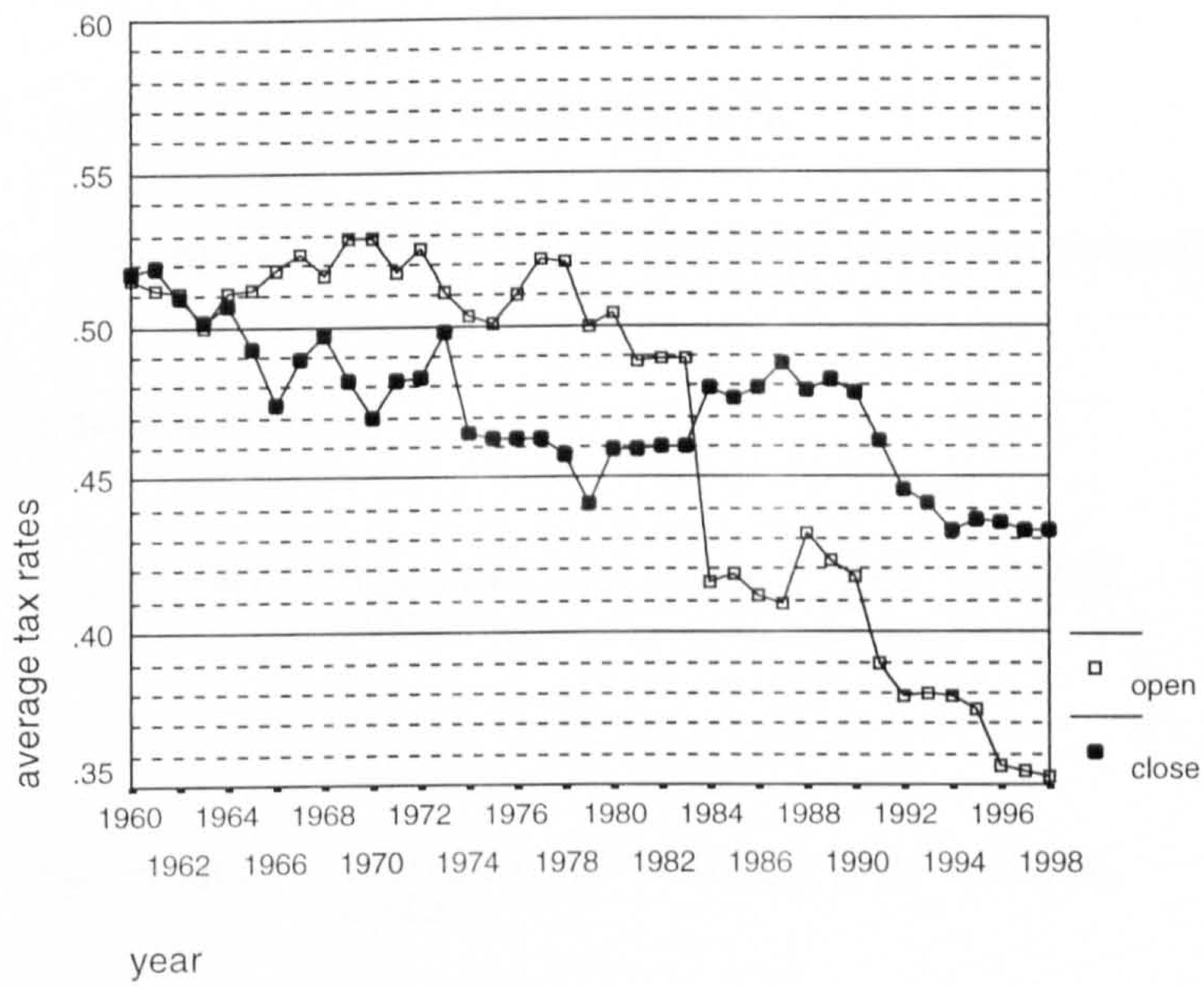

Figure 9.9: Average tax rates, grouped by product market openness

Figure 9.9 shows that more-open countries, divided by product market openness, have decreased on average their tax rates more than less-open countries. This figure also suggests that the result of the 'level-comparison test' is sensitive to the year of comparison. Before 1983, more-open countries had set higher tax rates on average than less-open countries.

The regression model is

$$\begin{aligned} \tau_{jt} &= \alpha_j + \beta_j t + \epsilon_{jt}, \quad \epsilon_{jt} \sim iid\ N(0, \sigma_j^2), \\ j &= 1 \text{ for more-open countries and 2 for less-open countries.} \end{aligned} \tag{9.28}$$

The results of estimation are

$$\tau_{1t} = 0.561 - \underset{(0.000392)}{0.00479}\, t, \ R^2 = 0.801, DW = 0.305 \tag{9.29}$$

and

$$\tau_{2t} = 0.505 - \underset{(0.000210)}{0.00165}\, t, \ R^2 = 0.625, DW = 0.558, \tag{9.30}$$

where the estimated standard errors are given in the parentheses.

The null and the alternative hypothesis are

$$H_0 : \beta_1 = \beta_2 \tag{9.31}$$

and

$$H_1 : \beta_1 < \beta_2. \tag{9.32}$$

The test statistic[22] is

[22] It is assumed that $\beta_1$and β_2 are distributed as the standard normal in the large number sample and that they are independently distributed.

$$z = \frac{-0.00479 - (-0.00165)}{\sqrt{(0.000392)^2 + (0.000210)^2}} = -7.06 < -z_{0.05}. \tag{9.33}$$

Therefore, the null hypothesis is rejected with the 5% significance level. This result is in contrast to that of the 'level-comparison test'.

However, we already know that a strong autocorrelation exists in disturbance terms. This indicates that the standard errors are underestimated and that the above test is invalid. The results of estimation with AR(1) disturbance term are

$$\tau_{1t} = 0.550 - \underset{(0.000928)}{0.00454}\, t, \;\; R^2 = 0.399, DW = 1.996, \hat{\rho} = 0.836 \tag{9.34}$$

and

$$\tau_{2t} = 0.509 - \underset{(0.000439)}{0.00183}\, t, \;\; R^2 = 0.324, DW = 1.966, \hat{\rho} = 0.719, \tag{9.35}$$

where the estimated standard errors are given in the parentheses. The test statistic is

$$z = -2.64 < -z_{0.05}. \tag{9.36}$$

The null hypothesis is rejected at the 5% significance level.

Figure 9.10 shows the different change of the average tax rates between more-open and less-open countries, grouped by capital market openness. The results of estimation are

$$\tau_{1t} = 0.528 - \underset{(0.000219)}{0.00432}\, t, \;\; R^2 = 0.913, DW = 0.857 \tag{9.37}$$

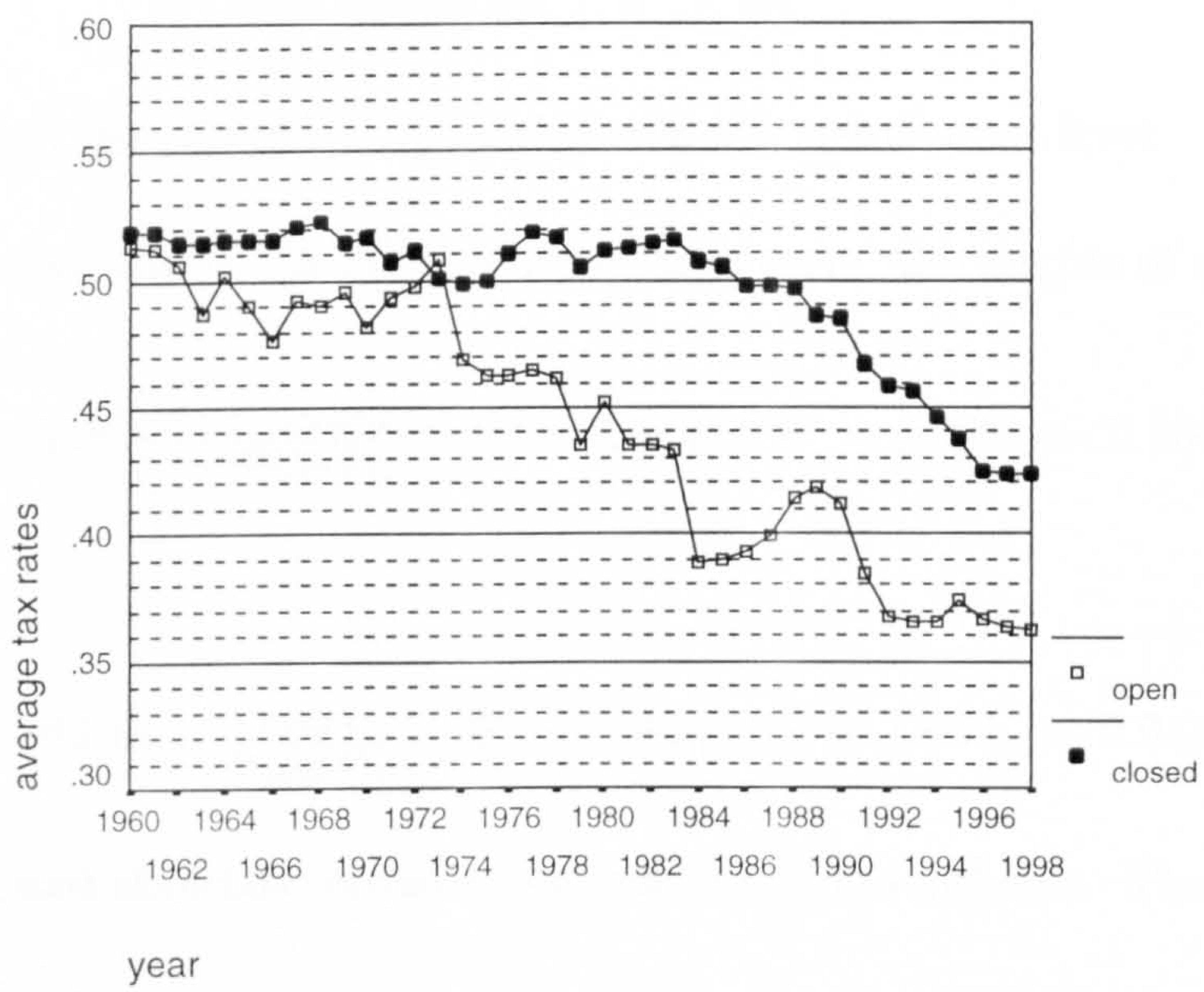

Figure 9.10: Average tax rates, grouped by capital market openness

and

$$\tau_{2t} = 0.538 - \underset{(0.000248)}{0.00212}\, t, \;\; R^2 = 0.663, DW = 0.129, \tag{9.38}$$

where the estimated standard errors are given in the parentheses. The test statistic is

$$z = -6.65 < -z_{0.05}. \tag{9.39}$$

Therefore, the null hypothesis is rejected at the 5% significance level.

With the assumption of the AR(1) disturbance term, the results of estimation are

$$\tau_{1t} = 0.526 - \underset{(0.000384)}{0.00426}\, t, \;\; R^2 = 0.774, DW = 1.925, \hat{\rho} = 0.568 \tag{9.40}$$

and

$$\tau_{2t} = 0.533 - \underset{(0.000685)}{0.00245}\, t, \;\; R^2 = 0.262, DW = 1.698, \hat{\rho} = 0.948, \tag{9.41}$$

where the estimated standard errors are given in the parentheses. The test statistic is

$$z = -2.30 < -z_{0.05}. \tag{9.42}$$

The null hypothesis is still rejected with the 5% significance level.

The above tests use only the average tax rates of the two groups. A more informative test is to run a single regression using tax rates of all countries with dummy variables. The residual is assumed to follow an AR(1) process with different value of ρ across countries and to have countrywise heteroscedasticity. The regression model is

$$\tau_{it} = \alpha_0 + \alpha_1 D_{it} + \beta_0 t + \beta_1 D_{it} t + u_{it}, \tag{9.43}$$

where dummy variable $D_{it} = 0$ for less-open countries and $D_{it} = 1$ for more-open countries[23] and $u_{it} = \rho_i u_{it-1} + \varepsilon_{it}$. The null and the alternative hypothesis are

$$H_0 : \beta_1 = 0$$

and

$$H_1 : \beta_1 < 0.$$

The result of estimation[24] is

$$\hat{\tau}_{it} = 0.48611 + 0.037851 D_{it} - 0.0011589t - \underset{(-2.187)}{0.0021667}\, D_{it} t,$$

where $z-$value is given in the parenthesis. The null hypothesis is rejected at the 5% significance level.

We can make three different assumptions on the covariance and the autocorrelation of the disturbance term respectively. This makes nine sets of results. S_0, S_1 and S_2 denote 'No correlation', 'Countrywise heteroscedasticity' and 'Cross country correlation and countrywise heteroscedasticity'. R_0, R_1 and R_2 denote 'No autocorrelation', 'AR(1) with the same ρ' and 'AR(1) with different ρ_i across countries'. The estimate of β_1 and its z-value for each model are provided in Table 9.7.

Only when the model is specified with 'Countrywise heteroscedasticity' and 'AR(1) with the same ρ', is the null hypothesis not rejected. If we relax the assumption that

[23]The market openness is used for grouping.

[24]LIMDEP produces two-step GLS estimates.

Model	estimates of β_1	z-value
$S_0 - R_0$	-0.31383E^{-2}	-4.886
$S_1 - R_0$	-0.23935E^{-2}	-5.564
$S_2 - R_0$	-0.23929E^{-2}	-34.191
$S_0 - R_1$	-0.23678E^{-2}	-1.705
$S_1 - R_1$	-0.10160E^{-2}	-1.058
$S_2 - R_1$	-0.98259E^{-3}	-1.883
$S_0 - R_2$	-0.27944E^{-2}	-2.215
$S_1 - R_2$	-0.21667E^{-2}	-2.187
$S_2 - R_2$	-0.22984E^{-2}	-3.572

Table 9.7: Estimates of coefficient of slope dummy variable (1)

the countries within the same group have the same intercept by adopting a new assumption that each country has a different intercept, the z-value of the estimates of β_1 with the same assumption on the disturbance term becomes -3.470.[25]

9.4.3 Test 3 : Do smaller countries cut tax rates more than larger countries?

According to GDP, 24 OECD countries are divided as follows. (1) Larger countries : Australia, Canada, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, Switzerland, UK, USA. (2) Smaller countries : Austria, Belgium, Denmark, Finland, Greece, Iceland, Ireland, Luxembourg, New Zealand, Norway, Portugal, Turkey.

The average tax rate of smaller countries and larger countries for a specific year, τ_{st} and τ_{lt}, are assumed to be a random sample respectively from the population with mean μ_s and μ_l. $\bar{d}$ and s_d^2 denote the sample mean and the sample variance for the

[25]This is estimated with a fixed effect model by LIMDEP.

differences $(\tau_{st} - \tau_{lt})$. The null and the alternative hypothesis are

$$H_0 : \mu_s - \mu_l = 0 \tag{9.44}$$

and

$$H_1 : \mu_s - \mu_l < 0. \tag{9.45}$$

The decision rule is to reject H_0, if

$$t = \frac{\bar{d}}{\frac{s_d}{\sqrt{n}}} < -t_{n-1,\alpha}, \tag{9.46}$$

where α is the significance level. The test statistic is

$$t = \frac{0.0215}{0.0077} = 2.79 > -t_{38,0.05}. \tag{9.47}$$

The null hypothesis is accepted at the 5% significance level. Therefore, the 'level-comparison test' do not reject the hypothesis that there is no difference in the level of tax rates between smaller countries and larger countries. Rather, the data show that smaller countries have higher tax rates than larger countries on average. Figure 9.11 shows that why the result of the simple mean-comparison contradicts the proposition of tax competition theory. Only since 1985, have smaller countries set their tax rates lower than those of larger countries.

Now, I try to test whether smaller countries on average have cut corporation tax rates more than larger countries. The regression model is

$$\tau_{it} = \alpha_j + \beta_j t + \epsilon_{jt}. \tag{9.48}$$

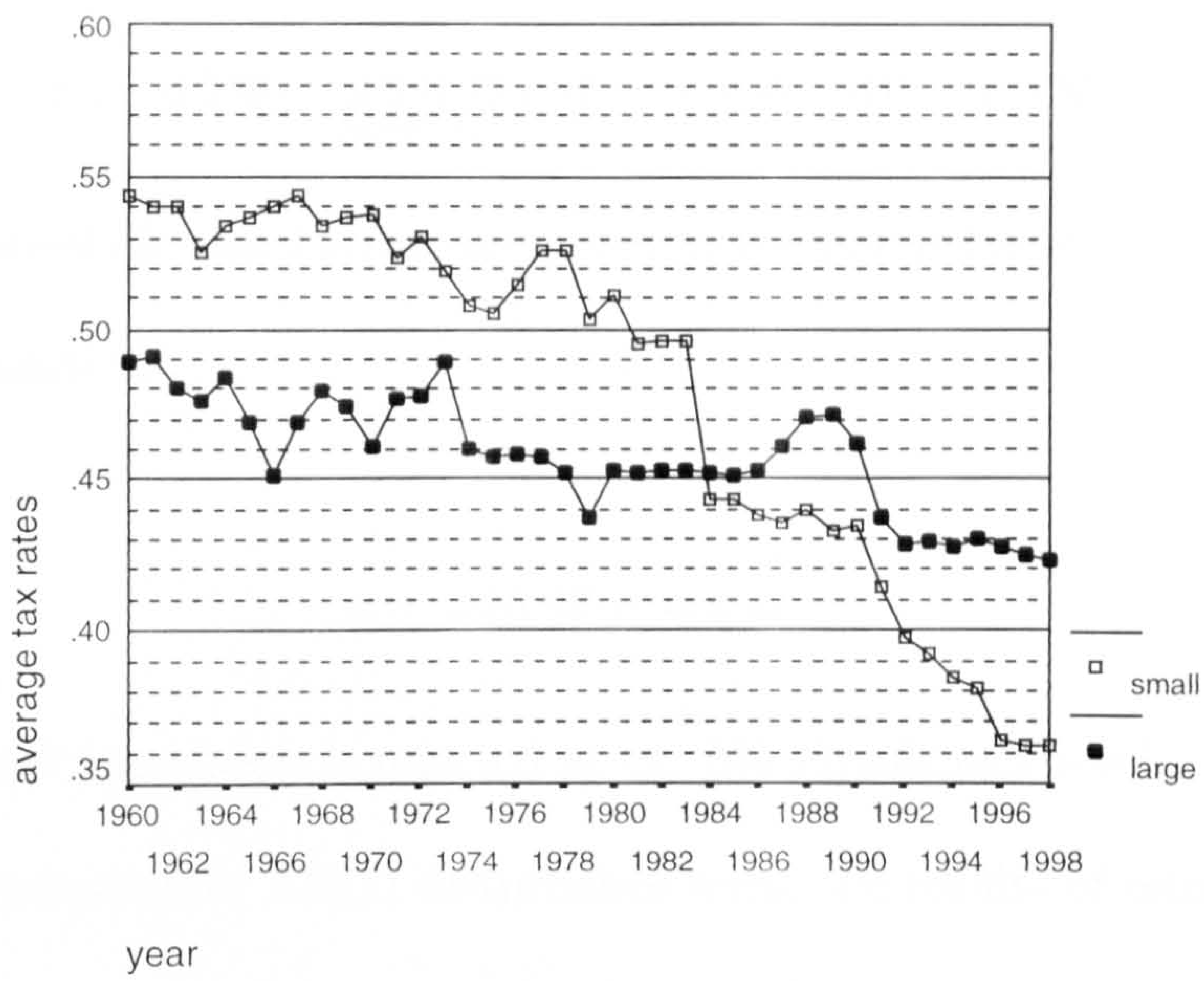

Figure 9.11: Average tax rates, grouped by country size

where $\varepsilon_{jt} \sim iid\ N(0, \sigma_j^2)$ and $j = 1$ for smaller countries and $j = 2$ for larger countries. The null and the alternative hypothesis are

$$H_0 : \beta_1 = \beta_2 \tag{9.49}$$

and

$$H_1 : \beta_1 < \beta_2. \tag{9.50}$$

The results of estimation are

$$\tau_{1t} = 0.580 - \underset{(0.000306)}{0.00505}\, t, \;\; R^2 = 0.880, DW = 0.294 \tag{9.51}$$

and

$$\tau_{2t} = 0.486 - \underset{(0.000162)}{0.00139}\, t \;\; R^2 = 0.666, DW = 0.826, \tag{9.52}$$

where the estimated standard errors are given in the parentheses.

The test statistic is

$$z = -10.57 < -z_{0.05}. \tag{9.53}$$

Therefore, the null hypothesis is rejected at the 5% significance level.

With the assumption of AR(1) disturbance term, the results of estimation are

$$\tau_{1t} = 0.572 - \underset{(0.000723)}{0.00491}\, t, \;\; R^2 = 0.561, DW = 2.048, \hat{\rho} = 0.840 \tag{9.54}$$

and

$$\tau_{2t} = 0.487 - \underset{(0.000288)}{0.00146}\, t, \;\; R^2 = 0.415, DW = 1.735, \hat{\rho} = 0.583, \tag{9.55}$$

where the estimated standard errors are given in the parentheses. The test statistic is

$$z = -4.43 < -z_{0.05}. \tag{9.56}$$

The null hypothesis is rejected at the 5% significance level.

A single regression is run using tax rates of all countries with dummy variables. The disturbance term is assumed to follow an AR(1) process with different value of ρ across countries and to have countrywise heteroscedasticity. The regression model is

$$\tau_{it} = \alpha_0 + \alpha_1 D_{it} + \beta_0 t + \beta_1 D_{it} t + u_{it}, \tag{9.57}$$

Model	etimates of β_1	z-value
$S_0 - R_0$	-0.36603E^{-2}	-5.750
$S_1 - R_0$	-0.20758E^{-2}	-4.620
$S_2 - R_0$	-0.20975E^{-2}	-26.931
$S_0 - R_1$	-0.31870E^{-2}	-2.192
$S_1 - R_1$	-0.32604E^{-2}	-3.203
$S_2 - R_1$	-0.33956E^{-3}	-6.912
$S_0 - R_2$	-0.21990E^{-2}	-1.684
$S_1 - R_2$	-0.30415E^{-2}	-2.791
$S_2 - R_2$	-0.32758E^{-2}	-5.769

Table 9.8: Estimates of coefficient of slope dummy variable (2)

where the dummy variable $D_{it} = 0$ for larger countries and $D_{it} = 1$ for smaller countries and $u_{it} = \rho_i u_{it-1} + \varepsilon_{it}$. The null and the alternative hypothesis are

$$H_0 : \beta_1 = 0$$

and

$$H_1 : \beta_1 < 0.$$

The result of estimation[26] is

$$\hat{r}_{it} = 0.47668 + 0.072068 D_{it} - 0.0012040t - \underset{(-2.791)}{0.0030415}\, D_{it}t,$$

where $z-$value is given in the parenthesis. The null hypothesis is rejected at the 5% significance level.

The estimates of $\beta_1$and their z-values for different models are provided in Table 9.8.

[26]LIMDEP produces two-step GLS estimates.

9.4.4 Test 4 : Do countries with a strong preference for public goods cut tax rates more than countries with a weak preference?

According to the total tax revenue divided by GDP between 1965-1995, the grouping is as follows. (1) Strong preference for public goods: Austria, Belgium, Canada, Denmark, Finland, France, Germany, Luxembourg, Netherlands, Norway, Sweden, UK. (2) Weak preference: Australia, Greece, Iceland, Ireland, Italy, Japan, New Zealand, Portugal, Spain, Switzerland, Turkey, USA.

The average tax rate of the countries with a strong and a weak preference for public goods in a specific year, τ_{st} and τ_{wt}, are assumed to be a random sample respectively from the population with mean μ_s and μ_w. $\bar{d}$ and s_d^2 denote the sample mean and the sample variance for the differences $(\tau_{st} - \tau_{wt})$. The null and the alternative hypothesis are

$$H_0 : \mu_s - \mu_w = 0 \tag{9.58}$$

and

$$H_1 : \mu_s - \mu_w > 0. \tag{9.59}$$

The decision rule is to reject H_0 if

$$t = \frac{\bar{d}}{\frac{s_d}{\sqrt{n}}} > t_{n-1,\alpha} \tag{9.60}$$

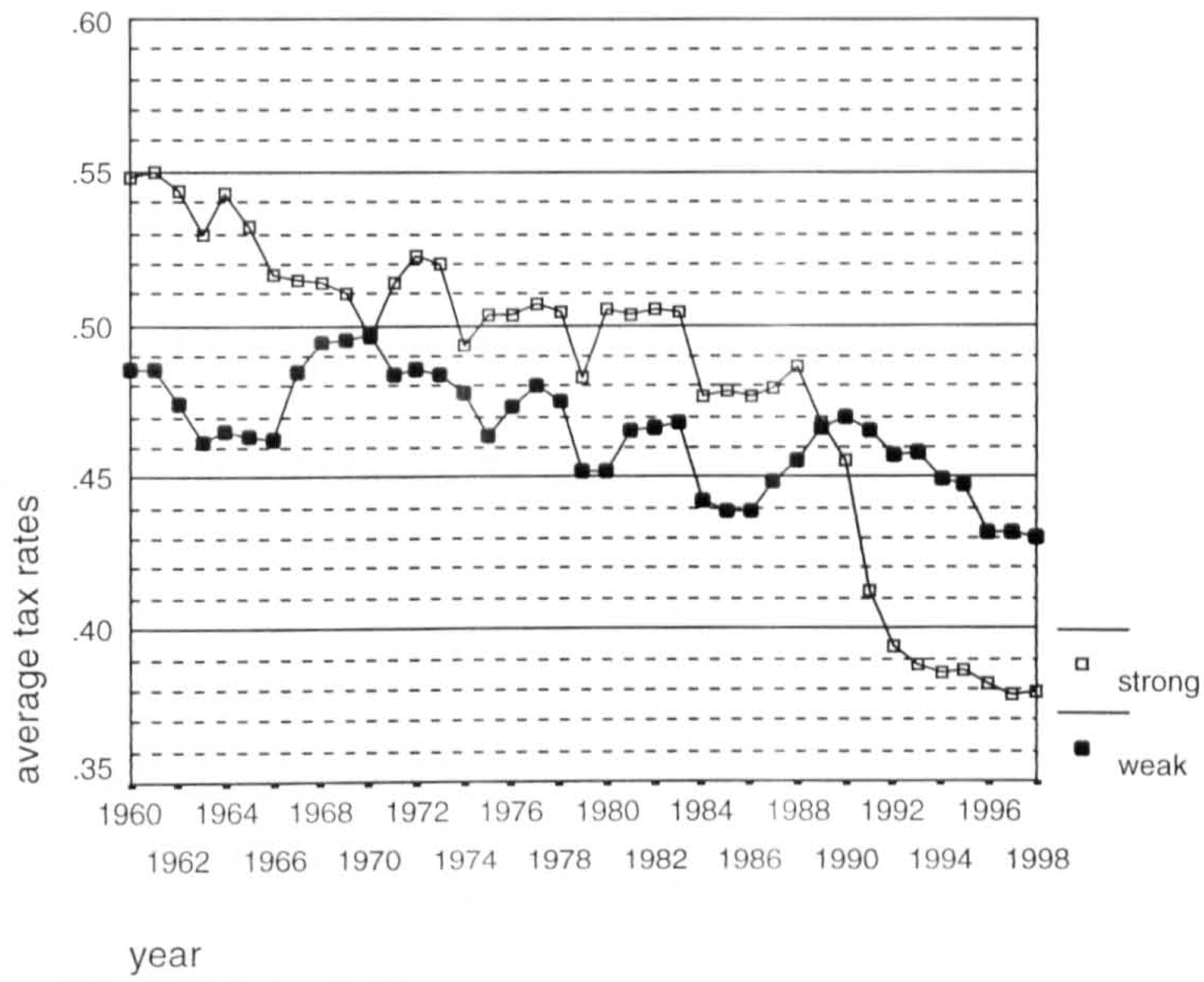

Figure 9.12: Average tax rate, grouped by preference for public goods

where α is the significance level. The test statistic is

$$t = \frac{0.0170}{0.0069} = 2.46 > t_{38,0.05}. \tag{9.61}$$

Therefore, the null hypothesis is rejected at the 5% significance level. However, as argued in chapter 8, this tax differential, by itself, is not relevant test of tax competition theory.

A better test is to see that tax rates of the countries with a strong preference for public goods have decreased more than those of the countries with a weak preference for public goods. The regression model is

$$\tau_{jt} = \alpha_j + \beta_j t + \epsilon_{jt}, \tag{9.62}$$

where $\varepsilon_{jt} \sim iid\ N(0, \sigma_j^2)$ and $j = 1$ for the countries with a strong preference for public goods and $j = 2$ for the countries with a weak preference for public goods. The null and the alternative hypothesis are

$$H_0 : \beta_1 = \beta_2 \tag{9.63}$$

and

$$H_1 : \beta_1 < \beta_2. \tag{9.64}$$

The results of estimation are

$$\tau_{1t} = 0.565 - \underset{(0.000332)}{0.00418}\, t,\ R^2 = 0.839,\ DW = 0.601 \tag{9.65}$$

and

$$\tau_{2t} = 0.488 - \underset{(0.000183)}{0.00114}\, t,\ R^2 = 0.863,\ DW = 0.388, \tag{9.66}$$

where the estimated standard errors are given in the parentheses. The test statistic is

$$z = -8.02 < -z_{0.05}. \tag{9.67}$$

Therefore, the null hypothesis is rejected at the 5% significance level.

The results of estimation with AR(1) disturbance term are

$$\tau_{1t} = 0.564 - \underset{(0.000799)}{0.00432}\, t,\ R^2 = 0.448, DW = 1.839, \hat{\rho} = 0.844 \tag{9.68}$$

and

$$\tau_{2t} = 0.489 - \underset{(0.000377)}{0.00124}\, t, \ R^2 = 0.230, DW = 1.467, \hat{\rho} = 0.714, \tag{9.69}$$

where the estimated standard errors are given in the parentheses. The test statistic is

$$z = -3.49 < -z_{0.05}. \tag{9.70}$$

The null hypothesis is rejected at the 5% significance level.

A single regression is run using tax rates of all countries with dummy variables. The regression model is

$$\tau_{it} = \alpha_0 + \alpha_1 D_{it} + \beta_0 t + \beta_1 D_{it} t + u_{it}, \tag{9.71}$$

where dummy variable $D_{it} = 0$ for the countries with a weak preference for public goods and $D_{it} = 1$ for the countries with a strong preference for public goods and $u_{it} = \rho_i u_{it-1} + \varepsilon_{it}$. The null and the alternative hypothesis are

$$H_0 : \beta_1 = 0$$

and

$$H_1 : \beta_1 < 0.$$

The result of estimation[27] is

$$\hat{\tau}_{it} = 0.47818 + 0.068074 D_{it} - 0.00095357t - \underset{(-2.902)}{0.0028535}\, D_{it} t,$$

[27] LIMDEP produces two-step GLS estimates.

Model	etimates of β_1	z-value
$S_0 - R_0$	-0.19098E^{-2}	-2.970
$S_1 - R_0$	-0.29078E^{-2}	-6.776
$S_2 - R_0$	-0.29012E^{-2}	-49.762
$S_0 - R_1$	-0.22654E^{-2}	-1.629
$S_1 - R_1$	-0.32038E^{-2}	-3.349
$S_2 - R_1$	-0.26804E^{-3}	-5.653
$S_0 - R_2$	-0.18051E^{-2}	-1.426
$S_1 - R_2$	-0.288535E^{-2}	-2.902
$S_2 - R_2$	-0.244910E^{-2}	-4.624

Table 9.9: Estimates of coefficient of slope dummy variable (3)

where $z-$value is given in the parenthesis. The null hypothesis is rejected at the 5% significance level. The estimate of β_1 and its z-value for different models are provided in Table 9.9.

One of the findings in Chennells and Griffith (1997) is a convergence of corporation tax rates between countries over 1979-1994. In contrast, Grubert (1999) reports that there was no notable convergence in tax rates between 1984-1992.[28] Can the convergence itself be evidence of tax competition? As far as the preference for public goods is concerned, it is interpreted as evidence for tax competition. The higher-tax country (the country with a strong preference for public goods) tends to decrease tax rate more than the lower-tax country (the country with a weak preference for public goods). However, when the differences of country size are considered, tax rates tend to diverge. The smaller country tends to decrease tax rate more than the larger

[28]The test result of the convergence depends on which tax rates are measured and used. Chennells and Griffith (1997) find a strong convergence with the marginal effective tax rates but fail to find with the average effective tax rates. In contrast, Grubert (1999) uses the average effective tax rates for the large multinational companies of the USA.

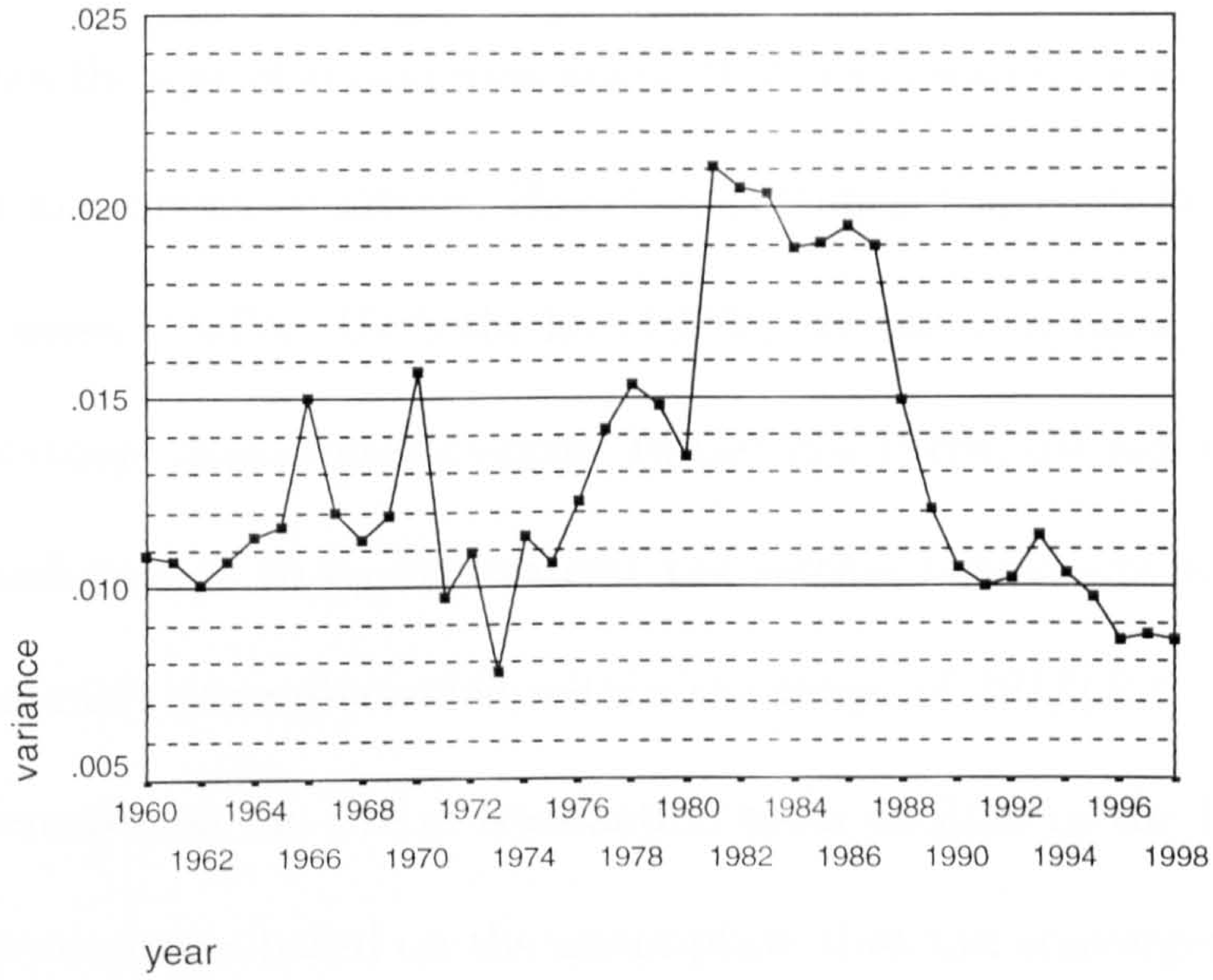

Figure 9.13: Variation of tax rates among OECD countries, 1960-1998

country although their tax rates are the same without tax competition.

Figure 9.13 shows the change in the variance of tax rates of OECD countries. It does not seem to be a clear sign for a consistent convergence. The variation of tax rates was relatively large in the 1980s and it has been reduced in the 1990s. With the data used in this thesis, a convergence of tax rates is shown between 1979-1994 as Chennells and Griffith (1997) have found. How can we explain the phenomenon of increased variation in the late 1970s and 1980s and its decline in the 1990s?

One hypothetical explanation can be drawn from the analysis presented in chapter 7. When the size of transaction costs of the international movement of capital is large, tax competition does not occur. As the size of transaction costs becomes smaller than certain critical level, countries randomize their tax rates within the range of $2\theta/f(K)'$, where θ represents the size of transaction costs. This randomization will increase the variation of tax rates among countries. However, as transaction costs become smaller, the variation becomes smaller. Until the late 1970s, the size of transactions costs was so large that tax competition did not occur. In the late 1970s, the size of transaction costs became small enough to ignite strategic tax setting behaviours of governments and therefore tax rates were diversified within the range of $2\theta/f(K)'$. However, the variation has decreased as the size of transaction costs declines in the 1990s.[29]

The above discussion is based on the assumption that tax convergence is derived solely by tax reforms[30] and the tax reforms are motivated by the pressure from tax competition. When we detect convergence in tax rates, the next step must be to investigate how much of the convergence is derived from tax reforms solely motivated by tax competition.

9.5 Overall test of tax competition theory

The previous tests have two drawbacks. The first is that the results of previous tests do not tell us about the overall effect of tax competition. The effects of the

[29] I must be cautious in making this statement because this is based solely on the model presented in chapter 7, not on the comprehensive results of tax competition theory. The other explanation is that the unemployment rates are significant in deciding the level of corporation tax rates and were diversified greatly among countries in the late 1970s and 1980s.

[30] Devereux (1995) stresses that much of the convergence in the European Community over 1980-1991 can be traced to economic ones, such as convergence of inflation rates and interest rates, rather than tax reform. This argument is relevant when the METR is measured using actual inflation rates and interest rates of each countries. His argument is not applied to the MECTR of this thesis because it is computed using the same economic values across countries.

openness of a country, the size and its preference for public goods need to be taken into account together. The other is that they do not consider explicitly the effects of factors other than those suggested by tax competition theory. Here, I will analyse whether tax competition theory is significant in explaining differences in the levels of corporate tax rates among countries. For this purpose, multiple regression analysis is applied.

The first step is to identify the factors which have influences on the level of corporation tax rates. This task is difficult in that there are many socio-political factors which may affect the level of corporation tax rates and that the degree of their effects are different across countries. I have not found literature which is suggestive in identifying these factors. What can these explanatory variables be?

Firstly, corporation tax rate has been thought to be related with decision on investment.[31] Therefore, it might be recognized as an tool through which to boost investment. The level of tax rates is expected to be negatively related to the unemployment rate. In other words, governments with high unemployment rates are more likely to decrease their corporate tax rates to encourage investment in the corporate sector and thus to create employment. Secondly, the level of corporate tax rate is likely to be higher when the overall tax revenue, proportional to GDP, is

[31] Musgrave and Musgrave (1984) suggest that "the corporation tax may be used to provide incentives or disincentives to investment, as distinct from corporate savings. Divices like the investment credit or accelerated depreciation may be used for this purpose and they may be applied on a cyclical or a secular basis (p390)." They also suggest that corporation tax has an effect on investment because "investment is expressed as a function of the expected net rate of return. .... investment is taken to be a function of the availability of internal funds including after tax profits and depreciation charges (p663)."

larger, assuming that corporation tax produces constant share of total revenue across countries. Therefore, in our econometric model, the non-tax competition explanatory variables are the total tax revenue as a fraction of GDP ($TREV$) and unemployment rate($UNEMPLOY$).[32]

As for tax competition variables, the openness and the size of country are used. The openness is measured either by the openness of product market ($OPEN1$) or by the openness of capital market ($OPEN2$), and the size of a country is measured either by GDP(GDP) or by population (POP). Because the relative size is relevant, the size is measured either by $\ln GDP$ or by $\ln POP$.

The regression model is

$$\tau_{it} = \alpha_t + X_{it}\beta_t + \varepsilon_{it}, \quad \varepsilon_{it} \sim iid\ N(0, \sigma_t^2), \tag{9.72}$$

where

$$\beta_t' = [\beta_{1t}\beta_{2t}\beta_{3t}\beta_{4t}]' \tag{9.73}$$

and

$$X_{it} = [TREV_{it}\ UNEMPLOY_{it}\ OPEN1_{it}\ \ln GDP_{it}]. \tag{9.74}$$

Here, β_{1t} and β_{2t} are expected to be positive. The null and the alternative hypothesis are

$$H_0 : \beta_{3t} = \beta_{4t} = 0 \tag{9.75}$$

[32]The natural unemployment rate differs across OECD countries. For example, 7% of unemployment rate may be thought to be high for UK government but to be low for Spanish governemnt. In this context, the differnece between actual unempolyment rate and the nutual unemployment rate might be more appropriate in my regression. This, however, brings about another controversial problem. What is the natural unemployment rate for each country?

and

$$H_1 : \beta_{3t} > 0 \text{ or } \beta_{4t} > 0. \tag{9.76}$$

The results of estimation are provided in Table 9.10 and Table 9.11. The values in the parentheses are *p-values*.[33] The $F-$test statistics are computed by

$$F = \frac{(RSS_R - RSS_U)/(m-k)}{RSS_U/(n-m-1)}, \tag{9.77}$$

where RSS_R is the sum of the squares of the residual of estimation run without $OPEN1$ and $lnGDP$ as explanatory variables and RSS_U is the sum of the squares of the residual of estimation run with all four explanatory variables. Here, n is 24, m is 4 and k is 2.

Considering $F_{2,19,0.05} = 3.51$, $OPEN$ and $lnGDP$ have explanatory power jointly in 1965, 1966[34] and between 1988-1995. However, the sign of $lnGDP$ is the opposite of what might be predicted by tax competition theory. The reason for the negative estimates for the coefficient of $lnGDP$ is the high correlation coefficient between $OPEN1$ and $lnGDP$, around -0.60. The partial correlation coefficient between tax rate and $lnGDP$ has been positive since 1984.

The estimates of the coefficient of $TREV$ is significant in 1965 and 1966 at the 5% significance level. For other years, it is positive, except 1991 and 1992, but is not significantly different from zero. This result is consistent with the prediction of tax competition theory. During the early period, the corporation tax rates are more

[33] $P - value$ means the smallest significance level at which a null hypothesis can be rejected.

[34] This is not expected and I do not carry out further analysis with this result.

year	$TREV$	$UNEMP$	$OPEN1$	$lnGDP$	F-statistic
1965	1.074 (0.012)	−0.287 (0.797)	−0.212 (0.042)	−0.04171 (0.027)	4.229
1966	0.929 (0.039)	−0.144 (0.912)	−0.217 (0.089)	−0.04763 (0.032)	3.738
1967	0.667 (0.109)	−0.532 (0.658)	−0.183 (0.132)	−0.03900 (0.055)	2.896
1968	0.318 (0.410)	−0.788 (0.506)	−0.133 (0.279)	−0.02550 (0.203)	1.238
1969	0.335 (0.401)	−1.085 (0.364)	−0.139 (0.261)	−0.02977 (0.157)	1.549
1970	0.002 (0.996)	−1.373 (0.409)	−0.062 (0.632)	−0.02413 (0.308)	0.807
1971	0.206 (0.516)	−2.086 (0.088)	−0.090 (0.317)	−0.01372 (0.412)	0.747
1972	0.306 (0.475)	−1.643 (0.200)	−0.078 (0.456)	−0.01321 (0.475)	0.438
1973	0.364 (0.222)	−1.459 (0.189)	−0.096 (0.259)	−0.01309 (0.389)	0.922
1974	0.249 (0.540)	−2.730 (0.049)	−0.097 (0.268)	−0.01118 (0.528)	0.876
1975	0.234 (0.540)	−1.629 (0.141)	−0.033 (0.760)	−0.0005 (0.981)	0.064
1976	0.201 (0.617)	−1.228 (0.228)	−0.055 (0.636)	−0.00755 (0.712)	0.157
1977	0.248 (0.575)	−0.669 (0.493)	−0.078 (0.545)	−0.01510 (0.501)	0.348
1978	0.462 (0.293)	−0.715 (0.458)	−0.153 (0.254)	−0.02593 (0.244)	1.170
1979	0.399 (0.318)	−1.525 (0.126)	−0.155 (0.165)	−0.02609 (0.3214)	1.533
1980	0.265 (0.482)	−2.161 (0.012)	−0.112 (0.279)	−0.00999 (0.593)	0.938
1981	0.547 (0.206)	−2.482 (0.003)	−0.174 (0.152)	−0.00722 (0.735)	2.047
1982	0.417 (0.337)	−2.455 (0.001)	−0.112 (0.342)	−0.00453 (0.828)	1.604
1983	0.373 (0.340)	−2.407 (0.000)	−0.128 (0.262)	−0.00081 (0.967)	1.665
1984	0.413 (0.794)	−1.744 (0.004)	−0.121 (0.243)	0.005284 (0.794)	2.464
1985	0.383 (0.306)	−1.656 (0.004)	−0.101 (0.312)	0.006318 (0.757)	2.132
1986	0.226 (0.534)	−1.692 (0.003)	−0.086 (0.401)	0.01083 (0.599)	1.913
1987	0.156 (0.655)	−1.641 (0.005)	−0.093 (0.362)	0.01047 (0.617)	2.183
1988	0.318 (0.271)	−1.622 (0.002)	−0.108 (0.167)	0.008718 (0.596)	3.819
1989	0.397 (0.143)	−1.367 (0.006)	−0.145 (0.034)	−0.00286 (0.842)	5.129

Table 9.10: Results of multiple regression (1)

year	$TREV$	$UNEMP$	$OPEN$	$lnGDP$	F-statistic
1990	0.380 (0.146)	−1.347 (0.008)	−0.165 (0.014)	−0.00748 (0.585)	6.248
1991	−0.128 (0.619)	−1.317 (0.008)	−0.114 (0.081)	0.00098 (0.949)	3.519
1992	−0.089 (0.716)	−1.377 (0.002)	−0.156 (0.018)	0.00048 (0.699)	5.982
1993	0.101 (0.662)	−1.418 (0.000)	−0.190 (0.006)	0.00592 (0.622)	8.794
1994	0.124 (0.602)	−1.155 (0.002)	−0.172 (0.013)	−0.198 (0.626)	7.136
1995	0.234 (0.350)	−0.969 (0.013)	−0.178 (0.009)	−0.201 (0.640)	7.957

Table 9.11: Results of multiple regression (2)

closely related to the preference for public goods in such a way that countries with a strong preference for public goods set their tax rates higher than those countries with a weak preference. However, as tax competition occurs, the relationship between the preference for public goods and tax rates becomes weak.

Throughout the period, the coefficient of $UNEMPLOY$ is consistently negative, implying that countries with higher unemployment rates set their tax rates lower than those with lower unemployment rates. However, it is only since 1980 that the relationship between them has been significantly different from zero at the 5% significance level.

Throughout the period, the coefficient of $OPEN1$ is consistently negative, suggesting that more-open countries set their tax rates lower than less-open countries. However, it is only since 1989 that the relationship between them has been significantly different from zero at the 5% significance level. If we ignore the fact that it is significantly different from zero in 1965, the result can be interpreted in such a way that international capital mobility is high enough to cause tax competition between countries in recent years.

The estimates of coefficient of $lnGDP$ are problematic. The negative coefficient implies that smaller countries set their tax rates higher than those of larger countries. This is the opposite of the prediction of tax competition theory. This may be caused by higher negative sample correlation coefficient between $\ln GDP$ and $OPEN1$.

We therefore use an alternative set of explanatory variables. The size of a country is measured by their population and its openness is measured by the sum of the inflow and outflow of direct investment divided by GDP. When the degree of openness is measured by the openness of capital market, there are two problems. Firstly, because the amount of capital flow is highly volatile with annual data, annual data cannot be a good proxy variable for the degree of the openness of capital market. A new variable is created by the moving average method such that

$$OP\bar{E}N2_t = \frac{OPEN2_{t-2} + OPEN2_{t-1} + OPEN2_t + OPEN2_{t+1} + OPEN2_{t+2}}{5}. \tag{9.78}$$

Secondly, the data on inflow and outflow of direct capital for all 24 countries are available only for recent years.

The estimated results are presented in Table 9.12. For the lack of the data for several countries, the estimation is carried out only for 1986–1994. All signs of coefficients are as expected except that the estimated coefficient of $TREV$ is negative in 1991 and 1992. But they are not significantly different from zero. The joint explana-

year	$TREV$	$UNEMP$	$OP\bar{E}N2$	$lnPOP$	F-statistic
1986	0.229 (0.446)	−1.896 (0.001)	−0.002319 (0.139)	0.02579 (0.127)	2.48
1987	0.219 (0.481)	−1.900 (0.002)	−0.001978 (0.152)	0.02549 (0.132)	2.32
1988	0.362 (0.195)	−1.909 (0.001)	−0.001372 (0.197)	0.02801 (0.053)	2.93
1989	0.349 (0.240	−1.586 (0.005)	−0.001046 (0.307)	0.02000 (0.147	1.69
1990	0.283 (0.327	−1.422 (0.014)	−0.001159 (0.220)	0.01501 (0.255)	1.63
1991	−0.187 (0.489)	−1.288 (0.014)	−0.0008142 (0.350)	0.01359 (0.267)	1.35
1992	−0.119 (0.649	−1.275 (0.007)	−0.001586 (0.092)	0.01207 (0.294)	2.75
1993	0.089 (0.723)	−1.354 (0.001)	−0.001983 (0.036)	0.01458 (0.185)	4.38
1994	0.166 (0.513)	−1.184 (0.003)	−0.002104 (0.028)	0.01272 (0.255)	4.28

Table 9.12: Results of multiple regression (3)

tory power of the tax competition variables, $OP\bar{E}N2$ and $lnPOP$, was significant in 1993 and 1994.

Two points are worthy of mention. Firstly, the estimated coefficient for each year is not stable throughout the period. This suggests that an econometric estimation with pooled data may be misleading. If the data for recent years are pooled with those for early years and then are used for the estimation of a single equation, the estimates of the coefficients of tax competition variables are not likely to be significant in explaining tax differences among countries. Secondly, in spite of theoretical emphasis on the effect of the size of country on the tax difference, the size of a country has little marginal explanatory power in explaining tax difference among countries if the effect of the openness is excluded.

It should be stressed that the analysis in this section is an exploratory consideration of the data, which does not make use of the benefits of panel data techniques. It would be possible to regress tax rates with respect to the explanatory variables, with either time or country dummy capturing movements over time or unobserved country effects respectively. There are, however, three reasons why panel data analysis was not carried out within this thesis. Firstly, the two non-tax competition explanatory variable - unemployment rate and tax revenue proportionl to GDP - are merely examples taken from a range of possible candidates. Further consideration therefore needs to given to choosing explanatory variables which may have effects on the level of tax rates across different countries and throughout the period under study.[35] Secondly, the relationship between tax rates and these explaatory variables are far from being simple 'direction of causation'. Indeed, a completely reverse causation is possible. Tax rates might influence unemployment rates, the relative size of the government sector and the degree of openness. Lower corporation tax rates can boost capital investment which often creates more jobs, reduces tax revenue and increases the amount of international direct investment. These mutual causation requires a structural form.econometric model instead of reduced form which was used in this section. Lastly, we cannot include both time and country dummies because we have one single observation with correspondng combinations of these two dummies. Therefore, we are forced to decide which dummy variable is to be used. The decision

[35]The characteristic of political regimes in power, the dominent ideologies of countries, the degree of incorporation, and the effectiveness of lobbying by corporations are some of these possible explanatory variables.

depends on the aim of the regression analysis and the properties of the data. For example, if the aim of the regression is to investigate tax differentials across countries, the time dummy should be used. However, if the aim is to investigate changes in tax rates throughout the period under consideration, the country dummy should be used. These three issues must be addressed before panel data analysis can be successfully carried out.

9.6 Concluding remarks

The data shows a decreasing trend in corporation tax rates on average across OECD countries. The result is robust in that various statistical models for estimation detect a decline in corporation tax rates. However, it is noteworthy that the degree of decrease in tax rates differ across countries. Five countries have experienced an increase in tax rates.

The 'level-comparison test' produces inconsistent results. When countries are grouped according to product market openness, more-open countries are found not to have significantly lower tax rates than less-open countries. In contrary, when countries are grouped according to capital market openness, more-open countries are found to have significantly lower tax rates than less-open countries. When countries are grouped according to their GDP, larger countries are found to have lower tax rates than smaller countries, which contradicts the prediction of tax competition theory.

Alternatively, the 'change-comparison test' produces consistent results. More-open countries, smaller countries and countries with a strong preference for public goods have decreased corporation tax rates respectively more than less-open countries, larger countries and countries with a weak preference for public goods.

Lastly, an econometric model is set up to consider explicitly other factors which may have an effect on corporate tax rates and to see the effect of the openness and the size of country. The results of estimation show that the explanatory variables of tax competition theory have significant joint power in explaining tax differences among countries only for recent years, 1988-1995. However, the marginal explanatory power of the size of country is negligible throughout the period if the effect of the openness of the country is excluded.

Two caveats need to be made. The first is the robustness of the tests. The result of the unit root test suggests that 'difference-stationary process' is more appropriate than 'trend-stationary process' in fitting the data. When the data is fitted to a 'difference-stationary process', the null hypothesis of no decline in corporate tax rates is rejected by a narrow margin. Therefore, with a 'difference-stationary process', the results of Test (2)-(4) will be reversed. The null hypothesis that there is no difference in degree of tax cutting between groups is not rejected.

The second concerns the problem of 'direction of causation' between tax rates as dependent variable and explanatory variables in (9.72). A completely reverse causation is possible. Tax rates might have influenced unemployment rate, relative size of the government sector and openness. Lower corporation tax rates can boost capital investment which creates more jobs, can reduce tax revenue and can increase the amount of flow of direct investment which result in higher degree of openness. In order to consider these mutual causation, the econometric model in (9.72) as a reduced form should be changed into a structural form.

Is the marginal effective tax rate the only relevant measurement of the level of corporation tax rates in testing validity of tax competition theory? As Devereux (1995) mentions, a simple statutory tax rate is more relevant if tax competition occurs mainly via profit shifting by transfer pricing because tax burden is proportional to nominal tax rates. The other alternative is the average effective corporate tax rate, which is corporate tax revenue divided by profits of corporation sector. This will be better measurement of tax burden when other tax provisions, not included in computing the marginal effective tax rate, are influential on decision of investment location; for example, tax-free reserve in Japan and Sweden; and regional investment incentives in Italy.

Considering the difficulty of getting and interpreting the effective tax rates, the empirical tests may be carried out with the data on the supply of public goods. Tax rate and the level of the supply of public goods are different sides of the same coin. While most theoretical models predict the under-supply of public goods as a whole, Boskin (1973) predicts the under-supply of redistributive public goods and, at the same time, the over-supply of non-distributive goods. Therefore, the analysis of the total amount and composition of the supply of public goods will provide an alternative approach to testing the validity of tax competition theory.

Chapter 10

Summary, conclusion and further exploration

10.1 Summary

The aim of chapter 3 was to set up a model to analyse international tax competition with corporation tax. The model is stylized to show the size of tax cutting caused by tax competition. Two identical countries decide their source-based tax rates simultaneously and, with a knowledge of these tax rates, firms decide to locate their capital according to the marginal rate of return net of corporation tax. The equilibrium concept is the Nash equilibrium of a non-cooperative game. The main findings are as follows.

1. The tax rate at the Nash equilibrium is not zero but rather a positive value

below the optimal level. The equilibrium is unique and stable with Cobb-Douglas production and social welfare functions.

2. The results of numerical calibration are presented to indicate the size of tax cutting caused by tax competition. It is shown that the degree of tax cutting depends on two parameters: α, the share of income of capital, and β[1], preference for private goods. Generally speaking, tax cutting ranges from 40-50% of the optimal tax rate.

3. Three extensions are presented by changing the objective functions of governments. Firstly, when governments are assumed to be Leviathan, tax competition is shown to be a desirable pressure to place a limit on the expansion of governments. Tax competition between Leviathan governments leads to either higher or lower tax rates than the socially optimal level. Secondly, when government are concerned to maximise domestic products rather than national products, tax competition is more serious and the tax rate is set at the lower level. Lastly, as more countries become involved in tax competition, tax cutting becomes greater. However, even if an infinite number of countries become involved in tax competition, the tax rate does not drop to zero but rather remains at a positive value.

[1] β can be interpreted as the degree of restriction in increasing tax revenue by other taxes. The higher β, the more easily a country can increase tax revenue by other taxes.

In chapter 4, three asymmetric cases have been analysed and a simple form of tax coordination is suggested. The main findings are as follows.

1. The smaller country undercuts the larger country. Therefore, at the non-cooperative equilibrium, the smaller country attracts capital from the larger country. The latter is worse off due to capital flight and the under-supply of public goods while the former can be better off if the benefit of increased capital outweighs the distortion of the under-supply of public goods. Tax differential creates inefficiency in the allocation of world capital.

2. Tax competition between countries with different per capita capital endowments leads to the same size of tax cutting in both countries. Therefore, at the non-cooperative equilibrium, the tax rates are the same in both countries and a half of world capital is allocated to each country, which is the efficient allocation of world capital. Distortion derives from the under-supply of public goods due to lower tax rates in both countries.

3. The country with a weak preference for public goods undercuts the country with a strong preference for public goods. However, the latter decreases tax rate more than the former. At the non-cooperative equilibrium, the country with a weak preference for public goods attracts capital from the country with a strong preference for public goods. The latter is worse off due to capital flight and the under-supply of public goods while the former can be better off if

the benefit of increased capital outweighs the distortion of the under-supply of public goods. Tax differential creates inefficiency in allocation of world capital.

4. The equal increase in the tax rates of both countries is shown to be a feasible tax coordination in all three asymmetric cases. The smaller country (the country with smaller per capita capital endowment and the country with a weak preference for public goods) always prefers this cooperative equilibrium to the non-cooperative equilibrium because the tax differential at the non-cooperative equilibrium is maintained and thus the amount of capital inflow is the same, while the problem of the under-supply of public goods is lessened. However, the larger country (the country with larger per capita capital endowment and the country with a strong preference for public goods) accepts this coordination only when the positive effect of an increase in public goods outweighs the negative effect of a decrease in income from foreign investment. This is the case with Cobb-Douglas production and social welfare functions.

The aim of chapter 5 was to analyse a case in which tax rules are a strategic variable used by governments as tax rates. The subgame perfect Nash equilibrium is sought by backward induction. The main findings are as follows.

1. When both governments choose tax principles between the residence principle and the source principle, they adopt one of four variations of the residence principle: 'no adjustment', 'deduction', 'credit with limitation' and 'exemption'.

Tax rates under one of these four tax rules are identical to the optimal tax rate and thus there is no distortion from tax competition.

2. When both governments choose the method of double taxation relief, they adopt the credit method or the deduction method. Tax competition does not occur at all.

3. The tax rates in both countries are optimal for each country and worldwide when both countries are free to decide their tax rules and tax rates. International tax coordination (harmonization) is not necessary.

The aim of chapter 6 was to analyse a game where subsidies are manipulated to attract foreign capital along with tax rates. The subgame perfect Nash equilibrium is sought in a dynamic game in which both countries decide their tax rates in the first stage and amounts of subsidies at the next stage. The main findings are as follows.

1. Universal subsidies have the same effect on capital movement as tax cutting. However, preferential subsidies can attract foreign capital but this always causes a cross-hauling of capital.

2. Under the exemption method (a source-based tax), the availability of subsidy does not change the level of the effective tax rate. Universal subsidies are used along with tax cutting while preferential subsidies are not.

3. Even under the credit method (a residence-based tax), both governments set

their tax rate strategically due to the subsequent subsidy competition. Availability of subsidies in attracting foreign capital, both preferential and universal subsidies, leads to lower effective tax rates.

4. If subsidies can be used by governments, tax coordinations (tax harmonization and the imposition of minimum tax rate) lead to higher tax rates and larger subsidies, failing to increase efficiency in world capital allocation and to alleviate the distortion from the under-supply of public goods.

The aim of chapter 7 was to establish how the imperfection in capital mobility affects the existence of an equilibrium and the level of tax rate under tax competition. The main findings are as follows.

1. With a symmetric two countries model, the pure strategy Nash equilibrium no longer exists. Both countries may randomize their tax rates over those lower than the optimal level. The tax rates of identical countries may differ from each other due to randomization. As transaction costs decrease, the level of tax rates and the expected tax differential also decrease.

2. With a small-open economy model, it is found that the small economy always sets its tax rate lower than the world tax rate. Tax cutting becomes larger as transaction costs become smaller.

The aim of chapter 8 was to define testable proposition which are based on theoretical analyses. The testable propositions are as follows.

1. As the degree of international mobility of capital increases, corporate tax rates decrease. As long as alternative taxes can be used only with limitations in financing supply of public goods, tax rates do not drop to zero.

2. As the number of countries involved in the international capital market increases, corporation tax rates decrease. Even if an infinite number of countries, however, are involved in tax competition, tax rates do not drop to zero.

3. Smaller countries undercut larger countries. If other things are equal between smaller and larger countries, the former should have lower tax rates than those of the latter under the pressure of tax competition. When other things are not equal, the former should decrease tax rates more than the latter.

4. The countries with a weak preference for public goods undercut the countries with a strong preference. However, this tax differential turns up even under either myopic or *status quo* tax setting behaviour other than tax competition. Under the pressure of tax competition, the countries with a strong preference for public goods should cut their tax rates more than the countries with a weak preference.

The last chapter of this thesis presented the results of empirical tests. Five main propositions were tested against the marginal effective corporate tax rates (MECTRs) of 24 OECD member countries between 1960-1998, which are computed by the method suggested by King and Fullerton (1984). The main results of the tests are as follows.

1. The average corporation tax rates of 24 OECD countries dropped from 54% in 1960 to 37% in 1998. While 19 countries experienced a decrease, 5 countries experienced an increase of tax rates. However, the data, as a whole, support that corporation tax rates has decreased.

2. The 'level-comparison test' produces inconsistent results. When countries are divided by product market openness, the difference of sample mean between more-open countries and less-open countries is not significantly different from zero. In contrast, when capital market openness is used in grouping, more-open countries set their tax rates significantly lower than those of less-open countries. Moreover, smaller countries set their tax rates higher than those of larger countries on average. This contradicts the proposition of tax competition theory.

3. The 'change-comparison test' produces consistent results which support the propositions of tax competition theory. More-open countries (regardless of the criterion of grouping), smaller countries and countries with a strong preference for public goods have cut their tax rates more than less-open countries, larger countries and countries with a weak preference. The differences between groups are found to be significant.

4. By regressing the marginal effective tax rates with respect to 'non-tax competition' variables (unemployment rate and the total tax revenue proportional to

GDP) and 'tax competition' variables (the openness and the size of a country), it is shown that tax competition theory is significant in explaining the difference of tax rates among countries only for recent years.

10.2 Conclusion

The aim of this thesis was specified in three ways at the beginning of the thesis: to suggest not only the direction but also the magnitude of effect of tax competition, to analyse tax competition in a more international context and to investigate the validity of tax competition theory with empirical data. Among many taxes which are vulnerable to tax competition, corporation tax is analysed in this thesis.

For the first objective, the model is stylised to identify the magnitude of the effect of tax competition in terms of the size of tax cutting. Numerical calibration exercises are used for this purpose. In symmetric cases, countries decrease their tax rate around 40-50% below the optimal tax rates. In asymmetric cases, not only the level of tax rate at the non-cooperative equilibrium but also the size of tax cutting are provided. For example, the size of tax cutting of both the smaller country and the larger country is much greater than tax differential between them at the non-cooperative equilibrium. Furthermore, even if the country with a weak preference for public goods has the higher tax rate than the country with a strong preference at the non-cooperative equilibrium, the latter decreases tax rate to a greater degree than the former.

For the second objective, this thesis analysed asymmetric cases which are more significant across countries than across regions in a federal country. Countries differ in their preference for public goods and in per capita capital endowment. In addition, this thesis analysed tax competition in which governments can use other measures than tax rates under the pressure of tax competition. Those measures are tax rules and subsidies. Tax competition is also analysed in the context of imperfect international capital mobility. These considerations produced various strategic tax setting behaviour which is different from that in the standard model.

For the third objective, the main propositions of tax competition theory are defined as testable forms and then tested against empirical data. This thesis carried out analysis with time-series data, in addition to cross-section data. Consistent evidence in favour of tax competition theory is provided.

The aims of this thesis have, however, been achieved at the cost of generality. My desire to get over the limitations of the 'comparative static analysis' has forced me to adopt a stylised model. The existence of the unique and stable Nash equilibrium, 40–50% tax undercutting below the optimal level at the Nash equilibrium and the level of tax rates in the cases of three asymmetric tax competition cases all depend crucially on my simplifying assumptions. Although the results depend on these assumptions, they are suggestive for the future research.

The analysis is targeted not at '*the capital tax*' but at corporate tax which is relevant to the allocation of real capital. If the analysis is targeted at tax competition for financial capital, some assumptions, such as objective functions, equilibrium condition in the international capital market, tax rules, subsidies and imperfection in capital mobility, must be modelled differently.

The tenor of the analysis presented here is not normative but rather positive. This is because the aim of the thesis is not to establish whether tax competition is a good thing or bad thing. However, most of the public debates on tax competition focus on this issue. One influential economic magazine asserted that "a bit of tax competition in European countries would be beneficial because it would keep down the general level of taxes, which tends to be too high" and that "European countries should embrace tax competition, not try to stifle it".[2]

It seems to me that a balanced judgement for tax competition requires more comprehensive analysis which extends beyond the existing results of tax competition theory. Here, it may be helpful to go back to a classic work in which economic thinking is not elaborate and mathematical but rather broad and comprehensive. Oates (1972) suggests three ways in which welfare can be enhanced through decentralized governments:

> In summary, a decentralized public sector possesses several economically desirable characteristics. First, it provides a means by which the levels of consumption of some public goods can be tailored to the preferences of subsets of the society. In this way, economic efficiency is enhanced by providing an allocation of resources that is more responsive to the tastes of consumers. Second, by providing more increased innovation over time and by providing competitive pressures to include local governments to adopt the most efficient techniques of production, decentralization may increase both static and dynamic efficiency in the production of public goods. Third, a system of local government may

[2]The Economist, Auguet 1st 1998, p19

> provide an institutional setting that promotes better public decision-making by compelling a more explicit recognition of costs of public programs.

The first advantage is ignored implicitly in most literature on tax competition theory because they assume the existence of homogeneous consumers in the economy. This is a mechanism for which Tiebout (1952) admires fiscal federalism. The third advantage is in line with the perspective of Public Choice Theory. The second advantage is rarely investigated[3] because all governments are assumed to be equipped with same level of productivity in the provision of public goods. Theoretical and empirical studies on the relationship between productivity of governments and tax competition are required for comprehensive evaluation of the effects of tax competition.

In predicting the changing role of the state in the future, Tanzi (1997) asserts that globalization will reduce the scope of stabilization and redistributive policies because tax competition is likely to reduce the revenue of governments. It is challenging for public finance economists to investigate whether traditional disciplines of taxation and provision of public goods can operate in the closely integrated world economy. The separation between economic reality and principles of taxation and provision of public goods emerges from the fact that taxation and the provision of public goods are designed and implemented by national sovereignty whilst economic activities, both of firms and consumers, are performed beyond the boundaries of that national sovereignty. Tax competition is one of many problems caused by this separation. Existing research, including my own, takes it for granted that the current discipline

[3] Wilson (1986) analyses the inefficiency in production of public goods by governments.

both of taxation and of the provision of public service will remain unchanged in the future. This issue remains the subject of future research

10.3 Further exploration

The unchanged feature of tax competition models is their assumption that governments decide their tax rates 'only once' and 'at the same time'. This assumption may illuminate the strategic interaction of countries but fails to produce more realistic outcomes. In reality, decision on tax rates is a repeated game. Moreover, some governments may exploit aggressively the incentive to attract foreign capital but others passively respond to the tax cutting of foreign countries. Therefore, tax competition can be modelled with an infinite repeated game or a 'first mover-follower' game.

One of the issues regarding tax competition is whether it leads to convergence of the tax rates across countries. This thesis has suggested that this is not necessarily the case. It has been shown that countries of different sizes have different tax rates under tax competition even if their tax rates are the same without tax competition. Moreover, the convergence of tax rates could be derived either by tax competition or by a convergence in economic variables. This subject requires further theoretical analysis and empirical research.

Given the difficulty of obtaining and interpreting effective tax rates, empirical tests may be carried out on data from the level of supply of public goods. The tax rates and the level of the supply of public goods are different sides of the same coin. While most theoretical models predict the under-supply of public goods as a whole, Boskin (1973) predicts an under-supply of redistributive public goods and, at the same time, the over-supply of non-distributive goods. Therefore, the analysis of the total amount and composition of the supply of public goods will provide an alternative approach for testing the validity of tax competition theory.

The theoretical analysis presented in this thesis has resulted in a number of propositions which have not yet been tested against empirical data. Theses are: (1) Tax competition between countries with different per capita capital endowments (this is equivalent to tax competition between poor and rich countries) leads to the same tax rates at the non-cooperative equilibrium. (2) Subsidies are more likely to be used by the countries which employ the credit method. (3) There is no difference in the effective tax rates of those employing the exemption method and those employing the credit method.

The difficult but significant research agenda for tax competition theory is how tax competition changes the productivity of governments in providing public goods. This research will be informative in establishing whether tax competition among governments works in a positive way as competition in private markets enhances the efficiency of the economy.

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Appendix A

Marginal effective corporate tax rates

A.1 Concept of MECTR

An effective tax rate is better measurement for tax burden on capital income than a statutory tax rate. Many different effective tax rates have been used for different purposes. According to Fullerton (1984), there are three dimensions; marginal or average, tax rate or tax wedge, and corporate level or sum of corporate and personal level. The combination of these three dimensions produces eight different effective tax rates. Economists have long been concerned with allocational inefficiency of capital incurred by capital taxes. The main interest is the disincentives for investments and savings which capital taxes impose. Comparison of tax burden among countries and *ante-* or *ex*-tax reform comparison in certain country are of frequent purposes. More complicated calculation of tax rates are done to see the allocational inefficiency caused by different treatments of capital taxes among industries, assets of investment, methods of finance and investors.

Marginal effective tax rate (METR) is the most frequently used concept for all these purposes. King and Fullerton (1984) have made the concept of METR operational and refined. Their aim is to see differences of tax burdens among different assets, different financing and different investors for the USA, the UK, Sweden and Germany. Jorgenson and Landow (1993) apply the same method to G7 countries, Australia and Sweden. Their additional analysis is to distinguish distortion caused by corporate income tax and personal income tax and analyse different tax burdens between corporate sector and non-corporate sector. OECD (1991) enlarges application of METR by calculating METR for domestic investment and for cross-border investment separately.

Empirical studies on tax competition, Devereax (1995) and Chennells and Griffith (1997), use the same concept of King and Fullerton (1984). However, it is doubtful whether METR of King and Fullerton (1984) can be applied in the context of tax competition. This is because the main interest of tax competition theory is not to analyse the disincentives for saving and investment but to analyse the comparative advantage of countries in attracting capital. I modified the concept of King and Fullerton (1984) mainly in two ways.

Firstly, only corporate taxes are included in computing the METR. When a firm decides between alternative locations for an investment, it is less relevant who provides the capital which it uses. Secondly, the values of all parameters except those of tax system are assumed to be fixed across countries and across periods. We can exclude the effect of non-tax variables by setting them being equal across countries and across period. This also makes the calculation of METR much simpler.

It is important to describe what is the hypothetical investment and how conversion of complicated tax provisions into simple numerical values is carried out because value of MECTRs heavily depends on these two factors. Next section is to make clear the hypothetical marginal investment. Section 3 is to describe technical matters in calculating MECTRs.

A.2 Assumptions of marginal investment

One of the most difficult problems in measuring MECTR is that it may differ greatly from investment project to investment project. Even in a specific economy, it varies greatly according to which industry the investment occurs in, which asset the investment formulates, which source the investment is financed by, which situation firms are in, and how high inflation rate is, etc. One way to get around this difficulty is to assume a hypothetical investment project and measure marginal effective corporate tax rate of the project.

1. **The firm is a large manufacturing company.** The applicable tax rates

depend on the size of firms and source of income of firms in some countries. Almost of half of countries have applied a reduced tax rate for income of small and medium sized companies or for small profits. The corporate income from manufacturing is subject to favourite tax rates in some countries. For example, the income from manufacturing is subject to special tax rate which is 10% instead of the normal tax rate of 40% in Ireland. In Switzerland, the income from manufacturing is subject to 7% of rebaitment.

2. The firm earns large profits from the first year of investment enough to fully utilize capital allowances. It is common for firms to suffer losses in the first few years after investments. For this reason, tax provisions of loss carry-over are one of keen interests of investors. By assuming that firms earn profits from the first year of the investment, we ignore the possibility that tax provisions on the loss carry-over matter. Furthermore, it is assumed that the firms earn profits enough to fully utilize capital allowances. When, firms do not have enough earnings in the first few years, they are allowed to defer capital allowances to later years which are specified in tax provisions. By this assumption, we ignore tax provisions on deferring of capital allowances.

3. The marginal investment consists of 45% of the general machinery, 30% of industrial buildings and 25% of inventories. Composition of assets of the marginal investment matters because capital allowances are different among different assets. King and Fullerton (1984) assume that the marginal investment

Author	Country	Machinery	Buildings	Inventories
King and Fullerton	UK	46.8%	33.2%	20.0%
	USA	22.47%	53.85%	23.68%
	Sweden	32.3%	34.1%	33.6%
	Germany	41.72%	29.75%	28.53%
Chennel and Griffith	All	50%	28%	22%
OECD	UK	53%	24%	23%
	USA	48%	23%	29%
	Sweden	37%	35%	28%
	Germany	38%	34%	28%

Table A.1: Composition of assets used in previous studies

has a composition of assets which is the same in the economy. They use different compositions across countries because their aim is to compare allocational inefficiency which each country's tax system causes on typical domestic saving and investment of each country. Instead, Chennells and Griffith (1997) use the same composition across countries because their interest is to see which country gives favourite tax treatment for a single international investment. Table A.1 gives the compositions which are used in previous studies.

Among the machinery, vehicles are treated differently. Among buildings, commercial buildings are treated less favourably than industrial buildings and residential buildings are treated less favourably than non-residential buildings. We ignore all these complicated tax provisions. Furthermore, we also ignore intangible assets which become significant in modern industries.

4. The opportunity cost of capital is 10% of the nominal interest rate which is a sum of 5% of the real interest rate and 5% of inflation rate. The

Author	Country	Machinery	Buildings	Inventories
King and Fullerton	UK	7.9%	2.5%	0%
	USA	13.31%	3.43%	0%
	Sweden	7.1%	2.6%	0%
	Germany	5.66%	4.56%	0%
Chennel and Griffith	All	12.5%	3.61%	0%
OECD	All	12.3%	3.6%	0%

Table A.2: Economic depreciation rates used in previous studies

opportunity cost depends on the source of capital and is a key element in calculating METRs by King and Fullerton. We assume that capital is owned by firms which decide location of capital. We can think this is the case of retained earnings in King and Fullerton (1984) and, with an assumption of no personal capital income taxes and no capital gains taxes, firms' discount rate is equal to the market interest rate. The other way to define the discount rate is to think the real interest rate as the preference for consumption. If capital is not to be consumed but to be invested, the required yield, which is the discount rate, must be at least sum of consumption preference rate and the inflation rate. The latter interpretation is more related with the model we are explored.

5. The machinery and industrial buildings are depreciated at an exponential rate of 12.5% and 4% respectively. Inventory is not depreciated at all. King and Fullerton (1984) use different economic depreciation rates across countries while Chennells and Griffith (1997) use the same economic depreciation rates. Table A.2 gives economic depreciation rates which are used in previous studies.

A.3 Calculation of MECTRs

A.3.1 General

For computing marginal effective tax rate, I use the methodology suggested by King and Fullerton (1984). The tax wedge, w, is the difference between pre-corporation tax rate of return and post-corporation tax rate of return.

$$w = p - r, \tag{A.1}$$

where r is the real interest rate in the international capital market and p is the minimum rate of return which the investment must yield before paying corporation tax in order to provide at least real rate of return. MECTR is defined to be the tax wedge either divided by the post rate of return or divided by pre-tax rate of return. The formal is a tax-exclusive measurement and the latter is a tax-inclusive measurement. Our MECTRs are defined as the latter.

$$METR_{exclusive} = \frac{w}{r} \tag{A.2}$$

and

$$METR_{inclusive} = \frac{w}{p}. \tag{A.3}$$

Consider an investment project with an initial cost of one unit. Let MRR denote the gross marginal rate of return of the marginal investment. Then,

$$p = MRR - \delta, \tag{A.4}$$

where δ is the real economic depreciation rate, assuming assets are depreciated at a single exponential rate. δ is different from the tax depreciation rate which is specified by tax provisions and generally calculated by the declining balance method (DB method) or the straight line method (SL method).

The present discounted value, PV, of the profits of the marginal investment, net of taxes, is

$$\begin{aligned} PV &= \int_{s=0}^{\infty} (1-t)MRR \cdot e^{(-\rho-\delta+\pi)s} ds \\ &= \frac{(1-t)MRR}{\rho+\delta-\pi}, \end{aligned} \tag{A.5}$$

where ρ is the rate at which firms discount cash flows in nominal terms and π is the inflation rate. The rate at which firms will discount after-tax cash flows is the market interest rate which is the sum of real interest rate, r, and inflation rate, π. Then,

$$\rho = r + \pi. \tag{A.6}$$

If the initial cost of the marginal investment is assumed to be a unit, the present cost of the investment is a unit less of the present discounted value of investment grants and capital allowances given by tax provisions. The present value of such grants and allowances is denoted by A. Hence, the present cost of capital, PC, is

$$PC = 1 - A. \tag{A.7}$$

The value of MRR that equates the present value of the investment with the present cost of the investment is the return the investment must earn if it is to be a feasible investment. By setting PV equal to PC, the pre-tax rate of return, p, is

$$p = \frac{(1-A)(\rho+\delta-\pi)}{(1-t)} - \delta. \tag{A.8}$$

Finally, $METR_{inclusive}$ is defined as

$$METR_{inclusive} = \frac{\frac{(1-A)(\rho+\delta-\pi)}{(1-t)} - \delta - r}{p}. \tag{A.9}$$

A.3.2 Tax rates

First of all, it is necessary to distinguish the taxes which are considered in computing MECTRs and the taxes which are not considered. Generally corporations are subject to corporate income taxes, net wealth taxes, property taxes, payroll taxes, poll taxes, cost-based taxes, etc. The only taxes which are considered in computing MECTRs are corporate income taxes. The other taxes are not considered not because they are not important as much as corporation income taxes but because they are difficult to be converted into income related tax rates. For example, there are complicated local taxes in Iceland; turnover tax, the tax base of which is defined as total turnover cost of companies, Industrial Fee, Industrial Loan Fund Contribution, Municipal Business Operating Expense Tax, etc. However, the base of all these taxes are operating expenses which are allowed as deduction from gross income for State income tax purpose. None of these taxes are considered in our calculation.

What is the value of t when only corporate income taxes are considered? Even if defining t looks straightforward at a first sight, it is not a simple task. Different tax

Taxable income		Tax rate
over	*not − over*	
0	50,000	15%
50,000	75,000	25%
75,000	100,000	34%
100,000	335,000	39%
335,000	10,000,000	34%
10,000,000	15,000,000	35%
15,000,000	18,333,333	38%
18,333,333		35%

Table A.3: Federal corporate tax rates of USA as of January 1, 1999

rates are applied according to the size of corporate income, legal forms of corporations, sources of corporate incomes, size of firms, etc.

First, we use the tax rates which are applied to the highest income bracket when the tax rates are a graduated system. For example, the federal corporate tax rates of USA are given in Table A.3. The value of t used for $METRs$ of the USA is 0.35.

In Switzerland, tax rates depend on the value of income divided by equity. We use the highest tax rates with the assumption that the value belong to the threshold of the highest tax rates.

In some countries, different tax rate is applied to the retained profits and the distributed profits. Only tax rate for the retained profits is considered in our calculation of MECTRs.

Local corporate taxes cause a different problem because local governments have different tax rates. King and Fullerton (1984) calculate the average local tax rate of USA using the weights which are based on the value of existing assets in each states in 1981. Their approach is difficult to apply to ours because necessary data on the tax rates of each local government throughout period and the data on the relevant weights are difficult to get. Instead, we use maximum tax rates which are restricted by the central government. In some countries, we use the tax rates of a local government which may represent the country. For example, the tax rate of Geneva is used for the local tax in Switzerland.

When there are multiple corporate income taxes, the payment of one tax may be deducted from the corporate income for the others. Suppose that t_1 and t_2 are the tax rate of national tax and local tax and the payment of local tax is deducted from the corporate income for the national tax, then total tax rate is

$$t = t_2 + t_1(1 - t_2). \tag{A.10}$$

In some countries, local tax is deducted not only from the corporate income for a national tax but also for its own tax base. Then the total tax rate is

$$t = (\frac{t_2}{1 + t_2}) + t_1\{1 - (\frac{t_2}{1 + t_2})\}. \tag{A.11}$$

A.3.3 Capital allowances

Capital allowances are deducted from income of firms and thus reduce their tax liabilities. Therefore, firms are assumed to maximize the present value of capital allowances by taking the shortest useful lives of assets, the maximum rates and the most profitable methods of depreciation, and earliest depreciation. In some countries, tax depreciation follows accepted accounting practices. We assume that the accepted useful life for the machinery and industrial buildings are respectively 8 years and 40 years.

In addition to the assumptions in the section 2, we assume that the investment is made at the beginning of an accounting year. This assumption is necessary to calculate A because timing of investment matters when initial allowances are granted and when the half-year convention is applied. Initial allowances can be claimed in the first accounting year irrespective of asset's service period. Therefore, an investment at the last day of an accounting year gives large present value of initial capital allowance than an investment at the first day of an accounting year. Timing of an investment also matters when only half of capital allowances can be claimed in the first year of the investment, so-called the half-year convention. If an investment occurs at the second half of a year, the half-year convention grants benefits. Otherwise, it is harmful.

The most frequently used methods for calculation of the capital allowances are the DB method and the SL method. Assume that the depreciation is granted at the DB method at a rate of a per annum for infinite years.[1] The present value of tax saving from the capital allowances is

$$A_s = \int_{s=0}^{\infty} tae^{-(a+\rho)s} ds = \frac{ta}{a+\rho}. \tag{A.12}$$

With the SL method for the asset with tax life time, L, the present value of tax saving

[1]OECD (1991) assumes that depreciation by the DB method occurs until 99% of asset cost is recovered.

from the capital allowances is

$$A_s = \int_{s=0}^{L} t(\frac{1}{L})e^{-\rho s}ds = \frac{t(1-e^{-\rho L})}{\rho L}. \tag{A.13}$$

For the USA, the sum-of-the-years-digits method (SYD method) is used. When the tax life is L, the capital allowance for each year, J, is

$$C_J = \frac{L-J-1}{\sum_{i=1}^{L} i}, \text{ } i \text{ is integral not greater than } L. \tag{A.14}$$

For example $L = 3$, then the capital allowances for three years are respectively 3/6, 2/6 and 1/6. The present value of tax saving from the capital allowances is

$$A_s = \sum_{J=1}^{L} \frac{L-J-1}{\sum_{i=1}^{L} i} \int_{s=0}^{L} te^{-\rho s}ds = t\sum_{J=1}^{L} \frac{L-J-1}{\sum_{i=1}^{L} i}\{\frac{1-e^{-\rho L}}{\rho}\}. \tag{A.15}$$

The rate of the DB method is 1.5 - 3 times higher than that of the SL method. Therefore, the DB method is better than the SL method in that it allows large capital allowances in the early years. However, it dose not give complete recovery of cost of the investment. Therefore, the switch-over to the SL method is allowed in many countries.[2] The switch-over is assumed not to be allowed during an accounting year.

There are two different switch-overs. First, the rate of the SL method is fixed regardless of the years when the DB method is applied. Second, the rate of SL methods is calculated to give the same depreciation for each remaining year. The remaining value of the asset is divided by the remaining useful life of asset. The switch-over by the second method leaves the useful tax life of the asset unchanged while the first method shortens the useful life.

[2]In some countries, the switch-over is compulsory.

The first method of switch-over incurs another problem in calculating present value of capital allowances. the remaining capital allowance for the last year may be less than the normal capital allowance. We assume that the remaining capital allowance is granted throughout a whole year. King and Fullerton (1984) assume that the accounting year is shortened if the remaining capital allowance is less than the normal one.

When the switch-over follows the first method for the asset with a useful life of L, the switch time from the DB method to the SL method is optimal when the latter provides more deduction than the first. Let define L_s be the year of switch-over and B be the times of the DB method rate in terms of the SL method rate. Since the DB method provides a deduction of $\frac{B}{L}$ times $(1-\frac{B}{L})^{J-1}$ in the year of J and the SL method allows $\frac{1}{L}$ in every year, L_S is

$$L_S \geq 1 + \frac{\ln B}{\ln L}. \tag{A.16}$$

When is the best switch-over in the case of the second method? Since the DB method would allow capital allowance at a rate of B/L on remaining basis and straight line would allow $1/(L-L_S)$ on the same remaining basis, L_S is

$$L_S \geq (\frac{B-1}{B})L. \tag{A.17}$$

When is time for the optimal switch from the DB method to the SYD method? Since the DB method starts out with higher depreciation allowances and the SYD method on the remaining basis must exceed the DB method, the optimal switching point can be found by equating depreciation under the two methods. The switching time is

$$\frac{L - L_S}{F(L - L_S)} \geq \frac{B}{L}, \tag{A.18}$$

where the F function is defined by

$$F(L) = \sum_{J=0}^{L}(L - J). \tag{A.19}$$

Additional thing to be considered is the use of the half-year convention, which allows only half of capital allowance in the first year. This makes depreciation period one year longer than the useful tax life of the asset. For example, if the useful life of the asset is 5 years, the annual rate of the SL method is 20%. But, with half year convention, it will be 10%, 20%, 20%, 20%, 20%, and 10%. USA has a special rule not to make the depreciation period longer. the capital allowance of the last half year can be moved up to the previous year. Therefore, the capital allowances are 10%, 20%, 20%, 20% and 30%.

In many countries, accelerated capital allowances are granted with different forms. If it is given additional to the normal capital allowance, we call it initial allowance. If it is given alternative of the normal capital allowance of the first year, we call it the first year allowance. They are also different in that initial allowances can be claimed in the first accounting period irrespective of the date of the investment while first-year capital allowances can be claimed only proportional with the period when the asset is used in the first accounting period. However, this can not make a difference when an investment is assumed to be made on the first day of every accounting year.

A.3.4 Stock valuation

Generally, inventories are not granted capital allowances and thus A is equal to zero. The use of historical cost accounting means that the inflationary gain on inventory is taxed as current profit when inventories are turned over. This realization of inventory profits for tax purpose can occur fairly soon if traditional $FIFO$ (first in, first out) accounting is used, or it can be postponed almost indefinitely if $LIFO$ (last in, first out) accounting is used. We assume that v denotes the proportion of inventories taxed on historical cost principles, and thus it is 1 when $FIFO$ accounting is used, or 0 when $LIFO$ accounting is used. The marginal investment of one unit of inventory, if there is no change in relative price, will incur an additional tax of $tv\pi$ per annum. This modifies the equation of present discounted value of the marginal investment.

$$\begin{aligned} PV &= \int_{s=0}^{\infty} \{(1-t)MRR - tv\pi\} \cdot e^{(-\rho-\delta+\pi)s} ds \\ &= \frac{(1-t)MRR - tv\pi}{\rho+\delta-\pi}. \end{aligned} \tag{A.20}$$

With high inflations, especially in 1970s', corporations suffered from increase of tax burden due to higher profits from stock valuation. Many countries had implemented scheme to counteract this effect. In some countries, stock relief is granted. With stock relief, $A = \phi t$, where ϕ is the proportion of the stock relief.

During 1974-1980, UK corporations were allowed to deduct for tax purposes the excess of the change in the book value of inventories over 15% of trading profits. The increase in the book value of inventories in any one year consists of the inventory valuation adjustment plus the value of the net physical investment in inventories. The initial idea was to take the former component out of the tax base to leave in for the latter. Since distinguishing between two components was impossible, the scheme not only offered relief for the effect of inflation, but also granted immediate expense on the purchase of inventories. Thus, in this period, inventories are valued by $LIFO$ even if $FIFO$ is applied. In addition, an investment in inventory has the tax saving of the amount of t. Therefore, $A = t$.

A.3.5 Investment incentives

It is difficult to measure the benefits of investment incentives by a single value because the systems are so complicated. The incentives heavily depend on which assets a new investment forms, which industries a investment belongs to, which locality an investment occurs in, how large an investment is, for which function assets of an investment does, how many jobs an investment creates, whether an investment is for exports, etc. Recently, the amount of incentives is likely to be decided by negotiations between the government and investors. We consider only investment incentives which are granted to the general investment at a fixed rate.

The investment incentives considered in our calculation of MECTRs take three forms; investment allowances, tax credits and cash grants. Investment allowances are different from accelerated capital allowances and additional capital allowances in that they do not reduce the cost of assets for depreciation purpose. Accelerated capital allowances and additional capital allowances are classified into capital allowances even if they have names of investment allowances in some countries.

When an investment allowance is given at the rate of $a\%$, the tax saving is

$$A = \int_{s=0}^{1} tae^{-\rho s} ds = \frac{ta(1 - e^{-\rho})}{\rho}. \tag{A.21}$$

Tax saving from a tax credit of $a\%$ is different from that from a cash grant of the same rate because the tax credit can be claimed at the end of the first accounting year while cash grant can be claimed at the first day of investment. The amount of tax saving from a tax credit, A_c, and from a cash grant, A_g, are

$$A_c = \int_{s=0}^{1} ate^{-\rho s} ds = \frac{at(1 - e^{-\rho})}{\rho} \tag{A.22}$$

and

$$A_g = \int_{s=0}^{1} ate^{-\rho s} ds = at. \tag{A.23}$$

Appendix B

Corporation Taxes in OECD countries

B.1 Australia

[1] Tax rates

In 1957, the income tax rate for corporations was 7s per £1,[1] which was changed to 7s 6d in 1957, to 8s 0d in 1960, to 8s 6d in 1964, to 42.5% in 1965, 45% in 1968, to 47.5% in 1970, to 45% in 1974, to 42.5% in 1975, to 46% in 1984, 49% in 1985, to 39% in 1988[2], to 33% in 1993 and to 36% in 1995.[3]

[1] 1s is equal to 1/20 £ and 1d is equal to 1/240£.

[2] The dramatic decrease in tax rate was accompanied by an introduction of an imputation system and abolition of accelerated depreciation in 1988.

[3] These were the tax rates for public companies. The tax rates for private companies were slightly lower than those for public companies because undistributed profits of private companies might be taxed by Additional tax at the rate of 50%.

There have been no other taxes on corporate income, local and national.

[2] Capital allowances

For the machinery, 150% of the SL rate was permitted for the DB method until 1974. In 1975, DDB was permitted. In 1979, depreciation was calculated by the DB of 150 % of the SL rate, which was loaded 20% of the original cost. In 1981, the loading was changed to 18%. The life time was 10 years.

During 1982-1987, the machinery was eligible for write-off over three or five years. We use the SL method at an annual rate of 20%.

During 1988-1991, taxpayers were allowed to make their own estimate of the effective life and to determine their own depreciation rate. The rate of the DB method was 150% of the rate of the SL method. Since 1992, a six-band depreciation schedule applies; for the machinery the SL method at an annual rate of 20% or the DB method at an annual rate of 30%.

For industrial buildings, capital allowance was not allowed before 1982. Only buildings in specific industries such as farming, grazing and mining were allowed for depreciation deduction. From 1982, the SL method of 2.5% was used. The rate was increased to 4% during 1984-1987. During 1988-1991, taxpayers made their own estimate of the effective life and determined their own depreciation rate. Since 1992, a six-band depreciation schedule applies; for the industrial buildings the SL method of 7% or the DB method of 10%.

Throughout the period, the switch-over is assumed to be not allowed because the switch-over requires the Commissioner's approval and the approval is granted in certain circumstances.

For cost of inventory, *LIFO* has not been permitted unless it approximates actual physical flows.

[3] Investment grants and incentives

Until 1985, a special deduction, known as the investment allowance, equal to 20% of the cost of the machinery was granted. From 1981, the rate was reduced to 18%. Capital cost remains unchanged for the tax depreciation purpose.

B.2 Austria

[1] Tax rates

During 1958-1972, the corporation tax rate was 44% and Equalization of Burden Tax, surtax, was levied at a rate of 18% on the corporation tax. During 1967-1972, Flood and Damage surcharge on corporation tax was levied at the rate of 3% and Special additional tax on the corporation income was levied at the rate of 10% during 1969-1972.

In 1973, corporation tax rate was 50% and there were no more surcharges. The tax rate was raised to 55% in 1976. Until 1988, the corporation tax rate for distribution and retention were 27.5% and 55%, and changed to 30% regardless of distribution or retention of profit in 1989. Since 1995, the rate has been 34%.

Before 1995, there was a local Trade tax. The tax rate was different across local governments. The maximum rate was 15%, which was decreased to 13.5% in 1989. The local corporation tax payment was deducted from the tax base of the national corporation tax.

[2] Capital allowances

Throughout the period, only the SL method is permitted for the tax depreciations. The rate is 10% for the machinery and 4% for the industrial buildings. Initial allowances were granted as of 20% for the machinery and buildings before 1972. During 1967-1979, there was an accelerated depreciation in addition to the normal depreciation only for the machinery. The rate was 20% before 1972, 25% during 1973-1975 and 50% during 1976-1979. During 1976-1979, the remaining was depreciated by the SL method for 4 years.

In general, inventories are valued at the lower of cost or market value. *FIFO* is generally accepted but *LIFO* is permitted only if it can be shown that they accord with the facts.

[3] Investment grants and incentives

Since 1979, an investment allowance of a percentage of the acquisition cost can be claimed in the year of acquisition without reducing the basis for computing annual depreciation. The percentage was 20% for the machinery and buildings, 9% in 1992 and 12% in 1997.

There are also regional incentives as forms of cash grants per job created, an interest rate subsidy and extended loan terms as well as industry incentive. Because of their specification, none of incentives except the investment allowance are not included in computing the METRs.

B.3 Belgium

[1] Tax rates

Until 1962, corporations were taxed as the same with individuals. Business tax was levied at the rate of 40%. In addition, there was 5% of a surcharge.

In 1962, a tax reform introduced separated taxation of corporate income. Company tax rate was 35%, which was changed to 42% in 1973, to 48% in 1975, to 39% in 1979, to 45% in 1984, to 43% in 1987 and to 39% in 1992[4].

During 1968-1972, 10% surcharge was levied on the company tax except 1972 when the surcharge was 20%. During 1975-1978, 4.8% of Solidarity Contribution was levied on the income of corporations. Since 1994, an additional 3% Crisis Tax has been levied on the company tax.

There is no local tax on the corporate income.

[2] Capital allowances

Until 1978, only the SL method for useful life was allowed. Therefore, the machinery was depreciated at an annual rate of 12.5% and buildings were depreciated at an annual rate of 4%. Since 1979, no depreciation rates are laid in the Belgian tax

[4]This is the rate for Belgian companies. For foreign companies, the basic rate is 43% in 1997. However, companis from most of countries are taxed by treat rate of 39%.

laws or regulations. The only criterion stipulated in the tax law is that rates should be based on the normal useful life of the assets. Only guidelines are suggested; 5% for industrial buildings and 20% for the machinery and equipment.

The SL method, the DB method and the switch over from the DB method to the SL method are permitted. In the case of the DB method, the SL rate is doubled. For the machinery, the DB method at an annual rate of 25%, switching to the SL method at an annual rate of 12.5% from the fourth year is used. For buildings, the DB method at an annual rate of 8%, switching to the SL method at an annual rate of 4% from fifth year is used.

Inventory is valued at cost price or replacement value, whichever is lower. The *LIFO* method has been allowed since 1992. Before 1992, the *LIFO* method was not permitted unless it approximates actual physical flows.

[3] Investment grants and incentives

The Investment Credit (deduction) for equipment was 5% in 1959. This may reduce the taxable basis and consequently reduce the tax payable. Since 1990, the rate is 3.5% unless the inflation rate of the calendar year preceding the year of investment plus 1% point would result in a percentage exceeding 3%. Otherwise, the latter percentage would apply. Because we assume that inflation rate is 5%, the Investment Credit is 6% throughout the period. In 1998, the Investment Credit was repealed for companies other than small and medium-sized companies.

There had been other legislation for investment incentives. The Law of Economic

Reorientation in 1978 was to stimulate small and medium-sized businesses. Regional Law in 1970 was to promote activities that contribute directly to the formation of industrial undertakings in specific development areas. Only the Investment Credit is included in computing the METRs.

B.4 Canada

[1] Tax rates

Federal corporate tax rate is reduced by the Provincial abatement and the Manufacturing and processing deduction and is increased by a corporation surtax. The basic rate[5] was 45% in 1956, which was changed to 47% in 1959. In 1972, the tax rate was increased to 50%, which was lowered down 1% point in each year until 1976, when the tax rate became 46%. The tax rate was changed to 45% in 1987 and to 38% in 1988.

Old-age Security tax was levied at the rate of 2% in 1956, which was raised to 3% during 1958-1971 and repealed in 1972. There was Temporary surtax of 3% during 1968-1970.

Provincial abatement[6] was 7% of payable tax during 1962-1978 and was raised

[5]These tax rates are for public corporations. In Canada, a public corporation is defined as a corporation resident in Canada and having a class of its shares listed in a prescribed Canadian stock exchange. A resident corporation not fulfilling this condition may, however, elect or be designated by the Minister of National Revenue to be a public corporation subject to certain requirements. A private corporation is defined as a corporation resident in Canada which is not a public corporation and is not directly or indirectly controlled by one or more public corporations.

[6]The provincial abatement is applied only to the income earned in a province other than the Northwest or Yukon territory. It is assumed all income comes from other provinces.

to 10% in 1979. In addition, Manufacturing and processing deduction was 5% since 1979, which was changed to 6% in 1984, to 2% in 1987, to 5% in 1991, to 6% in 1993 and to 7% in 1994.

Since 1986, Federal surtax has been imposed on basic rate net of provincial abatement. Federal surtax was 5%, which was changed to 4% in 1994,

We consider Provincial tax of Ontario. The tax rate was 11% until 1976, which was changed to 12%. The tax rate was changed to 13% in 1978, to 13.5% in 1979, to 14% in 1984 and 14.5% in 1988.[7] The provincial tax payment is not deducted from the tax base of the federal tax. Specific provincial taxes such as those on income from mining and logging operations are not considered.

It is informative to show a sample of corporate tax calculation.

Taxable income	\$100
Federal income tax	\$22.84
Basic tax (38% of taxable income)	\$38
Deduct Provincial tax abatement (10% of taxable income)	(\$10)
Tax payable	\$28
Add surtax 3%	\$0.84
Deduct Manufacturing and processing profits tax credit	
(6% of taxable income)	(\$6)
Provincial income tax	\$13.5

[7]These are the tax rate for the income from manufacturing and processing.

Provincial tax (15.5% of taxable income)	\$15.5
Deduct Manufacturing and processing profits tax credit	
(2% of taxable income)	(\$2)

[2] Capital allowances

For the machinery, until 1962, the SL method at a rate of 12.5% was applied. During 1963-1981, a special two-year write off of 50% SL method was available. In 1982, it changed to a special three-year write off of SL method, 25% in the first year, 50% in the second year and 25% in the third year. This reflects the principle that only half allowance is permitted in the first year. In 1988, the special three-year write off no longer existed, and it was replaced by the DB method at a rate of 35%. The rate has been changed to 30% in 1990, to 25% in 1991 and to 30% since 1992.

For the buildings, the DB method at a rate of 5% was applied before 1988 and the rate was lowered to 4% in 1988. Only half allowance has been permitted in the first year since 1982.

During 1970-1971, depreciation for the machinery and buildings were calculated by 115% of acquisition cost.

All the property included in inventory may be valued at its fair market value or each item may be valued at the lower of its cost or fair market value. The *LIFO* basis is generally not acceptable for tax purpose. There was an inventory allowance which was 3% annual deduction of the cost of inventory during 1977-1985.

[3] Investment grants and incentives

Federal and provincial governments have offered a wide range of investment incentive programmes and tax incentives. The federal Income Tax Act provided investment tax credits (ITCs) that were available to all taxpayers in Canada. Manufacturing and processing goods was qualified to 5% of tax credit during 1975-1977, which was increased to 7% in 1978, 7-35% in 1984 and 3-60% in 1987. The cost of the qualified property was reduced for capital cost allowance. Since 1988, it has been available only in the limited areas.

Regional non-tax incentives include grants, favourable loans, forgivable loans, loan guarantees, guidance, contribution toward salaries and training assistance. There are also industry-specific incentives; the targeted industries include agriculture, energy, exporting, mining, research and development, tourism, housing, technology, and the film industry. These are not included in computing the METRs here because they are available in the specific areas such as in less-developed regions or in specific industries.

B.5 Denmark

[1] Tax rates

The corporation tax rate was 44%, which was changed to 36% in 1968, to 37% in 1974, to 40% in 1979, to 50% in 1988, to 38% in 1991, and to 34% in 1992. Since 1993, corporation income has been taxed at 38%. However, corporations making tax payments in the income year by two equal instalments are subject to 34% instead of 38%.

There is no local tax on corporation income. Local taxes such as Communal income tax, County income tax and Church tax are levied only on the income of individuals.

[2] Capital allowances

The DB method of depreciation is mandatory for the machinery. The maximum rate is 30%.[8]

Before 1968, buildings were depreciated at the annual rate of 4%. Since 1968, industrial buildings are permitted to be depreciated by the modified SL method. In the initial years, a higher rate of depreciation may be applied. The maximum rate is 6% until the accumulated depreciation amounts to 60%. Thereafter the rate is 2%.

Inventories are valued at cost or market value, whichever is lower. The *LIFO* method is not permitted unless it approximates actual physical flows.

Stock in trade could be depreciated by an annual rate of 26% in 1992. The rate was reduced by 3% point until 1995, when the rate was 15%. The rate was 12% in 1996 and 8% in 1997. In 1998, the depreciation was abolished.

[3] Investment grants and incentives

The Danish government's policy is to encourage investment in specific regions, activities and in some industry sectors rather than to provide general incentives. Regional support is granted in regions with high unemployment. Activity support

[8]During 1982-1990, there was a yearly inflation adjustment of the depreciated balance for the machinery and buildings. For the machinery, the basis of depreciation was indexed except in the year of aquisition and disposal. In addition, in the year of aquisition, depreciation was calculated on 5/6 (83.33%) of the acquisition cost. We do not consider this fact in computing the METRs.

is given mainly to export industries and industries investing in technological development. Most of incentives are given in the form of financial assistance such as favourable loans and government guarantees.

Local authorities provide incentives in the form of inexpensive land or development of new industrial areas through negotiations.

B.6 Finland

[1] Tax rates

Undistributed profit was taxed at 38%, which was changed to 45% in 1964, to 48% in 1965, to 49% in 1968, to 43% in 1969, to 33% in 1988, to 23% in 1991, to 19% in 1992, to 25% in 1993, and to 28% in 1996.

There was additional income tax of 12% during 1960-1966, which was deducted from taxable income.

Municipalities levied a tax before 1993. The communal tax[9] was levied at a rate of 14.5%, which was changed to 16.5% in 1989.

In addition, Church income tax had been 2%, changed to 1% in 1979, to 2% in 1989 and to 1% in 1992.

The local taxes are not deducted from the tax base of the national corporation income tax.

[2] Capital allowances

[9]We take the middle figure.

The act on Taxation of Business and Professional Income (EVL) has detailed rules for the depreciation of different kinds of assets. Before 1969, the machinery was depreciated by the DB method at an annual rate of 12.5%. Since 1969, the machinery is allowed to be depreciated according to the DB method up to 30% per annum.

Before 1969, industrial buildings are depreciated by the SL method at an annual rate of 2.5%. Since 1969, the maximum amount of deprecation on industrial buildings had been 9% by the DB method. In 1995, the rate was lowered to 7%.

Inventory is valued at acquisition price, cost price or net selling price. Cost price can be determined by *FIFO*. The *LIFO* method is not permitted unless it approximates actual physical flows.

[3] Investment grants and incentives

There are no tax concessions aimed at attracting capitals. The main form of general nontax incentives to business and industry is low-interest loans. A wide range of investment grants and start-up subsidies are available for industry established within so-called development areas in the northern and eastern parts of Finland. No incentives are included in computing the METRs.

B.7 France

[1] Tax rates

Tax rates for distributed profits by dividends and retained profits were 50% during 1959-1985. In 1986, they were 50% and 45%, which were changed to 45% and 45%

in 1987, to 42% and 42% in 1988, 42% and 39% in 1989, to 42% and 37% in 1990, to 42% and 34% in 1991, to 34% and 34% in 1992 and finally to 33.3% and 33.3% in 1994.

Surcharge of 18% was levied on the company tax only in 1973. There was a surtax of 10% in 1994, which was changed to 25% in 1995 and 20% in 1999.

No tax is levied on the corporate income at the regional or local level. Towns and counties levy rates which are not assessed on income of corporations.

[2] Capital allowances

Throughout the period, normal useful life years have been used for the machinery and buildings. For the machinery, depreciation was allowed by the DB method at a rate of 2.5 times of the rate of the SL method, switching to the SL method for the remaining cost of assets. In 1996, the rate was increased to 3.5 times.

For industrial buildings, depreciation is done by the SL method.

Inventories are valued at cost price. Cost price can be determined by $FIFO$. The $LIFO$ method is not permitted unless it approximates actual physical flows.

[3] Investment grants and incentives

Most incentives offered by the French government and local municipals have been related to their policy to locate industries in the less industrialized areas of the country, where jobs are most needed. There are no investment grants and tax incentives generally available to the manufacturing sector.

B.8 Germany

[1] Tax rates

The German corporation tax has been based on a split rate system; the higher tax rate for the retained profit and the lower tax rate for the dividends. Under this system, while dividends were subject to a tax rate of 15%, retained profits were taxed at 51% in 1958. During 1968-1976, both rates were subject to 3% surcharge, making them 15.45% and 52.45%. In 1977 when a new system was introduced to give a dividend credit, the tax rate on retained profit was increased to 56% and the tax rate on the dividend was increased to 36%. At the same time the 3% surcharge was invalid. The tax rate for retained profits was decreased to 50% in 1990 and further to 45% in 1994. Solidarity surcharge was 3.75% in 1992, which was increased to 5.5% in 1994 and to 7.5% in 1995.

The tax base of the local profits tax (Gewerbeertragsteuer) is different from that of the corporation tax in that interest payments on long-term debt are not deductible and 12% of the value of land is excluded from the tax base. Here, we ignore the difference in computing tax bases. The tax rate is assumed to be 14% as King and Fullerton (1984) estimated throughout the period. The local taxes are deductible from the Corporation income.

There were temporary surcharges; 10% demand pressure surcharge during 1970-1971, 10% stabilization surcharge 1973-1974 and 5% surcharge in 1984 to encourage investments. Because the surcharges were repaid later, we do not consider these surcharges.

[2] Capital allowances

Service lives for individual investment goods have been provided by depreciation table and these are compulsory. Even if there has been a shortening of the economic and tax lives of both the machinery and buildings, we assume that the service lives for the machinery and buildings are 8 years and 50 years throughout the period because deviation from compulsory rates is permissible where it can be justified.[10]

For the machinery, corporations can choose between the DB method and the SL method for computing depreciation with a maximum limit. The rate for the DB method was 2.0 times rate of the SL method with 20% maximum limit in 1960, and increased to 2.5 times with 25% maximum limit in 1977 and 3.0 times with 30% maximum limit in 1981.[11]

For the buildings, the SL method is mandatory. However, a special DB method was permitted. Before 1985, the rates were 5% for the first 8 years, 2.5% for the next 6 years and 1.25% for the last 36 years. Since 1985, the rates have been changed to 10% for the first 5 years, 5% for the following 3 years and 2.5% for the remaining 18 years.

Inventories can be valued by the *LIFO* method. King and Fullerton (1984) con-

[10]For example, average economic lives of the machinery and buildings were reduced from 15 years and 52 years in 1960 to 13 years and 44 years in 1978. These shortening of tax lives reflected the fact that their economic lives were reduced from 14 years and 42 years in 1960 to 11 years and 30 years in 1978. This shows that there was no shortening of tax lives in excess of shortening of economic lives.

[11]For some period of high demand pressure, for example 1971 and 1973, the DB method was not permitted. However, we ignore this exception in computing tax rates.

sider the real practice that half of inventories are valued by $FIFO$ and set $v = 0.5$. However, here we set $v = 0$, because firms will use $LIFO$ as long as it is available and is profitable.

[3] Investment grants and incentives

The federal government and state governments offered financial incentives, direct subsidies as well as tax reliefs. These were restricted to the regions bordering with the East Germany or to specific types of assets such as R&D and energy supply industries. There were special investment incentives for investments in former East Germany. With the merger of East Germany, the tax system of West Germany has been adopted with some minor exceptions, which aim at encouraging investment in the old East Germany. For example, Municipal trade tax is not levied, Special depreciation up to 50% is available, and various investment subsidies are granted.

However, there are no general cash grants and tax incentives. Therefore, we do not include any incentives in computing the METRs.

B.9 Greece

[1] Tax rates

The income tax on corporations was 35%, which changed to 30% in 1974, to 49%

in 1984, to 40% in 1988,[12] to 35% in 1992 and to 40% in 1993.[13].

The tax rate was increased by 15% as a contribution towards social insurance, Agricultural Social Insurance Fund. Since 1963, this contribution was deductible from taxable profit.

Only in 1973, there was Special Levy of 20% over DR10,000,000, which was deductible from the taxable income.

There is no local income tax for corporations.

[2] Capital allowances

Throughout the period, the SL method was compulsory. The SL method was applied at an annual rate of 12% for the machinery and 8% for factory buildings. Until 1972, normal depreciation rates were increased by 50% in respect of new installations and machinery.

During 1973-1982, the normal depreciation allowances were increased according to the number of shifts[14] working and the location of the plant. For example, the machinery for two shifts and locating in Zone A had a 25-200% increase of the normal depreciation. We do not include this additional allowance.

Inventory is valued at cost price or fair market value, whichever is lower. The

[12]In 1988, the corporate tax rate depends on type of corporations and their realized investments. The tax rate was 46% for commercial corporations, 40% for manufacturing corporations, and 35% for the manufacturing corporation the share of which is quoted on the Adens Stock Exchange or realized investments of which are over certain amount.

[13]Corporations (SA) are taxed at the rate of 40%. The tax rate of 35% is applied if Corporations are quoted on the Athens Stock Exchange. Limited liability companies (EPE) are subject to 35%.

[14]A shift means 8 hours working in a day. Therefore, two shifts is 16 hours working and three shifts is 24 hours working.

LIFO method is permitted.

[3] Investment grants and incentives

In order to encourage the decentralization of industry away from the Athens-Piraeus area, various regional tax incentives had been adopted. Investment incentives include both tax and non-tax incentives. Tax incentives are tax allowances and increased tax depreciation rates and non-tax incentives are investment grants, interest rate subsidies of investment loans. A grant up to 50% of total investment, extra depreciation allowances up to a maximum of 150% of the normal depreciation, and fixed corporation tax rates were among many.

Greece is divided into separate areas; A,B,C, and D[15]. Regular investments in area A do not receive tax and non-tax incentives. Therefore, we do not include any incentives in computing the METRs.

B.10 Iceland

[1] Tax rates

The corporate tax rate of the central government was 51% in 1984, 48% in 1988, 45% in 1990 and 33% in 1996.

There is a local turnover tax, the tax base of which is defined as total turnover

[15]Legislative Decree 1078/1971 divided Greece into three regions; (1) Region A: the district of Attica except for the municipality of Lavrion (2) Region B: the municipality of Lavrion, the districts of Thessaloniki, Boeotia, Euboea, corinthia and the province of Chalkis (3) Region C: all other areas in the country. Legislative Decree 1892/1990 divides the country into four regions, defining Region A the most developed area and Region D the least developed area.

cost of companies. An average tax rate was approximately 1%, which was 1.5% in 1996. Local governments impose many other taxes on corporations; Industrial Fee, Industrial Loan Fund Contribution, Municipal Business Operating Expense Tax, etc. However, the base of these taxes are operating expenses which are allowed as deduction from gross income for State income tax purpose. There are no local income taxes for corporations.

[2] Capital allowances

The SL method is applied for the depreciation . The rate was 12% for the machinery and 2% for industrial buildings. The rate for the machinery was increased to 15% in 1984. 10% residual value should be remained before 1992.

Inventory is valued at cost price allowing for inflation in 1990. Inventory is valued by the $FIFO$ method.

[3] Investment grants and incentives

There is no investment incentives which is included in computing the METRs.

B.11 Ireland

[1] tax rates

Corporations were subject to income tax as well as corporation profits tax before 1974. The payment of corporation profits tax was deducted from the taxable income base of the income tax. Income tax rate as 7s 6d in 1955, which was changed to 7s in 1959, to 6s 4d in 1961, to 7s in 1966, to 35% in 1970.[16] There was a surtax[17] of 8s 6d in 1955, which was changed to 7s 6d in 1959, 9s in 1967 and to 45% in 1970. Corporation Profit tax rate was 10% in 1955, which was changed to 15% in 1961, and to 23% in 1966.

In 1974, Corporation tax replaced the previous two taxes and the rate was 50%, which changed to 45% in 1979, to 50% in 1984, to 47% in 1988, to 43% in 1989 and to 40% in 1991. However, 10% corporation tax rate was introduced in 1981. This is designed to promote the development of manufacturing industry and certain services in Ireland. The 10% tax rate is available to companies on their manufacturing and certain non-manufacturing profits earned between January 1, 1981 and December 31, 2010. We use 10% for the corporation tax rate for 1981-1999.

There is no local corporate income tax in Ireland.

[2] **Capital allowances**

Machinery was depreciated by the DB method at an annual rate of 12.5%. Taxpayers could speed up the depreciation allowances for the machinery by initial allowances up to 20% in 1960, which changed to 40% in 1961, to 50% in 1967, to 75% in 1968, to 100% in 1971, to 75% in 1988, to 50% in 1989, to 25% in 1991 and abolished in 1992. Since 1992, the machinery has been depreciated over 7 years by the SL method; 15% for the first 6 years and 10% in the seventh year.

[16] 1d is one penny which equals 1/240 of one pound and 1s is one shilling which equals 12 pennies, i.e. 1/20 of one pound.

[17] Surtax is levied on the higher incomes of individuals and also on the undistributed income of certain private companies.

Industrial buildings were depreciated by the SL method at an annual rate of 2% before 1975 and 4% on and after 1975. Taxpayers could speed up the depreciation allowances for buildings by initial allowances up to 10% in 1960, which changed to 20% in 1966, to 50% in 1967, to 75% in 1968, to 100% in 1971, to 75% in 1988, to 50% in 1989, to 25% in 1991 and abolished in 1992.

Inventories are valued at cost price or market value which is lower. Cost price can be determined by *FIFO*. The *LIFO* is not permitted. There was a 3% of stock relief only in 1984.

[3] Investment grants and incentives

Since the late 1950s, a wide range of investment incentives have been used to increase industrial development. A broad range of financial and fiscal incentives have been offered including capital grants, training grants and tax relief. Among them, Fixed asset grants, administered by the Industrial Development Authority (IDA), can be acquired up to 45% of the expenditure on fixed assets including the machinery and buildings. If the grants are given, capital allowances are applied to the acquisition cost net of the grants.

However, we do not include the Fixed asset grants in computing the METRs because it is not granted automatically, but through negotiation.

B.12 Italy

[1] Tax rates

Until 1974, the income of corporation was subject to Company tax as well as the schedular income tax, which was called Movable wealth tax. Tax payment of Movable wealth tax was deducted from the tax base of Company tax. Company tax rate was 15% and Movable wealth tax rate was 20% in 1960, which changed to 24% in 1962 and to 25% in 1965. There were three local taxes of 7.75%; Chamber of Commerce of 2.5%, provincial tax of 1.75% and Commutal tax of 3.5%.

There was a surcharge on the above three taxes at a rate of 10%, which was Local assistance boards tax. During 1967-1973, there was another 10% of surcharge, which was Flood relief due to the flood in autumn of 1966. The rate was increased to 15% from 1971[18].

There was a tax reform in 1974. Corporation tax (IRPEG) rate was 35% in 1974, which changed to 25% in 1976, to 27% by 8% surcharge in 1982, to 30% in 1983, 36% in 1984 and to 37% in 1995.

During 1974-1976, five local taxes were levied and these were deducted from the tax base; 8.5% of Municipal tax, 2.5% of Provincial tax, 2.0% of Regional tax, 1.2% of Chamber of Commerce, and 0.5% of Health, holidays and tourist centre tax. In 1976, these were singled into one tax of 15%, local income tax (ILOR). The rate was 15% and fully deductible, 16.2% and fully deductible in 1982, 16.2% and 75% deductible in 1991, and 16.2% and no longer deductible in 1993. There was a surcharge of 1%

[18]There were surcharge of 5% on Movable Wealth tax and the Local taxes during 1967-1972, which was to finance work in Calabria. However, this surcharge was not considered in computing the METRs because it is not clear whether this surcharge was levied only in Calabria or nation widely.

in 1994 only.

Since 1998, local tax on productive activities (IRAP) has substituted ILOR. IRAP is computed not on the taxable income but on the gross margin basis. Any cost associated with labour, interest and accruals for risk are not deductible for the tax base for IRAP. This implies that the tax burden by IRAP is heavier than from ILOR even if both have the same rate. Therefore, it is difficult to convert the tax rate of IRAP to the tax rate of ILOR and we thus use the rate for 1998 same with in 1997. The ordinary IRAP rate is 4.25% and is not deductible for the calculation of corporate taxable income.

[2] Capital allowances

Until 1973, depreciation as given on the SL method and the maximum rates were laid down by the tax authorities. For general machinery, the rate was 10% and, for industrial buildings, the rate was 3%. Accelerated depreciation for the machinery was 15% of the cost in four years and the maximum deduction of 40% in four years. These were additional to the normal depreciation and thus reduced depreciation period by two-fifths.

During 1974-1987, the normal depreciation rates were the same as the previous period but accelerated rates were allowed up to a maximum depreciation of 15% of the cost of the asset for the first 3 years. This implies the first 3 years at 25% and the remaining years at 10% for the machinery and the first 3 years at 18% and the remaining 15.3 years at 3% for industrial buildings.

In 1988, accelerated depreciation was changed, so that the additional allowances were defined as not exceeding 150% of the usual depreciation allowances in the first three years and only half the depreciation in the first period, so-called half year convention, was applied. In 1990, the additional allowances were defined as not exceeding 100%. In 1996, it was changed to 200%.

Tax code lays down a system of pricing of inventories, which is basically the $LIFO$ method.

[3] Investment grants and incentives

The most important incentives involve investments in the Mezzogiorno, the southern and relatively less developed parts of Italy. This area is defined as beginning a few kilometres east and south of Rome and includes Sicily, Sardinia and some other very small municipalities in northern Italy and is inhabited by 35-40% of the total population of Italy. These incentives include non-tax incentives as form of low-interest rate loans and grants as well as tax incentives. Tax incentives are exemption from IRPEG and ILOR for ten years.

According to Alworth and Castellucci (1994), the effective tax rates for investments in the Mezzpgiorno are considerably lower than those for the rest of Italy due to interest rate subsidies and tax exemptions. However, we do not consider this in computing the METRs.

B.13 Japan

[1] Tax rates

Since 1899, the tax on corporate profits had been combined with the individual income tax until 1940, when separate corporate income tax began. Corporation income is taxed not only by the central government but also by the two-tier local governments, prefectures and municipals.

The national corporation tax rate was 38% in 1958, which was decreased to 37% in 1965 and further to 35% in 1966. Since 1970, there had been a trend towards raising tax rates due to fiscal deficits. The tax rate was increased to 36.75% in 1970, to 40% in 1974 and to 43.3% in 1981. However, the tax rate was decreased to 42% in 1987, to 40% in 1989 and to 37.5% in 1990.

There have been five local taxes which increase tax burden significantly. Prefectural Inhabitants Taxes and Municipal Inhabitants Taxes consist of per capita tax of lump-sum and income tax computed as a percentage of the corporation tax. In 1963, Prefectural Inhabitants Per Capita Tax was levied at ¥600, which was increased to ¥1,000 in 1967[19] and to ¥6,000 in 1976. Municipal Inhabitants Per Capita Tax was levied at ¥4,000 in 1963, which was increased to ¥7,000 in 1967[20] and to ¥40,000 in 1976.

Each prefecture and municipality may elect a tax rate of Inhabitants income tax within the range; The range for a prefecture was 5.2-6.2% in 1963, which changed to

[19]This was for corporations with capital in excess of ten million yen.
[20]This was for corporations with capital in excess of ten million yen.

5.8-7% in 1967, to 5.6-6.6% in 1970, to 5.4-6.5% in 1976, and to 5.0-6.0% in 1984. For a municipal, it was 8.1-9.7% in 1963, which changed to 8.9-10.7% in 1966, 9.1-10.7% in 1970, 12.1-14.5% in 1976, to 12.3-14.7% in 1984 and to 8.4-10.1% in 1995.

Prefectural Enterprise Tax is imposed on the corporation's income and deducted from tax base not only for the corporation tax but also for its own. The maximum rate was 12%, which changed to 13.2% in 1984 and returned to 12% in 1995.

Table B.1 shows the local taxes in 1963 and 1976. The maximum rates for the highest income band are used in computing tax rates. As far as per capita taxes are concerned, lump-sum taxes are converted to the proportional tax by the following formula.

$$\text{tax rate for per capita tax}=\frac{\text{lum-sum tax}}{\text{threshold amount of the highest income band}}.$$

For 1976, Prefectural Inhabitants Per Capita Tax was converted to 0.006% and Municipal Inhabitants Per Capita Tax was converted to 0.04%. For 1963, when there was not any threshold, the threshold of the closest year is used. Therefore, using the threshold of 1976, Prefectural Inhabitants Per Capita Tax was converted to 0.0006% and Municipal Inhabitants Per Capita Tax was converted to 0.004%.

In addition, for some period, there were surcharges on the corporation tax. During 1974-1976, surcharge on corporation tax was 10% and during 1991-1994, it was 2.5% to recoup tax revenue reduction.

[2] Capital allowances

Capital allowance has remained the same throughout the period. This is partly

Tax	1963	1976
Prefectural Inhabitants Tax		
Per capita Tax	600	1,800 up to ¥10m 3,000 between ¥10m and ¥100m 6,000 over ¥100m
Income tax	standard rate 5.2% maximum rate 6.2%	standard rate 5.4% maximum rate 6.5%
Prefectural Enterprise Tax	6% up to ¥1m 9% ¥1m-1.5m 9% ¥1.5m-2m 12% over ¥2m	6% up to ¥3.5m 9% ¥3.5m-7m 12% over ¥7m
Municipal Inhabitants Tax		
Per capital tax	1,200-4,000	12,000 up to ¥10m 20,000 ¥10m-¥100m 40,000 over ¥100m
Income tax	standard rate 8.1% maximum rate 9.7%	standard rate 12.1% maximum rate 14.5%

Table B.1: Local taxes in Japan in 1963 and 1976

because Japan has used tax-free reserves for investment incentives instead of generous capital allowance. Depreciation is computed by using the DB method switching to the SL method. The law provides useful lives for various categories of assets and the rates of depreciation for both the SL method and the DB method. All assets can be depreciated up to 90% until 1963 and 95% from 1964. Here, it is assumed that the life time of the machinery and buildings are 9 years and 43 years. These are life times for the machinery in a petrochemical plant and for ferroconcrete factory building. The DB rate per annum are 22.6% and 5% and later they will change to SL method.

For computing cost, the *LIFO* method has been allowed.

[3] Investment grants and incentives

Japan implemented rigorous industrial policies to stimulate investments in key industries by tax exemption, tax credit, or special depreciation, for example, in the petrochemicals and exports industries in the 1950s and 1960s. These tax incentives have been phased out because of the large fiscal deficit since 1970s. At the same time, the Japanese government had used a wide range of investment incentives such as initial depreciations and accelerated depreciations for specific industries and assets. R&D, energy-saving and anti-pollution have been the main targets of investment incentives. Recently, import incentives were available during 1990-1998 and capital investment in computer systems receives special tax incentives.

However, throughout the period, there are no tax incentives which are available to general investments.

B.14 Luxembourg

[1] Tax rates

The basic rate of Corporation tax was 40%, which changed to 45% in 1970, to 40% in 1971, to 38% in 1987, to 36% in 1988, to 33% in 1991, to 32% in 1996, to 31% in 1997 and to 30% in 1998.

A surtax, Solidarity tax, was levied. Before 1981, the surtax rate was 1% of Corporate income tax, which changed to 0.5% in 1976, to 2% in 1982, to 3% in 1986, to 2% in 1988, to 1% in 1991 and to 4% in 1995.

There had been surcharges which were repaid later. For example, only in 1973, there was 5% surcharge and the payment was reimbursed not later than the end of 1975. Therefore, we do not consider this surcharge.

Municipal business tax on income is levied at a rate of 4% on adjusted income, which is reduced by an allowance of LF 700,000.[21] The tax is then multiplied by a coefficient that ranges from 200% to 350%, depending on the commune where the company is located. The coefficient was 140-250%, which was increased to 140-300% in 1965, to 140-350% in 1967 and 140-370% in 1973. We use the maximum rates. The tax is deductible as an expense from its own as well as from the corporate income tax base. Therefore, the nominal rate of 10% is equivalent to an effective rate of 9.09%.

[2] Capital allowances

The depreciation must be calculated on the normal life of the asset. Depreciation is normally calculated using the SL method. However, the DB method is permitted for other than buildings and intangible assets. The depreciation rate for the DB method may not exceed three times the rate for the SL method or 30%. It is permissible to change from the DB method to the SL method.

Inventory is valued at the cost price or selling value, whichever is lower. Cost price is determined by the *FIFO* method. The *LIFO* method is not permitted unless it approximates actual physical flows. In 1996, the *LIFO* method was permitted.

[3] Investment grants and incentives

Tax credit was available at a rate of 9% of the cost of the machinery for supple-

[21] The allowance was increased to LF800,000 in 1973.

mentary investment and 6% for the first LF 6 million and 2% for the excess of acquisition cost for an new investment during 1967-1983. The rate for the supplementary investment was increased to 12% in 1984. We use the rate for the supplementary investments.

B.15 Netherlands

[1] Tax rates

Corporation tax rate was 47% in 1957, which changed to 45% in 1963, to 47% in 1966, 46% in 1967, to 48% in 1973, to 43% in 1984, to 42% in 1988 and to 35% in 1990[22]. There was 3% of surtax on Corporation tax only in 1971 and 4% only in 1972.

No other taxes, national or local, are levied on corporate income.

[2] Capital allowances

Assets should be depreciated over their economic lives. No specific tables for tax depreciation rates are provided in the law. A number of depreciation methods are permissible if the method is in keeping with sound business practice and is consistently applied. The SL method, DDB method and the switch from DDB method to SL method are allowed. Here, we use actual life times for the buildings, 25 years and for the machinery, 8 years and the DDB method switching to the SL method is used.

[22] The tax rate on the first amount of taxable income (for example, NTG100,000 in 1996) is 40% (38% in 1996), with 35% applying thereafter.

For buildings, accelerated depreciation was granted during 1960-1962. One-third of the initial cost of an asset was written-off at will, subject to a restriction of the maximum annual rate to 6%.

Inventory is valued at the lower of cost or market value. Cost can be determined on the basis of *FIFO* and *LIFO*. A inventory deduction of 4% of the fiscal book value of inventories at the beginning of the year was granted during 1984-1988.

[3] Investment grants and incentives

Investment allowance of 5% of cost in the first two years was granted to the machinery during 1960-1966 and to industrial buildings during 1960-1963. In 1978, tax credit was granted at the rate of 12.5% for general investment. This was to reduce unemployment through the encouragement of new investment. This general investment credit was eliminated in 1988. In 1989, tax credit was granted only to small and medium enterprises, which was replaced by investment deduction in 1990.

B.16 New Zealand

[1] Tax rates

In 1956, Income tax rate was 8s 8d, which was changed to 8s 6d in 1958. In 1967, Income tax rate for corporations was 42.5%, which changed to 50% in 1969, to 45% in 1971, to 28% in 1988 and to 33% in 1989.

Until 1974, there was Excess Retention Tax, which was imposed on undistributed profits of private companies at a rate of 35%. We do not consider this tax because it was imposed on the excess of undistributed profits over certain amount.

There are no local taxes on corporate income.

[2] Capital allowances

Before 1984, the machinery was allowed to be depreciated by the DB method at an annual rate of 10%. There were special additional depreciations during 1960-1975. For the machinery, 6%, 5%, 4%, 3% and 2% were added to the normal depreciation before 1962 and 10%, 5%, 3% and 2% were added on and after 1962. In 1975, 25% of the first year allowance was granted. In 1984, depreciation by the DB method at an annual rate of 10% was allowed. In 1991, the rate was increased to 12.5%.

Industrial buildings were depreciated by the SL method at an annual rate of 1%.

Since 1993, new depreciation rates have been applied for the machinery and buildings. However, we do not have enough information and thus we use the same rates before 1993, 12.5% and 1% for the machinery and buildings.

Inventory may be valued at cost price, replacement price or market selling value. $LIFO$ is not permitted.

[3] Investment grants and incentives

There was investment allowance of 10% for the machinery during 1963-1966. During 1975-1980, four investment allowances were granted; Regional allowances except Auckland and Wellington, Industrial Development Plan allowance, High Priority Activity allowance and Exporting Manufacturing allowance. We consider only the Regional allowance of 20% of allowance for the machinery and buildings because the rest were not granted to the general investments. These allowances did not reduce the cost of assets for depreciation.

In 1984, a special investment allowance up to 40% was granted for the machinery, which terminated in 1988. The special investment allowance did not reduce the cost of asset for tax depreciation.

The government no longer offers general incentives except some limited grant assistance to create new jobs.

B.17 Norway

[1] Tax rates

During 1957-1966, State income tax was levied at a rate of 30%, which was lowered to 26.5% in 1970, to 27.8% in 1977 and to 28% in 1988.

In addition, Commutal income tax was levied by county districts and municipals at a rate of 14-18%, which was raised to 16-19% in 1963, to 17-20% in 1970, to 18-22% in 1977 and to 18-21% in 1979. Maximum tax rates are used in computing the METRs.

From 1964, 5% of Equalization Levy was taxed. The rate was decreased to 3% in 1970, to 1.7% in 1973 and to 1% in 1977. These two taxes were not deducted from the taxable income base for State income tax.

There was a tax reform in 1992. The national income tax was no longer applicable. Local income tax rate became 28% including contribution to the tax equalization fund.

During 1966-1972, Special Development tax, to finance Norwegian aid to developing countries, was levied at the rate of 0.25% in 1966, 0.5% in 1969, 1% in 1970 and 1.3% in 1972.

[2] Capital allowances

Until 1965, the SL method was used and the standard rates were given by the State Taxation Authorities. We assume that useful lives for the machinery and for buildings were 8 years and 40 years. Since 1966, the DB method of depreciation is mandatory for tax purpose. For the machinery, the rate was 30%, which is decreased to 20% in 1984. For industrial buildings, the rate was 7%, which was lowered to 5% in 1984.

During 1966-1979, for the machinery, an additional allowance, 50% of the normal depreciation could be claimed for the first 5 years. For industrial buildings, an additional allowance, 25% of the normal depreciation, could be claimed for the first 5 years.

The *FIFO* is used for calculating cost price while the *LIFO* method is not permitted.

[3] Investment grants and incentives

There are no general investment incentives. However, investment incentives are granted by local agencies and normally take the form of cheaply available developed industrial sites. Norwegian Industrial and Regional Development Fund (SND) helps enhance profitable businesses and economic trade development throughout the country. The SND's most common client are small-medium businesses in need of risk capital and long-term capital.

B.18 Portugal

[1] Tax rates

Industrial tax rate was 15%, which changed to 18% in 1968, to 15% in 1971, to 18% in 1974 and to 20% in 1976. There were five surcharges on Industrial tax; 14% of Municipal surcharge which changed to 15% in 1971, 45% of Tax on Trade and Industry[23], 3% of Tax on Tourism, 2% of District Council Surcharge, 8% of State Surcharge on Tax on Trade and Industry.

Tax on Income from capital was 15%, which was changed to 18% in 1971, to 15% in 1974 and to 22% in 1977. There were two surcharges on Tax on Income from capital; 10% of Municipal surcharge and 2% of District Council Surcharge.

Complementary tax was levied at a rate of 8%, which was increased to 12% in 1976. There was 25% of State surcharge on Complementary Tax. In 1977, there was a surcharge on Complementary tax at a rate of 15%. In 1985, Complementary tax was suspended.

All these taxes were increased by 10% in 1976 and 15% in 1978.

The corporate tax rate was 40%, which was decreased to 35% in 1988, to 36% in 1989 and to 34% in 1996. Additional tax which varied up to 10% was levied by

[23]This is the tax rate in Lisbon and Oporto.

municipals. As OECD (1991) did, we use 7.5%, the middle value between 5% for Lisbon and 10% for Oporto. In 1991, the additional tax changed to 10% surtax.

We do not include Defence tax, which was levied at a rate of 10% on the profits arising from the operation in Portugal of public concessions, industrial monopolies or other privileged commercial activities such as arms dealers and manufacturers. We also do not consider the taxes of specific areas. For example, Industrial tax in certain areas such as Northern Portugal, the North and South of Oporto but excluding Oporto itself is surcharged at 7%, 9% or 10%. The surcharge is paid to the autonomous port authorities.

[2] Capital allowances

Depreciation is allowed in an amount agreed by the revenue authorities as being reasonable. For the machinery, the rate of the SL method is 12.5% and the rate of the DB method is 2.5 times of the rate of the SL method. The switch-over from the DB method to the SL method is not permitted. Rates can be increased up to 50% when assets are used for more than one shift. We assume that assets are used for one shift.

For industrial buildings, the rate of the SL method was 4%, which was increased to 5% in 1991 but depreciation by the DB method has not been permitted.

For the valuation of the inventory, $LIFO$ is expressly permitted for statutory accounting and is normally accepted by the tax authorities.

[3] Investment grants and incentives

There was a tax credit. Companies were allowed to deduct 10% of investment made in new plant and equipment from corporation tax in 1986, which was lowered to 8% in 1987, to 6% in 1988 and to 4% in 1989. In 1990, the tax credit was no longer available.

Government policy is to stimulate investment in depressed areas and industries. The general tax benefits and incentives are available as forms of exemption of the capital gains tax , exemption of corporate tax on dividends, and exemption of personal and corporate income tax on interest on bonds. Financial incentives are available for specific activities such as regional development, R&D, agriculture, tourist, energy, trade and telecommunications projects. None of these incentives are included in computing the METRs.

B.19 Spain

[1] Tax rates

The corporation tax rate was 30% in 1959, which was raised to 32% in 1976. There was Additional tax for Joint-stock companies, which were prevalent forms of corporation in Spain, at a rate of 4%. Additional tax was not allowable expense for Company tax.

Only in 1968, there was Special Temporary tax of 10% and, during 1975-1978, Temporary surtax was 10%.

The income of a corporation was subject to the licence fee and local taxes[24], which were surcharges on the licence fee. However, we do not consider the licence fee and its surcharges due to lack of information about the amount.

A major reform of Spanish income taxes was carried out with effect from 1979. The previous Schedular system was abandoned and a new single national tax on the income of individuals and a corresponding tax on the income of companies were introduced. Company tax rate was 33% in 1979 and 35% in 1984. There is no local tax but a tax of 1.5% [25] levied by the Chamber of Commerce, which was changed to 2% in 1984, to 1.5% in 1993, to 1% in 1995, to 0.8% in 1997 and to 0.75% in 1998. This surtax is deductible.

[2] Capital allowances

Throughout the period, assets can be depreciated by the DB method or the SL method. Therefore, we assume that the machinery and buildings are depreciated by the DB method.

For the machinery, until 1978 the DB method of 30% was generally accepted. The annual rate could be increased to 40%. Since 1979, there have been guideline rates of depreciation by both industry sector and asset type, expressing a maximum rate per annum and a maximum number of years. For the general machinery, the maximum rate was 8% for the SL method, which was increased to 10% in 1990 and to 15% in

[24]Provincial surcharge was 38% of the licence fee and Municipal surcharge was 18% of the licence fee.

[25]The tax base of the surtax is not exactly the same as that of corporation income tax.

1993. The rate for the DB method is 200% of the SL rate.[26] During 1993-1994, the depreciation was allowed to be accelerated up to 1.5 times of normal depreciation.

For industrial buildings, the maximum rate is 3% for the SL method. Since 1979, the DB method has been allowed. The rate for the DB method was 200% of the rate of the SL, which was increased to 250% in 1990.

Until 1990, the *LIFO* was not permitted. Since 1991, *FIFO* and *LIFO* have been accepted.

[3] Investment grants and incentives

An investment tax credit of 12% could be taken in the first year on the acquisition of a new asset. The investment tax credit was changed to 15% in 1985, to 10% 1989, and to 5% in 1990. The investment credit was repealed in 1994. The higher investment credit is applied to the specific activities such as 20% for research and development and 25% for exportation activities.

There are also tax credits and tax deductions for specific activities such as new technology, small and medium sized firms, job creation, regional investment, R&D investments, etc.

B.20 Sweden

[1] Tax rates

[26]The most profitable method is the SYD with 8 years of useful life. However, we compute capital allowance by the DB method because the DB is normally used and the SYD method cannot show the change in the depreciation.

In 1958, Company tax rate was 50%, which changed to 40% in 1960 and to 32% in 1984. The tax rate was increased to 52% in 1985 due to the incorporation of the local tax. The tax rate was decreased to 30% in 1991 and further to 28% in 1994.[27]

Local corporation tax was imposed until 1984. The rate was 16% until 1966 and 29% afterwards. The local taxes were deductible from the tax base of the national corporation tax. After 1985, local tax was incorporated into the national company tax.

[2] Capital allowances

For the machinery, the acquisition cost may be depreciated at an annual rate of 30% by the DB method. However, a firm is free to write-off an amount needed to bring the remaining value down to what would have been if the firm had written 20% of the original amount invested from the outset. With this arrangement, it is profitable for a firm to switch from the DB method at an annual rate of 30% to the SL method at an annual rate of 20% after 3 years.[28]

For buildings, depreciation is carried out by the SL method and the life time varies according to its type and use, which is specified by the guideline of the tax authorities. According to the estimate of King and Fullerton (1984), the buildings are assumed to be written off using a life time of 28 years. Since 1970, buildings have been depreciated more favourably. During the first five years, firms are allowed to

[27]There has been Undistributed Profit Tax, which is levied on the undistributed profits of joint-stock companies. The tax is charged at a flat rate of 25% on the difference between the amount deemed to constitute a reasonable distribution and the amount actually distributed.

[28]This method is called book depreciation.

deduct an additional 2% per year, which shortens the tax life time of the asset. With the original 28 years, time life becomes to 25 years with 2% extra depreciation. Since 1984, the life time of buildings has changed to 25 years.

Inventories are valued at acquisition cost or market value, whichever is lower. The acquisition cost is determined on a *FIFO* basis. *LIFO* is not permitted. According to King and Fullerton (1984), a deduction was allowed up to a maximum of 60% of the value of net purchases of inventories during 1980-1984 and 50% during 1985-1990.

[3] Investment grants and incentives

The Investment fund (IF) is one of important features of the Swedish corporate income tax. It is to induce firms to reserve profits during boom years to be used for investments during subsequent recessions. Each year a firm can deduct up to 50% of its tax profits by allocating an equivalent amount to its investment fund. This reduces tax payment by an amount equal to the allocation times the statutory corporate tax. According to King and Fullerton (1984), however, firms financed less than 20% of their investments by IF during 1970s when the IF was extensively used. We do not consider IF in computing the METRs.

B.21 Switzerland

[1] Tax rates

The maximum rate of National Defence tax was 8% in 1967. Since 1971, Federation corporate income tax rates had been progressive, based on the ratio of taxable income to net taxable equity. The overall maximum rate was 9.8% when taxable income was in excess of approximately 23.15% of equity. Since 1998, the Swiss Federation has levied direct corporation income tax at a flat rate of 8.5% on profits.

We take local taxes applied to Geneva. The tax rate is computed by

$$\text{Basic tax rate} \times \text{multiplier}.$$

The basic tax rates are determined based on a formula such as

$$\frac{\text{Taxable income}}{\text{Equity}} \times \text{Coefficient}.$$

For Geneva, minimum and maximum basic rates were 3% and 15% and the multiplier is 1.875, which changed to 1.86 in 1961, to 1.85 in 1962, to 1.86 in 1963, to 2.16 in 1964, to 2.18 in 1965, to 2.20 in 1966, to 2.26 in 1967 and to 2.28 in 1968.

The local tax payment is not deducted from the profit of firms in terms of Federation corporate income tax base.

Since 1998 with the introduction of the flat rate of Federation corporate income tax, all taxes have been treated as tax-deductible expenses.

[2] Capital allowances

The rates must reasonably reflect the normal period of exhaustion and/or wear and tear. The Federal tax authorities have indicated depreciation rates for many types of assets on the basis of the DB method. If the SL method is used, depreciation by one-half of these rates is permissible. The allowance may, at the taxpayer's option, be calculated by either the SL method or the DB method. It is assumed that the switch from the DB method to the SL method is not permitted.

Inventories may not be valued in excess of the lower of cost or market value. Cost is generally determined by the *FIFO*. *LIFO* is not found in practice. Since 1984, it is permissible to write down inventories by one-third of the purchase or market value without further justification.

[3] Investment grants and incentives

The federal government maintains a policy of neutrality in encouraging investing in Switzerland and no general incentives are granted. However, federal government grants may be claimed for investments in specific regions threatened by economic decline. The promotion of industry is primarily under the responsibility of the cantons and a wide variety of investment incentives are granted by cantonal and communal governments. Tax and non-tax incentives are granted on a case-by case basis and thus none of incentives are included in computing the METRs.

B.22 Turkey

[1] Tax rates

Tax rate was 40% in 1984 and 46% in 1988. Supplemental levies amounted to 6% of the corporation tax, which was increased to 7% in 1991 and to 10% in 1992.

Since 1994, corporations are liable to Corporate tax and Withholding tax. The amount of paid Corporate tax is deducted from tax base for Withholding tax. Corporation tax is imposed at a rate of 25%, which was increased to 30% in 1999 and

Withholding tax is imposed at a rate of 20%.

There are no local income taxes.

[2] Capital allowances

Depreciation was given by the SL method or the DB method and the switch from the DB method to the SL method is permissible. If the taxpayer switches from the DB method to the SL method, the remaining value of the asset is equally divided over the remaining years.

For the SL method, the annual rate was 25% for the machinery and 4% for buildings. The rate for the DB method was 200% of the rates of the SL method. From 1983, for the machinery, the SL method up to 25% per annum and the DB method up to 50% per annum were available. Since 1995, the rates have been reduced to 20% and 40%.

[3] Investment grants and incentives

Investment allowance depends on the type of asset and region of the investment. Investments approved by the States Planning Organization (SPO)[29] benefit 30-100% reduction of cost from taxable income.

B.23 United Kingdom

[1] Tax rates

In the UK, the separate taxation of corporations started in 1947, until when the

[29]In 1992, the approval was granted by Undersacretariat of Treasure and Foreign Trade.

taxation of corporate profits was integrated with the personal income tax. After 1947, the corporation tax system has subsequently changed and thus the tax rate has changed also. The major changes occurred in 1958, 1965, 1973 and 1984.

Between 1947-1958, a two-rate system was in force, in which undistributed profits were taxed at a relatively lower rate of profits tax and distributed profits were taxed at a higher rate. In 1958, the differential elements in profit taxation were abolished. Both distributed and undistributed profits were taxed at a single rate. In addition, shareholders were given credit for the tax paid on dividends at the corporation level. Companies were liable to income tax at the standard rate and to profits tax as well. Profit tax payable was allowable as a deduction in computing profits for income tax purpose. The standard income tax rate was 8s 3d and profit tax rate was 12.5%, which was changed to 15% in 1961.

The election of a Labour government in 1965 saw the introduction of a straightforward system of corporation tax. Under the new system, profits were taxed at a single rate of 40%, which was increased to 42.5% during 1967-1969.

But in 1973, the Conservative government went back to an imputation system with a single rate of corporation tax, where corporation tax rate was increased from 40% to 52%, which was lowered to 50% in 1983. At the same time, two corporate tax rates, full rate for large corporations and special rate for small corporations, were introduced. Only the full rate is considered in computing the METRs. The other change in 1973 reform was Advanced Corporation Tax (ACT).[30] Corporations were required to make advanced payment of corporation tax for the distributed profits. These payments entitled the shareholders to tax credits of corresponding amounts which were set off against their liability to income tax at the basic rate in the gross dividend. When the corporations paid their corporation tax bill, the ACT paid was deducted from the gross liability calculated on all profits. Here, we do not consider ACT because the corporation is assumed to have enough profit to set the ACT off against the total corporation tax bill.

The tax rate was substantially reduced during 1984-1986 as part of a range of measures which induced the abolition of stock relief and the reduction of capital allowances. The tax rate was 45% in 1984, 40% in 1985 and 35% in 1986. In 1990s, the tax rates have been lowered mainly due to the economic recession. The tax rate was lowered to 34% in 1990, to 33% in 1991, to 31% in 1998 and to 30% in 1999.

[2] Capital allowances

Throughout the period, capital allowances for the machinery is calculated by the DB method at an annual rate of 25% and capital allowance for buildings is calculated by the SL method at an annual rate of 4%. For the machinery, the first-year allowance at a rate of 30% was granted in 1960, which was replaced by the initial allowance in 1970. The rate of initial allowance was 60% in 1970, which was increased to 80% in 1971 and 100% in 1972. The initial allowance was decreased to 75% in 1984 and to

[30]The ACT was repealed in 1999.

50% in 1985 and finally terminated in 1986.

For buildings, the first-year allowance had been given before 1986. The rate was 15% in 1960, which changed to 30% in 1970, to 40% in 1972, to 50% in 1974, 75% in 1981, 50% in 1984 and to 25% in 1985.

Only in 1992, there were the first-year allowances; 40% for the machinery and 20% for buildings.

Inventories have been taxed on a *FIFO* basis. During 1974-1979, however, companies were allowed to deduct for tax purposes the excess of the change in the book value of inventories over 15% of trading profits measured after depreciation allowances for tax purposes. King and Fullerton (1984) claim that at the margin the scheme not only offered relief for the effect of inflation but also granted immediate expensing on the purchase of inventories and thus inventories could be thought to be taxed according to the *LIFO* method in this period. We would follow their consideration.

[3] Investment grants and incentives

All investments in manufacturing were qualified for investment grants of 20-45% between 1966-1970. However, general cash grants have not been available since 1971. Only Regional Assistance and National Selective Assistance are available. Regional Assistance is to stimulate industrial investment in those areas suffering from high unemployment and National Selective Assistance is given on discretion of the government. King and Fullerton (1984) estimated the former grant to be 19.46% for machinery and 14.76% for buildings. Here, we only consider the grants of 32.5%, which was the simple average of the minimum rate and the maximum rate, for 1966-1970.

All the other current investment incentives such as cash grants for investments in manufacturing and certain service industries, 100% of capital allowances for investments in the Enterprise Zone and tax exemption for investments in the Free zone are not considered in computing the METRs.

B.24 United States

[1] Tax rates

The federal corporate income tax started in 1913 at a rate of 1%. Since then, the tax rate had been gradually increased to around 50%. During 1954-1963, corporate income was taxed at the rate of 52% by the federal corporate income tax. The tax rate was decreased to 50% in 1964, to 48% in 1965 and to 46% in 1979. In 1980, the federal corporate income tax was changed to a graduated rate structure, with a tax rate of 46% on the income above $100,000. We use only the tax rate of the highest income band. The tax rate for the highest income band was drastically decreased to 34% in 1986 but increased to 35% in 1993.

A tax surcharge was imposed at a rate of 10% during 1968-1969 and at a rate of 5% in 1970.

States and municipal taxing authorities impose corporate income taxes on corporations within their jurisdictions. Tax rates and tax bases are different among states and municipals. Here, we use the tax rate of 6.55% throughout the period, which is estimated for 1980 by King and Fullerton (1984). Those local taxes are deductible from the corporation income for the federal corporate income tax.

[2] Capital allowances

The United states have had the most complicated capital allowance scheme and the scheme has been changed frequently. The 1954 Code, adopted in 1956 was a basic legislation on the tax depreciation. The regulation was supplemented by a set of 'Depreciation Guidelines and Rules' (hereafter the Guideline) published by the Internal Revenue Service in 1962.

Before 1981 when the Economic Recovery Tax Act of 1981 introduced the Accelerated Cost Recovery System (ACRS), the capital allowance for machinery was calculated by the DDB method switching to the SYD method. The life time for the machinery was 8 years during 1960-1970[31] and 7 years[32] during 1971-1980 because the Asset Depreciation Range in 1971 made all assets to be depreciated at the rate of 20% shorter than the Guideline suggested.[33] Since 1981, the life time for all the machinery have been 5 years and capital allowances have been calculated by the DB method switching to the SL method. The rate of the DB method was 1.5 times the SL rate, which was increased to DDB in 1986.

[31] The Guidelene shortened the useful lifes of assets by 30-40%. However, we do not consider this change because companies could not recieve full investment credit if the useful life was less than 7 years.

[32] To get full Investment Credit, the life time of asset must be 7 years at least.

[33] The 20% shortening of the life time was not applied to the buildings except public utility structures.

During 1960-1968, the life time for industrial buildings was 25 years and the capital allowances were calculated by the DDB method switching to the SL method. In 1969, the DDB method was decreased to the 150% DB method. In 1981, the useful life was shortened to 15 years and 175% DB method was used. In, 1986, the life time was increased to 30 years and only the SL method was used. Since 1993, the life time has been increased to 39 years.

Throughout the period, the half-year convention is considered, for all assets, the machinery as well as buildings. In addition, since 1981, the depreciation of the last half year has been moved up to the preceding year only for the machinery. These are discussed in detail in the section for the methodology.

Inventories have been valued by the *LIFO* method throughout the period.

[3] Investment grants and incentives

The Investment Tax Credit (ITC) was introduced in 1962 at 7% only on the machinery. The ITC did not reduce the basis of the depreciation. It was repealed in 1969 but reintroduced in 1971 at a rate of 7%. A 1975 act temporarily increased the credit 10%. In 1978, the 10% credit was made permanent. The Tax Equity and Fiscal Responsibility Act of 1982 reduced the depreciation basis by half of the investment tax credit. Since 1986, the ITC has been no longer available.

Appendix C

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Appendix D

Tax data used in computing MECTRs

variable	description
ntax	national corporation tax rate
ltax	local corporation tax rate
stax	surtax on the corporation tax rate
ttax	total nominal tax rate
metr	marginal effective tax rate
ded	0 indicates local tax is not deducted from tax base of national tax
	1 indicates local tax is fully deducted from tax base of national tax
invent	0 indicates inventory is valued by LIFO
	1 indicates inventory is valued by FIFO
srelief	stock relief
m, b, i	m for machinery, b for buildings and i for inventory
method	0 indicates straight line method
	1 indicates declining balance method
	2 indicates sum of the year's digits method
incent	tax credit
cash	cash grant
1, 2, 3, 4	the sequence of applying capital allowance method when it change
a	total capital allowance for machinery or building
p	pre-tax rate of return

Table D.1: A description of abbreviations used in the statistic sheets(1)

country	variable	description
Austria	atax	additional tax
Canada	ftax	federal surtax
	pbate	provisional abatement
	mbate	manufacturing and processing deduction
Finland	ctax	commutal tax
Ireland	ctax	corporation profit tax
Italy	ctax	company tax
	wtax	movable wealth tax
Japan	piitax	prefectural inhabitants income tax
	pictax	prefectural inhabitants per capita tax
	miitax	municipal inhabitants income tax
	mictax	municipal inhabitants per capita tax
	pretax	prefectural enterprise tax
Norway	etax	equalization levy
	sdtax	special development tax
Portugal	indtax	industrial tax
	catax	tax on income from capital
	comtax	complementary tax
	alltax	tax increase for all taxes
Spain	atax	additional tax
	chtax	chamber of commerce levy
Turkey	wtax	withholding tax

Table D.2: A description of abbreviations of specific capital income taxes

Appendix E

Macroeconomic data used in grouping and estimation

variable	description
tax	marginal effective tax rates
un	unemployment rate
rev	total tax revenue/GDP
op	openness measured by (export+import)/GDP
loggdp	log GDP
logpo	log population
cop	simple centred 3-point moving average of the openness measured by (inflow+outflow of investment)/GDP

Table E.1: A description of abbreviations used in the statistic sheets(2)

	year	ntax	ltax	ded	invent	mrate1	myear1	mmethod1	brate1	byear1	bmethod1
1	1960	.3500	.	.	1	.1500	.	1	.	.	.
2	1961	.3500	.	.	1	.1500	.	1	.	.	.
3	1962	.3500	.	.	1	.1500	.	1	.	.	.
4	1963	.3500	.	.	1	.1500	.	1	.	.	.
5	1964	.3750	.	.	1	.1500	.	1	.	.	.
6	1965	.3750	.	.	1	.1500	.	1	.	.	.
7	1966	.3750	.	.	1	.1500	.	1	.	.	.
8	1967	.4750	.	.	1	.1500	.	1	.	.	.
9	1968	.4750	.	.	1	.1500	.	1	.	.	.
10	1969	.4750	.	.	1	.1500	.	1	.	.	.
11	1970	.4750	.	.	1	.1500	.	1	.	.	.
12	1971	.4750	.	.	1	.1500	.	1	.	.	.
13	1972	.4750	.	.	1	.1500	.	1	.	.	.
14	1973	.4750	.	.	1	.1500	.	1	.	.	.
15	1974	.4500	.	.	1	.1500	.	1	.	.	.
16	1975	.4250	.	.	1	.2000	.	1	.	.	.
17	1976	.4250	.	.	1	.2000	.	1	.	.	.
18	1977	.4250	.	.	1	.2000	.	1	.	.	.
19	1978	.4250	.	.	1	.2000	.	1	.	.	.
20	1979	.4250	.	.	1	.3500	.	1	.	.	.
21	1980	.4250	.	.	1	.3500	.	1	.	.	.
22	1981	.4250	.	.	1	.3300	.	1	.	.	.
23	1982	.4250	.	.	1	.2000	5.0	0	.0250	40.0	0
24	1983	.4250	.	.	1	.2000	5.0	0	.0250	40.0	0
25	1984	.4600	.	.	1	.2000	5.0	0	.0250	40.0	0
26	1985	.4600	.	.	1	.2000	5.0	0	.0400	25.0	0
27	1986	.4600	.	.	1	.2000	5.0	0	.0400	25.0	0
28	1987	.4900	.	.	1	.2000	5.0	0	.0400	25.0	0
29	1988	.3900	.	.	1	.1875	.	1	.0600	.	1
30	1989	.3900	.	.	1	.1875	.	1	.0600	.	1
31	1990	.3900	.	.	1	.1875	.	1	.0600	.	1
32	1991	.3900	.	.	1	.1875	.	1	.0600	.	1
33	1992	.3900	.	.	1	.3000	.	1	.1000	.	1
34	1993	.3300	.	.	1	.3000	.	1	.1000	.	1
35	1994	.3300	.	.	1	.3000	.	1	.1000	.	1
36	1995	.3600	.	.	1	.3000	.	1	.1000	.	1
37	1996	.3600	.	.	1	.3000	.	1	.1000	.	1
38	1997	.3600	.	.	1	.3000	.	1	.1000	.	1
39	1998	.3600	.	.	1	.3000	.	1	.1000	.	1

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	mincent	bincent	ttax	ma	ba	mp	bp	ip	metr
1	.2000	.	.350	.6000	.0000	.0698	.0985	.1038	.4246
2	.2000	.	.350	.6000	.0000	.0698	.0985	.1038	.4246
3	.2000	.	.350	.6000	.0000	.0698	.0985	.1038	.4246
4	.2000	.	.350	.6000	.0000	.0698	.0985	.1038	.4246
5	.2000	.	.375	.6000	.0000	.0720	.1040	.1100	.4512
6	.2000	.	.375	.6000	.0000	.0720	.1040	.1100	.4512
7	.2000	.	.375	.6000	.0000	.0720	.1040	.1100	.4512
8	.2000	.	.475	.6000	.0000	.0832	.1314	.1405	.5535
9	.2000	.	.475	.6000	.0000	.0832	.1314	.1405	.5535
10	.2000	.	.475	.6000	.0000	.0832	.1314	.1405	.5535
11	.2000	.	.475	.6000	.0000	.0832	.1314	.1405	.5535
12	.1800	.	.475	.6000	.0000	.0862	.1314	.1405	.5589
13	.1800	.	.475	.6000	.0000	.0862	.1314	.1405	.5589
14	.1800	.	.475	.6000	.0000	.0862	.1314	.1405	.5589
15	.1800	.	.450	.6000	.0000	.0827	.1236	.1318	.5339
16	.1800	.	.425	.6670	.0000	.0709	.1165	.1239	.4890
17	.1800	.	.425	.6670	.0000	.0709	.1165	.1239	.4890
18	.1800	.	.425	.6670	.0000	.0709	.1165	.1239	.4890
19	.1800	.	.425	.6670	.0000	.0709	.1165	.1239	.4890
20	.1800	.	.425	.7778	.0000	.0566	.1165	.1239	.4530
21	.1800	.	.425	.7778	.0000	.0566	.1165	.1239	.4530
22	.1800	.	.425	.7674	.0000	.0579	.1165	.1239	.4565
23	.1800	.	.425	.7869	.2454	.0554	.1002	.1239	.4184
24	.1800	.	.425	.7869	.2454	.0554	.1002	.1239	.4184
25	.1800	.	.460	.7869	.3672	.0562	.0985	.1352	.4360
26	.1800	.	.460	.7869	.3672	.0562	.0985	.1352	.4360
27	.0000	.	.460	.7869	.3672	.0818	.0985	.1352	.5007
28	.0000	.	.490	.7869	.3750	.0858	.1040	.1461	.5299
29	.0000	.	.390	.6522	.3750	.0889	.0860	.1139	.4697
30	.0000	.	.390	.6522	.3750	.0889	.0860	.1139	.4697
31	.0000	.	.390	.6522	.3750	.0889	.0860	.1139	.4697
32	.0000	.	.390	.6522	.3750	.0889	.0860	.1139	.4697
33	.0000	.	.390	.7500	.5000	.0780	.0788	.1139	.4266
34	.0000	.	.330	.7500	.5000	.0715	.0722	.0993	.3643
35	.0000	.	.330	.7500	.5000	.0715	.0722	.0993	.3643
36	.0000	.	.360	.7500	.5000	.0746	.0753	.1063	.3956
37	.0000	.	.360	.7500	.5000	.0746	.0753	.1063	.3956
38	.0000	.	.360	.7500	.5000	.0746	.0753	.1063	.3956
39	.0000	.	.360	.7500	.5000	.0746	.0753	.1063	.3956

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	year	ntax	stax	atax	ltax	ded	invent	mrate1	myear1	mmethod1	mrate2
1	1960	.4400	.1800	.0000	.1500	1	1	.3000	1.0	0	.1000
2	1961	.4400	.1800	.0000	.1500	1	1	.3000	1.0	0	.1000
3	1962	.4400	.1800	.0000	.1500	1	1	.3000	1.0	0	.1000
4	1963	.4400	.1800	.0000	.1500	1	1	.3000	1.0	0	.1000
5	1964	.4400	.1800	.0000	.1500	1	1	.3000	1.0	0	.1000
6	1965	.4400	.1800	.0000	.1500	1	1	.3000	1.0	0	.1000
7	1966	.4400	.2100	.0000	.1500	1	1	.3000	1.0	0	.1000
8	1967	.4400	.2100	.0000	.1500	1	1	.3000	1.0	0	.1000
9	1968	.4400	.2100	.0000	.1500	1	1	.3000	1.0	0	.1000
10	1969	.4400	.2100	.1000	.1500	1	1	.3000	1.0	0	.1000
11	1970	.4400	.2100	.1000	.1500	1	1	.3000	1.0	0	.1000
12	1971	.4400	.2100	.1000	.1500	1	1	.3000	1.0	0	.1000
13	1972	.5000	.2100	.1000	.1500	1	1	.3000	1.0	0	.1000
14	1973	.5000	.0000	.0000	.1500	1	1	.3500	1.0	0	.1000
15	1974	.5000	.0000	.0000	.1500	1	1	.3500	1.0	0	.1000
16	1975	.5000	.0000	.0000	.1500	1	1	.3500	1.0	0	.1000
17	1976	.5500	.0000	.0000	.1500	1	1	.6000	1.0	0	.1000
18	1977	.5500	.0000	.0000	.1500	1	1	.6000	1.0	0	.1000
19	1978	.5500	.0000	.0000	.1500	1	1	.6000	1.0	0	.1000
20	1979	.5500	.0000	.0000	.1500	1	1	.6000	1.0	0	.1000
21	1980	.5500	.0000	.0000	.1500	1	1	.1000	10.0	0	.
22	1981	.5500	.0000	.0000	.1500	1	1	.1000	10.0	0	.
23	1982	.5500	.0000	.0000	.1500	1	1	.1000	10.0	0	.
24	1983	.5500	.0000	.0000	.1500	1	1	.1000	10.0	0	.
25	1984	.5500	.0000	.0000	.1500	1	1	.1000	10.0	0	.
26	1985	.5500	.0000	.0000	.1500	1	1	.1000	10.0	0	.
27	1986	.5500	.0000	.0000	.1500	1	1	.1000	10.0	0	.
28	1987	.5500	.0000	.0000	.1500	1	1	.1000	10.0	0	.
29	1988	.5500	.0000	.0000	.1500	1	1	.1000	10.0	0	.
30	1989	.3000	.0000	.0000	.1350	1	1	.1000	10.0	0	.
31	1990	.3000	.0000	.0000	.1350	1	1	.1000	10.0	0	.
32	1991	.3000	.0000	.0000	.1350	1	1	.1000	10.0	0	.
33	1992	.3000	.0000	.0000	.1350	1	1	.1000	10.0	0	.
34	1993	.3000	.0000	.0000	.1350	1	1	.1000	10.0	0	.
35	1994	.3000	.0000	.0000	.1350	1	1	.1000	10.0	0	.
36	1995	.3400	.0000	.0000	.0000	.	1	.1000	10.0	0	.
37	1996	.3400	.0000	.0000	.0000	.	1	.1000	10.0	0	.
38	1997	.3400	.0000	.0000	.0000	.	1	.1000	10.0	0	.
39	1998	.3400	.0000	.0000	.0000	.	1	.1000	10.0	0	.

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	myear2	mmethod2	mrate3	myear3	mmethod3	brate1	byear1	bmethod1	brate2	byear2	bmethod2
1	7.0	0	.	.	.	.2400	1.0	0	.0400	19.0	0
2	7.0	0	.	.	.	.2400	1.0	0	.0400	19.0	0
3	7.0	0	.	.	.	.2400	1.0	0	.0400	19.0	0
4	7.0	0	.	.	.	.2400	1.0	0	.0400	19.0	0
5	7.0	0	.	.	.	.2400	1.0	0	.0400	19.0	0
6	7.0	0	.	.	.	.2400	1.0	0	.0400	19.0	0
7	7.0	0	.	.	.	.2400	1.0	0	.0400	19.0	0
8	7.0	0	.	.	.	.0400	25.0	0	.	.	.
9	7.0	0	.	.	.	.0400	25.0	0	.	.	.
10	7.0	0	.	.	.	.0400	25.0	0	.	.	.
11	7.0	0	.	.	.	.0400	25.0	0	.	.	.
12	7.0	0	.	.	.	.0400	25.0	0	.	.	.
13	7.0	0	.	.	.	.0400	25.0	0	.	.	.
14	6.0	0	.0500	1.0	0	.0400	25.0	0	.	.	.
15	6.0	0	.0500	1.0	0	.0400	25.0	0	.	.	.
16	6.0	0	.0500	1.0	0	.0400	25.0	0	.	.	.
17	4.0	0	.	.	.	.0400	25.0	0	.	.	.
18	4.0	0	.	.	.	.0400	25.0	0	.	.	.
19	4.0	0	.	.	.	.0400	25.0	0	.	.	.
20	4.0	0	.	.	.	.0400	25.0	0	.	.	.
21	.	.	.	.	.	.0400	25.0	0	.	.	.
22	.	.	.	.	.	.0400	25.0	0	.	.	.
23	.	.	.	.	.	.0400	25.0	0	.	.	.
24	.	.	.	.	.	.0400	25.0	0	.	.	.
25	.	.	.	.	.	.0400	25.0	0	.	.	.
26	.	.	.	.	.	.0400	25.0	0	.	.	.
27	.	.	.	.	.	.0400	25.0	0	.	.	.
28	.	.	.	.	.	.0400	25.0	0	.	.	.
29	.	.	.	.	.	.0400	25.0	0	.	.	.
30	.	.	.	.	.	.0400	25.0	0	.	.	.
31	.	.	.	.	.	.0400	25.0	0	.	.	.
32	.	.	.	.	.	.0400	25.0	0	.	.	.
33	.	.	.	.	.	.0400	25.0	0	.	.	.
34	.	.	.	.	.	.0400	25.0	0	.	.	.
35	.	.	.	.	.	.0400	25.0	0	.	.	.
36	.	.	.	.	.	.0400	25.0	0	.	.	.
37	.	.	.	.	.	.0400	25.0	0	.	.	.
38	.	.	.	.	.	.0400	25.0	0	.	.	.
39	.	.	.	.	.	.0400	25.0	0	.	.	.

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	mincent	bincent	ttax	mp	bp	ip	tp	metr
1	.0000	.0000	.591	.1156	.1104	.1947	.1338	.6263
2	.0000	.0000	.591	.1156	.1104	.1947	.1338	.6263
3	.0000	.0000	.591	.1156	.1104	.1947	.1338	.6263
4	.0000	.0000	.591	.1156	.1104	.1947	.1338	.6263
5	.0000	.0000	.591	.1156	.1104	.1947	.1338	.6263
6	.0000	.0000	.591	.1156	.1104	.1947	.1338	.6263
7	.0000	.0000	.603	.1187	.1133	.2016	.1378	.6372
8	.0000	.0000	.603	.1187	.1363	.2016	.1447	.6545
9	.0000	.0000	.603	.1187	.1363	.2016	.1447	.6545
10	.0000	.0000	.688	.1497	.1753	.2700	.1875	.7333
11	.0000	.0000	.688	.1497	.1753	.2700	.1875	.7333
12	.0000	.0000	.688	.1497	.1753	.2700	.1875	.7333
13	.0000	.0000	.749	.1854	.2202	.3488	.2367	.7888
14	.0000	.0000	.575	.1057	.1271	.1853	.1320	.6212
15	.0000	.0000	.575	.1057	.1271	.1853	.1320	.6212
16	.0000	.0000	.575	.1057	.1271	.1853	.1320	.6212
17	.0000	.0000	.618	.0869	.1419	.2114	.1346	.6284
18	.0000	.0000	.618	.0869	.1419	.2114	.1346	.6284
19	.0000	.0000	.618	.0869	.1419	.2114	.1346	.6284
20	.0000	.0000	.618	.0869	.1419	.2114	.1346	.6284
21	.0000	.0000	.618	.1539	.1419	.2114	.1647	.6964
22	.0000	.0000	.618	.1539	.1419	.2114	.1647	.6964
23	.0000	.0000	.618	.1539	.1419	.2114	.1647	.6964
24	.0000	.0000	.618	.1539	.1419	.2114	.1647	.6964
25	.2000	.2000	.618	.1002	.1143	.2114	.1322	.6218
26	.2000	.2000	.618	.1002	.1143	.2114	.1322	.6218
27	.2000	.2000	.618	.1002	.1143	.2114	.1322	.6218
28	.2000	.2000	.618	.1002	.1143	.2114	.1322	.6218
29	.2000	.2000	.618	.1002	.1143	.2114	.1322	.6218
30	.2000	.2000	.395	.0702	.0759	.1152	.0832	.3989
31	.2000	.2000	.395	.0702	.0759	.1152	.0832	.3989
32	.2000	.2000	.395	.0702	.0759	.1152	.0832	.3989
33	.0900	.0900	.395	.0822	.0821	.1152	.0904	.4469
34	.0900	.0900	.395	.0822	.0821	.1152	.0904	.4469
35	.0900	.0900	.395	.0822	.0821	.1152	.0904	.4469
36	.0900	.0900	.340	.0754	.0754	.1015	.0819	.3898
37	.0900	.0900	.340	.0754	.0754	.1015	.0819	.3898
38	.1200	.1200	.340	.0729	.0740	.1015	.0804	.3780
39	.1200	.1200	.340	.0729	.0740	.1015	.0804	.3780

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	year	ntax	stax	atax	invent	mrate1	myear1	mmethod1	mrate2	myear2	mmethod2
1	1960	.4000	.0500	.0000	1	.1250	8.0	0	.	.	.
2	1961	.4000	.0500	.0000	1	.1250	8.0	0	.	.	.
3	1962	.4000	.0500	.0000	1	.1250	8.0	0	.	.	.
4	1963	.3500	.0000	.0000	1	.1250	8.0	0	.	.	.
5	1964	.3500	.0000	.0000	1	.1250	8.0	0	.	.	.
6	1965	.3500	.0000	.0000	1	.1250	8.0	0	.	.	.
7	1966	.3500	.0000	.0000	1	.1250	8.0	0	.	.	.
8	1967	.3500	.0000	.0000	1	.1250	8.0	0	.	.	.
9	1968	.3500	.1000	.0000	1	.1250	8.0	0	.	.	.
10	1969	.3500	.1000	.0000	1	.1250	8.0	0	.	.	.
11	1970	.3500	.1000	.0000	1	.1250	8.0	0	.	.	.
12	1971	.3500	.1000	.0000	1	.1250	8.0	0	.	.	.
13	1972	.3500	.2000	.0000	1	.1250	8.0	0	.	.	.
14	1973	.4200	.0000	.0000	1	.1250	8.0	0	.	.	.
15	1974	.4200	.0000	.0000	1	.1250	8.0	0	.	.	.
16	1975	.4800	.0000	.0480	1	.1250	8.0	0	.	.	.
17	1976	.4800	.0000	.0480	1	.1250	8.0	0	.	.	.
18	1977	.4800	.0000	.0480	1	.1250	8.0	0	.	.	.
19	1978	.4800	.0000	.0480	1	.1250	8.0	0	.	.	.
20	1979	.3900	.0000	.0000	1	.2500	4.0	1	.1250	3.0	0
21	1980	.3900	.0000	.0000	1	.2500	4.0	1	.1250	3.0	0
22	1981	.3900	.0000	.0000	1	.2500	4.0	1	.1250	3.0	0
23	1982	.3900	.0000	.0000	1	.2500	4.0	1	.1250	3.0	0
24	1983	.3900	.0000	.0000	1	.2500	4.0	1	.1250	3.0	0
25	1984	.4500	.0000	.0000	1	.2500	4.0	1	.1250	3.0	0
26	1985	.4500	.0000	.0000	1	.2500	4.0	1	.1250	3.0	0
27	1986	.4500	.0000	.0000	1	.2500	4.0	1	.1250	3.0	0
28	1987	.4300	.0000	.0000	1	.2500	4.0	1	.1250	3.0	0
29	1988	.4300	.0000	.0000	1	.2500	4.0	1	.1250	3.0	0
30	1989	.4300	.0000	.0000	1	.2500	4.0	1	.1250	3.0	0
31	1990	.4300	.0000	.0000	1	.2500	4.0	1	.1250	3.0	0
32	1991	.4300	.0000	.0000	1	.2500	4.0	1	.1250	3.0	0
33	1992	.3900	.0000	.0000	0	.2500	4.0	1	.1250	3.0	0
34	1993	.3900	.0000	.0000	0	.2500	4.0	1	.1250	3.0	0
35	1994	.3900	.0300	.0000	0	.2500	4.0	1	.1250	3.0	0
36	1995	.3900	.0300	.0000	0	.2500	4.0	1	.1250	3.0	0
37	1996	.3900	.0300	.0000	0	.2500	4.0	1	.1250	3.0	0
38	1997	.3900	.0300	.0000	0	.2500	4.0	1	.1250	3.0	0
39	1998	.3900	.0300	.0000	0	.2500	4.0	1	.1250	3.0	0

	mrate3	myear3	mmethod3	brate1	byear1	bmethod1	brate2	byear2	bmethod2	brate3	byear3
1	.	.	.	.0400	25.0	0	.	.	.	.	.
2	.	.	.	.0400	25.0	0	.	.	.	.	.
3	.	.	.	.0400	25.0	0	.	.	.	.	.
4	.	.	.	.0400	25.0	0	.	.	.	.	.
5	.	.	.	.0400	25.0	0	.	.	.	.	.
6	.	.	.	.0800	25.0	0	.	.	.	.	.
7	.	.	.	.0400	25.0	0	.	.	.	.	.
8	.	.	.	.0400	25.0	0	.	.	.	.	.
9	.	.	.	.0400	25.0	0	.	.	.	.	.
10	.	.	.	.0400	25.0	0	.	.	.	.	.
11	.	.	.	.0400	25.0	0	.	.	.	.	.
12	.	.	.	.0400	25.0	0	.	.	.	.	.
13	.	.	.	.0400	25.0	0	.	.	.	.	.
14	.	.	.	.0400	25.0	0	.	.	.	.	.
15	.	.	.	.0400	25.0	0	.	.	.	.	.
16	.	.	.	.0400	25.0	0	.	.	.	.	.
17	.	.	.	.0400	25.0	0	.	.	.	.	.
18	.	.	.	.0400	25.0	0	.	.	.	.	.
19	.	.	.	.0400	25.0	0	.	.	.	.	.
20	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0
21	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0
22	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0
23	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0
24	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0
25	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0
26	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0
27	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0
28	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0
29	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0
30	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0
31	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0
32	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0
33	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0
34	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0
35	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0
36	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0
37	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0
38	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0
39	.0469	1.0	0	.0800	9.0	1	.0400	11.0	0	.0322	1.0

	bmethod3	mincent	bincent	ttax	mp	bp	ip	metr
1	.	.0500	.0500	.4200	.0835	.0881	.1224	.4715
2	.	.0500	.0500	.4200	.0835	.0881	.1224	.4715
3	.	.0500	.0500	.4200	.0835	.0881	.1224	.4715
4	.	.0500	.0500	.3500	.0749	.0784	.1038	.3988
5	.	.0500	.0500	.3500	.0749	.0784	.1038	.3988
6	.	.0500	.0500	.3500	.0749	.0784	.1038	.3988
7	.	.0500	.0500	.3500	.0749	.0784	.1038	.3988
8	.	.0500	.0500	.3500	.0749	.0784	.1038	.3988
9	.	.0500	.0500	.3850	.0789	.0830	.1126	.4354
10	.	.0500	.0500	.3850	.0789	.0830	.1126	.4354
11	.	.0500	.0500	.3850	.0789	.0830	.1126	.4354
12	.	.0500	.0500	.3850	.0789	.0830	.1126	.4354
13	.	.0500	.0500	.4200	.0835	.0881	.1224	.4715
14	.	.0500	.0500	.4200	.0835	.0881	.1224	.4715
15	.	.0500	.0500	.4200	.0835	.0881	.1224	.4715
16	.	.0500	.0500	.5280	.1017	.1089	.1619	.5795
17	.	.0500	.0500	.5280	.1017	.1089	.1619	.5795
18	.	.0500	.0500	.5280	.1017	.1089	.1619	.5795
19	.	.0500	.0500	.5280	.1017	.1089	.1619	.5795
20	0	.0600	.0500	.3900	.0685	.0778	.1139	.3951
21	0	.0600	.0500	.3900	.0685	.0778	.1139	.3951
22	0	.0600	.0500	.3900	.0685	.0778	.1139	.3951
23	0	.0600	.0500	.3900	.0685	.0778	.1139	.3951
24	0	.0600	.0500	.3900	.0685	.0778	.1139	.3951
25	0	.0600	.0500	.4500	.0737	.0856	.1318	.4553
26	0	.0600	.0500	.4500	.0737	.0856	.1318	.4553
27	0	.0600	.0500	.4500	.0737	.0856	.1318	.4553
28	0	.0600	.0500	.4300	.0718	.0828	.1254	.4352
29	0	.0600	.0500	.4300	.0718	.0828	.1254	.4352
30	0	.0600	.0500	.4300	.0718	.0828	.1254	.4352
31	0	.0600	.0600	.4300	.0718	.0822	.1254	.4340
32	0	.0600	.0600	.4300	.0718	.0822	.1254	.4340
33	0	.0600	.0600	.3900	.0685	.0773	.0820	.3289
34	0	.0600	.0600	.3900	.0685	.0773	.0820	.3289
35	0	.0600	.0600	.4017	.0694	.0786	.0836	.3397
36	0	.0600	.0600	.4017	.0694	.0786	.0836	.3397
37	0	.0600	.0600	.4017	.0694	.0786	.0836	.3397
38	0	.0600	.0600	.4017	.0694	.0786	.0836	.3397
39	0	.0600	.0600	.4017	.0694	.0786	.0836	.3397

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	year	ntax	stax1	stax2	pbate	mabate	ftax	ltax	ded	invent	srelief
1	1960	.4700	.0300	.0000	.0000	.0000	.0000	.1100	0	1.00	.0000
2	1961	.4700	.0300	.0000	.0000	.0000	.0000	.1100	0	1.00	.0000
3	1962	.4700	.0300	.0000	.0700	.0000	.0000	.1100	0	1.00	.0000
4	1963	.4700	.0300	.0000	.0700	.0000	.0000	.1100	0	1.00	.0000
5	1964	.4700	.0300	.0000	.0700	.0000	.0000	.1100	0	1.00	.0000
6	1965	.4700	.0300	.0000	.0700	.0000	.0000	.1100	0	1.00	.0000
7	1966	.4700	.0300	.0000	.0700	.0000	.0000	.1100	0	1.00	.0000
8	1967	.4700	.0300	.0000	.0700	.0000	.0000	.1100	0	1.00	.0000
9	1968	.4700	.0300	.0300	.0700	.0000	.0000	.1100	0	1.00	.0000
10	1969	.4700	.0300	.0300	.0700	.0000	.0000	.1100	0	1.00	.0000
11	1970	.4700	.0300	.0300	.0700	.0000	.0000	.1100	0	1.00	.0000
12	1971	.4700	.0300	.0000	.0700	.0000	.0000	.1100	0	1.00	.0000
13	1972	.5000	.0000	.0000	.0700	.0000	.0000	.1100	0	1.00	.0000
14	1973	.4900	.0000	.0000	.0700	.0000	.0000	.1100	0	1.00	.0000
15	1974	.4800	.0000	.0000	.0700	.0000	.0000	.1100	0	1.00	.0000
16	1975	.4700	.0000	.0000	.0700	.0000	.0000	.1100	0	1.00	.0000
17	1976	.4600	.0000	.0000	.0700	.0000	.0000	.1200	0	1.00	.0000
18	1977	.4600	.0000	.0000	.0700	.0000	.0000	.1200	0	1.00	.0300
19	1978	.4600	.0000	.0000	.0700	.0000	.0000	.1130	0	1.00	.0300
20	1979	.4600	.0000	.0000	.1000	.0500	.0000	.1350	0	1.00	.0300
21	1980	.4600	.0000	.0000	.1000	.0500	.0000	.1350	0	1.00	.0300
22	1981	.4600	.0000	.0000	.1000	.0500	.0000	.1350	0	1.00	.0300
23	1982	.4600	.0000	.0000	.1000	.0500	.0000	.1350	0	1.00	.0300
24	1983	.4600	.0000	.0000	.1000	.0500	.0000	.1350	0	1.00	.0300
25	1984	.4600	.0000	.0000	.1000	.0500	.0000	.1400	0	1.00	.0300
26	1985	.4600	.0000	.0000	.1000	.0500	.0000	.1400	0	1.00	.0300
27	1986	.4600	.0000	.0000	.1000	.0600	.0500	.1400	0	1.00	.0000
28	1987	.4500	.0000	.0000	.1000	.0200	.0500	.1400	0	1.00	.0000
29	1988	.3800	.0000	.0000	.1000	.0200	.0500	.1450	0	1.00	.0000
30	1989	.3800	.0000	.0000	.1000	.0200	.0500	.1450	0	1.00	.0000
31	1990	.3800	.0000	.0000	.1000	.0200	.0500	.1450	0	1.00	.0000
32	1991	.3800	.0000	.0000	.1000	.0500	.0500	.1450	0	1.00	.0000
33	1992	.3800	.0000	.0000	.1000	.0500	.0500	.1450	0	1.00	.0000
34	1993	.3800	.0000	.0000	.1000	.0600	.0500	.1450	0	1.00	.0000
35	1994	.3800	.0000	.0000	.1000	.0700	.0400	.1450	0	1.00	.0000
36	1995	.3800	.0000	.0000	.1000	.0700	.0400	.1450	0	1.00	.0000
37	1996	.3800	.0000	.0000	.1000	.0700	.0400	.1450	0	1.00	.0000
38	1997	.3800	.0000	.0000	.1000	.0700	.0400	.1450	0	1.00	.0000
39	1998	.3800	.0000	.0000	.1000	.0700	.0400	.1450	0	1.00	.0000

	mrate1	myear1	mmethod1	mrate2	myear2	mmethod2	mrate3	myear3	mmethod3	brate1	byear1
1	.1250	8.0	0	.	.	.	.	.	.	.0500	.
2	.1250	8.0	0	.	.	.	.	.	.	.0500	.
3	.1250	8.0	0	.	.	.	.	.	.	.0500	.
4	.5000	2.0	0	.	.	.	.	.	.	.0500	.
5	.5000	2.0	0	.	.	.	.	.	.	.0500	.
6	.5000	2.0	0	.	.	.	.	.	.	.0500	.
7	.5000	2.0	0	.	.	.	.	.	.	.0500	.
8	.5000	2.0	0	.	.	.	.	.	.	.0500	.
9	.5000	2.0	0	.	.	.	.	.	.	.0500	.
10	.5000	2.0	0	.	.	.	.	.	.	.0500	.
11	.5000	2.0	0	.	.	.	.	.	.	.0500	.
12	.5000	2.0	0	.	.	.	.	.	.	.0500	.
13	.5000	2.0	0	.	.	.	.	.	.	.0500	.
14	.5000	2.0	0	.	.	.	.	.	.	.0500	.
15	.5000	2.0	0	.	.	.	.	.	.	.0500	.
16	.5000	2.0	0	.	.	.	.	.	.	.0500	.
17	.5000	2.0	0	.	.	.	.	.	.	.0500	.
18	.5000	2.0	0	.	.	.	.	.	.	.0500	.
19	.5000	2.0	0	.	.	.	.	.	.	.0500	.
20	.5000	2.0	0	.	.	.	.	.	.	.0500	.
21	.5000	2.0	0	.	.	.	.	.	.	.0500	.
22	.5000	2.0	0	.	.	.	.	.	.	.0500	.
23	.2500	1.0	0	.5000	1.0	0	.2500	1.0	0	.0250	1.0
24	.2500	1.0	0	.5000	1.0	0	.2500	1.0	0	.0250	1.0
25	.2500	1.0	0	.5000	1.0	0	.2500	1.0	0	.0250	1.0
26	.2500	1.0	0	.5000	1.0	0	.2500	1.0	0	.0250	1.0
27	.2500	1.0	0	.5000	1.0	0	.2500	1.0	0	.0250	1.0
28	.2500	1.0	0	.5000	1.0	0	.2500	1.0	0	.0250	1.0
29	.1750	1.0	1	.3500	.	1	.	.	.	.0200	1.0
30	.1750	1.0	1	.3500	.	1	.	.	.	.0200	1.0
31	.1500	1.0	1	.3000	.	1	.	.	.	.0200	1.0
32	.1250	1.0	1	.2500	.	1	.	.	.	.0200	1.0
33	.1500	1.0	1	.3000	.	1	.	.	.	.0200	1.0
34	.1500	1.0	1	.3000	.	1	.	.	.	.0200	1.0
35	.1500	1.0	1	.3000	.	1	.	.	.	.0200	1.0
36	.1500	1.0	1	.3000	.	1	.	.	.	.0200	1.0
37	.1500	1.0	1	.3000	.	1	.	.	.	.0200	1.0
38	.1500	1.0	1	.3000	.	1	.	.	.	.0200	1.0
39	.1500	1.0	1	.3000	.	1	.	.	.	.0200	1.0

414

	bmethod1	brate2	byear2	bmethod2	mincent	bincent	ttax	mp	bp	lp	metr
1	1	.	.	.	.0000	.0000	.594	.1298	.1378	.1564	.6399
2	1	.	.	.	.0000	.0000	.594	.1298	.1378	.1564	.6399
3	1	.	.	.	.0000	.0000	.523	.1098	.1158	.1197	.5618
4	1	.	.	.	.0000	.0000	.523	.0680	.1158	.1197	.4751
5	1	.	.	.	.0000	.0000	.523	.0680	.1158	.1197	.4751
6	1	.	.	.	.0000	.0000	.523	.0680	.1158	.1197	.4751
7	1	.	.	.	.0000	.0000	.523	.0680	.1158	.1197	.4751
8	1	.	.	.	.0000	.0000	.523	.0680	.1158	.1197	.4751
9	1	.	.	.	.0000	.0000	.536	.0689	.1194	.1256	.4911
10	1	.	.	.	.0000	.0000	.536	.0689	.1194	.1256	.4911
11	1	.	.	.	.0000	.0000	.536	.0689	.1194	.1256	.4911
12	1	.	.	.	.0000	.0000	.523	.0680	.1158	.1197	.4751
13	1	.	.	.	.0000	.0000	.540	.0692	.1204	.1274	.4956
14	1	.	.	.	.0700	.0700	.530	.0562	.1073	.1228	.4329
15	1	.	.	.	.0700	.0700	.520	.0555	.1048	.1183	.4186
16	1	.	.	.	.0500	.0500	.510	.0583	.1053	.1141	.4209
17	1	.	.	.	.0500	.0500	.510	.0583	.1053	.1141	.4209
18	1	.	.	.	.0500	.0500	.510	.0583	.1053	.1126	.4184
19	1	.	.	.	.0700	.0700	.503	.0544	.1008	.1098	.3913
20	1	.	.	.	.0700	.0700	.445	.0510	.0890	.0890	.3048
21	1	.	.	.	.0700	.0700	.445	.0510	.0890	.0890	.3048
22	1	.	.	.	.0700	.0700	.445	.0510	.0905	.0890	.3092
23	1	.0500	.	1	.0700	.0700	.445	.0567	.0905	.0890	.3326
24	1	.0500	.	1	.0700	.0700	.445	.0567	.0905	.0890	.3326
25	1	.0500	.	1	.0700	.0700	.450	.0570	.0915	.0907	.3401
26	1	.0500	.	1	.0700	.0700	.450	.0570	.0915	.0907	.3401
27	1	.0500	.	1	.0700	.0700	.461	.0579	.0936	.0954	.3587
28	1	.0500	.	1	.0300	.0300	.490	.0676	.1055	.1062	.4356
29	1	.0400	.	1	.0000	.0000	.422	.0949	.0982	.0830	.4618
30	1	.0400	.	1	.0000	.0000	.422	.0949	.0982	.0830	.4618
31	1	.0400	.	1	.0000	.0000	.422	.0966	.0982	.0830	.4663
32	1	.0400	.	1	.0000	.0000	.392	.0934	.0925	.0745	.4346
33	1	.0400	.	1	.0000	.0000	.392	.0911	.0925	.0745	.4279
34	1	.0400	.	1	.0000	.0000	.382	.0894	.0908	.0718	.4148
35	1	.0400	.	1	.0000	.0000	.369	.0873	.0885	.0684	.3970
36	1	.0400	.	1	.0000	.0000	.369	.0873	.0885	.0684	.3970
37	1	.0400	.	1	.0000	.0000	.369	.0873	.0885	.0684	.3970
38	1	.0400	.	1	.0000	.0000	.369	.0873	.0885	.0684	.3970
39	1	.0400	.	1	.0000	.0000	.369	.0873	.0885	.0684	.3970

415

	year	ntax	ltax	ded	invent	iallow	mrate1	myear1	mmethod1	brate1	byear1
1	1960	.4400	.	.	1	.0000	.3000	.	1	.0400	25.0
2	1961	.4400	.	.	1	.0000	.3000	.	1	.0400	25.0
3	1962	.4400	.	.	1	.0000	.3000	.	1	.0400	25.0
4	1963	.4400	.	.	1	.0000	.3000	.	1	.0400	25.0
5	1964	.4400	.	.	1	.0000	.3000	.	1	.0400	25.0
6	1965	.4400	.	.	1	.0000	.3000	.	1	.0400	25.0
7	1966	.4400	.	.	1	.0000	.3000	.	1	.0400	25.0
8	1967	.4400	.	.	1	.0000	.3000	.	1	.0400	25.0
9	1968	.3600	.	.	1	.0000	.3000	.	1	.0600	10.0
10	1969	.3600	.	.	1	.0000	.3000	.	1	.0600	10.0
11	1970	.3600	.	.	1	.0000	.3000	.	1	.0600	10.0
12	1971	.3600	.	.	1	.0000	.3000	.	1	.0600	10.0
13	1972	.3600	.	.	1	.0000	.3000	.	1	.0600	10.0
14	1973	.3600	.	.	1	.0000	.3000	.	1	.0600	10.0
15	1974	.3700	.	.	1	.0000	.3000	.	1	.0600	10.0
16	1975	.3700	.	.	1	.0000	.3000	.	1	.0600	10.0
17	1976	.3700	.	.	1	.0000	.3000	.	1	.0600	10.0
18	1977	.3700	.	.	1	.0000	.3000	.	1	.0600	10.0
19	1978	.3700	.	.	1	.0000	.3000	.	1	.0600	10.0
20	1979	.4000	.	.	1	.0000	.3000	.	1	.0600	10.0
21	1980	.4000	.	.	1	.0000	.3000	.	1	.0600	10.0
22	1981	.4000	.	.	1	.0000	.3000	.	1	.0600	10.0
23	1982	.4000	.	.	1	.0000	.3000	.	1	.0600	10.0
24	1983	.4000	.	.	1	.0000	.3000	.	1	.0600	10.0
25	1984	.4000	.	.	1	.0000	.3000	.	1	.0600	10.0
26	1985	.4000	.	.	1	.0000	.3000	.	1	.0600	10.0
27	1986	.4000	.	.	1	.0000	.3000	.	1	.0600	10.0
28	1987	.4000	.	.	1	.0000	.3000	.	1	.0600	10.0
29	1988	.5000	.	.	1	.0000	.3000	.	1	.0600	10.0
30	1989	.5000	.	.	1	.0000	.3000	.	1	.0600	10.0
31	1990	.5000	.	.	1	.0000	.3000	.	1	.0600	10.0
32	1991	.3800	.	.	1	.0000	.3000	.	1	.0600	10.0
33	1992	.3400	.	.	1	.2600	.3000	.	1	.0600	10.0
34	1993	.3400	.	.	1	.2300	.3000	.	1	.0600	10.0
35	1994	.3400	.	.	1	.2000	.3000	.	1	.0600	10.0
36	1995	.3400	.	.	1	.1600	.3000	.	1	.0600	10.0
37	1996	.3400	.	.	1	.1200	.3000	.	1	.0600	10.0
38	1997	.3400	.	.	1	.0800	.3000	.	1	.0600	10.0
39	1998	.3400	.	.	1	.0000	.3000	.	1	.0600	10.0

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	bmethod1	brate2	byear2	bmethod2	mincent	bincent	ttax	mp	bp	lp	metr
1	0	.	.	.	.	.	.440	.0844	.0948	.1286	.4926
2	0	.	.	.	.	.	.440	.0844	.0948	.1286	.4926
3	0	.	.	.	.	.	.440	.0844	.0948	.1286	.4926
4	0	.	.	.	.	.	.440	.0844	.0948	.1286	.4926
5	0	.	.	.	.	.	.440	.0844	.0948	.1286	.4926
6	0	.	.	.	.	.	.440	.0844	.0948	.1286	.4926
7	0	.	.	.	.	.	.440	.0844	.0948	.1286	.4926
8	0	.	.	.	.	.	.440	.0844	.0948	.1286	.4926
9	0	.0200	20.0	0	.	.	.360	.0746	.0791	.1063	.4038
10	0	.0200	20.0	0	.	.	.360	.0746	.0791	.1063	.4038
11	0	.0200	20.0	0	.	.	.360	.0746	.0791	.1063	.4038
12	0	.0200	20.0	0	.	.	.360	.0746	.0791	.1063	.4038
13	0	.0200	20.0	0	.	.	.360	.0746	.0791	.1063	.4038
14	0	.0200	20.0	0	.	.	.360	.0746	.0791	.1063	.4038
15	0	.0200	20.0	0	.	.	.370	.0757	.0804	.1087	.4142
16	0	.0200	20.0	0	.	.	.370	.0757	.0804	.1087	.4142
17	0	.0200	20.0	0	.	.	.370	.0757	.0804	.1087	.4142
18	0	.0200	20.0	0	.	.	.370	.0757	.0804	.1087	.4142
19	0	.0200	20.0	0	.	.	.370	.0757	.0804	.1087	.4142
20	0	.0200	20.0	0	.	.	.400	.0792	.0845	.1167	.4452
21	0	.0200	20.0	0	.	.	.400	.0792	.0845	.1167	.4452
22	0	.0200	20.0	0	.	.	.400	.0792	.0845	.1167	.4452
23	0	.0200	20.0	0	.	.	.400	.0792	.0845	.1167	.4452
24	0	.0200	20.0	0	.	.	.400	.0792	.0845	.1167	.4452
25	0	.0200	20.0	0	.	.	.400	.0792	.0845	.1167	.4452
26	0	.0200	20.0	0	.	.	.400	.0792	.0845	.1167	.4452
27	0	.0200	20.0	0	.	.	.400	.0792	.0845	.1167	.4452
28	0	.0200	20.0	0	.	.	.400	.0792	.0845	.1167	.4452
29	0	.0200	20.0	0	.	.	.500	.0938	.1017	.1500	.5462
30	0	.0200	20.0	0	.	.	.500	.0938	.1017	.1500	.5462
31	0	.0200	20.0	0	.	.	.500	.0938	.1017	.1500	.5462
32	0	.0200	20.0	0	.	.	.380	.0768	.0817	.1113	.4246
33	0	.0200	20.0	0	.	.	.340	.0725	.0766	.0951	.3704
34	0	.0200	20.0	0	.	.	.340	.0725	.0766	.0959	.3718
35	0	.0200	20.0	0	.	.	.340	.0725	.0766	.0966	.3733
36	0	.0200	20.0	0	.	.	.340	.0725	.0766	.0976	.3752
37	0	.0200	20.0	0	.	.	.340	.0725	.0766	.0986	.3771
38	0	.0200	20.0	0	.	.	.340	.0725	.0766	.0996	.3790
39	0	.0200	20.0	0	.	.	.340	.0725	.0766	.1015	.3828

	year	ntax	atax	ded1	ltax	ded2	ctax	ded3	invent	mrate1	myear1
1	1960	.3800	.1200	1	.1450	0	.0200	0	1	.1250	.
2	1961	.3800	.1200	1	.1450	0	.0200	0	1	.1250	.
3	1962	.3800	.1200	1	.1450	0	.0200	0	1	.1250	.
4	1963	.3800	.1200	1	.1450	0	.0200	0	1	.1250	.
5	1964	.4500	.1200	1	.1450	0	.0200	0	1	.1250	.
6	1965	.4800	.1200	1	.1450	0	.0200	0	1	.1250	.
7	1966	.4800	.1200	1	.1450	0	.0200	0	1	.1250	.
8	1967	.4800	.0000	0	.1450	0	.0200	0	1	.1250	.
9	1968	.4900	.0000	0	.1450	0	.0200	0	1	.1250	.
10	1969	.4300	.0000	0	.1450	0	.0200	0	1	.3000	.
11	1970	.4300	.0000	0	.1450	0	.0200	0	1	.3000	.
12	1971	.4300	.0000	0	.1450	0	.0200	0	1	.3000	.
13	1972	.4300	.0000	0	.1450	0	.0200	0	1	.3000	.
14	1973	.4300	.0000	0	.1450	0	.0200	0	1	.3000	.
15	1974	.4300	.0000	0	.1450	0	.0200	0	1	.3000	.
16	1975	.4300	.0000	0	.1450	0	.0200	0	1	.3000	.
17	1976	.4300	.0000	0	.1450	0	.0200	0	1	.3000	.
18	1977	.4300	.0000	0	.1450	0	.0200	0	1	.3000	.
19	1978	.4300	.0000	0	.1450	0	.0200	0	1	.3000	.
20	1979	.4300	.0000	0	.1450	0	.0100	0	1	.3000	.
21	1980	.4300	.0000	0	.1450	0	.0100	0	1	.3000	.
22	1981	.4300	.0000	0	.1450	0	.0100	0	1	.3000	.
23	1982	.4300	.0000	0	.1450	0	.0100	0	1	.3000	.
24	1983	.4300	.0000	0	.1450	0	.0100	0	1	.3000	.
25	1984	.4300	.0000	0	.1450	0	.0100	0	1	.3000	.
26	1985	.4300	.0000	0	.1450	0	.0100	0	1	.3000	.
27	1986	.4300	.0000	0	.1450	0	.0100	0	1	.3000	.
28	1987	.4300	.0000	0	.1450	0	.0100	0	1	.3000	.
29	1988	.3300	.0000	0	.1450	0	.0100	0	1	.3000	.
30	1989	.3300	.0000	0	.1650	0	.0200	0	1	.3000	.
31	1990	.3300	.0000	0	.1650	0	.0200	0	1	.3000	.
32	1991	.2300	.0000	0	.1650	0	.0200	0	1	.3000	.
33	1992	.1900	.0000	0	.1650	0	.0100	0	1	.3000	.
34	1993	.2500	.0000	0	.0000	0	.0100	0	1	.3000	.
35	1994	.2500	.0000	0	.0000	0	.0100	0	1	.3000	.
36	1995	.2500	.0000	0	.0000	0	.0100	0	1	.3000	.
37	1996	.2800	.0000	0	.0000	0	.0100	0	1	.3000	.
38	1997	.2800	.0000	0	.0000	0	.0100	0	1	.3000	.
39	1998	.2800	.0000	0	.0000	0	.0100	0	1	.3000	.

418

	mmethod1	brate1	byear1	bmethod1	ttax	mp	bp	ip	tp	metr
1	1	.0250	40.0	0	.619	.1766	.1605	.2127	.1808	.7235
2	1	.0250	40.0	0	.619	.1766	.1605	.2127	.1808	.7235
3	1	.0250	40.0	0	.619	.1766	.1605	.2127	.1808	.7235
4	1	.0250	40.0	0	.619	.1766	.1605	.2127	.1808	.7235
5	1	.0250	40.0	0	.681	.2161	.1950	.2635	.2216	.7744
6	1	.0250	40.0	0	.707	.2381	.2142	.2918	.2443	.7954
7	1	.0250	40.0	0	.707	.2381	.2142	.2918	.2443	.7954
8	1	.0250	40.0	0	.645	.1913	.1734	.2317	.1960	.7449
9	1	.0250	40.0	0	.655	.1977	.1789	.2399	.2026	.7532
10	1	.0900	.	1	.595	.1143	.1196	.1969	.1365	.6338
11	1	.0900	.	1	.595	.1143	.1196	.1969	.1365	.6338
12	1	.0900	.	1	.595	.1143	.1196	.1969	.1365	.6338
13	1	.0900	.	1	.595	.1143	.1196	.1969	.1365	.6338
14	1	.0900	.	1	.595	.1143	.1196	.1969	.1365	.6338
15	1	.0900	.	1	.595	.1143	.1196	.1969	.1365	.6338
16	1	.0900	.	1	.595	.1143	.1196	.1969	.1365	.6338
17	1	.0900	.	1	.595	.1143	.1196	.1969	.1365	.6338
18	1	.0900	.	1	.595	.1143	.1196	.1969	.1365	.6338
19	1	.0900	.	1	.595	.1143	.1196	.1969	.1365	.6338
20	1	.0900	.	1	.585	.1117	.1168	.1910	.1330	.6241
21	1	.0900	.	1	.585	.1117	.1168	.1910	.1330	.6241
22	1	.0900	.	1	.585	.1117	.1168	.1910	.1330	.6241
23	1	.0900	.	1	.585	.1117	.1168	.1910	.1330	.6241
24	1	.0900	.	1	.585	.1117	.1168	.1910	.1330	.6241
25	1	.0900	.	1	.585	.1117	.1168	.1910	.1330	.6241
26	1	.0900	.	1	.585	.1117	.1168	.1910	.1330	.6241
27	1	.0900	.	1	.585	.1117	.1168	.1910	.1330	.6241
28	1	.0900	.	1	.585	.1117	.1168	.1910	.1330	.6241
29	1	.0900	.	1	.485	.0912	.0946	.1442	.1055	.5259
30	1	.0900	.	1	.515	.0965	.1003	.1562	.1125	.5557
31	1	.0900	.	1	.515	.0965	.1003	.1562	.1125	.5557
32	1	.0900	.	1	.415	.0810	.0836	.1209	.0918	.4552
33	1	.0900	.	1	.365	.0751	.0772	.1075	.0839	.4037
34	1	.0900	.	1	.260	.0654	.0666	.0851	.0707	.2927
35	1	.0900	.	1	.260	.0654	.0666	.0851	.0707	.2927
36	1	.0700	.	1	.260	.0654	.0666	.0851	.0707	.2927
37	1	.0700	.	1	.290	.0679	.0693	.0908	.0741	.3248
38	1	.0700	.	1	.290	.0679	.0693	.0908	.0741	.3248
39	1	.0700	.	1	.290	.0679	.0693	.0908	.0741	.3248

419

	year	ntax	stax	ded	invent	mrate1	myear1	mmethod1	mrate2	myear2	mmethod2
1	1960	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
2	1961	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
3	1962	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
4	1963	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
5	1964	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
6	1965	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
7	1966	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
8	1967	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
9	1968	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
10	1969	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
11	1970	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
12	1971	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
13	1972	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
14	1973	.5000	.1800	.	1	.3125	4.0	1	.0558	4.0	0
15	1974	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
16	1975	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
17	1976	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
18	1977	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
19	1978	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
20	1979	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
21	1980	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
22	1981	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
23	1982	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
24	1983	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
25	1984	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
26	1985	.5000	.0000	.	1	.3125	4.0	1	.0558	4.0	0
27	1986	.4500	.0000	.	1	.3125	4.0	1	.0558	4.0	0
28	1987	.4500	.0000	.	1	.3125	4.0	1	.0558	4.0	0
29	1988	.4200	.0000	.	1	.3125	4.0	1	.0558	4.0	0
30	1989	.3900	.0000	.	1	.3125	4.0	1	.0558	4.0	0
31	1990	.3700	.0000	.	1	.3125	4.0	1	.0558	4.0	0
32	1991	.3400	.0000	.	1	.3125	4.0	1	.0558	4.0	0
33	1992	.3400	.0000	.	1	.3125	4.0	1	.0558	4.0	0
34	1993	.3330	.0000	.	1	.3125	4.0	1	.0558	4.0	0
35	1994	.3330	.1000	.	1	.3125	4.0	1	.0558	4.0	0
36	1995	.3330	.2500	.	1	.3125	4.0	1	.0558	4.0	0
37	1996	.3330	.2500	.	1	.3125	4.0	1	.0558	4.0	0
38	1997	.3330	.2500	.	1	.3125	4.0	1	.0558	4.0	0
39	1998	.3330	.2500	.	1	.3125	4.0	1	.0558	4.0	0

420

	brate1	byear1	bmethod1	mincent	bincent	ttax	mp	bp	lp	metr
1	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
2	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
3	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
4	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
5	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
6	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
7	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
8	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
9	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
10	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
11	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
12	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
13	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
14	.0400	25.0	0	.	.	.590	.1166	.1320	.1939	.6443
15	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
16	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
17	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
18	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
19	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
20	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
21	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
22	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
23	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
24	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
25	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
26	.0400	25.0	0	.	.	.500	.0963	.1070	.1500	.5572
27	.0400	25.0	0	.	.	.450	.0879	.0966	.1318	.5073
28	.0400	25.0	0	.	.	.450	.0879	.0966	.1318	.5073
29	.0400	25.0	0	.	.	.420	.0835	.0912	.1224	.4768
30	.0400	25.0	0	.	.	.390	.0796	.0864	.1139	.4459
31	.0400	25.0	0	.	.	.370	.0772	.0834	.1087	.4250
32	.0400	25.0	0	.	.	.340	.0739	.0793	.1015	.3933
33	.0400	25.0	0	.	.	.340	.0739	.0793	.1015	.3933
34	.0400	25.0	0	.	.	.333	.0731	.0784	.0999	.3859
35	.0400	25.0	0	.	.	.366	.0768	.0829	.1078	.4211
36	.0400	25.0	0	.	.	.416	.0830	.0906	.1213	.4730
37	.0400	25.0	0	.	.	.416	.0830	.0906	.1213	.4730
38	.0400	25.0	0	.	.	.416	.0830	.0906	.1213	.4730
39	.0400	25.0	0	.	.	.416	.0830	.0906	.1213	.4730

421

	year	ntax	stax	ltax	ded	invent	mrate1	myear1	mmethod1	mrate2	myear2
1	1960	.5100	.0000	.1400	1	0	.2000	3.0	1	.1024	5.0
2	1961	.5100	.0000	.1400	1	0	.2000	3.0	1	.1024	5.0
3	1962	.5100	.0000	.1400	1	0	.2000	3.0	1	.1024	5.0
4	1963	.5100	.0000	.1400	1	0	.2000	3.0	1	.1024	5.0
5	1964	.5100	.0000	.1400	1	0	.2000	3.0	1	.1024	5.0
6	1965	.5100	.0000	.1400	1	0	.2000	3.0	1	.1024	5.0
7	1966	.5100	.0000	.1400	1	0	.2000	3.0	1	.1024	5.0
8	1967	.5100	.0000	.1400	1	0	.2000	3.0	1	.1024	5.0
9	1968	.5100	.0300	.1400	1	0	.2000	3.0	1	.1024	5.0
10	1969	.5100	.0300	.1400	1	0	.2000	3.0	1	.1024	5.0
11	1970	.5100	.0300	.1400	1	0	.2000	3.0	1	.1024	5.0
12	1971	.5100	.0300	.1400	1	0	.2000	3.0	1	.1024	5.0
13	1972	.5100	.0300	.1400	1	0	.2000	3.0	1	.1024	5.0
14	1973	.5100	.0300	.1400	1	0	.2000	3.0	1	.1024	5.0
15	1974	.5100	.0300	.1400	1	0	.2000	3.0	1	.1024	5.0
16	1975	.5100	.0300	.1400	1	0	.2000	3.0	1	.1024	5.0
17	1976	.5100	.0300	.1400	1	0	.2000	3.0	1	.1024	5.0
18	1977	.5600	.0000	.1400	1	0	.2500	4.0	1	.0791	4.0
19	1978	.5600	.0000	.1400	1	0	.2500	4.0	1	.0791	4.0
20	1979	.5600	.0000	.1400	1	0	.2500	4.0	1	.0791	4.0
21	1980	.5600	.0000	.1400	1	0	.2500	4.0	1	.0791	4.0
22	1981	.5600	.0000	.1400	1	0	.3000	5.0	1	.0560	3.0
23	1982	.5600	.0000	.1400	1	0	.3000	5.0	1	.0560	3.0
24	1983	.5600	.0000	.1400	1	0	.3000	5.0	1	.0560	3.0
25	1984	.5600	.0000	.1400	1	0	.3000	5.0	1	.0560	3.0
26	1985	.5600	.0000	.1400	1	0	.3000	5.0	1	.0560	3.0
27	1986	.5600	.0000	.1400	1	0	.3000	5.0	1	.0560	3.0
28	1987	.5600	.0000	.1400	1	0	.3000	5.0	1	.0560	3.0
29	1988	.5600	.0000	.1400	1	0	.3000	5.0	1	.0560	3.0
30	1989	.5600	.0000	.1400	1	0	.3000	5.0	1	.0560	3.0
31	1990	.5000	.0000	.1400	1	0	.3000	5.0	1	.0560	3.0
32	1991	.5000	.0375	.1400	1	0	.3000	5.0	1	.0560	3.0
33	1992	.5000	.0375	.1400	1	0	.3000	5.0	1	.0560	3.0
34	1993	.5000	.0375	.1400	1	0	.3000	5.0	1	.0560	3.0
35	1994	.4500	.0550	.1400	1	0	.3000	5.0	1	.0560	3.0
36	1995	.4500	.0750	.1400	1	0	.3000	5.0	1	.0560	3.0
37	1996	.4500	.0750	.1400	1	0	.3000	5.0	1	.0560	3.0
38	1997	.4500	.0750	.1400	1	0	.3000	5.0	1	.0560	3.0
39	1998	.4500	.0750	.1400	1	0	.3000	5.0	1	.0560	3.0

	mmethod2	brate1	byear1	bmethod1	brate2	byear2	bmethod2	brate3	byear3	bmethod3	mincent
1	0	.0500	8.0	1	.0250	6.0	1	.0150	36.0	1	.
2	0	.0500	8.0	1	.0250	6.0	1	.0150	36.0	1	.
3	0	.0500	8.0	1	.0250	6.0	1	.0150	36.0	1	.
4	0	.0500	8.0	1	.0250	6.0	1	.0150	36.0	1	.
5	0	.0500	8.0	1	.0250	6.0	1	.0150	36.0	1	.
6	0	.0500	8.0	1	.0250	6.0	1	.0150	36.0	1	.
7	0	.0500	8.0	1	.0250	6.0	1	.0150	36.0	1	.
8	0	.0500	8.0	1	.0250	6.0	1	.0150	36.0	1	.
9	0	.0500	8.0	1	.0250	6.0	1	.0150	36.0	1	.
10	0	.0500	8.0	1	.0250	6.0	1	.0150	36.0	1	.
11	0	.0500	8.0	1	.0250	6.0	1	.0150	36.0	1	.
12	0	.0500	8.0	1	.0250	6.0	1	.0125	36.0	1	.
13	0	.0500	8.0	1	.0250	6.0	1	.0125	36.0	1	.
14	0	.0500	8.0	1	.0250	6.0	1	.0125	36.0	1	.
15	0	.0500	8.0	1	.0250	6.0	1	.0125	36.0	1	.
16	0	.0500	8.0	1	.0250	6.0	1	.0125	36.0	1	.
17	0	.0500	8.0	1	.0250	6.0	1	.0125	36.0	1	.
18	0	.0500	8.0	1	.0250	6.0	1	.0125	36.0	1	.
19	0	.0500	8.0	1	.0250	6.0	1	.0125	36.0	1	.
20	0	.0500	8.0	1	.0250	6.0	1	.0125	36.0	1	.
21	0	.0500	8.0	1	.0250	6.0	1	.0125	36.0	1	.
22	0	.0500	8.0	1	.0250	6.0	1	.0125	36.0	1	.
23	0	.0500	8.0	1	.0250	6.0	1	.0125	36.0	1	.
24	0	.0500	8.0	1	.0250	6.0	1	.0125	36.0	1	.
25	0	.1000	5.0	1	.0500	3.0	1	.0250	18.0	1	.
26	0	.1000	5.0	1	.0500	3.0	1	.0250	18.0	1	.
27	0	.1000	5.0	1	.0500	3.0	1	.0250	18.0	1	.
28	0	.1000	5.0	1	.0500	3.0	1	.0250	18.0	1	.
29	0	.1000	5.0	1	.0500	3.0	1	.0250	18.0	1	.
30	0	.1000	5.0	1	.0500	3.0	1	.0250	18.0	1	.
31	0	.1000	5.0	1	.0500	3.0	1	.0250	18.0	1	.
32	0	.1000	5.0	1	.0500	3.0	1	.0250	18.0	1	.
33	0	.1000	5.0	1	.0500	3.0	1	.0250	18.0	1	.
34	0	.1000	5.0	1	.0500	3.0	1	.0250	18.0	1	.
35	0	.1000	5.0	1	.0500	3.0	1	.0250	18.0	1	.
36	0	.1000	5.0	1	.0500	3.0	1	.0250	18.0	1	.
37	0	.1000	5.0	1	.0500	3.0	1	.0250	18.0	1	.
38	0	.1000	5.0	1	.0500	3.0	1	.0250	18.0	1	.
39	0	.1000	5.0	1	.0500	3.0	1	.0250	18.0	1	.

423

	bincent	ttax	mp	bp	ip	metr
1	.	.579	.1235	.1368	.1187	.6041
2	.	.579	.1235	.1368	.1187	.6041
3	.	.579	.1235	.1368	.1187	.6041
4	.	.579	.1235	.1368	.1187	.6041
5	.	.579	.1235	.1368	.1187	.6041
6	.	.579	.1235	.1368	.1187	.6041
7	.	.579	.1235	.1368	.1187	.6041
8	.	.579	.1235	.1368	.1187	.6041
9	.	.592	.1276	.1417	.1225	.6170
10	.	.592	.1276	.1417	.1225	.6170
11	.	.592	.1276	.1417	.1225	.6170
12	.	.592	.1276	.1417	.1225	.6170
13	.	.592	.1276	.1417	.1225	.6170
14	.	.592	.1276	.1417	.1225	.6170
15	.	.592	.1276	.1417	.1225	.6170
16	.	.592	.1276	.1417	.1225	.6170
17	.	.592	.1276	.1417	.1225	.6170
18	.	.622	.1325	.1539	.1321	.6398
19	.	.622	.1325	.1539	.1321	.6398
20	.	.622	.1325	.1539	.1321	.6398
21	.	.622	.1325	.1539	.1321	.6398
22	.	.622	.1257	.1539	.1321	.6318
23	.	.622	.1257	.1539	.1321	.6318
24	.	.622	.1257	.1539	.1321	.6318
25	.	.622	.1257	.1321	.1321	.6132
26	.	.622	.1257	.1321	.1321	.6132
27	.	.622	.1257	.1321	.1321	.6132
28	.	.622	.1257	.1321	.1321	.6132
29	.	.622	.1257	.1321	.1321	.6132
30	.	.622	.1257	.1321	.1321	.6132
31	.	.570	.1111	.1163	.1163	.5612
32	.	.586	.1153	.1208	.1208	.5774
33	.	.586	.1153	.1208	.1208	.5774
34	.	.586	.1153	.1208	.1208	.5774
35	.	.548	.1060	.1107	.1107	.5394
36	.	.556	.1077	.1126	.1126	.5472
37	.	.556	.1077	.1126	.1126	.5472
38	.	.556	.1077	.1126	.1126	.5472
39	.	.556	.1077	.1126	.1126	.5472

424

	year	ntax	atax	ded	invent	mrate1	myear1	mmethod1	mrate2	myear2	mmethod2
1	1960	.3500	.1500	0	0	.1800	5.0	0	.1000	1.0	0
2	1961	.3500	.1500	0	0	.1800	5.0	0	.1000	1.0	0
3	1962	.3500	.1500	0	0	.1800	5.0	0	.1000	1.0	0
4	1963	.3500	.1500	1	0	.1800	5.0	0	.1000	1.0	0
5	1964	.3500	.1500	1	0	.1800	5.0	0	.1000	1.0	0
6	1965	.3500	.1500	1	0	.1800	5.0	0	.1000	1.0	0
7	1966	.3500	.1500	1	0	.1800	5.0	0	.1000	1.0	0
8	1967	.4000	.1500	1	0	.1800	5.0	0	.1000	1.0	0
9	1968	.3500	.1500	1	0	.1800	5.0	0	.1000	1.0	0
10	1969	.3500	.1500	1	0	.1800	5.0	0	.1000	1.0	0
11	1970	.3500	.1500	1	0	.1800	5.0	0	.1000	1.0	0
12	1971	.3500	.1500	1	0	.1800	5.0	0	.1000	1.0	0
13	1972	.3500	.1500	1	0	.1800	5.0	0	.1000	1.0	0
14	1973	.3500	.1500	1	0	.1200	8.0	0	.0400	1.0	0
15	1974	.3000	.1500	1	0	.1200	8.0	0	.0400	1.0	0
16	1975	.3000	.1500	1	0	.1200	8.0	0	.0400	1.0	0
17	1976	.3000	.1500	1	0	.1200	8.0	0	.0400	1.0	0
18	1977	.3000	.1500	1	0	.1200	8.0	0	.0400	1.0	0
19	1978	.3000	.1500	1	0	.1200	8.0	0	.0400	1.0	0
20	1979	.3000	.1500	1	0	.1200	8.0	0	.0400	1.0	0
21	1980	.3000	.1500	1	0	.1200	8.0	0	.0400	1.0	0
22	1981	.3000	.1500	1	0	.1200	8.0	0	.0400	1.0	0
23	1982	.3000	.1500	1	0	.1200	8.0	0	.0400	1.0	0
24	1983	.3000	.1500	1	0	.1200	8.0	0	.0400	1.0	0
25	1984	.4900	.1500	1	0	.1200	8.0	0	.0400	1.0	0
26	1985	.4900	.1500	1	0	.1200	8.0	0	.0400	1.0	0
27	1986	.4900	.1500	1	0	.1200	8.0	0	.0400	1.0	0
28	1987	.4900	.1500	1	0	.1200	8.0	0	.0400	1.0	0
29	1988	.4000	.1500	1	0	.1200	8.0	0	.0400	1.0	0
30	1989	.4000	.1500	1	0	.1200	8.0	0	.0400	1.0	0
31	1990	.4000	.1500	1	0	.1200	8.0	0	.0400	1.0	0
32	1991	.4000	.1500	1	0	.1200	8.0	0	.0400	1.0	0
33	1992	.3500	.1500	1	0	.1200	8.0	0	.0400	1.0	0
34	1993	.4000	.1500	1	0	.1200	8.0	0	.0400	1.0	0
35	1994	.4000	.1500	1	0	.1200	8.0	0	.0400	1.0	0
36	1995	.4000	.1500	1	0	.1200	8.0	0	.0400	1.0	0
37	1996	.4000	.1500	1	0	.1200	8.0	0	.0400	1.0	0
38	1997	.4000	.1500	1	0	.1200	8.0	0	.0400	1.0	0
39	1998	.4000	.1500	1	0	.1200	8.0	0	.0400	1.0	0

425

	brate1	byear1	bmethod1	brate2	byear2	bmethod2	ttax	mp	bp	lp	metr
1	.0800	12.0	0	.0400	1.0	0	.500	.0910	.0887	.1000	.4596
2	.0800	12.0	0	.0400	1.0	0	.500	.0910	.0887	.1000	.4596
3	.0800	12.0	0	.0400	1.0	0	.500	.0910	.0887	.1000	.4596
4	.0800	12.0	0	.0400	1.0	0	.448	.0832	.0813	.0905	.4079
5	.0800	12.0	0	.0400	1.0	0	.448	.0832	.0813	.0905	.4079
6	.0800	12.0	0	.0400	1.0	0	.448	.0832	.0813	.0905	.4079
7	.0800	12.0	0	.0400	1.0	0	.448	.0832	.0813	.0905	.4079
8	.0800	12.0	0	.0400	1.0	0	.490	.0894	.0871	.0980	.4497
9	.0800	12.0	0	.0400	1.0	0	.448	.0832	.0813	.0905	.4079
10	.0800	12.0	0	.0400	1.0	0	.448	.0832	.0813	.0905	.4079
11	.0800	12.0	0	.0400	1.0	0	.448	.0832	.0813	.0905	.4079
12	.0800	12.0	0	.0400	1.0	0	.448	.0832	.0813	.0905	.4079
13	.0800	12.0	0	.0400	1.0	0	.448	.0832	.0813	.0905	.4079
14	.0800	12.0	0	.0400	1.0	0	.448	.0957	.0813	.0905	.4448
15	.0800	12.0	0	.0400	1.0	0	.405	.0884	.0763	.0840	.4024
16	.0800	12.0	0	.0400	1.0	0	.405	.0884	.0763	.0840	.4024
17	.0800	12.0	0	.0400	1.0	0	.405	.0884	.0763	.0840	.4024
18	.0800	12.0	0	.0400	1.0	0	.405	.0884	.0763	.0840	.4024
19	.0800	12.0	0	.0400	1.0	0	.405	.0884	.0763	.0840	.4024
20	.0800	12.0	0	.0400	1.0	0	.405	.0884	.0763	.0840	.4024
21	.0800	12.0	0	.0400	1.0	0	.405	.0884	.0763	.0840	.4024
22	.0800	12.0	0	.0400	1.0	0	.405	.0884	.0763	.0840	.4024
23	.0800	12.0	0	.0400	1.0	0	.405	.0884	.0763	.0840	.4024
24	.0800	12.0	0	.0400	1.0	0	.405	.0884	.0763	.0840	.4024
25	.0800	12.0	0	.0400	1.0	0	.567	.1237	.1005	.1153	.5638
26	.0800	12.0	0	.0400	1.0	0	.567	.1237	.1005	.1153	.5638
27	.0800	12.0	0	.0400	1.0	0	.567	.1237	.1005	.1153	.5638
28	.0800	12.0	0	.0400	1.0	0	.567	.1237	.1005	.1153	.5638
29	.0800	12.0	0	.0400	1.0	0	.490	.1042	.0871	.0980	.4873
30	.0800	12.0	0	.0400	1.0	0	.490	.1042	.0871	.0980	.4873
31	.0800	12.0	0	.0400	1.0	0	.490	.1042	.0871	.0980	.4873
32	.0800	12.0	0	.0400	1.0	0	.490	.1042	.0871	.0980	.4873
33	.0800	12.0	0	.0400	1.0	0	.448	.0957	.0813	.0905	.4448
34	.0800	12.0	0	.0400	1.0	0	.490	.1042	.0871	.0980	.4873
35	.0800	12.0	0	.0400	1.0	0	.490	.1042	.0871	.0980	.4873
36	.0800	12.0	0	.0400	1.0	0	.490	.1042	.0871	.0980	.4873
37	.0800	12.0	0	.0400	1.0	0	.490	.1042	.0871	.0980	.4873
38	.0800	12.0	0	.0400	1.0	0	.490	.1042	.0871	.0980	.4873
39	.0800	12.0	0	.0400	1.0	0	.490	.1042	.0871	.0980	.4873

426

	year	ntax	ltax	ded	invent	mrate1	myear1	mmethod1	mrate2	myear2	mmethod2
1	1960	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
2	1961	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
3	1962	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
4	1963	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
5	1964	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
6	1965	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
7	1966	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
8	1967	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
9	1968	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
10	1969	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
11	1970	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
12	1971	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
13	1972	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
14	1973	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
15	1974	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
16	1975	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
17	1976	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
18	1977	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
19	1978	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
20	1979	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
21	1980	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
22	1981	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
23	1982	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
24	1983	.5100	.	.	1	.1200	7.0	0	.0600	1.0	0
25	1984	.5100	.	.	1	.1500	6.0	0	.	.	.
26	1985	.5100	.	.	1	.1500	6.0	0	.	.	.
27	1986	.5100	.	.	1	.1500	6.0	0	.	.	.
28	1987	.5100	.	.	1	.1500	6.0	0	.	.	.
29	1988	.4800	.	.	1	.1500	6.0	0	.	.	.
30	1989	.4800	.	.	1	.1500	6.0	0	.	.	.
31	1990	.4500	.	.	1	.1500	6.0	0	.	.	.
32	1991	.4500	.	.	1	.1500	6.0	0	.	.	.
33	1992	.4500	.	.	1	.1500	6.0	0	.1000	1.0	0
34	1993	.4500	.	.	1	.1500	6.0	0	.1000	1.0	0
35	1994	.4500	.	.	1	.1500	6.0	0	.1000	1.0	0
36	1995	.4500	.	.	1	.1500	6.0	0	.1000	1.0	0
37	1996	.3300	.	.	1	.1500	6.0	0	.1000	1.0	0
38	1997	.3300	.	.	1	.1500	6.0	0	.1000	1.0	0
39	1998	.3300	.	.	1	.1500	6.0	0	.1000	1.0	0

427

	brate1	byear1	bmethod1	mincent	bincent	ttax	mp	bp	ip	metr
1	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
2	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
3	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
4	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
5	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
6	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
7	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
8	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
9	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
10	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
11	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
12	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
13	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
14	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
15	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
16	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
17	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
18	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
19	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
20	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
21	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
22	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
23	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
24	.0200	45.0	0	.	.	.510	.1169	.1251	.1541	.611
25	.0200	45.0	0	.	.	.510	.1089	.1251	.1541	.600
26	.0200	45.0	0	.	.	.510	.1089	.1251	.1541	.600
27	.0200	45.0	0	.	.	.510	.1089	.1251	.1541	.600
28	.0200	45.0	0	.	.	.510	.1089	.1251	.1541	.600
29	.0200	45.0	0	.	.	.480	.1022	.1166	.1423	.571
30	.0200	45.0	0	.	.	.480	.1022	.1166	.1423	.571
31	.0200	45.0	0	.	.	.450	.0963	.1091	.1318	.541
32	.0200	45.0	0	.	.	.450	.0963	.1091	.1318	.541
33	.0200	50.0	0	.	.	.450	.0888	.1090	.1318	.527
34	.0200	50.0	0	.	.	.450	.0888	.1090	.1318	.527
35	.0200	50.0	0	.	.	.450	.0888	.1090	.1318	.527
36	.0200	50.0	0	.	.	.450	.0888	.1090	.1318	.527
37	.0200	50.0	0	.	.	.330	.0734	.0855	.0993	.401
38	.0200	50.0	0	.	.	.330	.0734	.0855	.0993	.401
39	.0200	50.0	0	.	.	.330	.0734	.0855	.0993	.401

428

	year	ntax	stax	ctax	ded	invent	srelief	mrate1	myear1	mmethod1	mrate2
1	1960	.3500	.3750	.1000	1	1.00	.0000	.3250	1.0	0	.1250
2	1961	.3167	.3750	.1500	1	1.00	.0000	.5250	1.0	0	.1250
3	1962	.3167	.3750	.1500	1	1.00	.0000	.5250	1.0	0	.1250
4	1963	.3167	.3750	.1500	1	1.00	.0000	.5250	1.0	0	.1250
5	1964	.3167	.3750	.1500	1	1.00	.0000	.5250	1.0	0	.1250
6	1965	.3167	.3750	.1500	1	1.00	.0000	.5250	1.0	0	.1250
7	1966	.3167	.3750	.2300	1	1.00	.0000	.5250	1.0	0	.1250
8	1967	.3500	.4500	.2300	1	1.00	.0000	.6250	1.0	0	.1250
9	1968	.3500	.4500	.2300	1	1.00	.0000	.8750	1.0	0	.1250
10	1969	.3500	.4500	.2300	1	1.00	.0000	.8750	1.0	0	.1250
11	1970	.3500	.4500	.2300	1	1.00	.0000	.8750	1.0	0	.1250
12	1971	.3500	.4500	.2300	1	1.00	.0000	1.0000	1.0	0	.
13	1972	.3500	.4500	.2300	1	1.00	.0000	1.0000	1.0	0	.
14	1973	.3500	.4500	.2300	1	1.00	.0000	1.0000	1.0	0	.
15	1974	.5000	.0000	.0000	.	1.00	.0000	1.0000	1.0	0	.
16	1975	.5000	.0000	.0000	.	1.00	.0000	1.0000	1.0	0	.
17	1976	.5000	.0000	.0000	.	1.00	.0000	1.0000	1.0	0	.
18	1977	.5000	.0000	.0000	.	1.00	.0000	1.0000	1.0	0	.
19	1978	.5000	.0000	.0000	.	1.00	.0000	1.0000	1.0	0	.
20	1979	.5000	.0000	.0000	.	1.00	.0000	1.0000	1.0	0	.
21	1980	.5000	.0000	.0000	.	1.00	.0000	1.0000	1.0	0	.
22	1981	.1000	.0000	.0000	.	1.00	.0000	1.0000	1.0	0	.
23	1982	.1000	.0000	.0000	.	1.00	.0000	1.0000	1.0	0	.
24	1983	.1000	.0000	.0000	.	1.00	.0000	1.0000	1.0	0	.
25	1984	.1000	.0000	.0000	.	1.00	.0300	1.0000	1.0	0	.
26	1985	.1000	.0000	.0000	.	1.00	.0000	1.0000	1.0	0	.
27	1986	.1000	.0000	.0000	.	1.00	.0000	1.0000	1.0	0	.
28	1987	.1000	.0000	.0000	.	1.00	.0000	1.0000	1.0	0	.
29	1988	.1000	.0000	.0000	.	1.00	.0000	.8750	1.0	0	.1250
30	1989	.1000	.0000	.0000	.	1.00	.0000	.6250	1.0	0	.1250
31	1990	.1000	.0000	.0000	.	1.00	.0000	.6250	1.0	0	.1250
32	1991	.1000	.0000	.0000	.	1.00	.0000	.3750	1.0	0	.1250
33	1992	.1000	.0000	.0000	.	1.00	.0000	.1500	6.0	0	.1000
34	1993	.1000	.0000	.0000	.	1.00	.0000	.1500	6.0	0	.1000
35	1994	.1000	.0000	.0000	.	1.00	.0000	.1500	6.0	0	.1000
36	1995	.1000	.0000	.0000	.	1.00	.0000	.1500	6.0	0	.1000
37	1996	.1000	.0000	.0000	.	1.00	.0000	.1500	6.0	0	.1000
38	1997	.1000	.0000	.0000	.	1.00	.0000	.1500	6.0	0	.1000
39	1998	.1000	.0000	.0000	.	1.00	.0000	.1500	6.0	0	.1000

429

	myear2	mmethod2	brate1	byear1	bmethod1	brate2	byear2	bmethod2	brate3	byear3	bmethod3
1	.	1	.1200	1.0	0	.0200	44.0	0	.	.	.
2	.	1	.1200	1.0	0	.0200	44.0	0	.	.	.
3	.	1	.1200	1.0	0	.0200	44.0	0	.	.	.
4	.	1	.1200	1.0	0	.0200	44.0	0	.	.	.
5	.	1	.1200	1.0	0	.0200	44.0	0	.	.	.
6	.	1	.1200	1.0	0	.0200	44.0	0	.	.	.
7	.	1	.2200	1.0	0	.0200	39.0	0	.	.	.
8	.	1	.5200	1.0	0	.0200	24.0	0	.	.	.
9	.	1	.7700	1.0	0	.0200	11.0	0	.0100	1.0	0
10	.	1	.7700	1.0	0	.0200	11.0	0	.0100	1.0	0
11	.	1	.7700	1.0	0	.0200	11.0	0	.0100	1.0	0
12	.	.	1.0000	1.0	0	.	.	.	.	.	.
13	.	.	1.0000	1.0	0	.	.	.	.	.	.
14	.	.	1.0000	1.0	0	.	.	.	.	.	.
15	.	.	1.0000	1.0	0	.	.	.	.	.	.
16	.	.	1.0000	1.0	0	.	.	.	.	.	.
17	.	.	1.0000	1.0	0	.	.	.	.	.	.
18	.	.	1.0000	1.0	0	.	.	.	.	.	.
19	.	.	1.0000	1.0	0	.	.	.	.	.	.
20	.	.	1.0000	1.0	0	.	.	.	.	.	.
21	.	.	1.0000	1.0	0	.	.	.	.	.	.
22	.	.	1.0000	1.0	0	.	.	.	.	.	.
23	.	.	1.0000	1.0	0	.	.	.	.	.	.
24	.	.	1.0000	1.0	0	.	.	.	.	.	.
25	.	.	1.0000	1.0	0	.	.	.	.	.	.
26	.	.	1.0000	1.0	0	.	.	.	.	.	.
27	.	.	1.0000	1.0	0	.	.	.	.	.	.
28	.	.	1.0000	1.0	0	.	.	.	.	.	.
29	.	1	.7900	1.0	0	.0400	5.0	0	.	.	.
30	.	1	.5400	1.0	0	.0400	11.0	0	.	.	.
31	.	1	.5400	1.0	0	.0400	11.0	0	.	.	.
32	.	1	.2900	1.0	0	.0400	19.0	0	.	.	.
33	1.0	0	.0400	25.0	0	.	.	.	.	.	.
34	1.0	0	.0400	25.0	0	.	.	.	.	.	.
35	1.0	0	.0400	25.0	0	.	.	.	.	.	.
36	1.0	0	.0400	25.0	0	.	.	.	.	.	.
37	1.0	0	.0400	25.0	0	.	.	.	.	.	.
38	1.0	0	.0400	25.0	0	.	.	.	.	.	.
39	1.0	0	.0400	25.0	0	.	.	.	.	.	.

430

	mincent	bincent	ttax	mp	bp	ip	metr
1	.	.	.533	.1282	.1226	.1642	.631
2	.	.	.520	.1049	.1189	.1584	.592
3	.	.	.520	.1049	.1189	.1584	.592
4	.	.	.520	.1049	.1189	.1584	.592
5	.	.	.520	.1049	.1189	.1584	.592
6	.	.	.520	.1049	.1189	.1584	.592
7	.	.	.565	.1159	.1218	.1800	.626
8	.	.	.621	.1184	.1002	.2137	.634
9	.	.	.621	.0821	.0712	.2137	.552
10	.	.	.621	.0821	.0712	.2137	.552
11	.	.	.621	.0821	.0712	.2137	.552
12	.	.	.621	.0639	.0571	.2137	.496
13	.	.	.621	.0639	.0571	.2137	.496
14	.	.	.621	.0639	.0571	.2137	.496
15	.	.	.500	.0585	.0544	.1500	.376
16	.	.	.500	.0585	.0544	.1500	.376
17	.	.	.500	.0585	.0544	.1500	.376
18	.	.	.500	.0585	.0544	.1500	.376
19	.	.	.500	.0585	.0544	.1500	.376
20	.	.	.500	.0585	.0544	.1500	.376
21	.	.	.500	.0585	.0544	.1500	.376
22	.	.	.100	.0509	.0505	.0611	.063
23	.	.	.100	.0509	.0505	.0611	.063
24	.	.	.100	.0509	.0505	.0611	.063
25	.	.	.100	.0509	.0505	.0610	.062
26	.	.	.100	.0509	.0505	.0611	.063
27	.	.	.100	.0509	.0505	.0611	.063
28	.	.	.100	.0509	.0505	.0611	.063
29	.	.	.100	.0522	.0510	.0611	.075
30	.	.	.100	.0546	.0524	.0611	.100
31	.	.	.100	.0571	.0524	.0611	.118
32	.	.	.100	.0553	.0546	.0611	.116
33	.	.	.100	.0553	.0563	.0611	.124
34	.	.	.100	.0553	.0563	.0611	.124
35	.	.	.100	.0553	.0563	.0611	.124
36	.	.	.100	.0553	.0563	.0611	.124
37	.	.	.100	.0553	.0563	.0611	.124
38	.	.	.100	.0553	.0563	.0611	.124
39	.	.	.100	.0553	.0563	.0611	.124

431

	year	ctax	wtax	ded1	ltax	ded2	stax	invent	mrate1	myear1	mmethod1
1	1960	.1500	.2000	1	.0750	.00	.1000	0	.2500	2.0	0
2	1961	.1500	.2000	1	.0750	.00	.1000	0	.2500	2.0	0
3	1962	.1500	.2400	1	.0750	.00	.1000	0	.2500	2.0	0
4	1963	.1500	.2400	1	.0750	.00	.1000	0	.2500	2.0	0
5	1964	.1500	.2400	1	.0750	.00	.1000	0	.2500	2.0	0
6	1965	.1500	.2500	1	.0750	.00	.1000	0	.2500	2.0	0
7	1966	.1500	.2500	1	.0750	.00	.1000	0	.2500	2.0	0
8	1967	.1500	.2500	1	.0750	.00	.2000	0	.2500	2.0	0
9	1968	.1500	.2500	1	.0750	.00	.2000	0	.2500	2.0	0
10	1969	.1500	.2500	1	.0750	.00	.2000	0	.2500	2.0	0
11	1970	.1500	.2500	1	.0750	.00	.2000	0	.2500	2.0	0
12	1971	.1500	.2500	1	.0750	.00	.2000	0	.2500	2.0	0
13	1972	.1500	.2500	1	.0750	.00	.2000	0	.2500	2.0	0
14	1973	.1500	.2500	1	.0750	.00	.2000	0	.2500	2.0	0
15	1974	.3500	.0000	.	.1470	1.00	.	0	.2500	3.0	0
16	1975	.3500	.0000	.	.1470	1.00	.	0	.2500	3.0	0
17	1976	.2500	.0000	.	.1500	1.00	.	0	.2500	3.0	0
18	1977	.2500	.0000	.	.1500	1.00	.	0	.2500	3.0	0
19	1978	.2500	.0000	.	.1500	1.00	.	0	.2500	3.0	0
20	1979	.2500	.0000	.	.1500	1.00	.	0	.2500	3.0	0
21	1980	.2500	.0000	.	.1500	1.00	.	0	.2500	3.0	0
22	1981	.2500	.0000	.	.1500	1.00	.	0	.2500	3.0	0
23	1982	.2700	.0000	.	.1620	1.00	.	0	.2500	3.0	0
24	1983	.3000	.0000	.	.1620	1.00	.	0	.2500	3.0	0
25	1984	.3600	.0000	.	.1620	1.00	.	0	.2500	3.0	0
26	1985	.3600	.0000	.	.1620	1.00	.	0	.2500	3.0	0
27	1986	.3600	.0000	.	.1620	1.00	.	0	.2500	3.0	0
28	1987	.3600	.0000	.	.1620	1.00	.	0	.2500	3.0	0
29	1988	.3600	.0000	.	.1620	1.00	.	0	.1250	1.0	0
30	1989	.3600	.0000	.	.1620	1.00	.	0	.1250	1.0	0
31	1990	.3600	.0000	.	.1620	1.00	.	0	.1000	1.0	0
32	1991	.3600	.0000	.	.1620	.75	.	0	.1000	1.0	0
33	1992	.3600	.0000	.	.1620	.75	.	0	.1000	1.0	0
34	1993	.3600	.0000	.	.1620	.00	.	0	.1000	1.0	0
35	1994	.3800	.0000	.	.1620	.00	.	0	.1000	1.0	0
36	1995	.3700	.0000	.	.1620	.00	.	0	.1000	1.0	0
37	1996	.3700	.0000	.	.1620	.00	.	0	.1500	1.0	0
38	1997	.3700	.0000	.	.1620	.00	.	0	.1500	1.0	0
39	1998	.3700	.0000	.	.1620	.00	.	0	.1500	1.0	0

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	mrate2	myear2	mmethod2	mrate3	myear3	mmethod3	mrate4	myear4	mmethod4	brate1	byear1
1	.2000	1.0	0	.1000	3.0	.	.	.	.	.0300	33.0
2	.2000	1.0	0	.1000	3.0	0	.	.	.	.0300	33.0
3	.2000	1.0	0	.1000	3.0	0	.	.	.	.0300	33.0
4	.2000	1.0	0	.1000	3.0	0	.	.	.	.0300	33.0
5	.2000	1.0	0	.1000	3.0	0	.	.	.	.0300	33.0
6	.2000	1.0	0	.1000	3.0	0	.	.	.	.0300	33.0
7	.2000	1.0	0	.1000	3.0	0	.	.	.	.0300	33.0
8	.2000	1.0	0	.1000	3.0	0	.	.	.	.0300	33.0
9	.2000	1.0	0	.1000	3.0	0	.	.	.	.0300	33.0
10	.2000	1.0	0	.1000	3.0	0	.	.	.	.0300	33.0
11	.2000	1.0	0	.1000	3.0	0	.	.	.	.0300	33.0
12	.2000	1.0	0	.1000	3.0	0	.	.	.	.0300	33.0
13	.2000	1.0	0	.1000	3.0	0	.	.	.	.0300	33.0
14	.2000	1.0	0	.1000	3.0	0	.	.	.	.0300	33.0
15	.1000	2.0	0	.0500	1.0	0	.	.	.	.1800	3.0
16	.1000	2.0	0	.0500	1.0	0	.	.	.	.1800	3.0
17	.1000	2.0	0	.0500	1.0	0	.	.	.	.1800	3.0
18	.1000	2.0	0	.0500	1.0	0	.	.	.	.1800	3.0
19	.1000	2.0	0	.0500	1.0	0	.	.	.	.1800	3.0
20	.1000	2.0	0	.0500	1.0	0	.	.	.	.1800	3.0
21	.1000	2.0	0	.0500	1.0	0	.	.	.	.1800	3.0
22	.1000	2.0	0	.0500	1.0	0	.	.	.	.1800	3.0
23	.1000	2.0	0	.0500	1.0	0	.	.	.	.1800	3.0
24	.1000	2.0	0	.0500	1.0	0	.	.	.	.1800	3.0
25	.1000	2.0	0	.0500	1.0	0	.	.	.	.1800	3.0
26	.1000	2.0	0	.0500	1.0	0	.	.	.	.1800	3.0
27	.1000	2.0	0	.0500	1.0	0	.	.	.	.1800	3.0
28	.1000	2.0	0	.0500	1.0	0	.	.	.	.1800	3.0
29	.2500	2.0	0	.1000	3.0	0	.0750	1.0	0	.0375	1.0
30	.2500	2.0	0	.1000	3.0	0	.0750	1.0	0	.0375	1.0
31	.2000	2.0	0	.1000	5.0	0	.	.	.	.0300	1.0
32	.2000	2.0	0	.1000	5.0	0	.	.	.	.0300	1.0
33	.2000	2.0	0	.1000	5.0	0	.	.	.	.0300	1.0
34	.2000	2.0	0	.1000	5.0	0	.	.	.	.0300	1.0
35	.2000	2.0	0	.1000	5.0	0	.	.	.	.0300	1.0
36	.2000	2.0	0	.1000	5.0	0	.	.	.	.0300	1.0
37	.3000	2.0	0	.1000	2.0	0	.0500	1.0	0	.0450	1.0
38	.3000	2.0	0	.1000	2.0	0	.0500	1.0	0	.0450	1.0
39	.3000	2.0	0	.1000	2.0	0	.0500	1.0	0	.0450	1.0

	bmethod1	brate2	byear2	bmethod2	brate3	byear3	bmethod3	brate4	byear4	bmethod4	mincent
1	0	.0100	1.0	0	.	.	.	.	.	.	.
2	0	.0100	1.0	0	.	.	.	.	.	.	.
3	0	.0100	1.0	0	.	.	.	.	.	.	.
4	0	.0100	1.0	0	.	.	.	.	.	.	.
5	0	.0100	1.0	0	.	.	.	.	.	.	.
6	0	.0100	1.0	0	.	.	.	.	.	.	.
7	0	.0100	1.0	0	.	.	.	.	.	.	.
8	0	.0100	1.0	0	.	.	.	.	.	.	.
9	0	.0100	1.0	0	.	.	.	.	.	.	.
10	0	.0100	1.0	0	.	.	.	.	.	.	.
11	0	.0100	1.0	0	.	.	.	.	.	.	.
12	0	.0100	1.0	0	.	.	.	.	.	.	.
13	0	.0100	1.0	0	.	.	.	.	.	.	.
14	0	.0100	1.0	0	.	.	.	.	.	.	.
15	0	.0300	15.0	0	.0100	1.0	0	.	.	.	.
16	0	.0300	15.0	0	.0100	1.0	0	.	.	.	.
17	0	.0300	15.0	0	.0100	1.0	0	.	.	.	.
18	0	.0300	15.0	0	.0100	1.0	0	.	.	.	.
19	0	.0300	15.0	0	.0100	1.0	0	.	.	.	.
20	0	.0300	15.0	0	.0100	1.0	0	.	.	.	.
21	0	.0300	15.0	0	.0100	1.0	0	.	.	.	.
22	0	.0300	15.0	0	.0100	1.0	0	.	.	.	.
23	0	.0300	15.0	0	.0100	1.0	0	.	.	.	.
24	0	.0300	15.0	0	.0100	1.0	0	.	.	.	.
25	0	.0300	15.0	0	.0100	1.0	0	.	.	.	.
26	0	.0300	15.0	0	.0100	1.0	0	.	.	.	.
27	0	.0300	15.0	0	.0100	1.0	0	.	.	.	.
28	0	.0300	15.0	0	.0100	1.0	0	.	.	.	.
29	0	.0750	2.0	0	.0300	27.0	0	.0025	1.0	0	.
30	0	.0750	2.0	0	.0300	27.0	0	.0025	1.0	0	.
31	0	.0600	2.0	0	.0300	28.0	0	.0100	1.0	0	.
32	0	.0600	2.0	0	.0300	28.0	0	.0100	1.0	0	.
33	0	.0600	2.0	0	.0300	28.0	0	.0100	1.0	0	.
34	0	.0600	2.0	0	.0300	28.0	0	.0100	1.0	0	.
35	0	.0600	2.0	0	.0300	28.0	0	.0100	1.0	0	.
36	0	.0600	2.0	0	.0300	28.0	0	.0100	1.0	0	.
37	0	.0900	2.0	0	.0300	25.0	0	.0250	1.0	0	.
38	0	.0900	2.0	0	.0300	25.0	0	.0250	1.0	0	.
39	0	.0900	2.0	0	.0300	25.0	0	.0250	1.0	0	.

	bincent	ttax	mp	bp	ip	metr
1	.	.395	.0727	.0918	.0826	.382
2	.	.395	.0727	.0918	.0826	.382
3	.	.395	.0727	.0918	.0826	.382
4	.	.429	.0762	.0981	.0876	.416
5	.	.429	.0762	.0981	.0876	.416
6	.	.438	.0771	.0998	.0889	.424
7	.	.438	.0771	.0998	.0889	.424
8	.	.438	.0771	.0998	.0889	.424
9	.	.438	.0771	.0998	.0889	.424
10	.	.438	.0771	.0998	.0889	.424
11	.	.438	.0771	.0998	.0889	.424
12	.	.438	.0771	.0998	.0889	.424
13	.	.438	.0771	.0998	.0889	.424
14	.	.438	.0771	.0998	.0889	.424
15	.	.446	.0766	.0760	.0902	.373
16	.	.446	.0766	.0760	.0902	.373
17	.	.363	.0688	.0684	.0784	.297
18	.	.363	.0688	.0684	.0784	.297
19	.	.363	.0688	.0684	.0784	.297
20	.	.363	.0688	.0684	.0784	.297
21	.	.363	.0688	.0684	.0784	.297
22	.	.363	.0688	.0684	.0784	.297
23	.	.388	.0710	.0705	.0817	.320
24	.	.413	.0733	.0728	.0852	.343
25	.	.464	.0786	.0780	.0932	.391
26	.	.464	.0786	.0780	.0932	.391
27	.	.464	.0786	.0780	.0932	.391
28	.	.464	.0786	.0780	.0932	.391
29	.	.464	.0863	.0992	.0932	.456
30	.	.464	.0863	.0992	.0932	.456
31	.	.464	.0932	.1017	.0932	.478
32	.	.478	.0958	.1048	.0958	.492
33	.	.478	.0958	.1048	.0958	.492
34	.	.522	.1045	.1152	.1046	.536
35	.	.542	.1091	.1207	.1092	.556
36	.	.532	.1068	.1179	.1068	.546
37	.	.532	.0902	.1118	.1068	.504
38	.	.532	.0902	.1118	.1068	.504
39	.	.532	.0902	.1118	.1068	.504

	year	ntax	stax	piitax	miitax	pictax	mictax	petax	ded	invent	mrate1
1	1960	.3800	.0000	.0000	.0000	.0620	.0970	.1200	1	0	.2260
2	1961	.3800	.0000	.0000	.0000	.0620	.0970	.1200	1	0	.2260
3	1962	.3800	.0000	.0000	.0000	.0620	.0970	.1200	1	0	.2260
4	1963	.3800	.0000	.0000	.0000	.0620	.0970	.1200	1	0	.2260
5	1964	.3800	.0000	.0000	.0000	.0620	.0970	.1200	1	0	.2260
6	1965	.3700	.0000	.0000	.0000	.0620	.0970	.1200	1	0	.2260
7	1966	.3500	.0000	.0000	.0000	.0620	.1070	.1200	1	0	.2260
8	1967	.3500	.0000	.0000	.0001	.0620	.1070	.1200	1	0	.2260
9	1968	.3500	.0000	.0000	.0001	.0620	.1070	.1200	1	0	.2260
10	1969	.3500	.0000	.0000	.0001	.0620	.1070	.1200	1	0	.2260
11	1970	.3675	.0000	.0000	.0001	.0660	.1070	.1200	1	0	.2260
12	1971	.3675	.0000	.0000	.0001	.0660	.1070	.1200	1	0	.2260
13	1972	.3675	.0000	.0000	.0001	.0660	.1070	.1200	1	0	.2260
14	1973	.3675	.0000	.0000	.0001	.0660	.1070	.1200	1	0	.2260
15	1974	.4000	.1000	.0000	.0001	.0660	.1070	.1200	1	0	.2260
16	1975	.4000	.1000	.0000	.0001	.0660	.1070	.1200	1	0	.2260
17	1976	.4000	.1000	.0001	.0004	.0650	.1450	.1200	1	0	.2260
18	1977	.4000	.0000	.0001	.0004	.0650	.1450	.1200	1	0	.2260
19	1978	.4000	.0000	.0001	.0004	.0650	.1450	.1200	1	0	.2260
20	1979	.4000	.0000	.0001	.0004	.0650	.1450	.1200	1	0	.2260
21	1980	.4000	.0000	.0001	.0004	.0650	.1450	.1200	1	0	.2260
22	1981	.4330	.0000	.0001	.0004	.0650	.1450	.1200	1	0	.2260
23	1982	.4330	.0000	.0001	.0004	.0650	.1450	.1200	1	0	.2260
24	1983	.4330	.0000	.0001	.0004	.0650	.1450	.1200	1	0	.2260
25	1984	.4330	.0000	.0001	.0004	.0600	.1470	.1320	1	0	.2260
26	1985	.4330	.0000	.0001	.0004	.0600	.1470	.1320	1	0	.2260
27	1986	.4330	.0000	.0001	.0004	.0600	.1470	.1320	1	0	.2260
28	1987	.4200	.0000	.0001	.0004	.0600	.1470	.1320	1	0	.2260
29	1988	.4200	.0000	.0001	.0004	.0600	.1470	.1320	1	0	.2260
30	1989	.4000	.0000	.0001	.0004	.0600	.1470	.1320	1	0	.2260
31	1990	.3750	.0000	.0001	.0004	.0600	.1470	.1320	1	0	.2260
32	1991	.3750	.0250	.0001	.0004	.0600	.1470	.1320	1	0	.2260
33	1992	.3750	.0250	.0001	.0004	.0600	.1470	.1320	1	0	.2260
34	1993	.3750	.0250	.0001	.0004	.0600	.1470	.1320	1	0	.2260
35	1994	.3750	.0250	.0001	.0004	.0600	.1470	.1320	1	0	.2260
36	1995	.3750	.0000	.0001	.0004	.0600	.1010	.1200	1	0	.2260
37	1996	.3750	.0000	.0001	.0004	.0600	.1010	.1200	1	0	.2260
38	1997	.3750	.0000	.0001	.0004	.0600	.1010	.1200	1	0	.2260
39	1998	.3750	.0000	.0001	.0004	.0600	.1010	.1200	1	0	.2260

	myear1	mmethod1	mrate2	myear2	mmethod2	brate1	byear1	bmethod1	brate2	byear2	bmethod2
1	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
2	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
3	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
4	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
5	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
6	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
7	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
8	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
9	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
10	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
11	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
12	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
13	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
14	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
15	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
16	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
17	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
18	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
19	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
20	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
21	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
22	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
23	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
24	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
25	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
26	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
27	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
28	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
29	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
30	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
31	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
32	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
33	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
34	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
35	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
36	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
37	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
38	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0
39	4.0	1	.0720	5.0	0	.0500	21.0	1	.0155	22.0	0

437

	mincent	bincent	ttax	mp	bp	ip	metr
1	.	.	.553	.1160	.1239	.1119	.5740
2	.	.	.553	.1160	.1239	.1119	.5740
3	.	.	.553	.1160	.1239	.1119	.5740
4	.	.	.553	.1160	.1239	.1119	.5740
5	.	.	.553	.1160	.1239	.1119	.5740
6	.	.	.546	.1141	.1218	.1101	.5668
7	.	.	.538	.1121	.1196	.1082	.5590
8	.	.	.538	.1121	.1196	.1082	.5590
9	.	.	.538	.1121	.1196	.1082	.5590
10	.	.	.538	.1121	.1196	.1082	.5590
11	.	.	.553	.1160	.1239	.1118	.5738
12	.	.	.553	.1160	.1239	.1118	.5738
13	.	.	.553	.1160	.1239	.1118	.5738
14	.	.	.553	.1160	.1239	.1118	.5738
15	.	.	.604	.1315	.1412	.1263	.6243
16	.	.	.604	.1315	.1412	.1263	.6243
17	.	.	.625	.1390	.1496	.1334	.6448
18	.	.	.598	.1295	.1390	.1245	.6186
19	.	.	.598	.1295	.1390	.1245	.6186
20	.	.	.598	.1295	.1390	.1245	.6186
21	.	.	.598	.1295	.1390	.1245	.6186
22	.	.	.620	.1372	.1477	.1317	.6402
23	.	.	.620	.1372	.1477	.1317	.6402
24	.	.	.620	.1372	.1477	.1317	.6402
25	.	.	.625	.1391	.1498	.1335	.6452
26	.	.	.625	.1391	.1498	.1335	.6452
27	.	.	.625	.1391	.1498	.1335	.6452
28	.	.	.617	.1360	.1462	.1305	.6368
29	.	.	.617	.1360	.1462	.1305	.6368
30	.	.	.604	.1313	.1410	.1262	.6239
31	.	.	.587	.1259	.1350	.1211	.6077
32	.	.	.593	.1279	.1372	.1230	.6138
33	.	.	.593	.1279	.1372	.1230	.6138
34	.	.	.593	.1279	.1372	.1230	.6138
35	.	.	.593	.1279	.1372	.1230	.6138
36	.	.	.551	.1155	.1233	.1113	.5719
37	.	.	.551	.1155	.1233	.1113	.5719
38	.	.	.551	.1155	.1233	.1113	.5719
39	.	.	.551	.1155	.1233	.1113	.5719

	year	ntax	stax	ltax	ded	invent	mrate1	myear1	mmethod1	mrate2	myear2
1	1960	.4000	.0100	.0909	1	1	.3000	4.0	1	.0600	4.0
2	1961	.4000	.0100	.0909	1	1	.3000	4.0	1	.0600	4.0
3	1962	.4000	.0100	.0909	1	1	.3000	4.0	1	.0600	4.0
4	1963	.4000	.0100	.0909	1	1	.3000	4.0	1	.0600	4.0
5	1964	.4000	.0100	.0909	1	1	.3000	4.0	1	.0600	4.0
6	1965	.4000	.0100	.1071	1	1	.3000	4.0	1	.0600	4.0
7	1966	.4000	.0100	.1071	1	1	.3000	4.0	1	.0600	4.0
8	1967	.4000	.0100	.1228	1	1	.3000	4.0	1	.0600	4.0
9	1968	.4000	.0100	.1228	1	1	.3000	4.0	1	.0600	4.0
10	1969	.4000	.0100	.1228	1	1	.3000	4.0	1	.0600	4.0
11	1970	.4500	.0100	.1228	1	1	.3000	4.0	1	.0600	4.0
12	1971	.4000	.0100	.1228	1	1	.3000	4.0	1	.0600	4.0
13	1972	.4000	.0100	.1228	1	1	.3000	4.0	1	.0600	4.0
14	1973	.4000	.0100	.1289	1	1	.3000	4.0	1	.0600	4.0
15	1974	.4000	.0100	.1289	1	1	.3000	4.0	1	.0600	4.0
16	1975	.4000	.0100	.1289	1	1	.3000	4.0	1	.0600	4.0
17	1976	.4000	.0050	.1289	1	1	.3000	4.0	1	.0600	4.0
18	1977	.4000	.0050	.1289	1	1	.3000	4.0	1	.0600	4.0
19	1978	.4000	.0050	.1289	1	1	.3000	4.0	1	.0600	4.0
20	1979	.4000	.0050	.1289	1	1	.3000	4.0	1	.0600	4.0
21	1980	.4000	.0050	.1289	1	1	.3000	4.0	1	.0600	4.0
22	1981	.4000	.0050	.1289	1	1	.3000	4.0	1	.0600	4.0
23	1982	.4000	.0200	.1289	1	1	.3000	4.0	1	.0600	4.0
24	1983	.4000	.0200	.1289	1	1	.3000	4.0	1	.0600	4.0
25	1984	.4000	.0200	.1289	1	1	.3000	4.0	1	.0600	4.0
26	1985	.4000	.0200	.1289	1	1	.3000	4.0	1	.0600	4.0
27	1986	.4000	.0300	.1289	1	1	.3000	4.0	1	.0600	4.0
28	1987	.3800	.0300	.1289	1	1	.3000	4.0	1	.0600	4.0
29	1988	.3600	.0200	.1289	1	1	.3000	4.0	1	.0600	4.0
30	1989	.3600	.0200	.1289	1	1	.3000	4.0	1	.0600	4.0
31	1990	.3600	.0200	.1289	1	1	.3000	4.0	1	.0600	4.0
32	1991	.3300	.0100	.1289	1	1	.3000	4.0	1	.0600	4.0
33	1992	.3300	.0100	.1289	1	1	.3000	4.0	1	.0600	4.0
34	1993	.3300	.0100	.1289	1	1	.3000	4.0	1	.0600	4.0
35	1994	.3300	.0100	.1289	1	1	.3000	4.0	1	.0600	4.0
36	1995	.3300	.0400	.1289	1	1	.3000	4.0	1	.0600	4.0
37	1996	.3200	.0400	.1289	1	0	.3000	4.0	1	.0600	4.0
38	1997	.3100	.0400	.1289	1	0	.3000	4.0	1	.0600	4.0
39	1998	.3100	.0400	.1289	1	0	.3000	4.0	1	.0600	4.0

	mmethod2	brate1	byear1	bmethod1	mincent	bincent	ttax	mp	bp	lp	metr
1	0	.0400	25.0	0	.0900	.	.458	.0719	.0898	.1346	.4620
2	0	.0400	25.0	0	.0900	.	.458	.0719	.0898	.1346	.4620
3	0	.0400	25.0	0	.0900	.	.458	.0719	.0898	.1346	.4620
4	0	.0400	25.0	0	.0900	.	.458	.0719	.0898	.1346	.4620
5	0	.0400	25.0	0	.0900	.	.458	.0719	.0898	.1346	.4620
6	0	.0400	25.0	0	.0900	.	.468	.0734	.0914	.1379	.4732
7	0	.0400	25.0	0	.0900	.	.468	.0734	.0914	.1379	.4732
8	0	.0400	25.0	0	.0900	.	.477	.0748	.0930	.1413	.4839
9	0	.0400	25.0	0	.0900	.	.477	.0748	.0930	.1413	.4839
10	0	.0400	25.0	0	.0900	.	.477	.0748	.0930	.1413	.4839
11	0	.0400	25.0	0	.0900	.	.521	.0826	.1013	.1590	.5340
12	0	.0400	25.0	0	.0900	.	.477	.0748	.0930	.1413	.4839
13	0	.0400	25.0	0	.0900	.	.477	.0748	.0930	.1413	.4839
14	0	.0400	25.0	0	.0900	.	.481	.0754	.0936	.1426	.4881
15	0	.0400	25.0	0	.0900	.	.481	.0754	.0936	.1426	.4881
16	0	.0400	25.0	0	.0900	.	.481	.0754	.0936	.1426	.4881
17	0	.0400	25.0	0	.0900	.	.479	.0751	.0933	.1420	.4861
18	0	.0400	25.0	0	.0900	.	.479	.0751	.0933	.1420	.4861
19	0	.0400	25.0	0	.0900	.	.479	.0751	.0933	.1420	.4861
20	0	.0400	25.0	0	.0900	.	.479	.0751	.0933	.1420	.4861
21	0	.0400	25.0	0	.0900	.	.479	.0751	.0933	.1420	.4861
22	0	.0400	25.0	0	.0900	.	.479	.0751	.0933	.1420	.4861
23	0	.0400	25.0	0	.0900	.	.484	.0760	.0942	.1439	.4921
24	0	.0400	25.0	0	.0900	.	.484	.0760	.0942	.1439	.4921
25	0	.0400	25.0	0	.1200	.	.484	.0699	.0942	.1439	.4775
26	0	.0400	25.0	0	.1200	.	.484	.0699	.0942	.1439	.4775
27	0	.0400	25.0	0	.1200	.	.488	.0705	.0949	.1452	.4817
28	0	.0400	25.0	0	.1200	.	.470	.0676	.0917	.1386	.4602
29	0	.0400	25.0	0	.1200	.	.449	.0646	.0883	.1314	.4345
30	0	.0400	25.0	0	.1200	.	.449	.0646	.0883	.1314	.4345
31	0	.0400	25.0	0	.1200	.	.449	.0646	.0883	.1314	.4345
32	0	.0400	25.0	0	.1200	.	.419	.0607	.0840	.1222	.3979
33	0	.0400	25.0	0	.1200	.	.419	.0607	.0840	.1222	.3979
34	0	.0400	25.0	0	.1200	.	.419	.0607	.0840	.1222	.3979
35	0	.0400	25.0	0	.1200	.	.419	.0607	.0840	.1222	.3979
36	0	.0400	25.0	0	.1200	.	.428	.0618	.0852	.1248	.4087
37	0	.0400	25.0	0	.1200	.	.419	.0606	.0839	.0860	.3240
38	0	.0400	25.0	0	.1200	.	.410	.0595	.0827	.0847	.3128
39	0	.0400	25.0	0	.1200	.	.410	.0595	.0827	.0847	.3128

	year	ntax	stax	ded	invent	srelief	mrate1	myear1	mmethod1	mrate2	myear2
1	1960	.4700	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
2	1961	.4700	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
3	1962	.4700	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
4	1963	.4500	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
5	1964	.4500	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
6	1965	.4500	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
7	1966	.4700	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
8	1967	.4600	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
9	1968	.4600	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
10	1969	.4600	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
11	1970	.4600	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
12	1971	.4600	.0300	.	0	.0000	.2500	4.0	1	.0791	4.0
13	1972	.4600	.0400	.	0	.0000	.2500	4.0	1	.0791	4.0
14	1973	.4800	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
15	1974	.4800	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
16	1975	.4800	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
17	1976	.4800	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
18	1977	.4800	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
19	1978	.4800	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
20	1979	.4800	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
21	1980	.4800	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
22	1981	.4800	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
23	1982	.4800	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
24	1983	.4800	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
25	1984	.4300	.0000	.	0	.0400	.2500	4.0	1	.0791	4.0
26	1985	.4300	.0000	.	0	.0400	.2500	4.0	1	.0791	4.0
27	1986	.4300	.0000	.	0	.0400	.2500	4.0	1	.0791	4.0
28	1987	.4300	.0000	.	0	.0400	.2500	4.0	1	.0791	4.0
29	1988	.4200	.0000	.	0	.0400	.2500	4.0	1	.0791	4.0
30	1989	.4200	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
31	1990	.3500	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
32	1991	.3500	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
33	1992	.3500	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
34	1993	.3500	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
35	1994	.3500	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
36	1995	.3500	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
37	1996	.3500	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
38	1997	.3500	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0
39	1998	.3500	.0000	.	0	.0000	.2500	4.0	1	.0791	4.0

	mmethod2	brate1	byear1	bmethod1	brate2	byear2	bmethod2	mallow	ballow	mincent	bincent
1	0	.0800	12.0	1	.0283	13.0	0	.0955	.0955	.0000	.0000
2	0	.0800	12.0	1	.0283	13.0	0	.0955	.0955	.0000	.0000
3	0	.0800	12.0	1	.0283	13.0	0	.0955	.0955	.0000	.0000
4	0	.0800	12.0	1	.0283	13.0	0	.0955	.0955	.0000	.0000
5	0	.0800	12.0	1	.0283	13.0	0	.0955	.0000	.0000	.0000
6	0	.0800	12.0	1	.0283	13.0	0	.0955	.0000	.0000	.0000
7	0	.0800	12.0	1	.0283	13.0	0	.0955	.0000	.0000	.0000
8	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
9	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
10	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
11	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
12	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
13	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
14	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
15	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
16	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
17	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
18	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
19	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.1250	.1250
20	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.1250	.1250
21	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.1250	.1250
22	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.1250	.1250
23	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.1250	.1250
24	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.1250	.1250
25	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.1250	.1250
26	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.1250	.1250
27	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.1250	.1250
28	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.1250	.1250
29	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
30	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
31	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
32	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
33	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
34	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
35	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
36	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
37	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
38	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000
39	0	.0800	12.0	1	.0283	13.0	0	.0000	.0000	.0000	.0000

	ttax	mp	bp	ip	metr
1	.470	.0646	.0781	.0943	.343
2	.470	.0646	.0781	.0943	.343
3	.470	.0646	.0781	.0943	.343
4	.450	.0622	.0753	.0909	.318
5	.450	.0622	.0901	.0909	.357
6	.450	.0622	.0901	.0909	.357
7	.470	.0646	.0935	.0943	.380
8	.460	.0928	.0918	.0926	.459
9	.460	.0928	.0918	.0926	.459
10	.460	.0928	.0918	.0926	.459
11	.460	.0928	.0918	.0926	.459
12	.474	.0952	.0941	.0950	.473
13	.478	.0961	.0950	.0959	.477
14	.480	.0964	.0953	.0962	.479
15	.480	.0964	.0953	.0962	.479
16	.480	.0964	.0953	.0962	.479
17	.480	.0964	.0953	.0962	.479
18	.480	.0964	.0953	.0962	.479
19	.480	.0707	.0794	.0962	.373
20	.480	.0707	.0794	.0962	.373
21	.480	.0707	.0794	.0962	.373
22	.480	.0707	.0794	.0962	.373
23	.480	.0707	.0794	.0962	.373
24	.480	.0707	.0794	.0962	.373
25	.430	.0631	.0721	.0877	.305
26	.430	.0631	.0721	.0971	.327
27	.430	.0631	.0721	.0877	.305
28	.430	.0631	.0721	.0877	.305
29	.420	.0864	.0855	.0862	.419
30	.420	.0864	.0855	.0862	.419
31	.350	.0771	.0764	.0769	.349
32	.350	.0771	.0764	.0769	.349
33	.350	.0771	.0764	.0769	.349
34	.350	.0771	.0764	.0769	.349
35	.350	.0771	.0764	.0769	.349
36	.350	.0771	.0764	.0769	.349
37	.350	.0771	.0764	.0769	.349
38	.350	.0771	.0764	.0769	.349
39	.350	.0771	.0764	.0769	.349

	year	ntax	ltax	ded	invent	mrate1	myear1	mmethod1	mrate2	myear2	mmethod2
1	1960	.4250	.	.	1	.1600	1.0	1	.1500	1.0	1
2	1961	.4250	.	.	1	.1600	1.0	1	.1500	1.0	1
3	1962	.4250	.	.	1	.2000	1.0	1	.1500	1.0	1
4	1963	.4250	.	.	1	.2000	1.0	1	.1500	1.0	1
5	1964	.4250	.	.	1	.2000	1.0	1	.1500	1.0	1
6	1965	.4250	.	.	1	.2000	1.0	1	.1500	1.0	1
7	1966	.4250	.	.	1	.2000	1.0	1	.1500	1.0	1
8	1967	.4250	.	.	1	.2000	1.0	1	.1500	1.0	1
9	1968	.4250	.	.	1	.2000	1.0	1	.1500	1.0	1
10	1969	.5000	.	.	1	.2000	1.0	1	.1500	1.0	1
11	1970	.5000	.	.	1	.2000	1.0	1	.1500	1.0	1
12	1971	.4500	.	.	1	.2000	1.0	1	.1500	1.0	1
13	1972	.4500	.	.	1	.2000	1.0	1	.1500	1.0	1
14	1973	.4500	.	.	1	.2000	1.0	1	.1500	1.0	1
15	1974	.4500	.	.	1	.2000	1.0	1	.1500	1.0	1
16	1975	.4500	.	.	1	.2500	1.0	1	.1000	.	1
17	1976	.4500	.	.	1	.2500	1.0	1	.1000	.	1
18	1977	.4500	.	.	1	.2500	1.0	1	.1000	.	1
19	1978	.4500	.	.	1	.2500	1.0	1	.1000	.	1
20	1979	.4500	.	.	1	.2500	1.0	1	.1000	.	1
21	1980	.4500	.	.	1	.2500	1.0	1	.1000	.	1
22	1981	.4500	.	.	1	.2500	1.0	1	.1000	.	1
23	1982	.4500	.	.	1	.2500	1.0	1	.1000	.	1
24	1983	.4500	.	.	1	.2500	1.0	1	.1000	.	1
25	1984	.4500	.	.	1	.1000	.	1	.	.	.
26	1985	.4500	.	.	1	.1000	.	1	.	.	.
27	1986	.4500	.	.	1	.1000	.	1	.	.	.
28	1987	.4500	.	.	1	.1000	.	1	.	.	.
29	1988	.2800	.	.	1	.1000	.	1	.	.	.
30	1989	.3300	.	.	1	.1000	.	1	.	.	.
31	1990	.3300	.	.	1	.1000	.	1	.	.	.
32	1991	.3300	.	.	1	.1250	.	1	.	.	.
33	1992	.3300	.	.	1	.1250	.	1	.	.	.
34	1993	.3300	.	.	1	.1250	.	1	.	.	.
35	1994	.3300	.	.	1	.1250	.	1	.	.	.
36	1995	.3300	.	.	1	.1250	.	1	.	.	.
37	1996	.3300	.	.	1	.1250	.	1	.	.	.
38	1997	.3300	.	.	1	.1250	.	1	.	.	.
39	1998	.3300	.	.	1	.1250	.	1	.	.	.

	mrate3	myear3	mmethod3	mrate4	myear4	mmethod	mrate5	myear5	mmethod5	mrate6	myear6
1	.1400	1.0	1	.1300	1.0	1	.1200	1.0	1	.1000	.
2	.1400	1.0	1	.1300	1.0	1	.1200	1.0	1	.1000	.
3	.1300	1.0	1	.1200	1.0	1	.1000	.	1	.	.
4	.1300	1.0	1	.1200	1.0	1	.1000	.	1	.	.
5	.1300	1.0	1	.1200	1.0	1	.1000	.	1	.	.
6	.1300	1.0	1	.1200	1.0	1	.1000	.	1	.	.
7	.1300	1.0	1	.1200	1.0	1	.1000	.	1	.	.
8	.1300	1.0	1	.1200	1.0	1	.1000	.	1	.	.
9	.1300	1.0	1	.1200	1.0	1	.1000	.	1	.	.
10	.1300	1.0	1	.1200	1.0	1	.1000	.	1	.	.
11	.1300	1.0	1	.1200	1.0	1	.1000	.	1	.	.
12	.1300	1.0	1	.1200	1.0	1	.1000	.	1	.	.
13	.1300	1.0	1	.1200	1.0	1	.1000	.	1	.	.
14	.1300	1.0	1	.1200	1.0	1	.1000	.	1	.	.
15	.1300	1.0	1	.1200	1.0	1	.1000	.	1	.	.
16	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.
19	.	.	.	.	.	.	.	.	.	.	.
20	.	.	.	.	.	.	.	.	.	.	.
21	.	.	.	.	.	.	.	.	.	.	.
22	.	.	.	.	.	.	.	.	.	.	.
23	.	.	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.	.	.
25	.	.	.	.	.	.	.	.	.	.	.
26	.	.	.	.	.	.	.	.	.	.	.
27	.	.	.	.	.	.	.	.	.	.	.
28	.	.	.	.	.	.	.	.	.	.	.
29	.	.	.	.	.	.	.	.	.	.	.
30	.	.	.	.	.	.	.	.	.	.	.
31	.	.	.	.	.	.	.	.	.	.	.
32	.	.	.	.	.	.	.	.	.	.	.
33	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.	.	.	.	.
39	.	.	.	.	.	.	.	.	.	.	.

	mmethod6	brate1	byear1	bmethod1	mallow	ballow	ttax	mp	bp	lp	metr
1	1	.0100	100.0	0	.0000	.	.425	.1132	.1099	.1239	.5647
2	1	.0100	100.0	0	.0000	.	.425	.1132	.1099	.1239	.5647
3	.	.0100	100.0	0	.0000	.	.425	.1111	.1099	.1239	.5611
4	.	.0100	100.0	0	.1000	.	.425	.0821	.1099	.1239	.5045
5	.	.0100	100.0	0	.1000	.	.425	.0821	.1099	.1239	.5045
6	.	.0100	100.0	0	.1000	.	.425	.0821	.1099	.1239	.5045
7	.	.0100	100.0	0	.1000	.	.425	.0821	.1099	.1239	.5045
8	.	.0100	100.0	0	.0000	.	.425	.1111	.1099	.1239	.5611
9	.	.0100	100.0	0	.0000	.	.425	.1111	.1099	.1239	.5611
10	.	.0100	100.0	0	.0000	.	.500	.1327	.1310	.1500	.6337
11	.	.0100	100.0	0	.0000	.	.500	.1327	.1310	.1500	.6337
12	.	.0100	100.0	0	.0000	.	.450	.1176	.1163	.1318	.5860
13	.	.0100	100.0	0	.0000	.	.450	.1176	.1163	.1318	.5860
14	.	.0100	100.0	0	.0000	.	.450	.1176	.1163	.1318	.5860
15	.	.0100	100.0	0	.0000	.	.450	.1176	.1163	.1318	.5860
16	.	.0100	100.0	0	.2000	.	.450	.0497	.1163	.1318	.4458
17	.	.0100	100.0	0	.2000	.	.450	.0497	.1163	.1318	.4458
18	.	.0100	100.0	0	.2000	.	.450	.0497	.1163	.1318	.4458
19	.	.0100	100.0	0	.2000	.	.450	.0497	.1163	.1318	.4458
20	.	.0100	100.0	0	.2000	.	.450	.0497	.1163	.1318	.4458
21	.	.0100	100.0	0	.2000	.	.450	.0497	.1163	.1318	.4458
22	.	.0100	100.0	0	.0000	.	.450	.1103	.1163	.1318	.5744
23	.	.0100	100.0	0	.0000	.	.450	.1103	.1163	.1318	.5744
24	.	.0100	100.0	0	.0000	.	.450	.1103	.1163	.1318	.5744
25	.	.0100	100.0	0	.4000	.	.450	.0005	.1163	.1318	.2652
26	.	.0100	100.0	0	.4000	.	.450	.0005	.1163	.1318	.2652
27	.	.0100	100.0	0	.4000	.	.450	.0005	.1163	.1318	.2652
28	.	.0100	100.0	0	.4000	.	.450	.0005	.1163	.1318	.2652
29	.	.0100	100.0	0	.4000	.	.280	-.0085	.0815	.0889	.4083
30	.	.0100	100.0	0	.0000	.	.330	.0931	.0899	.0993	.4662
31	.	.0100	100.0	0	.0000	.	.330	.0931	.0899	.0993	.4662
32	.	.0100	100.0	0	.0000	.	.330	.0883	.0899	.0993	.4537
33	.	.0100	100.0	0	.0000	.	.330	.0883	.0899	.0993	.4537
34	.	.0100	100.0	0	.0000	.	.330	.0883	.0899	.0993	.4537
35	.	.0100	100.0	0	.0000	.	.330	.0883	.0899	.0993	.4537
36	.	.0100	100.0	0	.0000	.	.330	.0883	.0899	.0993	.4537
37	.	.0100	100.0	0	.0000	.	.330	.0883	.0899	.0993	.4537
38	.	.0100	100.0	0	.0000	.	.330	.0883	.0899	.0993	.4537
39	.	.0100	100.0	0	.0000	.	.330	.0883	.0899	.0993	.4537

	year	ntax	ltax	ded1	etax	ded2	sdtax	invent	mrate1	myear1	mmethod1
1	1960	.3000	.1800	0	.0000	.	.	1	.1250	8.0	0
2	1961	.3000	.1800	0	.0000	.	.	1	.1250	8.0	0
3	1962	.3000	.1800	0	.0000	.	.	1	.1250	8.0	0
4	1963	.3000	.1900	0	.0000	.	.	1	.1250	8.0	0
5	1964	.3000	.1900	0	.0500	0	.	1	.1250	8.0	0
6	1965	.3000	.1900	0	.0500	0	.	1	.1250	8.0	0
7	1966	.3000	.1900	0	.0500	0	.0025	1	.1250	8.0	0
8	1967	.3000	.1900	0	.0500	0	.0025	1	.4500	5.0	1
9	1968	.3000	.1900	0	.0500	0	.0025	1	.4500	5.0	1
10	1969	.3000	.1900	0	.0500	0	.0050	1	.4500	5.0	1
11	1970	.2650	.2000	0	.0300	0	.0100	1	.4500	5.0	1
12	1971	.2650	.2000	0	.0300	0	.0100	1	.4500	5.0	1
13	1972	.2650	.2000	0	.0300	0	.0100	1	.4500	5.0	1
14	1973	.2650	.2000	0	.0170	0	.0130	1	.4500	5.0	1
15	1974	.2650	.2000	0	.0170	0	.	1	.4500	5.0	1
16	1975	.2650	.2000	0	.0170	0	.	1	.4500	5.0	1
17	1976	.2650	.2000	0	.0170	0	.	1	.4500	5.0	1
18	1977	.2780	.2200	0	.0100	0	.	1	.4500	5.0	1
19	1978	.2780	.2200	0	.0100	0	.	1	.4500	5.0	1
20	1979	.2780	.2100	0	.0100	0	.	1	.4500	5.0	1
21	1980	.2780	.2100	0	.0100	0	.	1	.3000	.	1
22	1981	.2780	.2100	0	.0100	0	.	1	.3000	.	1
23	1982	.2780	.2100	0	.0100	0	.	1	.3000	.	1
24	1983	.2780	.2100	0	.0100	0	.	1	.3000	.	1
25	1984	.2780	.0000	.	.0000	.	.	1	.2000	.	1
26	1985	.2780	.0000	.	.0000	.	.	1	.2000	.	1
27	1986	.2780	.0000	.	.0000	.	.	1	.2000	.	1
28	1987	.2780	.0000	.	.0000	.	.	1	.2000	.	1
29	1988	.2800	.0000	.	.0000	.	.	1	.2000	.	1
30	1989	.2800	.0000	.	.0000	.	.	1	.2000	.	1
31	1990	.2800	.0000	.	.0000	.	.	1	.2000	.	1
32	1991	.2800	.0000	.	.0000	.	.	1	.2000	.	1
33	1992	.2800	.0000	.	.0000	.	.	1	.2000	.	1
34	1993	.2800	.0000	.	.0000	.	.	1	.2000	.	1
35	1994	.2800	.0000	.	.0000	.	.	1	.2000	.	1
36	1995	.2800	.0000	.	.0000	.	.	1	.2000	.	1
37	1996	.2800	.0000	.	.0000	.	.	1	.2000	.	1
38	1997	.2800	.0000	.	.0000	.	.	1	.2000	.	1
39	1998	.2800	.0000	.	.0000	.	.	1	.2000	.	1

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	mrate2	myear2	mmethod2	brate1	byear1	bmethod1	brate2	byear2	bmethod2	mincent	bincnet
1	.	.	.	.0400	25.0	0	.	.	.	.	.
2	.	.	.	.0400	25.0	0	.	.	.	.	.
3	.	.	.	.0400	25.0	0	.	.	.	.	.
4	.	.	.	.0400	25.0	0	.	.	.	.	.
5	.	.	.	.0400	25.0	0	.	.	.	.	.
6	.	.	.	.0400	25.0	0	.	.	.	.	.
7	.	.	.	.0400	25.0	0	.	.	.	.	.
8	.3000	.	1	.0875	5.0	1	.0700	.	1	.	.
9	.3000	.	1	.0875	5.0	1	.0700	.	1	.	.
10	.3000	.	1	.0875	5.0	1	.0700	.	1	.	.
11	.3000	.	1	.0875	5.0	1	.0700	.	1	.	.
12	.3000	.	1	.0875	5.0	1	.0700	.	1	.	.
13	.3000	.	1	.0875	5.0	1	.0700	.	1	.	.
14	.3000	.	1	.0875	5.0	1	.0700	.	1	.	.
15	.3000	.	1	.0875	5.0	1	.0700	.	1	.	.
16	.3000	.	1	.0875	5.0	1	.0700	.	1	.	.
17	.3000	.	1	.0875	5.0	1	.0700	.	1	.	.
18	.3000	.	1	.0875	5.0	1	.0700	.	1	.	.
19	.3000	.	1	.0875	5.0	1	.0700	.	1	.	.
20	.3000	.	1	.0875	5.0	1	.0700	.	1	.	.
21	.	.	.	.0700	.	1	.	.	.	.	.
22	.	.	.	.0700	.	1	.	.	.	.	.
23	.	.	.	.0700	.	1	.	.	.	.	.
24	.	.	.	.0700	.	1	.	.	.	.	.
25	.	.	.	.0500	.	1	.	.	.	.	.
26	.	.	.	.0500	.	1	.	.	.	.	.
27	.	.	.	.0500	.	1	.	.	.	.	.
28	.	.	.	.0500	.	1	.	.	.	.	.
29	.	.	.	.0500	.	1	.	.	.	.	.
30	.	.	.	.0500	.	1	.	.	.	.	.
31	.	.	.	.0500	.	1	.	.	.	.	.
32	.	.	.	.0500	.	1	.	.	.	.	.
33	.	.	.	.0500	.	1	.	.	.	.	.
34	.	.	.	.0500	.	1	.	.	.	.	.
35	.	.	.	.0500	.	1	.	.	.	.	.
36	.	.	.	.0500	.	1	.	.	.	.	.
37	.	.	.	.0500	.	1	.	.	.	.	.
38	.	.	.	.0500	.	1	.	.	.	.	.
39	.	.	.	.0500	.	1	.	.	.	.	.

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	ttax	mp	bp	ip	metr
1	.480	.1003	.1026	.1423	.5516
2	.480	.1003	.1026	.1423	.5516
3	.480	.1003	.1026	.1423	.5516
4	.490	.1024	.1047	.1461	.5615
5	.540	.1140	.1169	.1674	.6100
6	.540	.1140	.1169	.1674	.6100
7	.540	.1140	.1169	.1674	.6100
8	.540	.0933	.1086	.1674	.5704
9	.540	.0933	.1086	.1674	.5704
10	.540	.0933	.1086	.1674	.5704
11	.495	.0861	.0989	.1480	.5258
12	.495	.0861	.0989	.1480	.5258
13	.495	.0861	.0989	.1480	.5258
14	.482	.0843	.0964	.1431	.5128
15	.482	.0843	.0964	.1431	.5128
16	.482	.0843	.0964	.1431	.5128
17	.482	.0843	.0964	.1431	.5128
18	.508	.0881	.1015	.1533	.5387
19	.508	.0881	.1015	.1533	.5387
20	.498	.0866	.0995	.1492	.5288
21	.498	.0934	.1025	.1492	.5458
22	.498	.0934	.1025	.1492	.5458
23	.498	.0934	.1025	.1492	.5458
24	.498	.0934	.1025	.1492	.5458
25	.278	.0725	.0731	.0885	.3478
26	.278	.0725	.0731	.0885	.3478
27	.278	.0725	.0731	.0885	.3478
28	.278	.0725	.0731	.0885	.3478
29	.280	.0727	.0733	.0889	.3501
30	.280	.0727	.0733	.0889	.3501
31	.280	.0727	.0733	.0889	.3501
32	.280	.0727	.0733	.0889	.3501
33	.280	.0727	.0733	.0889	.3501
34	.280	.0727	.0733	.0889	.3501
35	.280	.0727	.0733	.0889	.3501
36	.280	.0727	.0733	.0889	.3501
37	.280	.0727	.0733	.0889	.3501
38	.280	.0727	.0733	.0889	.3501
39	.280	.0727	.0733	.0889	.3501

	year	indtax	stax	catax	stax2	comtax	stax3	allstax	ltax	ded	invent
1	1960	.1500	.7200	.1500	.1200	.0800	.2500	.0000	.	.	0
2	1961	.1500	.7200	.1500	.1200	.0800	.2500	.0000	.	.	0
3	1962	.1500	.7200	.1500	.1200	.0800	.2500	.0000	.	.	0
4	1963	.1500	.7200	.1500	.1200	.0800	.2500	.0000	.	.	0
5	1964	.1500	.7200	.1500	.1200	.0800	.2500	.0000	.	.	0
6	1965	.1500	.7200	.1500	.1200	.0800	.2500	.0000	.	.	0
7	1966	.1500	.7200	.1500	.1200	.0800	.2500	.0000	.	.	0
8	1967	.1500	.7200	.1500	.1200	.0800	.2500	.0000	.	.	0
9	1968	.1800	.7200	.1500	.1200	.0800	.2500	.0000	.	.	0
10	1969	.1800	.7200	.1500	.1200	.0800	.2500	.0000	.	.	0
11	1970	.1800	.7200	.1500	.1200	.0800	.2500	.0000	.	.	0
12	1971	.1500	.7500	.1800	.1200	.0800	.2500	.0000	.	.	0
13	1972	.1500	.7500	.1800	.1200	.0800	.2500	.0000	.	.	0
14	1973	.1500	.7500	.1800	.1200	.0800	.2500	.0000	.	.	0
15	1974	.1800	.7500	.1500	.1200	.0800	.2500	.0000	.	.	0
16	1975	.1800	.7500	.1500	.1200	.0800	.2500	.0000	.	.	0
17	1976	.2000	.7500	.1500	.1200	.1200	.2500	.1000	.	.	0
18	1977	.2000	.7500	.2200	.1200	.1200	.1500	.1500	.	.	0
19	1978	.2000	.7500	.2200	.1200	.1200	.1500	.1500	.	.	0
20	1979	.2000	.7500	.2200	.1200	.1200	.1500	.0000	.	.	0
21	1980	.2000	.7500	.2200	.1200	.1200	.1500	.0000	.	.	0
22	1981	.2000	.7500	.2200	.1200	.1200	.1500	.0000	.	.	0
23	1982	.2000	.7500	.2200	.1200	.1200	.1500	.0000	.	.	0
24	1983	.2000	.7500	.2200	.1200	.1200	.1500	.0000	.	.	0
25	1984	.4000	.0000	.0000	.0000	.0000	.0000	.0000	.0750	0	0
26	1985	.4000	.0000	.0000	.0000	.0000	.0000	.0000	.0750	0	0
27	1986	.4000	.0000	.0000	.0000	.0000	.0000	.0000	.0750	0	0
28	1987	.4000	.0000	.0000	.0000	.0000	.0000	.0000	.0750	0	0
29	1988	.3500	.0000	.0000	.0000	.0000	.0000	.0000	.0750	0	0
30	1989	.3600	.0000	.0000	.0000	.0000	.0000	.0000	.0750	0	0
31	1990	.3600	.0000	.0000	.0000	.0000	.0000	.0000	.0750	0	0
32	1991	.3600	.1000	.0000	.0000	.0000	.0000	.0000	.	.	0
33	1992	.3600	.1000	.0000	.0000	.0000	.0000	.0000	.	.	0
34	1993	.3600	.1000	.0000	.0000	.0000	.0000	.0000	.	.	0
35	1994	.3600	.1000	.0000	.0000	.0000	.0000	.0000	.	.	0
36	1995	.3600	.1000	.0000	.0000	.0000	.0000	.0000	.	.	0
37	1996	.3400	.1000	.0000	.0000	.0000	.0000	.0000	.	.	0
38	1997	.3400	.1000	.0000	.0000	.0000	.0000	.0000	.	.	0
39	1998	.3400	.1000	.0000	.0000	.0000	.0000	.0000	.	.	0

	mrate1	myear1	mmethod1	brate1	byear1	bmethod1	mincent	bincent	ttax	mp	bp
1	.3125	.	1	.0400	25.0	0	.0000	.	.472	.0879	.1009
2	.3125	.	1	.0400	25.0	0	.0000	.	.472	.0879	.1009
3	.3125	.	1	.0400	25.0	0	.0000	.	.472	.0879	.1009
4	.3125	.	1	.0400	25.0	0	.0000	.	.472	.0879	.1009
5	.3125	.	1	.0400	25.0	0	.0000	.	.472	.0879	.1009
6	.3125	.	1	.0400	25.0	0	.0000	.	.472	.0879	.1009
7	.3125	.	1	.0400	25.0	0	.0000	.	.472	.0879	.1009
8	.3125	.	1	.0400	25.0	0	.0000	.	.472	.0879	.1009
9	.3125	.	1	.0400	25.0	0	.0000	.	.519	.0958	.1116
10	.3125	.	1	.0400	25.0	0	.0000	.	.519	.0958	.1116
11	.3125	.	1	.0400	25.0	0	.0000	.	.519	.0958	.1116
12	.3125	.	1	.0400	25.0	0	.0000	.	.507	.0936	.1086
13	.3125	.	1	.0400	25.0	0	.0000	.	.507	.0936	.1086
14	.3125	.	1	.0400	25.0	0	.0000	.	.507	.0936	.1086
15	.3125	.	1	.0400	25.0	0	.0000	.	.524	.0968	.1128
16	.3125	.	1	.0400	25.0	0	.0000	.	.524	.0968	.1128
17	.3125	.	1	.0400	25.0	0	.0000	.	.633	.1233	.1484
18	.3125	.	1	.0400	25.0	0	.0000	.	.742	.1717	.2134
19	.3125	.	1	.0400	25.0	0	.0000	.	.742	.1717	.2134
20	.3125	.	1	.0400	25.0	0	.0000	.	.645	.1270	.1534
21	.3125	.	1	.0400	25.0	0	.0000	.	.645	.1270	.1534
22	.3125	.	1	.0400	25.0	0	.0000	.	.645	.1270	.1534
23	.3125	.	1	.0400	25.0	0	.0000	.	.645	.1270	.1534
24	.3125	.	1	.0400	25.0	0	.0000	.	.645	.1270	.1534
25	.3125	.	1	.0400	25.0	0	.0000	.	.400	.0783	.0880
26	.3125	.	1	.0400	25.0	0	.0000	.	.400	.0783	.0880
27	.3125	.	1	.0400	25.0	0	.1000	.	.400	.0594	.0880
28	.3125	.	1	.0400	25.0	0	.0800	.	.400	.0631	.0880
29	.3125	.	1	.0400	25.0	0	.0600	.	.350	.0618	.0807
30	.3125	.	1	.0400	25.0	0	.0400	.	.360	.0664	.0820
31	.3125	.	1	.0400	25.0	0	.0000	.	.360	.0739	.0820
32	.3125	.	1	.0500	20.0	0	.0000	.	.396	.0778	.0835
33	.3125	.	1	.0500	20.0	0	.0000	.	.396	.0778	.0835
34	.3125	.	1	.0500	20.0	0	.0000	.	.396	.0778	.0835
35	.3125	.	1	.0500	20.0	0	.0000	.	.396	.0778	.0835
36	.3125	.	1	.0500	20.0	0	.0000	.	.396	.0778	.0835
37	.3125	.	1	.0500	20.0	0	.0000	.	.374	.0753	.0805
38	.3125	.	1	.0500	20.0	0	.0000	.	.374	.0753	.0805
39	.3125	.	1	.0500	20.0	0	.0000	.	.374	.0753	.0805

	ip	metr
1	.0947	.4652
2	.0947	.4652
3	.0947	.4652
4	.0947	.4652
5	.0947	.4652
6	.0947	.4652
7	.0947	.4652
8	.0947	.4652
9	.1040	.5127
10	.1040	.5127
11	.1040	.5127
12	.1014	.5003
13	.1014	.5003
14	.1014	.5003
15	.1051	.5177
16	.1051	.5177
17	.1364	.6272
18	.1935	.7364
19	.1935	.7364
20	.1408	.6387
21	.1408	.6387
22	.1408	.6387
23	.1408	.6387
24	.1408	.6387
25	.0833	.3936
26	.0833	.3936
27	.0833	.3238
28	.0833	.3390
29	.0769	.2980
30	.0781	.3247
31	.0781	.3538
32	.0828	.3809
33	.0828	.3809
34	.0828	.3809
35	.0828	.3809
36	.0828	.3809
37	.0799	.3592
38	.0799	.3592
39	.0799	.3592

	year	ntax	atax	stax	chtax	ded	invent	mrate1	myear1	mmethod1	brate1
1	1960	.3000	.0400	.0150	.0000	.	1	.3000	.	1	.0300
2	1961	.3000	.0400	.0150	.0000	.	1	.3000	.	1	.0300
3	1962	.3000	.0400	.0150	.0000	.	1	.3000	.	1	.0300
4	1963	.3000	.0400	.0150	.0000	.	1	.3000	.	1	.0300
5	1964	.3000	.0400	.0150	.0000	.	1	.3000	.	1	.0300
6	1965	.3000	.0400	.0000	.0000	.	1	.3000	.	1	.0300
7	1966	.3000	.0400	.0000	.0000	.	1	.3000	.	1	.0300
8	1967	.3000	.0400	.0000	.0000	.	1	.3000	.	1	.0300
9	1968	.3000	.0400	.1000	.0000	.	1	.3000	.	1	.0300
10	1969	.3000	.0400	.0000	.0000	.	1	.3000	.	1	.0300
11	1970	.3300	.0400	.0000	.0000	.	1	.3000	.	1	.0300
12	1971	.3000	.0400	.0000	.0000	.	1	.3000	.	1	.0300
13	1972	.3000	.0400	.0000	.0000	.	1	.3000	.	1	.0300
14	1973	.3000	.0400	.0000	.0000	.	1	.3000	.	1	.0300
15	1974	.3000	.0400	.0000	.0000	.	1	.3000	.	1	.0300
16	1975	.3000	.0400	.1000	.0000	.	1	.3000	.	1	.0300
17	1976	.3200	.0400	.1000	.0000	.	1	.3000	.	1	.0300
18	1977	.3200	.0400	.1000	.0000	.	1	.3000	.	1	.0300
19	1978	.3200	.0400	.1000	.0000	.	1	.3000	.	1	.0300
20	1979	.3300	.0000	.0000	.0150	1	1	.1600	.	1	.0600
21	1980	.3300	.0000	.0000	.0150	1	1	.1600	.	1	.0600
22	1981	.3300	.0000	.0000	.0150	1	1	.1600	.	1	.0600
23	1982	.3300	.0000	.0000	.0150	1	1	.1600	.	1	.0600
24	1983	.3300	.0000	.0000	.0150	1	1	.1600	.	1	.0600
25	1984	.3500	.0000	.0000	.0200	1	1	.1600	.	1	.0600
26	1985	.3500	.0000	.0000	.0200	1	1	.1600	.	1	.0600
27	1986	.3500	.0000	.0000	.0200	1	1	.1600	.	1	.0600
28	1987	.3500	.0000	.0000	.0200	1	1	.1600	.	1	.0600
29	1988	.3500	.0000	.0000	.0200	1	1	.1600	.	1	.0600
30	1989	.3500	.0000	.0000	.0200	1	1	.1600	.	1	.0600
31	1990	.3500	.0000	.0000	.0200	1	1	.2000	.	1	.0750
32	1991	.3500	.0000	.0000	.0200	1	0	.2000	.	1	.0750
33	1992	.3500	.0000	.0000	.0200	1	0	.2000	.	1	.0750
34	1993	.3500	.0000	.0000	.0150	1	0	.2400	.	1	.0750
35	1994	.3500	.0000	.0000	.0150	1	0	.2400	.	1	.0750
36	1995	.3500	.0000	.0000	.0100	1	0	.2400	.	1	.0750
37	1996	.3500	.0000	.0000	.0100	1	0	.2400	.	1	.0750
38	1997	.3500	.0000	.0000	.0080	1	0	.2400	.	1	.0750
39	1998	.3500	.0000	.0000	.0075	1	0	.2400	.	1	.0750

	byear1	bmethod1	mincent	bincent	ttax	mp	bp	ip	metr
1	33.3	0	.1200	.1200	.344	.0508	.0696	.1026	.2792
2	33.3	0	.1200	.1200	.344	.0508	.0696	.1026	.2792
3	33.3	0	.1200	.1200	.344	.0508	.0696	.1026	.2792
4	33.3	0	.1200	.1200	.344	.0508	.0696	.1026	.2792
5	33.3	0	.1200	.1200	.344	.0508	.0696	.1026	.2792
6	33.3	0	.1200	.1200	.340	.0504	.0690	.1015	.2727
7	33.3	0	.1200	.1200	.340	.0504	.0690	.1015	.2727
8	33.3	0	.1200	.1200	.340	.0504	.0690	.1015	.2727
9	33.3	0	.1200	.1200	.370	.0532	.0731	.1087	.3156
10	33.3	0	.1200	.1200	.340	.0504	.0690	.1015	.2727
11	33.3	0	.1200	.1200	.370	.0532	.0731	.1087	.3156
12	33.3	0	.1200	.1200	.340	.0504	.0690	.1015	.2727
13	33.3	0	.1200	.1200	.340	.0504	.0690	.1015	.2727
14	33.3	0	.1200	.1200	.340	.0504	.0690	.1015	.2727
15	33.3	0	.1200	.1200	.340	.0504	.0690	.1015	.2727
16	33.3	0	.1200	.1200	.370	.0532	.0731	.1087	.3156
17	33.3	0	.1200	.1200	.392	.0555	.0764	.1145	.3464
18	33.3	0	.1200	.1200	.392	.0555	.0764	.1145	.3464
19	33.3	0	.1200	.1200	.392	.0555	.0764	.1145	.3464
20	.	1	.1200	.1200	.340	.0611	.0655	.1015	.3104
21	.	1	.1200	.1200	.340	.0611	.0655	.1015	.3104
22	.	1	.1200	.1200	.340	.0611	.0655	.1015	.3104
23	.	1	.1200	.1200	.340	.0611	.0655	.1015	.3104
24	.	1	.1200	.1200	.340	.0611	.0655	.1015	.3104
25	.	1	.1200	.1200	.363	.0643	.0682	.1070	.3436
26	.	1	.1500	.1500	.363	.0583	.0648	.1070	.3097
27	.	1	.1500	.1500	.363	.0583	.0648	.1070	.3097
28	.	1	.1500	.1500	.363	.0583	.0648	.1070	.3097
29	.	1	.1500	.1500	.363	.0583	.0648	.1070	.3097
30	.	1	.1000	.1000	.363	.0683	.0705	.1070	.3644
31	.	1	.0500	.0500	.363	.0735	.0737	.1070	.3897
32	.	1	.0500	.0500	.363	.0735	.0737	.0785	.3316
33	.	1	.0500	.0500	.363	.0735	.0737	.0785	.3316
34	.	1	.0500	.0500	.360	.0694	.0733	.0781	.3126
35	.	1	.0500	.0500	.360	.0694	.0733	.0781	.3126
36	.	1	.0500	.0500	.357	.0690	.0729	.0777	.3089
37	.	1	.0500	.0500	.357	.0690	.0729	.0777	.3089
38	.	1	.0500	.0500	.355	.0688	.0728	.0775	.3074
39	.	1	.0500	.0500	.355	.0688	.0727	.0775	.3070

	year	ntax	ltax	ded	invent	srelief	mrate1	myear1	mmethod1	mrate2	myear2
1	1960	.4000	.1600	1	1.0	.000	.3000	3.0	1	.1430	1.0
2	1961	.4000	.1600	1	1.0	.000	.3000	3.0	1	.1430	1.0
3	1962	.4000	.1600	1	1.0	.000	.3000	3.0	1	.1430	1.0
4	1963	.4000	.1600	1	1.0	.000	.3000	3.0	1	.1430	1.0
5	1964	.4000	.1600	1	1.0	.000	.3000	3.0	1	.1430	1.0
6	1965	.4000	.1600	1	1.0	.000	.3000	3.0	1	.1430	1.0
7	1966	.4000	.1600	1	1.0	.000	.3000	3.0	1	.1430	1.0
8	1967	.4000	.0290	1	1.0	.000	.3000	3.0	1	.1430	1.0
9	1968	.4000	.0290	1	1.0	.000	.3000	3.0	1	.1430	1.0
10	1969	.4000	.0290	1	1.0	.000	.3000	3.0	1	.1430	1.0
11	1970	.4000	.0290	1	1.0	.000	.3000	3.0	1	.1430	1.0
12	1971	.4000	.0290	1	1.0	.000	.3000	3.0	1	.1430	1.0
13	1972	.4000	.0290	1	1.0	.000	.3000	3.0	1	.1430	1.0
14	1973	.4000	.0290	1	1.0	.000	.3000	3.0	1	.1430	1.0
15	1974	.4000	.0290	1	1.0	.000	.3000	3.0	1	.1430	1.0
16	1975	.4000	.0290	1	1.0	.000	.3000	3.0	1	.1430	1.0
17	1976	.4000	.0290	1	1.0	.000	.3000	3.0	1	.1430	1.0
18	1977	.4000	.0290	1	1.0	.000	.3000	3.0	1	.1430	1.0
19	1978	.5200	.0000	.	1.0	.000	.3000	3.0	1	.1430	1.0
20	1979	.5200	.0000	.	1.0	.000	.3000	3.0	1	.1430	1.0
21	1980	.5200	.0000	.	1.0	.600	.3000	3.0	1	.1430	1.0
22	1981	.5200	.0000	.	1.0	.600	.3000	3.0	1	.1430	1.0
23	1982	.5200	.0000	.	1.0	.600	.3000	3.0	1	.1430	1.0
24	1983	.5200	.0000	.	1.0	.600	.3000	3.0	1	.1430	1.0
25	1984	.5200	.0000	.	1.0	.600	.3000	3.0	1	.1430	1.0
26	1985	.5200	.0000	.	1.0	.500	.3000	3.0	1	.1430	1.0
27	1986	.5200	.0000	.	1.0	.500	.3000	3.0	1	.1430	1.0
28	1987	.5200	.0000	.	1.0	.500	.3000	3.0	1	.1430	1.0
29	1988	.5200	.0000	.	1.0	.500	.3000	3.0	1	.1430	1.0
30	1989	.5200	.0000	.	1.0	.500	.3000	3.0	1	.1430	1.0
31	1990	.5200	.0000	.	1.0	.500	.3000	3.0	1	.1430	1.0
32	1991	.3000	.0000	.	1.0	.000	.3000	3.0	1	.1430	1.0
33	1992	.3000	.0000	.	1.0	.000	.3000	3.0	1	.1430	1.0
34	1993	.3000	.0000	.	1.0	.000	.3000	3.0	1	.1430	1.0
35	1994	.2800	.0000	.	1.0	.000	.3000	3.0	1	.1430	1.0
36	1995	.2800	.0000	.	1.0	.000	.3000	3.0	1	.1430	1.0
37	1996	.2800	.0000	.	1.0	.000	.3000	3.0	1	.1430	1.0
38	1997	.2800	.0000	.	1.0	.000	.3000	3.0	1	.1430	1.0
39	1998	.2800	.0000	.	1.0	.000	.3000	3.0	1	.1430	1.0

	mmethod2	mrate3	myear3	mmethod3	brate1	byear1	bmethod1	brate2	byear2	bmethod2	mincent
1	0	.2000	1.0	0	.0357	28.0	0	.	.	.	.
2	0	.2000	1.0	0	.0357	28.0	0	.	.	.	.
3	0	.2000	1.0	0	.0357	28.0	0	.	.	.	.
4	0	.2000	1.0	0	.0357	28.0	0	.	.	.	.
5	0	.2000	1.0	0	.0357	28.0	0	.	.	.	.
6	0	.2000	1.0	0	.0357	28.0	0	.	.	.	.
7	0	.2000	1.0	0	.0357	28.0	0	.	.	.	.
8	0	.2000	1.0	0	.0357	28.0	0	.	.	.	.
9	0	.2000	1.0	0	.0357	28.0	0	.	.	.	.
10	0	.2000	1.0	0	.0357	28.0	0	.	.	.	.
11	0	.2000	1.0	0	.0557	5.0	0	.0357	20.0	0	.
12	0	.2000	1.0	0	.0557	5.0	0	.0357	20.0	0	.
13	0	.2000	1.0	0	.0557	5.0	0	.0357	20.0	0	.
14	0	.2000	1.0	0	.0557	5.0	0	.0357	20.0	0	.
15	0	.2000	1.0	0	.0557	5.0	0	.0357	20.0	0	.
16	0	.2000	1.0	0	.0557	5.0	0	.0357	20.0	0	.
17	0	.2000	1.0	0	.0557	5.0	0	.0357	20.0	0	.
18	0	.2000	1.0	0	.0557	5.0	0	.0357	20.0	0	.
19	0	.2000	1.0	0	.0557	5.0	0	.0357	20.0	0	.
20	0	.2000	1.0	0	.0557	5.0	0	.0357	20.0	0	.
21	0	.2000	1.0	0	.0557	5.0	0	.0357	20.0	0	.
22	0	.2000	1.0	0	.0557	5.0	0	.0357	20.0	0	.
23	0	.2000	1.0	0	.0557	5.0	0	.0357	20.0	0	.
24	0	.2000	1.0	0	.0557	5.0	0	.0357	20.0	0	.
25	0	.2000	1.0	0	.0400	25.0	0	.	.	.	.
26	0	.2000	1.0	0	.0400	25.0	0	.	.	.	.
27	0	.2000	1.0	0	.0400	25.0	0	.	.	.	.
28	0	.2000	1.0	0	.0400	25.0	0	.	.	.	.
29	0	.2000	1.0	0	.0400	25.0	0	.	.	.	.
30	0	.2000	1.0	0	.0400	25.0	0	.	.	.	.
31	0	.2000	1.0	0	.0400	25.0	0	.	.	.	.
32	0	.2000	1.0	0	.0400	25.0	0	.	.	.	.
33	0	.2000	1.0	0	.0400	25.0	0	.	.	.	.
34	0	.2000	1.0	0	.0400	25.0	0	.	.	.	.
35	0	.2000	1.0	0	.0400	25.0	0	.	.	.	.
36	0	.2000	1.0	0	.0400	25.0	0	.	.	.	.
37	0	.2000	1.0	0	.0400	25.0	0	.	.	.	.
38	0	.2000	1.0	0	.0400	25.0	0	.	.	.	.
39	0	.2000	1.0	0	.0400	25.0	0	.	.	.	.

	bincent	ttax	mp	bp	ip	metr
1	.	.496	.0926	.1089	.1484	.551
2	.	.496	.0926	.1089	.1484	.551
3	.	.496	.0926	.1089	.1484	.551
4	.	.496	.0926	.1089	.1484	.551
5	.	.496	.0926	.1089	.1484	.551
6	.	.496	.0926	.1089	.1484	.551
7	.	.496	.0926	.1089	.1484	.551
8	.	.417	.0810	.0929	.1216	.472
9	.	.417	.0810	.0929	.1216	.472
10	.	.417	.0810	.0929	.1216	.472
11	.	.417	.0810	.0883	.1216	.464
12	.	.417	.0810	.0883	.1216	.464
13	.	.417	.0810	.0883	.1216	.464
14	.	.417	.0810	.0883	.1216	.464
15	.	.417	.0810	.0883	.1216	.464
16	.	.417	.0810	.0883	.1216	.464
17	.	.417	.0810	.0883	.1216	.464
18	.	.417	.0810	.0883	.1216	.464
19	.	.520	.0969	.1079	.1583	.567
20	.	.520	.0969	.1079	.1583	.567
21	.	.520	.0969	.1079	.1274	.536
22	.	.520	.0969	.1079	.1274	.536
23	.	.520	.0969	.1079	.1274	.536
24	.	.520	.0969	.1079	.1274	.536
25	.	.520	.0969	.1117	.1274	.541
26	.	.520	.0969	.1117	.1326	.547
27	.	.520	.0969	.1117	.1326	.547
28	.	.520	.0969	.1117	.1326	.547
29	.	.520	.0969	.1117	.1326	.547
30	.	.520	.0969	.1117	.1326	.547
31	.	.520	.0969	.1117	.1326	.547
32	.	.300	.0686	.0744	.0929	.345
33	.	.300	.0686	.0744	.0929	.345
34	.	.300	.0686	.0744	.0929	.345
35	.	.280	.0668	.0721	.0889	.324
36	.	.280	.0668	.0721	.0889	.324
37	.	.280	.0668	.0721	.0889	.324
38	.	.280	.0668	.0721	.0889	.324
39	.	.280	.0668	.0721	.0889	.324

	year	ntax	ltax	ded	srelief	invent	mrate1	myear1	mmethod1	brate1	byear1
1	1960	.0800	.2813	0	.00	1	.2500	.	1	.0800	.
2	1961	.0800	.2790	0	.00	1	.2500	.	1	.0800	.
3	1962	.0800	.2775	0	.00	1	.2500	.	1	.0800	.
4	1963	.0800	.2790	0	.00	1	.2500	.	1	.0800	.
5	1964	.0800	.3240	0	.00	1	.2500	.	1	.0800	.
6	1965	.0800	.3270	0	.00	1	.2500	.	1	.0800	.
7	1966	.0800	.3300	0	.00	1	.2500	.	1	.0800	.
8	1967	.0800	.3390	0	.00	1	.2500	.	1	.0800	.
9	1968	.0800	.3420	0	.00	1	.2500	.	1	.0800	.
10	1969	.0800	.3420	0	.00	1	.2500	.	1	.0800	.
11	1970	.0800	.3420	0	.00	1	.2500	.	1	.0800	.
12	1971	.0980	.3420	0	.00	1	.2500	.	1	.0800	.
13	1972	.0980	.3420	0	.00	1	.2500	.	1	.0800	.
14	1973	.0980	.3420	0	.00	1	.2500	.	1	.0800	.
15	1974	.0980	.3420	0	.00	1	.2500	.	1	.0800	.
16	1975	.0980	.3420	0	.00	1	.2500	.	1	.0800	.
17	1976	.0980	.3420	0	.00	1	.2500	.	1	.0800	.
18	1977	.0980	.3420	0	.00	1	.2500	.	1	.0800	.
19	1978	.0980	.3420	0	.00	1	.2500	.	1	.0800	.
20	1979	.0980	.3420	0	.00	1	.2500	.	1	.0800	.
21	1980	.0980	.3420	0	.00	1	.2500	.	1	.0800	.
22	1981	.0980	.3420	0	.00	1	.2500	.	1	.0800	.
23	1982	.0980	.3420	0	.00	1	.2500	.	1	.0800	.
24	1983	.0980	.3420	0	.00	1	.2500	.	1	.0800	.
25	1984	.0980	.3420	0	.33	1	.2500	.	1	.0800	.
26	1985	.0980	.3420	0	.33	1	.2500	.	1	.0800	.
27	1986	.0980	.3420	0	.33	1	.2500	.	1	.0800	.
28	1987	.0980	.3420	0	.33	1	.2500	.	1	.0800	.
29	1988	.0980	.3420	0	.33	1	.2500	.	1	.0800	.
30	1989	.0980	.3420	0	.33	1	.2500	.	1	.0800	.
31	1990	.0980	.3420	0	.33	1	.2500	.	1	.0800	.
32	1991	.0980	.3420	0	.33	1	.2500	.	1	.0800	.
33	1992	.0980	.3420	0	.33	1	.2500	.	1	.0800	.
34	1993	.0980	.3420	0	.33	1	.2500	.	1	.0800	.
35	1994	.0980	.3420	0	.33	1	.2500	.	1	.0800	.
36	1995	.0980	.3420	0	.33	1	.2500	.	1	.0800	.
37	1996	.0980	.3420	0	.33	1	.2500	.	1	.0800	.
38	1997	.0980	.3420	0	.33	1	.2500	.	1	.0800	.
39	1998	.0783	.3420	0	.33	1	.2500	.	1	.0800	.

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	bmethod1	mincent	bincent	ttax	mp	bp	ip	metr
1	1	.	.	.361	.0783	.0783	.1066	.4142
2	1	.	.	.359	.0780	.0780	.1060	.4118
3	1	.	.	.358	.0778	.0778	.1056	.4102
4	1	.	.	.359	.0780	.0780	.1060	.4118
5	1	.	.	.404	.0839	.0839	.1178	.4587
6	1	.	.	.407	.0843	.0843	.1186	.4618
7	1	.	.	.410	.0847	.0847	.1195	.4649
8	1	.	.	.419	.0861	.0861	.1221	.4741
9	1	.	.	.422	.0865	.0865	.1230	.4772
10	1	.	.	.422	.0865	.0865	.1230	.4772
11	1	.	.	.422	.0865	.0865	.1230	.4772
12	1	.	.	.440	.0893	.0893	.1286	.4955
13	1	.	.	.440	.0893	.0893	.1286	.4955
14	1	.	.	.440	.0893	.0893	.1286	.4955
15	1	.	.	.440	.0893	.0893	.1286	.4955
16	1	.	.	.440	.0893	.0893	.1286	.4955
17	1	.	.	.440	.0893	.0893	.1286	.4955
18	1	.	.	.440	.0893	.0893	.1286	.4955
19	1	.	.	.440	.0893	.0893	.1286	.4955
20	1	.	.	.440	.0893	.0893	.1286	.4955
21	1	.	.	.440	.0893	.0893	.1286	.4955
22	1	.	.	.440	.0893	.0893	.1286	.4955
23	1	.	.	.440	.0893	.0893	.1286	.4955
24	1	.	.	.440	.0893	.0893	.1286	.4955
25	1	.	.	.440	.0893	.0893	.1162	.4793
26	1	.	.	.440	.0893	.0893	.1162	.4793
27	1	.	.	.440	.0893	.0893	.1162	.4793
28	1	.	.	.440	.0893	.0893	.1162	.4793
29	1	.	.	.440	.0893	.0893	.1162	.4793
30	1	.	.	.440	.0893	.0893	.1162	.4793
31	1	.	.	.440	.0893	.0893	.1162	.4793
32	1	.	.	.440	.0893	.0893	.1162	.4793
33	1	.	.	.440	.0893	.0893	.1162	.4793
34	1	.	.	.440	.0893	.0893	.1162	.4793
35	1	.	.	.440	.0893	.0893	.1162	.4793
36	1	.	.	.440	.0893	.0893	.1162	.4793
37	1	.	.	.440	.0893	.0893	.1162	.4793
38	1	.	.	.440	.0893	.0893	.1162	.4793
39	1	.	.	.420	.0863	.0863	.1111	.4593

	year	wtax	ntax	ded	stax	invent	mrate1	myear1	mmethod1	mrate2	myear2
1	1960	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
2	1961	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
3	1962	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
4	1963	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
5	1964	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
6	1965	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
7	1966	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
8	1967	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
9	1968	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
10	1969	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
11	1970	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
12	1971	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
13	1972	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
14	1973	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
15	1974	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
16	1975	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
17	1976	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
18	1977	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
19	1978	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
20	1979	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
21	1980	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
22	1981	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
23	1982	.0000	.4000	.	.0600	1	.4000	3.0	1	.1080	2.0
24	1983	.0000	.4000	.	.0600	1	.5000	2.0	1	.1250	2.0
25	1984	.0000	.4000	.	.0600	1	.5000	2.0	1	.1250	2.0
26	1985	.0000	.4000	.	.0600	1	.5000	2.0	1	.1250	2.0
27	1986	.0000	.4000	.	.0600	1	.5000	2.0	1	.1250	2.0
28	1987	.0000	.4000	.	.0600	1	.5000	2.0	1	.1250	2.0
29	1988	.0000	.4600	.	.0600	1	.5000	2.0	1	.1250	2.0
30	1989	.0000	.4600	.	.0600	1	.5000	2.0	1	.1250	2.0
31	1990	.0000	.4600	.	.0600	1	.5000	2.0	1	.1250	2.0
32	1991	.0000	.4600	.	.0700	1	.5000	2.0	1	.1250	2.0
33	1992	.0000	.4600	.	.1000	1	.5000	2.0	1	.1250	2.0
34	1993	.0000	.4600	.	.1000	1	.5000	2.0	1	.1250	2.0
35	1994	.2000	.2500	1	.0000	1	.5000	2.0	1	.1250	2.0
36	1995	.2000	.2500	1	.0000	1	.4000	3.0	1	.1080	2.0
37	1996	.2000	.2500	1	.0000	1	.4000	3.0	1	.1080	2.0
38	1997	.2000	.2500	1	.0000	1	.4000	3.0	1	.1080	2.0
39	1998	.2000	.2500	1	.0000	1	.4000	3.0	1	.1080	2.0

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	mmethod2	brate1	byear1	bmethod1	brate2	byear2	bmethod2	mincent	bincent	ttax	mp
1	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
2	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
3	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
4	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
5	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
6	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
7	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
8	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
9	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
10	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
11	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
12	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
13	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
14	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
15	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
16	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
17	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
18	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
19	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
20	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
21	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
22	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
23	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0801
24	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0799
25	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0799
26	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0799
27	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0799
28	0	.0800	13.0	1	.0282	12.0	0	.	.	.424	.0799
29	0	.0800	13.0	1	.0282	12.0	0	.	.	.488	.0887
30	0	.0800	13.0	1	.0282	12.0	0	.	.	.488	.0887
31	0	.0800	13.0	1	.0282	12.0	0	.	.	.488	.0887
32	0	.0800	13.0	1	.0282	12.0	0	.	.	.492	.0894
33	0	.0800	13.0	1	.0282	12.0	0	.	.	.506	.0916
34	0	.0800	13.0	1	.0282	12.0	0	.	.	.506	.0916
35	0	.0800	13.0	1	.0282	12.0	0	.	.	.400	.0771
36	0	.0800	13.0	1	.0282	12.0	0	.	.	.400	.0772
37	0	.0800	13.0	1	.0282	12.0	0	.	.	.400	.0772
38	0	.0800	13.0	1	.0282	12.0	0	.	.	.400	.0772
39	0	.0800	13.0	1	.0282	12.0	0	.	.	.400	.0772

	bp	ip	metr
1	.0861	.1236	.4610
2	.0861	.1236	.4610
3	.0861	.1236	.4610
4	.0861	.1236	.4610
5	.0861	.1236	.4610
6	.0861	.1236	.4610
7	.0861	.1236	.4610
8	.0861	.1236	.4610
9	.0861	.1236	.4610
10	.0861	.1236	.4610
11	.0861	.1236	.4610
12	.0861	.1236	.4610
13	.0861	.1236	.4610
14	.0861	.1236	.4610
15	.0861	.1236	.4610
16	.0861	.1236	.4610
17	.0861	.1236	.4610
18	.0861	.1236	.4610
19	.0861	.1236	.4610
20	.0861	.1236	.4610
21	.0861	.1236	.4610
22	.0861	.1236	.4610
23	.0861	.1236	.4610
24	.0861	.1236	.4605
25	.0861	.1236	.4605
26	.0861	.1236	.4605
27	.0861	.1236	.4605
28	.0861	.1236	.4605
29	.0966	.1452	.5246
30	.0966	.1452	.5246
31	.0966	.1452	.5246
32	.0975	.1469	.5292
33	.1002	.1524	.5429
34	.1002	.1524	.5429
35	.0827	.1167	.4360
36	.0827	.1167	.4365
37	.0827	.1167	.4365
38	.0827	.1167	.4365
39	.0827	.1167	.4365

	year	ntax	ltax	ded	srelief	invent	mrate1	myear1	mmethod1	mrate2	myear2
1	1960	.5063	.	.	.00	1	.3000	1.0	1	.2500	.
2	1961	.5313	.	.	.00	1	.3000	1.0	1	.2500	.
3	1962	.5375	.	.	.00	1	.3000	1.0	1	.2500	.
4	1963	.5375	.	.	.00	1	.3000	1.0	1	.2500	.
5	1964	.5625	.	.	.00	1	.3000	1.0	1	.2500	.
6	1965	.4000	.	.	.00	1	.3000	1.0	1	.2500	.
7	1966	.4000	.	.	.00	1	.3000	1.0	1	.2500	.
8	1967	.4250	.	.	.00	1	.3000	1.0	1	.2500	.
9	1968	.4250	.	.	.00	1	.3000	1.0	1	.2500	.
10	1969	.4250	.	.	.00	1	.3000	1.0	1	.2500	.
11	1970	.4000	.	.	.00	1	.8500	1.0	1	.2500	.
12	1971	.4000	.	.	.00	1	1.0000	1.0	1	.	.
13	1972	.4000	.	.	.00	1	1.0000	1.0	1	.	.
14	1973	.5200	.	.	.00	1	1.0000	1.0	1	.	.
15	1974	.5200	.	.	1.00	0	1.0000	1.0	1	.	.
16	1975	.5200	.	.	1.00	0	1.0000	1.0	1	.	.
17	1976	.5200	.	.	1.00	0	1.0000	1.0	1	.	.
18	1977	.5200	.	.	1.00	0	1.0000	1.0	1	.	.
19	1978	.5200	.	.	1.00	0	1.0000	1.0	1	.	.
20	1979	.5200	.	.	1.00	0	1.0000	1.0	1	.	.
21	1980	.5200	.	.	.00	1	1.0000	1.0	1	.	.
22	1981	.5200	.	.	.00	1	1.0000	1.0	1	.	.
23	1982	.5200	.	.	.00	1	1.0000	1.0	1	.	.
24	1983	.5000	.	.	.00	1	1.0000	1.0	1	.	.
25	1984	.4500	.	.	.00	1	1.0000	1.0	1	.	.
26	1985	.4000	.	.	.00	1	.7500	1.0	1	.2500	.
27	1986	.3500	.	.	.00	1	.2500	.	1	.	.
28	1987	.3500	.	.	.00	1	.2500	.	1	.	.
29	1988	.3500	.	.	.00	1	.2500	.	1	.	.
30	1989	.3500	.	.	.00	1	.2500	.	1	.	.
31	1990	.3400	.	.	.00	1	.2500	.	1	.	.
32	1991	.3300	.	.	.00	1	.2500	.	1	.	.
33	1992	.3300	.	.	.00	1	.6500	1.0	1	.2500	.
34	1993	.3300	.	.	.00	1	.2500	.	1	.	.
35	1994	.3300	.	.	.00	1	.2500	.	1	.	.
36	1995	.3300	.	.	.00	1	.2500	.	1	.	.
37	1996	.3300	.	.	.00	1	.2500	.	1	.	.
38	1997	.3100	.	.	.00	1	.2500	.	1	.	.
39	1998	.3100	.	.	.00	1	.2500	.	1	.	.

	mmethod2	brate1	byear1	bmethod1	brate2	byear2	bmethod2	brate3	byear3	bmethod3	mcash
1	1	.1500	1.0	0	.0400	21.0	0	.	.	.	.0000
2	1	.1500	1.0	0	.0400	21.0	0	.	.	.	.0000
3	1	.1500	1.0	0	.0400	21.0	0	.	.	.	.0000
4	1	.1500	1.0	0	.0400	21.0	0	.	.	.	.0000
5	1	.1500	1.0	0	.0400	21.0	0	.	.	.	.0000
6	1	.1500	1.0	0	.0400	21.0	0	.0100	1.0	0	.0000
7	1	.1500	1.0	0	.0400	21.0	0	.0100	1.0	0	.2000
8	1	.1500	1.0	0	.0400	21.0	0	.0100	1.0	0	.2000
9	1	.1500	1.0	0	.0400	21.0	0	.0100	1.0	0	.2000
10	1	.1500	1.0	0	.0400	21.0	0	.0100	1.0	0	.2000
11	1	.3000	1.0	0	.0400	17.0	0	.0100	1.0	0	.2000
12	.	.3000	1.0	0	.0400	17.0	0	.0100	1.0	0	.0000
13	.	.4000	1.0	0	.0400	15.0	0	.	.	.	.0000
14	.	.4000	1.0	0	.0400	15.0	0	.	.	.	.0000
15	.	.5000	1.0	0	.0400	12.0	0	.0200	1.0	0	.0000
16	.	.5000	1.0	0	.0400	12.0	0	.0200	1.0	0	.0000
17	.	.5000	1.0	0	.0400	12.0	0	.0200	1.0	0	.0000
18	.	.5000	1.0	0	.0400	12.0	0	.0200	1.0	0	.0000
19	.	.5000	1.0	0	.0400	12.0	0	.0200	1.0	0	.0000
20	.	.5000	1.0	0	.0400	12.0	0	.0200	1.0	0	.0000
21	.	.5000	1.0	0	.0400	12.0	0	.0200	1.0	0	.0000
22	.	.7500	1.0	0	.0400	6.0	0	.0100	1.0	0	.0000
23	.	.7500	1.0	0	.0400	6.0	0	.0100	1.0	0	.0000
24	.	.7500	1.0	0	.0400	6.0	0	.0100	1.0	0	.0000
25	.	.5000	1.0	0	.0400	12.0	0	.0200	1.0	0	.0000
26	1	.2500	1.0	0	.0400	18.0	0	.0300	1.0	0	.0000
27	.	.0400	25.0	0	.	.	.	.	.	.	.0000
28	.	.0400	25.0	0	.	.	.	.	.	.	.0000
29	.	.0400	25.0	0	.	.	.	.	.	.	.0000
30	.	.0400	25.0	0	.	.	.	.	.	.	.0000
31	.	.0400	25.0	0	.	.	.	.	.	.	.0000
32	.	.0400	25.0	0	.	.	.	.	.	.	.0000
33	1	.2000	1.0	0	.0400	20.0	0	.	.	.	.0000
34	.	.0400	25.0	0	.	.	.	.	.	.	.0000
35	.	.0400	25.0	0	.	.	.	.	.	.	.0000
36	.	.0400	25.0	0	.	.	.	.	.	.	.0000
37	.	.0400	25.0	0	.	.	.	.	.	.	.0000
38	.	.0400	25.0	0	.	.	.	.	.	.	.0000
39	.	.0400	25.0	0	.	.	.	.	.	.	.0000

	bcash	ttax	mp	bp	ip	metr
1	.0000	.506	.0966	.0997	.1525	.5517
2	.0000	.531	.1016	.1049	.1633	.5763
3	.0000	.538	.1029	.1063	.1662	.5825
4	.0000	.538	.1029	.1063	.1662	.5825
5	.0000	.563	.1085	.1123	.1786	.6068
6	.0000	.400	.0803	.0823	.1167	.4445
7	.2000	.400	.0393	.0579	.1167	.2211
8	.2000	.425	.0419	.0607	.1239	.2651
9	.2000	.425	.0419	.0607	.1239	.2651
10	.2000	.425	.0419	.0607	.1239	.2651
11	.2000	.400	.0237	.0519	.1167	.0981
12	.0000	.400	.0606	.0749	.1167	.3664
13	.0000	.400	.0606	.0703	.1167	.3551
14	.0000	.520	.0672	.0830	.1583	.4722
15	.0000	.520	.0672	.0759	.0526	.2446
16	.0000	.520	.0672	.0759	.0526	.2446
17	.0000	.520	.0672	.0759	.0526	.2446
18	.0000	.520	.0672	.0759	.0526	.2446
19	.0000	.520	.0672	.0759	.0526	.2446
20	.0000	.520	.0672	.0759	.0526	.2446
21	.0000	.520	.0672	.0759	.1583	.4602
22	.0000	.520	.0672	.0615	.1583	.4337
23	.0000	.520	.0672	.0615	.1583	.4337
24	.0000	.500	.0659	.0606	.1500	.4142
25	.0000	.450	.0630	.0696	.1318	.3917
26	.0000	.400	.0645	.0773	.1167	.3856
27	.0000	.350	.0769	.0807	.1038	.4102
28	.0000	.350	.0769	.0807	.1038	.4102
29	.0000	.350	.0769	.0807	.1038	.4102
30	.0000	.350	.0769	.0807	.1038	.4102
31	.0000	.340	.0758	.0793	.1015	.3996
32	.0000	.330	.0746	.0781	.0993	.3888
33	.0000	.330	.0633	.0720	.0993	.3324
34	.0000	.330	.0746	.0781	.0993	.3888
35	.0000	.330	.0746	.0781	.0993	.3888
36	.0000	.330	.0746	.0781	.0993	.3888
37	.0000	.330	.0746	.0781	.0993	.3888
38	.0000	.310	.0725	.0756	.0949	.3672
39	.0000	.310	.0725	.0756	.0949	.3672

	year	ntax	stax	ltax	ded	invent	mrate1	myear1	mmethod1	mrate2	myear2
1	1960	.5200	.0000	.0660	1	0	.1250	1.0	1	.2500	1.0
2	1961	.5200	.0000	.0660	1	0	.1250	1.0	1	.2500	1.0
3	1962	.5200	.0000	.0660	1	0	.1250	1.0	1	.2500	1.0
4	1963	.5200	.0000	.0660	1	0	.1250	1.0	1	.2500	1.0
5	1964	.5000	.0000	.0660	1	0	.1250	1.0	1	.2500	1.0
6	1965	.4800	.0000	.0660	1	0	.1250	1.0	1	.2500	1.0
7	1966	.4800	.0000	.0660	1	0	.1250	1.0	1	.2500	1.0
8	1967	.4800	.1000	.0660	1	0	.1250	1.0	1	.2500	1.0
9	1968	.4800	.1000	.0660	1	0	.1250	1.0	1	.2500	1.0
10	1969	.4800	.0500	.0660	1	0	.1250	1.0	1	.2500	1.0
11	1970	.4800	.0000	.0660	1	0	.1429	1.0	1	.2857	1.0
12	1971	.4800	.0000	.0660	1	0	.1429	1.0	1	.2857	1.0
13	1972	.4800	.0000	.0660	1	0	.1429	1.0	1	.2857	1.0
14	1973	.4800	.0000	.0660	1	0	.1429	1.0	1	.2857	1.0
15	1974	.4800	.0000	.0660	1	0	.1429	1.0	1	.2857	1.0
16	1975	.4800	.0000	.0660	1	0	.1429	1.0	1	.2857	1.0
17	1976	.4800	.0000	.0660	1	0	.1429	1.0	1	.2857	1.0
18	1977	.4800	.0000	.0660	1	0	.1429	1.0	1	.2857	1.0
19	1978	.4800	.0000	.0660	1	0	.1429	1.0	1	.2857	1.0
20	1979	.4600	.0000	.0660	1	0	.1429	1.0	1	.2857	1.0
21	1980	.4600	.0000	.0660	1	0	.1429	1.0	1	.2857	1.0
22	1981	.4600	.0000	.0660	1	0	.1500	1.0	1	.3000	2.0
23	1982	.4600	.0000	.0660	1	0	.1500	1.0	1	.3000	2.0
24	1983	.4600	.0000	.0660	1	0	.1500	1.0	1	.3000	2.0
25	1984	.4600	.0000	.0660	1	0	.1500	1.0	1	.3000	2.0
26	1985	.4600	.0000	.0660	1	0	.1500	1.0	1	.3000	2.0
27	1986	.3400	.0000	.0660	1	0	.2000	1.0	1	.4000	2.0
28	1987	.3400	.0000	.0660	1	0	.2000	1.0	1	.4000	2.0
29	1988	.3400	.0000	.0660	1	0	.2000	1.0	1	.4000	2.0
30	1989	.3400	.0000	.0660	1	0	.2000	1.0	1	.4000	2.0
31	1990	.3400	.0000	.0660	1	0	.2000	1.0	1	.4000	2.0
32	1991	.3400	.0000	.0660	1	0	.2000	1.0	1	.4000	2.0
33	1992	.3400	.0000	.0660	1	0	.2000	1.0	1	.4000	2.0
34	1993	.3500	.0000	.0660	1	0	.2000	1.0	1	.4000	2.0
35	1994	.3500	.0000	.0660	1	0	.2000	1.0	1	.4000	2.0
36	1995	.3500	.0000	.0660	1	0	.2000	1.0	1	.4000	2.0
37	1996	.3500	.0000	.0660	1	0	.2000	1.0	1	.4000	2.0
38	1997	.3500	.0000	.0660	1	0	.2000	1.0	1	.4000	2.0
39	1998	.3500	.0000	.0660	1	0	.2000	1.0	1	.4000	2.0

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	mmethod2	mrate3	myear3	mmethod3	mrate4	myear4	mmthod4	brate1	byear1	bmethod1	brate2
1	1	.	6.0	2	.	.	.	.0400	1.0	1	.0800
2	1	.	6.0	2	.	.	.	.0400	1.0	1	.0800
3	1	.	6.0	2	.	.	.	.0400	1.0	1	.0800
4	1	.	6.0	2	.	.	.	.0400	1.0	1	.0800
5	1	.	6.0	2	.	.	.	.0400	1.0	1	.0800
6	1	.	6.0	2	.	.	.	.0400	1.0	1	.0800
7	1	.	6.0	2	.	.	.	.0400	1.0	1	.0800
8	1	.	6.0	2	.	.	.	.0400	1.0	1	.0800
9	1	.	6.0	2	.	.	.	.0400	1.0	1	.0800
10	1	.	6.0	2	.	.	.	.0300	1.0	1	.0600
11	1	.	5.0	2	.	.	.	.0300	1.0	1	.0600
12	1	.	5.0	2	.	.	.	.0300	1.0	1	.0600
13	1	.	5.0	2	.	.	.	.0300	1.0	1	.0600
14	1	.	5.0	2	.	.	.	.0300	1.0	1	.0600
15	1	.	5.0	2	.	.	.	.0300	1.0	1	.0600
16	1	.	5.0	2	.	.	.	.0300	1.0	1	.0600
17	1	.	5.0	2	.	.	.	.0300	1.0	1	.0600
18	1	.	5.0	2	.	.	.	.0300	1.0	1	.0600
19	1	.	5.0	2	.	.	.	.0300	1.0	1	.0600
20	1	.	5.0	2	.	.	.	.0300	1.0	1	.0600
21	1	.	5.0	2	.	.	.	.0300	1.0	1	.0600
22	1	.1666	2.0	0	.0833	1.0	0	.0583	1.0	1	.1166
23	1	.1666	2.0	0	.0833	1.0	0	.0583	1.0	1	.1166
24	1	.1666	2.0	0	.0833	1.0	0	.0583	1.0	1	.1166
25	1	.1666	2.0	0	.0833	1.0	0	.0583	1.0	1	.1166
26	1	.1666	2.0	0	.0833	1.0	0	.0583	1.0	1	.1166
27	1	.1152	2.0	0	.0576	1.0	0	.0167	1.0	0	.0333
28	1	.1152	2.0	0	.0576	1.0	0	.0167	1.0	0	.0333
29	1	.1152	2.0	0	.0576	1.0	0	.0167	1.0	0	.0333
30	1	.1152	2.0	0	.0576	1.0	0	.0167	1.0	0	.0333
31	1	.1152	2.0	0	.0576	1.0	0	.0167	1.0	0	.0333
32	1	.1152	2.0	0	.0576	1.0	0	.0167	1.0	0	.0333
33	1	.1152	2.0	0	.0576	1.0	0	.0167	1.0	0	.0333
34	1	.1152	2.0	0	.0576	1.0	0	.0128	1.0	0	.0256
35	1	.1152	2.0	0	.0576	1.0	0	.0128	1.0	0	.0256
36	1	.1152	2.0	0	.0576	1.0	0	.0128	1.0	0	.0256
37	1	.1152	2.0	0	.0576	1.0	0	.0128	1.0	0	.0256
38	1	.1152	2.0	0	.0576	1.0	0	.0128	1.0	0	.0256
39	1	.1152	2.0	0	.0576	1.0	0	.0128	1.0	0	.0256

	byear2	bmethod2	brate3	byear3	bmethod3	mcash	bcash	ttax	mp	bp	lp
1	12.0	1	.0294	12.0	0	.0000	.0000	.552	.1050	.1203	.1115
2	12.0	1	.0294	12.0	0	.0000	.0000	.552	.1050	.1203	.1115
3	12.0	1	.0294	12.0	0	.0700	.0000	.552	.0790	.1203	.1115
4	12.0	1	.0294	12.0	0	.0700	.0000	.552	.0790	.1203	.1269
5	12.0	1	.0294	12.0	0	.0700	.0000	.533	.0760	.1152	.1071
6	12.0	1	.0294	12.0	0	.0700	.0000	.514	.0733	.1105	.1029
7	12.0	1	.0294	12.0	0	.0700	.0000	.514	.0733	.1105	.1029
8	12.0	1	.0294	12.0	0	.0700	.0000	.559	.0802	.1225	.1134
9	12.0	1	.0294	12.0	0	.0000	.0000	.559	.1066	.1225	.1134
10	8.0	1	.3696	16.0	0	.0000	.0000	.537	.1017	.1198	.1079
11	8.0	1	.3696	16.0	0	.0000	.0000	.514	.0891	.1138	.1029
12	8.0	1	.3696	16.0	0	.0700	.0000	.514	.0651	.1138	.1029
13	8.0	1	.3696	16.0	0	.0700	.0000	.514	.0651	.1138	.1029
14	8.0	1	.3696	16.0	0	.0700	.0000	.514	.0651	.1138	.1029
15	8.0	1	.3696	16.0	0	.0700	.0000	.514	.0651	.1138	.1029
16	8.0	1	.3696	16.0	0	.1000	.0000	.514	.0549	.1138	.1029
17	8.0	1	.3696	16.0	0	.0700	.0000	.514	.0651	.1138	.1029
18	8.0	1	.3696	16.0	0	.0700	.0000	.514	.0651	.1138	.1029
19	8.0	1	.3696	16.0	0	.1000	.0000	.514	.0549	.1138	.1029
20	8.0	1	.3696	16.0	0	.1000	.0000	.496	.0533	.1092	.0991
21	8.0	1	.3696	16.0	0	.1000	.0000	.496	.0533	.1092	.0991
22	6.0	1	.0410	8.0	0	.1000	.0000	.496	.0560	.1052	.0991
23	6.0	1	.0410	8.0	0	.1000	.0000	.496	.0560	.1052	.0991
24	6.0	1	.0410	8.0	0	.1000	.0000	.496	.0560	.1052	.0991
25	6.0	1	.0410	8.0	0	.1000	.0000	.496	.0560	.1052	.0991
26	6.0	1	.0410	8.0	0	.1000	.0000	.496	.0560	.1052	.0991
27	29.0	0	.0167	1.0	0	.0000	.0000	.384	.0714	.0892	.0811
28	29.0	0	.0167	1.0	0	.0000	.0000	.384	.0714	.0892	.0811
29	29.0	0	.0167	1.0	0	.0000	.0000	.384	.0714	.0892	.0811
30	29.0	0	.0167	1.0	0	.0000	.0000	.384	.0714	.0892	.0811
31	29.0	0	.0167	1.0	0	.0000	.0000	.384	.0714	.0892	.0811
32	29.0	0	.0167	1.0	0	.0000	.0000	.384	.0714	.0892	.0811
33	29.0	0	.0167	1.0	0	.0000	.0000	.384	.0714	.0892	.0811
34	38.0	0	.0128	1.0	0	.0000	.0000	.393	.0723	.0943	.0824
35	38.0	0	.0128	1.0	0	.0000	.0000	.393	.0723	.0943	.0824
36	38.0	0	.0128	1.0	0	.0000	.0000	.393	.0723	.0943	.0824
37	38.0	0	.0128	1.0	0	.0000	.0000	.393	.0723	.0943	.0824
38	38.0	0	.0128	1.0	0	.0000	.0000	.393	.0723	.0943	.0824
39	38.0	0	.0128	1.0	0	.0000	.0000	.393	.0723	.0943	.0824

	metr
1	.5504
2	.5504
3	.4975
4	.5162
5	.4766
6	.4558
7	.4558
8	.5059
9	.5579
10	.5401
11	.5000
12	.4394
13	.4394
14	.4394
15	.4394
16	.4087
17	.4394
18	.4394
19	.4087
20	.3868
21	.3868
22	.3869
23	.3869
24	.3869
25	.3869
26	.3869
27	.3685
28	.3685
29	.3685
30	.3685
31	.3685
32	.3685
33	.3685
34	.3858
35	.3858
36	.3858
37	.3858
38	.3858
39	.3858

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	country	tax1960	tax1961	tax1962	tax1963	tax1964	tax1965	tax1966	tax1967	tax1968	tax1969	tax1970	tax1971	tax1972	tax1973
1	AUSTRALI	.4246	.4246	.4246	.4246	.4512	.4512	.4512	.5535	.5535	.5535	.5535	.5589	.5589	.5589
2	AUSTRIA	.6263	.6263	.6263	.6263	.6263	.6263	.6372	.6545	.6545	.7333	.7333	.7333	.7888	.6212
3	BELGIUM	.4715	.4715	.4715	.3988	.3988	.3988	.3988	.3988	.4354	.4354	.4354	.4354	.4715	.4715
4	CANADA	.6399	.6399	.5618	.4751	.4751	.4751	.4751	.4751	.4911	.4911	.4911	.4751	.4956	.4329
5	DENMARK	.4926	.4926	.4926	.4926	.4926	.4926	.4926	.4926	.4038	.4038	.4038	.4038	.4038	.4038
6	FINLAND	.7235	.7235	.7235	.7235	.7744	.7954	.7954	.7449	.7532	.6338	.6338	.6338	.6338	.6338
7	FRANCE	.5572	.5572	.5572	.5572	.5572	.5572	.5572	.5572	.5572	.5572	.5572	.5572	.5572	.6443
8	GERMANY	.6041	.6041	.6041	.6041	.6041	.6041	.6041	.6041	.6170	.6170	.6170	.6170	.6170	.6170
9	GREECE	.4596	.4596	.4596	.4079	.4079	.4079	.4079	.4497	.4079	.4079	.4079	.4079	.4079	.4448
10	ICELAND	.6115	.6115	.6115	.6115	.6115	.6115	.6115	.6115	.6115	.6115	.6115	.6115	.6115	.6115
11	IRELAND	.6311	.5918	.5918	.5918	.5918	.5918	.6260	.6344	.5524	.5524	.5524	.4965	.4965	.4965
12	ITALY	.3821	.3821	.3821	.4158	.4158	.4242	.4242	.4242	.4242	.4242	.4242	.4242	.4242	.4242
13	JAPAN	.5740	.5740	.5740	.5740	.5740	.5668	.5590	.5590	.5590	.5590	.5738	.5738	.5738	.5738
14	LUXEM	.4620	.4620	.4620	.4620	.4620	.4732	.4732	.4839	.4839	.4839	.5340	.4839	.4839	.4881
15	NETHER	.3426	.3426	.3426	.3178	.3570	.3570	.3803	.4591	.4591	.4591	.4591	.4729	.4775	.4791
16	NEWZEAL	.5647	.5647	.5611	.5045	.5045	.5045	.5045	.5611	.5611	.6337	.6337	.5860	.5860	.5860
17	NORWAY	.5516	.5516	.5516	.5615	.6100	.6100	.6100	.5704	.5704	.5704	.5258	.5258	.5258	.5128
18	PORTUGA	.4652	.4652	.4652	.4652	.4652	.4652	.4652	.4652	.5127	.5127	.5127	.5003	.5003	.5003
19	SPAIN	.2792	.2792	.2792	.2792	.2792	.2727	.2727	.2727	.3156	.2727	.3156	.2727	.2727	.2727
20	SWEDEN	.5514	.5514	.5514	.5514	.5514	.5514	.5514	.4722	.4722	.4722	.4644	.4644	.4644	.4644
21	SWITZER	.4142	.4118	.4102	.4118	.4587	.4618	.4649	.4741	.4772	.4772	.4772	.4955	.4955	.4955
22	TURKEY	.4610	.4610	.4610	.4610	.4610	.4610	.4610	.4610	.4610	.4610	.4610	.4610	.4610	.4610
23	UK	.5517	.5763	.5825	.5825	.6068	.4445	.2211	.2651	.2651	.2651	.0981	.3664	.3551	.4722
24	USA	.5504	.5504	.4975	.5162	.4766	.4558	.4558	.5059	.5579	.5401	.5000	.4394	.4394	.4394

	tax1974	tax1975	tax1976	tax1977	tax1978	tax1979	tax1980	tax1981	tax1982	tax1983	tax1984	tax1985	tax1986	tax1987	tax1988
1	.5339	.4890	.4890	.4890	.4890	.4530	.4530	.4565	.4184	.4184	.4360	.4360	.5007	.5299	.4697
2	.6212	.6212	.6284	.6284	.6284	.6284	.6964	.6964	.6964	.6964	.6218	.6218	.6218	.6218	.6218
3	.4715	.5795	.5795	.5795	.5795	.3951	.3951	.3951	.3951	.3951	.4553	.4553	.4553	.4352	.4352
4	.4186	.4209	.4209	.4184	.3913	.3048	.3048	.3092	.3326	.3326	.3401	.3401	.3587	.4356	.4618
5	.4142	.4142	.4142	.4142	.4142	.4452	.4452	.4452	.4452	.4452	.4452	.4452	.4452	.4452	.5462
6	.6338	.6338	.6338	.6338	.6338	.6241	.6241	.6241	.6241	.6241	.6241	.6241	.6241	.6241	.5259
7	.5572	.5572	.5572	.5572	.5572	.5572	.5572	.5572	.5572	.5572	.5572	.5572	.5073	.5073	.4768
8	.6170	.6170	.6170	.6398	.6398	.6398	.6398	.6318	.6318	.6318	.6132	.6132	.6132	.6132	.6132
9	.4024	.4024	.4024	.4024	.4024	.4024	.4024	.4024	.4024	.4024	.5638	.5638	.5638	.5638	.4873
10	.6115	.6115	.6115	.6115	.6115	.6115	.6115	.6115	.6115	.6115	.6002	.6002	.6002	.6002	.5711
11	.3759	.3759	.3759	.3759	.3759	.3759	.3759	.0627	.0627	.0627	.0620	.0627	.0627	.0627	.0751
12	.3734	.3734	.2966	.2966	.2966	.2966	.2966	.2966	.3200	.3432	.3906	.3906	.3906	.3906	.4560
13	.6243	.6243	.6448	.6186	.6186	.6186	.6186	.6402	.6402	.6402	.6452	.6452	.6452	.6368	.6368
14	.4881	.4881	.4861	.4861	.4861	.4861	.4861	.4861	.4921	.4921	.4775	.4775	.4817	.4602	.4345
15	.4791	.4791	.4791	.4791	.3726	.3726	.3726	.3726	.3726	.3726	.3052	.3273	.3052	.3052	.4191
16	.5860	.4458	.4458	.4458	.4458	.4458	.4458	.5744	.5744	.5744	.2652	.2652	.2652	.2652	.4083
17	.5128	.5128	.5128	.5387	.5387	.5288	.5458	.5458	.5458	.5458	.3478	.3478	.3478	.3478	.3501
18	.5177	.5177	.6272	.7364	.7364	.6387	.6387	.6387	.6387	.6387	.3936	.3936	.3238	.3390	.2980
19	.2727	.3156	.3464	.3464	.3464	.3104	.3104	.3104	.3104	.3104	.3436	.3097	.3097	.3097	.3097
20	.4644	.4644	.4644	.4644	.5673	.5673	.5363	.5363	.5363	.5363	.5412	.5465	.5465	.5465	.5465
21	.4955	.4955	.4955	.4955	.4955	.4955	.4955	.4955	.4955	.4955	.4793	.4793	.4793	.4793	.4793
22	.4610	.4610	.4610	.4610	.4610	.4610	.4610	.4610	.4610	.4605	.4605	.4605	.4605	.4605	.5246
23	.2446	.2446	.2446	.2446	.2446	.2446	.4602	.4337	.4337	.4142	.3917	.3856	.4102	.4102	.4102
24	.4394	.4087	.4394	.4394	.4087	.3868	.3868	.3869	.3869	.3869	.3869	.3869	.3685	.3685	.3685

	tax1989	tax1990	tax1991	tax1992	tax1993	tax1994	tax1995	tax1996	tax1997	tax1998	un1960	un1961	un1962	un1963	un1964
1	.4697	.4697	.4697	.4266	.364	.3643	.3956	.3956	.3956	.3956	.0142	.0283	.0267	.0214	.0165
2	.3989	.3989	.3989	.4469	.447	.4469	.3898	.3898	.3780	.3780	.0241	.0186	.0190	.0209	.0194
3	.4352	.4340	.4340	.3289	.329	.3397	.3397	.3397	.3397	.3397	.0326	.0248	.0207	.0170	.0149
4	.4618	.4663	.4346	.4279	.415	.3970	.3970	.3970	.3970	.3970	.0637	.0655	.0540	.0508	.0429
5	.5462	.5462	.4246	.3704	.372	.3733	.3752	.3771	.3790	.3828	.0191	.0188	.0181	.0201	.0144
6	.5557	.5557	.4552	.4037	.293	.2927	.2927	.3248	.3248	.3248	.0144	.0120	.0128	.0147	.0149
7	.4459	.4250	.3933	.3933	.386	.4211	.4730	.4730	.4730	.4730	.0138	.0121	.0138	.0154	.0124
8	.6132	.5612	.5774	.5774	.577	.5394	.5472	.5472	.5472	.5472	.0102	.0068	.0058	.0069	.0063
9	.4873	.4873	.4873	.4448	.487	.4873	.4873	.4873	.4873	.4873	.0610	.0591	.0507	.0498	.0465
10	.5711	.5413	.5413	.5266	.527	.5266	.5266	.4011	.4011	.4011	.0145	.0145	.0141	.0139	.0137
11	.1005	.1181	.1157	.1235	.124	.1235	.1235	.1235	.1235	.1235	.0564	.0505	.0485	.0499	.0472
12	.4560	.4777	.4923	.4923	.536	.5559	.5460	.5042	.5042	.5042	.0551	.0503	.0444	.0378	.0424
13	.6239	.6077	.6138	.6138	.614	.6138	.5719	.5719	.5719	.5719	.0166	.0140	.0126	.0123	.0117
14	.4345	.4345	.3979	.3979	.398	.3979	.4087	.3240	.3128	.3128	.0063	.0063	.0063	.0063	.0063
15	.4191	.3492	.3492	.3492	.349	.3492	.3492	.3492	.3492	.3492	.0069	.0050	.0052	.0055	.0048
16	.4662	.4662	.4537	.4537	.454	.4537	.4537	.4537	.4537	.4537	.0011	.0011	.0011	.0011	.0010
17	.3501	.3501	.3501	.3501	.350	.3501	.3501	.3501	.3501	.3501	.0117	.0088	.0101	.0121	.0107
18	.3247	.3538	.3809	.3809	.381	.3809	.3809	.3592	.3592	.3592	.0190	.0222	.0247	.0247	.0247
19	.3644	.3897	.3316	.3316	.313	.3126	.3089	.3089	.3074	.3070	.0235	.0231	.0151	.0193	.0271
20	.5465	.5465	.3455	.3455	.345	.3238	.3238	.3238	.3238	.3238	.0172	.0149	.0148	.0167	.0156
21	.4793	.4793	.4793	.4793	.479	.4793	.4793	.4793	.4793	.4593	.0004	.0004	.0003	.0003	.0003
22	.5246	.5246	.5292	.5429	.543	.4360	.4365	.4365	.4365	.4365	.0916	.0905	.1012	.0968	.0943
23	.4102	.3996	.3888	.3324	.389	.3888	.3888	.3888	.3672	.3672	.0133	.0116	.0162	.0197	.0138
24	.3685	.3685	.3685	.3685	.386	.3858	.3858	.3858	.3858	.3858	.0539	.0651	.0538	.0551	.0504

	un1965	un1966	un1967	un1968	un1969	un1970	un1971	un1972	un1973	un1974	un1975	un1976	un1977	un1978	un1979
1	.0148	.0170	.0190	.0183	.0182	.0166	.0193	.0264	.0181	.0238	.0472	.0491	.0592	.0655	.0615
2	.0192	.0175	.0185	.0200	.0178	.0145	.0118	.0105	.0177	.0177	.0177	.0180	.0161	.0208	.0209
3	.0170	.0180	.0247	.0294	.0233	.0188	.0182	.0231	.0240	.0249	.0446	.0588	.0668	.0724	.0750
4	.0359	.0330	.0377	.0445	.0437	.0561	.0613	.0616	.0550	.0529	.0686	.0711	.0807	.0833	.0743
5	.0115	.0135	.0120	.0119	.0110	.0071	.0112	.0095	.0086	.0355	.0487	.0633	.0733	.0826	.0597
6	.0136	.0149	.0286	.0384	.0279	.0187	.0222	.0250	.0227	.0170	.0222	.0383	.0582	.0715	.0588
7	.0155	.0158	.0210	.0265	.0229	.0247	.0271	.0281	.0269	.0284	.0403	.0441	.0495	.0521	.0586
8	.0054	.0060	.0174	.0123	.0067	.0056	.0069	.0091	.0100	.0212	.0395	.0392	.0381	.0365	.0318
9	.0482	.0501	.0540	.0558	.0525	.0416	.0314	.0211	.0197	.0205	.0229	.0191	.0169	.0183	.0190
10	.0000	.0000	.0128	.0127	.0247	.0120	.0000	.0000	.0110	.0106	.0000	.0101	.0000	.0000	.0000
11	.0455	.0465	.0502	.0534	.0499	.0581	.0550	.0616	.0566	.0534	.0726	.0898	.0884	.0819	.0714
12	.0527	.0572	.0527	.0557	.0556	.0532	.0531	.0626	.0624	.0528	.0577	.0659	.0703	.0711	.0757
13	.0119	.0131	.0126	.0117	.0114	.0114	.0123	.0142	.0128	.0137	.0188	.0201	.0202	.0224	.0209
14	.0063	.0063	.0063	.0063	.0063	.0063	.0063	.0063	.0063	.0063	.0063	.0063	.0063	.0063	.0063
15	.0054	.0077	.0159	.0143	.0102	.0097	.0127	.0221	.0225	.0275	.0520	.0552	.0534	.0532	.0538
16	.0010	.0010	.0010	.0077	.0028	.0018	.0018	.0045	.0017	.0008	.0024	.0032	.0032	.0164	.0192
17	.0087	.0080	.0073	.0111	.0104	.0077	.0076	.0165	.0153	.0146	.0226	.0174	.0144	.0178	.0196
18	.0252	.0251	.0249	.0253	.0255	.0253	.0250	.0250	.0252	.0169	.0442	.0631	.0742	.0800	.0805
19	.0257	.0210	.0294	.0290	.0243	.0254	.0329	.0279	.0253	.0299	.0432	.0445	.0506	.0679	.0838
20	.0118	.0156	.0212	.0222	.0189	.0151	.0255	.0270	.0246	.0198	.0162	.0159	.0180	.0223	.0206
21	.0003	.0003	.0000	.0003	.0042	.0042	.0042	.0042	.0042	.0042	.0042	.0066	.0036	.0032	.0032
22	.0948	.0929	.1000	.1046	.1112	.0605	.0640	.0596	.0641	.0694	.0721	.0850	.0956	.0961	.0844
23	.0117	.0110	.0197	.0214	.0204	.0219	.0276	.0308	.0217	.0206	.0324	.0485	.0518	.0510	.0463
24	.0441	.0369	.0374	.0348	.0341	.0482	.0581	.0549	.0479	.0550	.0831	.0757	.0694	.0597	.0576

	un1980	un1981	un1982	un1983	un1984	un1985	un1986	un1987	un1988	un1989	un1990	un1991	un1992	un1993	un1994
1	.0622	.0589	.0715	.1088	.0924	.0849	.0856	.0841	.0726	.0628	.0772	.1073	.1211	.1235	.1073
2	.0185	.0252	.0351	.0410	.0381	.0361	.0313	.0379	.0355	.0313	.0323	.0347	.0362	.0426	.0359
3	.0791	.1016	.1189	.1317	.1321	.1231	.1163	.1132	.1030	.0927	.0873	.0929	.1029	.1196	.1196
4	.0747	.0753	.1093	.1186	.1122	.1046	.0954	.0881	.0774	.0748	.0808	.1030	.1127	.1119	.1034
5	.0685	.1032	.1096	.1142	.0849	.0726	.0547	.0540	.0646	.0813	.0831	.0910	.0899	.1068	.0799
6	.0461	.0483	.0531	.0540	.0517	.0497	.0532	.0503	.0451	.0345	.0342	.0754	.1298	.1770	.1823
7	.0628	.0744	.0810	.0832	.0973	.1021	.1038	.1050	.0997	.0940	.0887	.0938	.1031	.1162	.1225
8	.0318	.0449	.0642	.0789	.0791	.0797	.0763	.0759	.0757	.0684	.0620	.0557	.0663	.0786	.0837
9	.0275	.0405	.0578	.0786	.0814	.0781	.0738	.0736	.0767	.0746	.0703	.0765	.0868	.0966	.0964
10	.0000	.0000	.0087	.0086	.0085	.0082	.0079	.0076	.0078	.0156	.0156	.0284	.0420	.0556	.0552
11	.0730	.0991	.1142	.1400	.1561	.1736	.1743	.1759	.1672	.1563	.1372	.1567	.1527	.1575	.1474
12	.0747	.0780	.0843	.0928	.0988	.1014	.1094	.1178	.1183	.1182	.1122	.1078	.1137	.1059	.1153
13	.0202	.0221	.0236	.0265	.0272	.0262	.0277	.0284	.0251	.0226	.0210	.0209	.0216	.0251	.0289
14	.0063	.0125	.0125	.0188	.0186	.0183	.0120	.0174	.0169	.0109	.0104	.0102	.0148	.0193	.0235
15	.0603	.0848	.1134	.1176	.1193	.1091	.1032	.0959	.0917	.0831	.0751	.0699	.0670	.0617	.0685
16	.0223	.0356	.0351	.0561	.0569	.0415	.0395	.0404	.0553	.0710	.0774	.1020	.1027	.0945	.0813
17	.0165	.0203	.0261	.0343	.0315	.0256	.0197	.0207	.0316	.0492	.0523	.0546	.0592	.0596	.0539
18	.0768	.0738	.0732	.0779	.0841	.0853	.0845	.0698	.0568	.0498	.0455	.0429	.0414	.0555	.0701
19	.1108	.1375	.1556	.1699	.1970	.2110	.2076	.2010	.1906	.1691	.1593	.1603	.1809	.2238	.2383
20	.0199	.0249	.0314	.0345	.0310	.0283	.0267	.0190	.0161	.0135	.0165	.0295	.0526	.0824	.0797
21	.0019	.0018	.0043	.0088	.0105	.0089	.0076	.0072	.0063	.0048	.0050	.0193	.0301	.0381	.0360
22	.0788	.0693	.0682	.0751	.0741	.0695	.0772	.0813	.0823	.0836	.0781	.0767	.0786	.0752	.0794
23	.0564	.0896	.1038	.1121	.1111	.1147	.1162	.1038	.0829	.0613	.0546	.0785	.0969	.1032	.0962
24	.0704	.0750	.0954	.0947	.0741	.0709	.0689	.0611	.0543	.0520	.0553	.0675	.0741	.0684	.0604

	un1995	op60	op61	op62	op63	op64	op65	op66	op67	op68	op69	op70	op71	op72	op73
1	.0924	.3127	.2982	.3016	.3206	.3153	.3104	.2997	.3011	.2835	.2982	.2896	.2781	.2770	.2944
2	.0359	.4813	.4653	.4717	.4798	.4842	.4961	.5032	.4968	.5041	.5423	.5971	.5919	.5909	.5926
3	.1196	.7749	.8014	.8254	.8583	.8680	.8537	.8939	.8630	.9063	.9796	1.0113	.9867	.9838	1.0870
4	.0948	.3559	.3630	.3607	.3620	.3786	.3771	.3931	.4026	.4189	.4313	.4285	.4216	.4316	.4571
5	.0704	.6557	.6134	.6013	.6023	.6147	.5986	.5838	.5641	.5644	.5701	.5881	.5704	.5359	.5896
6	.1705	.4565	.4358	.4355	.4053	.4229	.4217	.4141	.4034	.4376	.4739	.5259	.5047	.5073	.5150
7	.1155	.2692	.2621	.2490	.2501	.2562	.2575	.2648	.2619	.2657	.2874	.3109	.3176	.3239	.3428
8	.0815	.3546	.3384	.3347	.3416	.3457	.3582	.3663	.3723	.3909	.4057	.4032	.3974	.3923	.4076
9	.1000	.2131	.2117	.2193	.2309	.2329	.2425	.2472	.2364	.2310	.2347	.2346	.2373	.2619	.3253
10	.0470	.8585	.7882	.8548	.8233	.7437	.7000	.6558	.6284	.6976	.8295	.8676	.7994	.7062	.7194
11	.1215	.6651	.7161	.6851	.7156	.7160	.7572	.7741	.7579	.8093	.8051	.7887	.7652	.7168	.7974
12	.1200	.2657	.2688	.2712	.2779	.2676	.2768	.2903	.2930	.2988	.3184	.3285	.3322	.3473	.3674
13	.0315	.2096	.2012	.1867	.1886	.1913	.1960	.1956	.1905	.1908	.1948	.2033	.2070	.1886	.2005
14	.0229	1.5793	1.6461	1.5665	1.5277	1.5507	1.5807	1.5000	1.4680	1.4863	1.5166	1.6205	1.6982	1.5712	1.6333
15	.0703	.9089	.8821	.8670	.8791	.8654	.8393	.8238	.7959	.7966	.8278	.8874	.8854	.8472	.8892
16	.0631	.4620	.4655	.4291	.4734	.4466	.4478	.4597	.3978	.4466	.4691	.4832	.4548	.4743	.4957
17	.0489	.7368	.7214	.6935	.7044	.7178	.7182	.7253	.7477	.7359	.7203	.7414	.7300	.7043	.7651
18	.0735	.3735	.3998	.3832	.3938	.5042	.5290	.5281	.5155	.4979	.4818	.5021	.5191	.5373	.5489
19	.2263	.1625	.1764	.1960	.1968	.2149	.2271	.2389	.2175	.2466	.2603	.2745	.2757	.2893	.2989
20	.0771	.4593	.4355	.4282	.4298	.4373	.4392	.4288	.4164	.4268	.4538	.4822	.4698	.4634	.5146
21	.0327	.5572	.5712	.5702	.5618	.5615	.5516	.5552	.5461	.5684	.6069	.6359	.6033	.5882	.5955
22	.0675	.1031	.1055	.1124	.1162	.0990	.0968	.1001	.0887	.0888	.0841	.1019	.1294	.1410	.1540
23	.0863	.4326	.4153	.4040	.4041	.4052	.3923	.3896	.3931	.4367	.4404	.4525	.4493	.4356	.4980
24	.0554	.0969	.0944	.0943	.0947	.0973	.0973	.1010	.1021	.1059	.1064	.1139	.1137	.1197	.1371

	op74	op75	op76	op77	op78	op79	op80	op81	op82	op83	op84	op85	op86	op87	op88
1	.3164	.2890	.3121	.3086	.3215	.3496	.3386	.3317	.3166	.3068	.3464	.3520	.3463	.3471	.3414
2	.6481	.6160	.6517	.6521	.6474	.6970	.7400	.7608	.7168	.7053	.7551	.7907	.7093	.6963	.7494
3	1.2157	1.0657	1.1331	1.1328	1.1040	1.2214	1.1717	1.2635	1.3442	1.3719	1.4664	1.4056	1.2671	1.2265	1.2921
4	.4980	.4722	.4561	.4740	.5059	.5412	.5508	.5372	.4821	.4805	.5363	.5446	.5414	.5229	.5254
5	.6644	.6110	.6234	.6126	.5773	.6131	.6647	.7236	.7231	.7072	.7216	.7301	.6453	.6105	.6199
6	.5873	.5397	.5260	.5578	.5652	.6191	.6715	.6536	.6140	.6042	.5920	.5810	.5226	.5114	.5033
7	.4239	.3693	.3989	.4085	.3949	.4188	.4427	.4610	.4550	.4513	.4765	.4716	.4134	.4114	.4253
8	.4839	.4646	.4910	.4856	.4707	.4949	.5334	.5667	.5734	.5548	.5879	.6152	.5512	.5291	.5391
9	.3434	.3598	.3567	.3459	.3465	.3508	.3859	.3912	.3870	.4097	.4233	.4436	.4368	.4611	.4425
10	.7131	.7368	.6755	.6550	.6890	.7348	.6979	.6922	.6769	.7614	.7587	.8059	.7309	.6965	.6461
11	.9604	.8803	.9670	1.0386	1.0567	1.1153	1.0838	1.0697	.9961	1.0365	1.1489	1.1434	1.0306	1.0694	1.1170
12	.4456	.4132	.4543	.4585	.4511	.4771	.4665	.4884	.4711	.4348	.4581	.4611	.3894	.3837	.3796
13	.2795	.2555	.2631	.2455	.2050	.2404	.2828	.2865	.2836	.2610	.2726	.2554	.1874	.1756	.1779
14	1.8120	1.7774	1.6770	1.6692	1.6348	1.7495	1.7491	1.7335	1.7678	1.7741	1.9729	2.0864	1.9139	1.9102	1.9537
15	1.0214	.9364	.9577	.9120	.8771	.9629	1.0266	1.0961	1.0734	1.0695	1.1440	1.1680	.9761	.9682	1.0108
16	.5546	.5489	.5789	.5680	.5504	.6190	.6209	.6245	.6235	.6191	.7057	.6461	.5548	.5240	.5062
17	.8328	.7877	.7993	.7870	.7226	.7727	.8033	.7965	.7819	.7632	.7748	.7874	.7285	.6770	.6740
18	.6263	.4822	.4378	.4704	.4775	.5893	.6298	.6451	.6473	.6845	.7485	.7151	.6280	.6924	.7389
19	.3360	.3085	.3189	.3098	.2952	.2963	.3352	.3743	.3839	.4189	.4345	.4311	.3726	.3828	.3856
20	.6444	.5586	.5634	.5580	.5479	.6111	.6083	.6007	.6493	.6899	.6904	.6890	.6251	.6309	.6290
21	.6338	.5672	.6043	.6690	.6407	.6731	.7283	.7237	.6787	.6835	.7217	.7465	.7062	.6958	.7142
22	.1692	.1632	.1610	.1414	.1189	.1070	.1719	.2100	.2677	.2928	.3556	.3500	.2965	.3334	.3621
23	.6096	.5356	.5817	.5942	.5566	.5569	.5233	.5051	.5075	.5209	.5700	.5662	.5206	.5194	.4965
24	.1732	.1638	.1687	.1722	.1781	.1928	.2108	.2036	.1847	.1762	.1858	.1764	.1795	.1912	.2033

	op89	op90	op91	op92	op93	op94	op95	op96	rev65	rev66	rev67	rev68	rev69	rev70	rev71
1	.3445	.3453	.3527	.3780	.3862	.3985	.4038	.4039	.2323	.2260	.2339	.2319	.2398	.2423	.2474
2	.7891	.7903	.7877	.7600	.7336	.7509	.7760	.8220	.3467	.3538	.3528	.3533	.3580	.3571	.3643
3	1.3838	1.3410	1.3087	1.2655	1.2017	1.2564	1.2993	1.3225	.3121	.3331	.3401	.3482	.3499	.3575	.3674
4	.5115	.5132	.5046	.5394	.5976	.6720	.7307	.7444	.2591	.2700	.2811	.2891	.3113	.3128	.3078
5	.6567	.6558	.6783	.6548	.6208	.6490	.6570	.6481	.2990	.3251	.3306	.3605	.3573	.4038	.4352
6	.4984	.4762	.4517	.5247	.6072	.6508	.6698	.6763	.3160	.3219	.3221	.3217	.3388	.3293	.3344
7	.4569	.4513	.4505	.4403	.4184	.4340	.4469	.4538	.3033	.3149	.3237	.3279	.3135	.3247	.3414
8	.5766	.5836	.5104	.4760	.4354	.4486	.4650	.4719	.3449	.3429	.3466	.3489	.3584	.3507	.3451
9	.4567	.4488	.4315	.4362	.4254	.4314	.4336	.4187	.2199	.2367	.2479	.2574	.2575	.2533	.2522
10	.6669	.6710	.6453	.6121	.6273	.6713	.6775	.7236	.2620	.2703	.2703	.2703	.2703	.2703	.2959
11	1.1939	1.1149	1.1164	1.1353	1.1964	1.2717	1.3769	1.3751	.2587	.2795	.2850	.2895	.2963	.3102	.3210
12	.4017	.4005	.3799	.3935	.4243	.4507	.5095	.4763	.2552	.2530	.2623	.2700	.2639	.2614	.2689
13	.1978	.2065	.1873	.1789	.1631	.1644	.1731	.1935	.1832	.1778	.1825	.1847	.1879	.1970	.2000
14	1.9496	1.9426	1.9540	1.8375	1.7806	1.7603	1.7407	1.7205	.2770	.2743	.2811	.2718	.2734	.2802	.3044
15	1.0649	1.0368	1.0330	.9964	.9471	.9599	.9994	1.0093	.3278	.3418	.3518	.3588	.3619	.3706	.3887
16	.5382	.5454	.5643	.6114	.5929	.6039	.5813	.5657	.2470	.2565	.2540	.2519	.2523	.2737	.2750
17	.7329	.7473	.7262	.6955	.7013	.7059	.7005	.7199	.2964	.3082	.3257	.3354	.3483	.3494	.3775
18	.7585	.7615	.7023	.6512	.6328	.6926	.7386	.7464	.1619	.1667	.1735	.1739	.1808	.2028	.2000
19	.3918	.3727	.3714	.3775	.3908	.4406	.4752	.4976	.1470	.1363	.1692	.1608	.1645	.1687	.1715
20	.6346	.5946	.5430	.5405	.6187	.6867	.7543	.7324	.3499	.3576	.3673	.3884	.3985	.3978	.4060
21	.7555	.7200	.6859	.6787	.6671	.6675	.6606	.6811	.2071	.2146	.2157	.2258	.2368	.2381	.2351
22	.3398	.3085	.3048	.3174	.3302	.4175	.4424	.4899	.1057	.1068	.1141	.1127	.1220	.1247	.1432
23	.5165	.5147	.4821	.4935	.5259	.5426	.5790	.5985	.3043	.3162	.3290	.3450	.3613	.3694	.3482
24	.2073	.2119	.2127	.2154	.2158	.2263	.2412	.2447	.2431	.2462	.2574	.2513	.2759	.2741	.2585

	rev72	rev73	rev74	rev75	rev76	rev77	rev78	rev79	rev80	rev81	rev82	rev83	rev84	rev85	rev86
1	.2377	.2529	.2707	.2757	.2803	.2799	.2682	.2742	.2836	.2919	.2945	.2845	.2998	.3004	.3088
2	.3688	.3706	.3809	.3864	.3760	.3793	.4022	.3981	.4030	.4146	.4023	.3990	.4165	.4240	.4238
3	.3704	.3799	.3894	.4182	.4225	.4376	.4502	.4553	.4444	.4498	.4645	.4637	.4738	.4735	.4622
4	.3129	.3087	.3326	.3241	.3185	.3117	.3081	.3058	.3160	.3358	.3353	.3297	.3299	.3307	.3368
5	.4287	.4239	.4422	.4135	.4155	.4189	.4342	.4449	.4548	.4534	.4448	.4646	.4756	.4903	.5078
6	.3476	.3628	.3646	.3602	.3680	.3818	.3793	.3778	.3817	.3773	.3765	.3745	.3758	.3811	.3775
7	.3462	.3546	.3466	.3774	.4173	.4191	.3819	.3674	.3692	.3888	.3783	.3759	.3918	.4079	.4238
8	.3492	.3500	.3550	.3690	.3874	.3866	.3855	.4023	.4171	.4189	.4283	.4355	.4457	.4446	.4397
9	.2537	.2379	.2459	.2545	.2804	.2851	.2881	.3013	.2938	.2956	.3309	.3336	.3439	.3448	.3614
10	.2959	.2959	.2959	.2959	.2959	.2959	.2959	.2959	.2959	.3023	.3058	.2812	.2968	.2843	.2846
11	.3058	.3070	.3110	.3134	.3476	.3311	.3133	.3092	.3378	.3496	.3647	.3798	.3883	.3640	.3721
12	.2687	.2441	.2570	.2622	.2716	.2761	.2768	.2677	.3036	.3159	.3393	.3592	.3501	.3454	.3603
13	.2070	.2246	.2299	.2095	.2179	.2232	.2401	.2444	.2543	.2617	.2655	.2702	.2715	.2764	.2843
14	.3099	.3146	.3248	.3881	.3898	.4320	.4412	.4126	.4196	.4333	.4453	.4695	.4539	.4672	.4403
15	.3974	.4117	.4172	.4305	.4274	.4340	.4411	.4446	.4515	.4452	.4491	.4598	.4437	.4413	.4487
16	.2721	.2852	.3132	.3107	.3075	.3324	.3182	.3272	.3303	.3391	.3462	.3232	.3248	.3362	.3388
17	.3991	.4030	.3983	.3993	.4112	.4205	.4123	.4115	.4266	.4438	.4364	.4250	.4174	.4326	.4548
18	.1975	.1929	.1976	.2174	.2361	.2409	.2326	.2291	.2524	.2670	.2738	.2895	.2836	.2782	.2936
19	.1811	.1871	.1810	.1954	.1953	.2145	.2277	.2332	.2413	.2542	.2557	.2752	.2878	.2878	.3062
20	.4199	.4116	.4235	.4338	.4765	.4990	.5030	.4899	.4881	.5010	.4906	.4982	.4950	.5002	.5247
21	.2391	.2627	.2731	.2961	.3130	.3163	.3158	.3108	.3078	.3056	.3100	.3158	.3233	.3200	.3255
22	.1457	.1516	.1414	.1597	.1632	.1705	.1664	.1574	.1794	.1901	.1841	.1718	.1434	.1544	.1753
23	.3328	.3132	.3491	.3554	.3532	.3469	.3295	.3255	.3525	.3653	.3895	.3726	.3790	.3795	.3764
24	.2664	.2662	.2709	.2673	.2598	.2669	.2656	.2653	.2687	.2733	.2711	.2549	.2549	.2604	.2582

	rev87	rev88	rev89	rev90	rev91	rev92	rev93	rev94	rev95	loggdp60	loggdp61	loggdp62	loggdp63	loggdp64	loggdp65
1	.3109	.3067	.3057	.3076	.2911	.2870	.2876	.2990	.3065	2.82	2.83	2.90	3.00	3.09	3.17
2	.4198	.4202	.4091	.4100	.4145	.4302	.4344	.4323	.4243	1.86	1.96	2.02	2.10	2.19	2.27
3	.4709	.4538	.4412	.4442	.4455	.4464	.4525	.4646	.4647	2.41	2.47	2.54	2.61	2.73	2.81
4	.3472	.3401	.3512	.3645	.3674	.3643	.3592	.3637	.3723	3.70	3.69	3.72	3.78	3.87	3.97
5	.5154	.5166	.5066	.4873	.4885	.4918	.5033	.5178	.5132	1.78	1.89	2.01	2.07	2.20	2.32
6	.3798	.3768	.3825	.3666	.3816	.3896	.3905	.3925	.3918	1.62	1.75	1.82	1.90	2.02	2.12
7	.4015	.4325	.4338	.4539	.4687	.4684	.4542	.4758	.4649	4.11	4.20	4.31	4.42	4.52	4.60
8	.4446	.4384	.4370	.4371	.4391	.4365	.4394	.4406	.4455	4.39	4.52	4.62	4.67	4.77	4.86
9	.3642	.3425	.3375	.3650	.3796	.3963	.3984	.4119	.4138	1.45	1.57	1.63	1.74	1.85	1.98
10	.2889	.3155	.3247	.3143	.3139	.3216	.3125	.3090	.3117	-1.33	-1.36	-1.25	-1.07	-.82	-.63
11	.3740	.3895	.3541	.3478	.3523	.3541	.3538	.3608	.3376	.61	.69	.77	.84	.97	1.03
12	.3613	.3677	.3791	.3917	.3971	.4215	.4379	.4174	.4131	3.68	3.79	3.90	4.04	4.13	4.20
13	.2970	.3028	.3075	.3134	.3082	.2919	.2912	.2782	.2850	3.79	3.98	4.11	4.25	4.41	4.51
14	.4450	.4310	.4211	.4338	.4263	.4181	.4392	.4430	.4399	-.55	-.55	-.50	-.43	-.30	-.26
15	.4745	.4762	.4486	.4458	.4719	.4678	.4749	.4529	.4396	2.47	2.57	2.65	2.73	2.89	3.00
16	.3708	.3648	.3911	.3808	.3664	.3702	.3716	.3760	.3816	1.39	1.40	1.48	1.56	1.65	1.73
17	.4366	.4308	.4133	.4176	.4178	.4095	.4014	.4130	.4154	1.65	1.74	1.81	1.88	1.98	2.07
18	.2764	.3009	.3081	.3101	.3174	.3335	.3143	.3301	.3379	1.05	1.12	1.18	1.26	1.34	1.45
19	.3254	.3275	.3460	.3440	.3473	.3586	.3495	.3495	.3398	2.43	2.57	2.72	2.89	3.00	3.15
20	.5536	.5478	.5546	.5559	.5369	.5100	.5012	.5081	.4970	2.65	2.73	2.81	2.89	3.00	3.10
21	.3204	.3257	.3173	.3150	.3118	.3186	.3324	.3362	.3394	2.20	2.32	2.42	2.52	2.62	2.69
22	.1882	.1780	.1868	.2003	.2099	.2243	.2267	.2224	.2254	2.62	2.06	2.21	2.35	2.42	2.49
23	.3721	.3712	.3617	.3640	.3573	.3512	.3345	.3420	.3530	4.28	4.34	4.39	4.45	4.54	4.61
24	.2706	.2691	.2703	.2672	.2681	.2666	.2698	.2750	.2787	6.24	6.27	6.34	6.40	6.47	6.55

	loggdp66	loggdp67	loggdp68	loggdp69	loggdp70	loggdp71	loggdp72	loggdp73	loggdp74	loggdp75	loggdp76	loggdp77	loggdp78	loggdp79	loggdp80
1	3.23	3.32	3.41	3.52	3.62	3.75	3.91	4.25	4.44	4.53	4.62	4.62	4.75	4.87	5.02
2	2.36	2.42	2.49	2.58	2.69	2.85	3.06	3.35	3.52	3.65	3.72	3.91	4.09	4.26	4.36
3	2.88	2.95	3.02	3.12	3.23	3.34	3.56	3.81	3.97	4.13	4.21	4.36	4.56	4.70	4.79
4	4.08	4.15	4.24	4.33	4.44	4.56	4.69	4.84	5.04	5.12	5.29	5.31	5.35	5.46	5.57
5	2.41	2.50	2.53	2.66	2.76	2.87	3.08	3.35	3.46	3.63	3.73	3.84	4.03	4.19	4.19
6	2.19	2.21	2.15	2.28	2.39	2.49	2.65	2.93	3.17	3.33	3.41	3.46	3.54	3.75	3.94
7	4.68	4.75	4.84	4.92	4.96	5.07	5.28	5.54	5.60	5.84	5.87	5.97	6.18	6.37	6.50
8	4.92	4.93	5.01	5.13	5.33	5.48	5.67	5.95	6.06	6.15	6.21	6.36	6.57	6.74	6.81
9	2.09	2.17	2.25	2.38	2.49	2.59	2.72	2.99	3.13	3.23	3.31	3.46	3.64	3.84	3.88
10	-.45	-.46	-.73	-.87	-.64	-.40	-.18	.14	.41	.34	.51	.79	.92	1.05	1.22
11	1.08	1.16	1.14	1.28	1.40	1.55	1.76	1.93	1.99	2.17	2.17	2.34	2.60	2.83	3.00
12	4.28	4.38	4.46	4.56	4.68	4.77	4.92	5.11	5.23	5.36	5.35	5.49	5.69	5.91	6.11
13	4.66	4.82	4.99	5.15	5.32	5.44	5.72	6.03	6.13	6.21	6.33	6.54	6.88	6.92	6.97
14	-.21	-.20	-.11	.04	.19	.24	.46	.78	.98	.96	1.05	1.15	1.37	1.53	1.61
15	3.09	3.18	3.29	3.41	3.53	3.68	3.89	4.16	4.32	4.48	4.57	4.73	4.93	5.07	5.15
16	1.77	1.78	1.64	1.75	1.86	2.04	2.22	2.51	2.62	2.59	2.60	2.68	2.87	3.01	3.11
17	2.15	2.24	2.31	2.39	2.53	2.65	2.82	3.08	3.27	3.46	3.56	3.70	3.82	3.95	4.15
18	1.55	1.66	1.76	1.85	1.96	2.09	2.28	2.58	2.73	2.83	2.88	2.93	3.02	3.15	3.36
19	3.30	3.40	3.39	3.53	3.63	3.75	3.99	4.28	4.49	4.66	4.69	4.80	4.99	5.28	5.36
20	3.18	3.26	3.32	3.40	3.52	3.61	3.77	3.96	4.07	4.29	4.37	4.42	4.53	4.69	4.83
21	2.76	2.83	2.90	2.98	3.09	3.27	3.48	3.77	3.91	4.05	4.10	4.16	4.50	4.61	4.68
22	2.66	2.77	2.87	2.97	2.89	2.84	3.07	3.30	3.62	3.84	3.98	4.11	4.21	4.52	4.23
23	4.67	4.71	4.65	4.73	4.82	4.94	5.08	5.20	5.28	5.45	5.41	5.54	5.78	6.04	6.29
24	6.64	6.70	6.79	6.86	6.92	7.00	7.09	7.21	7.28	7.37	7.48	7.59	7.71	7.82	7.90

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	loggdp81	loggdp82	loggdp83	loggdp84	loggdp85	loggdp86	loggdp87	loggdp88	loggdp89	loggdp90	loggdp91	loggdp92	loggdp93	loggdp94	loggdp95
1	5.15	5.13	5.10	5.21	5.08	5.12	5.29	5.52	5.64	5.69	5.69	5.67	5.65	5.78	5.86
2	4.22	4.22	4.23	4.17	4.19	4.55	4.77	4.84	4.84	5.07	5.12	5.23	5.21	5.28	5.44
3	4.59	4.46	4.41	4.36	4.40	4.73	4.96	5.04	5.05	5.28	5.30	5.41	5.37	5.45	5.61
4	5.69	5.71	5.79	5.83	5.85	5.89	6.02	6.19	6.30	6.34	6.37	6.34	6.30	6.30	6.33
5	4.05	4.02	4.03	4.00	4.06	4.41	4.63	4.69	4.65	4.86	4.86	4.95	4.90	4.98	5.15
6	3.92	3.92	3.89	3.93	3.98	4.25	4.48	4.64	4.73	4.90	4.80	4.67	4.44	4.58	4.84
7	6.37	6.31	6.26	6.21	6.26	6.60	6.79	6.87	6.87	7.09	7.09	7.19	7.13	7.19	7.34
8	6.63	6.60	6.60	6.54	6.55	6.90	7.12	7.20	7.19	7.40	7.45	7.59	7.56	7.63	7.79
9	3.80	3.84	3.75	3.71	3.70	3.87	4.03	4.17	4.21	4.42	4.49	4.58	4.52	4.58	4.74
10	1.25	1.16	1.01	1.03	1.07	1.37	1.69	1.79	1.69	1.83	1.91	1.93	1.81	1.83	1.94
11	2.95	2.99	2.95	2.92	2.98	3.28	3.44	3.55	3.59	3.82	3.83	3.95	3.89	3.99	4.17
12	6.01	5.99	6.03	6.02	6.05	6.40	6.63	6.73	6.77	7.00	7.05	7.11	6.89	6.92	6.99
13	7.06	6.99	7.08	7.14	7.20	7.60	7.79	7.98	7.97	8.00	8.13	8.22	8.36	8.45	8.54
14	1.44	1.34	1.33	1.31	1.34	1.73	1.94	2.06	2.12	2.34	2.39	2.54	2.55	2.68	2.85
15	4.97	4.94	4.91	4.84	4.85	5.19	5.38	5.44	5.43	5.65	5.67	5.77	5.75	5.82	5.99
16	3.19	3.16	3.15	3.10	3.11	3.35	3.59	3.77	3.75	3.76	3.73	3.69	3.78	3.94	4.10
17	4.13	4.11	4.09	4.10	4.15	4.33	4.51	4.59	4.59	4.75	4.77	4.84	4.75	4.81	4.99
18	3.33	3.28	3.17	3.09	3.16	3.52	3.74	3.88	3.95	4.21	4.34	4.52	4.41	4.44	4.60
19	5.23	5.20	5.07	5.08	5.12	5.45	5.69	5.85	5.95	6.20	6.28	6.37	6.18	6.19	6.33
20	4.74	4.62	4.53	4.57	4.61	4.89	5.08	5.20	5.25	5.44	5.48	5.51	5.22	5.29	5.44
21	4.59	4.61	4.61	4.56	4.57	4.93	5.15	5.23	5.19	5.43	5.45	5.49	5.47	5.57	5.73
22	4.26	4.17	4.12	4.09	4.21	4.33	4.47	4.51	4.67	5.02	5.02	5.07	5.20	4.87	5.13
23	6.24	6.19	6.13	6.07	6.12	6.33	6.54	6.73	6.74	6.88	6.92	6.95	6.85	6.93	7.01
24	8.02	8.06	8.14	8.24	8.31	8.36	8.42	8.49	8.57	8.62	8.65	8.70	8.75	8.81	8.86

	loggdp96	logp60	logp61	logp62	logp63	logp64	logp65	logp66	logp67	logp68	logp69	logp70	logp71	logp72	logp73
1	5.97	9.26	9.28	9.30	9.32	9.34	9.36	9.38	9.40	9.42	9.44	9.46	9.48	9.50	9.51
2	5.43	8.86	8.87	8.87	8.88	8.89	8.89	8.90	8.91	8.91	8.91	8.92	8.92	8.93	8.93
3	5.59	9.12	9.13	9.13	9.14	9.15	9.16	9.16	9.17	9.17	9.17	9.17	9.18	9.18	9.18
4	6.36	9.79	9.81	9.83	9.85	9.87	9.89	9.91	9.92	9.94	9.95	9.97	10.00	10.01	10.02
5	5.16	8.43	8.44	8.44	8.45	8.46	8.47	8.48	8.48	8.49	8.50	8.50	8.51	8.52	8.52
6	4.83	8.40	8.40	8.41	8.42	8.42	8.43	8.43	8.44	8.44	8.44	8.44	8.44	8.44	8.45
7	7.34	10.73	10.74	10.76	10.78	10.79	10.79	10.80	10.81	10.82	10.83	10.84	10.84	10.85	10.86
8	7.76	10.92	10.94	10.95	10.96	10.97	10.98	10.99	10.99	10.99	11.00	11.01	11.02	11.03	11.03
9	4.81	9.03	9.04	9.04	9.05	9.05	9.05	9.06	9.07	9.08	9.08	9.08	9.09	9.09	9.10
10	1.99	5.17	5.19	5.20	5.22	5.24	5.26	5.28	5.29	5.30	5.31	5.32	5.33	5.34	5.36
11	4.26	7.95	7.94	7.95	7.96	7.96	7.96	7.97	7.97	7.98	7.98	7.99	8.00	8.01	8.03
12	7.10	10.82	10.83	10.84	10.84	10.85	10.86	10.87	10.87	10.88	10.88	10.89	10.90	10.90	10.91
13	8.43	11.45	11.45	11.46	11.47	11.48	11.50	11.50	11.51	11.53	11.54	11.56	11.57	11.59	11.60
14	2.83	5.75	5.77	5.78	5.79	5.80	5.81	5.81	5.81	5.82	5.83	5.83	5.84	5.85	5.87
15	5.98	9.35	9.36	9.38	9.39	9.40	9.42	9.43	9.44	9.45	9.46	9.48	9.49	9.50	9.51
16	4.19	7.77	7.79	7.82	7.84	7.86	7.88	7.89	7.91	7.92	7.93	7.94	7.96	7.98	8.00
17	5.06	8.18	8.19	8.20	8.21	8.21	8.22	8.23	8.24	8.25	8.26	8.26	8.27	8.28	8.28
18	4.64	9.11	9.10	9.11	9.12	9.12	9.12	9.12	9.08	9.08	9.07	9.07	9.06	9.06	9.06
19	6.37	10.33	10.34	10.35	10.36	10.37	10.38	10.39	10.40	10.41	10.42	10.43	10.44	10.45	10.46
20	5.53	8.92	8.93	8.93	8.94	8.94	8.95	8.96	8.97	8.98	8.98	8.99	9.00	9.00	9.00
21	5.68	8.59	8.61	8.64	8.66	8.68	8.69	8.70	8.71	8.72	8.73	8.74	8.76	8.76	8.77
22	5.20	10.23	10.26	10.28	10.31	10.33	10.35	10.38	10.40	10.43	10.46	10.48	10.51	10.53	10.56
23	7.05	10.87	10.87	10.88	10.89	10.90	10.90	10.91	10.91	10.92	10.92	10.93	10.93	10.93	10.94
24	8.91	12.10	12.12	12.14	12.15	12.16	12.18	12.19	12.20	12.21	12.22	12.23	12.24	12.25	12.26

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	logp74	logp75	logp76	logp77	logp78	logp79	logp80	logp81	logp82	logp83	logp84	logp85	logp86	logp87	logp88
1	9.53	9.54	9.55	9.56	9.57	9.58	9.60	9.61	9.63	9.64	9.65	9.67	9.68	9.70	9.71
2	8.94	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.94
3	9.19	9.19	9.19	9.19	9.19	9.19	9.19	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20
4	10.04	10.05	10.07	10.08	10.09	10.10	10.11	10.12	10.13	10.14	10.15	10.16	10.17	10.19	10.20
5	8.53	8.53	8.53	8.53	8.54	8.54	8.54	8.54	8.54	8.54	8.54	8.54	8.54	8.54	8.54
6	8.45	8.46	8.46	8.46	8.47	8.47	8.47	8.48	8.48	8.49	8.49	8.50	8.50	8.50	8.51
7	10.87	10.87	10.88	10.88	10.89	10.89	10.89	10.90	10.91	10.91	10.92	10.92	10.92	10.93	10.94
8	11.04	11.03	11.03	11.03	11.02	11.02	11.03	11.03	11.03	11.03	11.02	11.02	11.02	11.02	11.03
9	9.10	9.11	9.12	9.14	9.15	9.16	9.17	9.18	9.19	9.19	9.20	9.20	9.21	9.21	9.21
10	5.37	5.38	5.39	5.40	5.41	5.42	5.43	5.44	5.46	5.47	5.48	5.48	5.49	5.51	5.52
11	8.05	8.06	8.08	8.09	8.11	8.12	8.13	8.14	8.15	8.16	8.17	8.17	8.17	8.17	8.17
12	10.92	10.92	10.93	10.93	10.94	10.94	10.94	10.94	10.94	10.95	10.95	10.95	10.96	10.96	10.96
13	11.61	11.63	11.64	11.65	11.65	11.66	11.67	11.68	11.68	11.69	11.70	11.70	11.71	11.71	11.72
14	5.88	5.89	5.89	5.89	5.89	5.90	5.90	5.90	5.90	5.90	5.90	5.91	5.91	5.92	5.93
15	9.51	9.52	9.53	9.54	9.54	9.55	9.56	9.56	9.57	9.57	9.58	9.58	9.59	9.59	9.60
16	8.02	8.03	8.04	8.05	8.05	8.05	8.05	8.06	8.07	8.08	8.09	8.09	8.09	8.10	8.11
17	8.29	8.30	8.30	8.30	8.31	8.31	8.32	8.32	8.32	8.33	8.33	8.33	8.34	8.34	8.34
18	9.09	9.14	9.15	9.16	9.17	9.18	9.19	9.20	9.20	9.21	9.21	9.21	9.21	9.21	9.21
19	10.47	10.48	10.49	10.50	10.51	10.52	10.53	10.54	10.54	10.55	10.55	10.56	10.56	10.56	10.56
20	9.01	9.01	9.01	9.02	9.02	9.02	9.03	9.03	9.03	9.03	9.03	9.03	9.03	9.04	9.04
21	8.77	8.76	8.75	8.75	8.75	8.76	8.76	8.77	8.77	8.78	8.78	8.78	8.79	8.80	8.81
22	10.57	10.60	10.62	10.64	10.66	10.68	10.70	10.73	10.75	10.78	10.80	10.83	10.85	10.87	10.89
23	10.94	10.94	10.94	10.94	10.94	10.94	10.94	10.94	10.94	10.94	10.94	10.95	10.95	10.95	10.95
24	12.27	12.28	12.29	12.30	12.31	12.32	12.34	12.35	12.36	12.36	12.37	12.38	12.39	12.40	12.41

	logp89	logp90	logp91	logp92	logp93	logp94	logp95	logp96	logp97	cop86	cop87	cop88	cop89	cop90	cop91
1	9.73	9.75	9.76	9.77	9.78	9.79	9.80	9.82	9.83	38.49	44.44	45.32	39.05	35.59	29.40
2	8.94	8.95	8.96	8.97	8.99	8.99	8.99	8.99	9.00	4.78	6.51	8.72	9.63	11.76	13.12
3	9.20	9.21	9.21	9.21	9.22	9.22	9.23	9.23	9.23	26.88	41.62	52.38	63.02	75.27	77.99
4	10.22	10.23	10.24	10.26	10.27	10.28	10.30	10.31	10.32	23.89	23.10	24.60	24.07	19.62	18.41
5	8.54	8.55	8.55	8.55	8.55	8.56	8.56	8.57	8.57	8.05	13.06	15.67	18.95	22.16	24.49
6	8.51	8.51	8.52	8.53	8.53	8.53	8.54	8.54	8.54	16.64	20.26	23.86	16.82	12.95	12.24
7	10.94	10.95	10.95	10.96	10.96	10.97	10.97	10.97	10.98	14.04	18.40	24.58	28.79	33.59	35.43
8	11.04	11.05	11.29	11.30	11.30	11.31	11.31	11.31	11.32	9.32	11.21	12.80	13.71	14.11	13.92
9	9.21	9.22	9.23	9.24	9.25	9.25	9.25	9.26	9.26	11.80	11.67	11.88	12.46	12.36	11.67
10	5.53	5.54	5.55	5.57	5.58	5.59	5.59	5.60	5.61	2.79	1.11	-.23	.36	.22	1.10
11	8.16	8.16	8.17	8.17	8.18	8.18	8.19	8.20	8.21	3.77	2.93	5.62	12.64	18.43	23.76
12	10.96	10.95	10.95	10.95	10.95	10.95	10.96	10.96	10.96	8.04	7.48	8.68	9.54	9.08	8.58
13	11.72	11.72	11.73	11.73	11.74	11.74	11.74	11.74	11.75	7.67	9.83	12.29	12.73	12.04	10.30
14	5.94	5.95	5.96	5.98	5.99	5.99	6.02	6.04	6.05	26.88	41.62	52.38	63.02	75.27	77.99
15	9.61	9.61	9.62	9.63	9.63	9.64	9.65	9.65	9.63	46.05	56.20	69.19	74.84	77.91	80.78
16	8.11	8.12	8.13	8.14	8.15	8.17	8.20	8.22	8.23	60.86	62.40	63.77	60.64	57.63	64.64
17	8.35	8.35	8.36	8.36	8.37	8.37	8.38	8.38	8.39	15.99	20.42	21.93	17.36	13.77	14.15
18	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.20	9.21	12.06	17.23	22.95	29.16	32.56	32.50
19	10.57	10.57	10.57	10.57	10.57	10.58	10.58	10.58	10.58	16.83	19.48	23.90	26.98	28.69	28.40
20	9.05	9.06	9.06	9.07	9.08	9.08	9.09	9.09	9.09	32.43	41.39	51.48	55.27	48.89	44.41
21	8.80	8.81	8.82	8.84	8.84	8.86	8.86	8.86	8.87	35.24	43.13	40.95	44.12	45.95	44.35
22	10.91	10.94	10.96	10.98	10.99	11.01	11.03	11.05	11.06	2.07	2.93	3.52	4.30	5.15	5.10
23	10.96	10.96	10.96	10.97	10.97	10.97	10.98	10.98	10.97	47.37	59.53	63.10	60.43	53.57	48.51
24	12.42	12.43	12.44	12.45	12.46	12.47	12.48	12.49	12.49	13.04	15.05	16.24	15.55	14.04	15.35

	cop92	cop93	cop94
1	25.84	29.54	31.11
2	14.26	13.93	17.49
3	69.61	71.03	71.77
4	20.73	23.65	28.37
5	31.07	35.24	33.74
6	18.10	16.80	28.19
7	35.30	32.43	32.66
8	12.39	13.36	14.91
9	11.43	10.85	10.03
10	2.62	3.42	5.78
11	28.02	30.69	33.43
12	9.05	8.71	9.10
13	8.01	5.36	4.46
14	69.61	71.03	71.77
15	75.00	71.64	81.18
16	64.62	60.21	52.83
17	16.31	19.19	28.33
18	29.17	23.70	20.41
19	28.65	25.07	22.69
20	44.80	53.11	50.16
21	43.85	44.18	49.47
22	4.86	5.16	4.96
23	41.32	42.41	46.55
24	15.19	16.85	19.90