MASTER THESIS

Tax evasion: how government cooperation could be a game changer.

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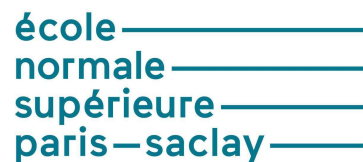
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Abstract

This paper models how a coalition of countries could force a tax haven to cooperate. The coalition is built around a common capital tax rate and a joint tariff on the imports from the tax haven. The tariff is the threat used to induce the tax haven to cooperate. Thanks to a game theoretical approach, we describe how the members of the coalition bargain to set the common capital tax. Then the optimal tariff and its incidence are derived. We show that a mutually beneficial common capital tax can be set in the coalition. Then, we demonstrate that a tariff on tax haven imports is efficient to force the tax haven to cooperate if the import level from the tax haven is sufficiently high and if the imported goods are normal.

Remerciements

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1 Introduction

"Globally, trillions are being lost to tax evasion. If countries tackled it seriously there would be no eurozone crisis."[1]

Tax evasion reached a trillion euros in the European Union in 2013. The missing revenue could fill the budget deficit of 16 EU members. For some countries (e.g Italy or Greece) tax evasion has a major role in the dire state of their economy, the proportion of evaded taxes is around 30%.

The missing fiscal revenue induced by tax evasion is a plague for the entire economy. Tax evasion has four major consequences[2]. First, it reduces the available budget to finance public commodities. The cost of tax evasion reached 98% of the global GDP, which is equivalent for each country to about 55% of healthcare spendings. Second, it creates missallocation of resources: agents modify their behaviours and implement new strategies to pay less taxes. Zucman (2013) estimates that about 8% of the world financial wealth of households is held in tax havens. Tax havens induce a distortion in the international accountancy: liabilities tend to be completely reported unlike assets. Fixing this inconsistency would transform the Europe continent, known as the second biggest debtor into a net creditor. According to Zucman (2013), the negative net foreign asset position of the Rich world is an "illusion caused by tax havens". Third, it requires that the state allocates resources to cure tax evasion, and to fine evaders. Fourth, evasion creates inequity: all agents are not equally able to evade. Tax evasion may also create an incentive to disrespect law: "if others evade, why should I not".

Zucman (2014) proposes solutions to fight tax evasion and tax havens. He argues that the best solution would be a world financial registry. It would permit to better account for what is owed to each country. This solution would require tax havens to contribute, otherwise the tax power could be miss-attributed: the opacity of tax havens induces difficulty to know who owns a company. In the meantime tax havens refuse to fully cooperate, this is harmful for all countries. It is truer for the powerless ones unable to impose sanctions or to reward whistle-blowers. Zucman (2014) also underlines that a

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[1] *Collect the evaded tax, avoid the cut*, Murphy 2010, The Guardian.
[2] according to Alm (2012).

joint tariff imposed on the exchanges with tax havens would force them to cooperate.

Non-tax-haven countries would not suffer from a reduction of commercial exchanges induced by tariffs since tax havens are often negligible clients. On the other hand, tax havens would be severely impacted. For example, the exports of Switzerland to France, Italy and Germany represent 35% of Swiss exports while Swiss imports account for less than 5% in these countries.

Nevertheless, tax havens could be tempted to trigger a tariff war. So, to completely drop this temptation, the solution would be to build a coalition among non-tax haven countries. The coalition should be made of countries that are the favourite trade partners of the tax haven. In this way, if the tax haven tries to respond by setting tariffs on its imports he would risk an economic paralysis. Such a threat should force tax havens to cooperate according to Zucman (2013). He takes the example of Switzerland and highlights that a 30% tariff on Swiss imports set by the coalition of Germany, France and Italy would be efficient. It would counter the profit made by Switzerland thanks to tax evasion and thus force it to cooperate.

Is setting a common tariff on exchanges with tax havens the right solution to fight tax evasion? Is it theoretically justified? These questions have not been precisely explored, these are some of the contributions of this paper.

This paper explores how efficient setting a common tariff on exchanges with tax havens to fight tax evasion is. This article focuses on the example of Switzerland and European countries but it can be generalized to other cases.

A game-theoretical approach is applied in this model. The game is made of two steps. First, the coalition determines a common tax rate set on the coalition's capital. To set this capital tax rate, members of the coalition negotiate together. Then, this common capital tax is implemented on the capital owned by the residents of the coalition. After having signed the treaty, the coalition behaves as a unique country. The members of the coalition are no more considered one by one. Second, the coalition of countries asks the targeted tax haven whether it is willing to cooperate. Cooperating means at most setting the same capital tax rate, at least reporting information about the coalition residents that invest their capital in the tax haven. If the tax haven cooperates, there is no retaliation against

it. Otherwise, the tax haven will be punished by the coalition: all imports from the tax haven to the coalition of countries will be taxed at a dissuasive rate. So, the coalition has to find a tariff that should deter the tax haven from sheltering coalition's capital. In case of non-cooperation, the tax haven suffers from high tariffs on its exports to the coalition. It may react to such tariffs and respond by a similar action. The tariffs may affect different economic agents in Switzerland (companies, banks, evaders...).

I differentiate tax evasion from tax avoidance following the definition of Alm and Torgler (2006): *tax avoidance* refers to "any legal activity that lowers taxes while *evasion* implies illegal means". Agents can evade by under-reporting income, overstating deductions and exemptions, by failing to file appropriate tax returns or even by engaging in negotiations (Alm (2012)). We will consider evasion in a comprehensive manner by considering tax evasion as an aggregate.

We find that the coalition is better off implementing a common positive tax rate on capital while threatening the tax haven. Then, we demonstrate that the coalition of countries is able to find a mutually beneficial tax on capital. Using the Nash bargaining solution, a common capital tax rate reflecting both the interests and the power of each member is derived. It also depends on the rates of the coalition members' previous capital taxes and on the share of perfectly mobile capital. We assume that France initiates the creation of the coalition: it starts the bargaining regarding the definition of a common capital tax rate.

Thereafter, regarding the tariff set on the imports from the tax haven, a formula similar to the Lerner index is derived. The larger the elasticity of the demand for Swiss goods to the tariff, the lower the tariff. The incidence of the tariff depends on the type of goods that are imported. If they are luxury goods, the consumer of the coalition is likely to bear the entire burden. In this case, the tariff on tax haven is maybe not the right solution to fight tax evasion. But if the imported goods are normal, the tariff incidence is more ambiguous: both consumers and producers are impacted. Since luxury goods represent only 19.6% of Swiss imports to the coalition and the other imports are likely to be substituable, implementing a tariff on Swiss imports seems to be an effective solution to fight tax evasion.

First, the main works on tax evasion and on the ways to fight it are reviewed. Section 3 describes the model and derives its main results. Section 4 proposes alternative approaches to solve some stages of the game: the definition of the optimal tariff and the common capital tax rate.

2 Literature review

Tax evasion is inherent to the development of taxation and the welfare state. It has reduced the resources of government and weakened its capacity to redistribute wealth. Economists have estimated the amount of tax evaded to measure how harmful it is to countries. Fist, the main empirical works are summarized. Second, the theoretical part covers the solutions that have been proposed to fight tax evasion and their consequences.

2.1 Empirical literature

Alstadsæter et al. (2017) identify who is more likely to evade taxes. Their empirical study combines the data from HSBC leak, Panama leak and the data on tax amnesty participants in Scandinavian countries. All these data sources confirm that the habit of evading taxes is much more common for wealthy people: the 0.01% wealthiest are 13 times more likely to evade taxes. The Rich people evade about 40% of their tax duty. The effective marginal tax rate faced by the richest is around 35%: 10 points lower than what they really owe to their home country. Tax evasion makes the tax system regressive at the top. After that, Alstadsæter et al. (2017) focus on the tax amnesty and check whether after having complied with the tax law by declaring completely their wealth, evaders tend to avoid more taxes. The answer is negative. Another issue generated with tax evasion is that common estimations of inequalities based on fiscal data are likely to be downward biased.

Concerning companies, Zucman (2014) explains how agents exploit the weaknesses of the current fiscal system. The three principles on which the international fiscal system is built are: the corporate tax is owed to the home country, agreements on taxation should be done thanks to bilateral treaties and the arm's length pricing is the principle used to compute corporate profits. The author underlines that these principles induce harmful

behaviors. Since bilateral treaties offer different tax systems, corporations can optimize the tax they have to pay by exploiting these inconsistencies. This phenomenon is called *tax shopping*. The current international tax system also gives incentives to displace head office in low tax countries; companies realize a *tax inversion*. These practices allow for example US companies to reduce their tax bill by about 20%. Dharmapala and Riedel (2013) used affiliate companies located in high tax jurisdictions as counterfactuals to check whether the income shifting was really motivated by tax evasion. Income shifting is indeed motivated by evasion. Different measures of the shifted income share support that the shifted income lies around 2-4% of the parent company's income (Dharmapala (2014)).

Companies are quite sensible to tax rate changes. Some studies[3] estimate a semi-elasticity of companies' reported income with respect to the tax differential across countries in a range from 0.4 (for the most recent estimation) to 2.25 (for the oldest one). To define a "consensus" estimation of this semi-elasticity, Heckemeyer and Overesch (2013) use a meta-regression approach and agree on a level of 0.8. These results are often obtained thanks to the method of Hines and Rice (1994) which consists in determining the shifted income by the difference of tax rates between the location of the affiliate company and that of the parent company. The income reported by low-tax affiliates is therefore attributed to income shifting. Another method exploits the Computstat database[4]. It consists in computing the ratio between foreign pretax income to foreign sales as a function of the foreign tax rate. The measure of the foreign tax rate is related to the incentives for shifting income. This method assumes that in the absence of income shifting, this ratio should equalize between the US and foreign operations. Whichever the method used, economists do not agree on whether income shifting has grown over time.

To tackle tax evasion many solutions have been found: dropping arm's length pricing, harmonization of tax rules through treaties or implementing automatic information exchange, but all have drawbacks. By exploiting the data of the BIS and the exchange of tax information portal, Johannesen and Zucman (2014) evaluate the impact of imple-

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[3]Hines and Rice (1994), Huizinga and Laeven (2008), Dischinger and Riedel (2010) and Lohse and Riedel (2013).

[4]This is a worldwide database on multinational companies containing financial, statistical and market information.

menting bilateral treaties to fight tax evasion. This time, in 2009, tax havens were forced to accept this proposition since they were threatened by the G20. They had to sign at least 12 information exchange treaties otherwise they risked economic sanctions. But this constraint did not really reduce the amount of evaded taxes. A modification of the repartition of these funds rather than an increase of tax compliance and/or funds repatriation were observed. An additional treaty signed by a tax haven induced a decrease of 3.8% of deposits in its banks. So, these treaties have benefited to the least compliant tax havens. The G20's initiative had poor effects on the amount of evaded taxes.

In the European Union (hereafter EU), the Savings Taxation Directive has been implemented to fight tax evasion. It started in 2005 and applied on the earnings of savings in the form of interest payments. This directive consists in two alternative regimes of cooperation: automatic information exchange or withholding tax. The automatic information exchange entails that all member states will have to automatically report the interests paid to other member states so that the individual concerned will be taxed by his home country. The withholding tax consists in levying directly a tax on non-residents and transferring it to their home country without revealing their identity. This second regime is mostly used by small countries like Luxembourg. It enables countries to maintain the bank secrecy if they want to.

Hemmelgarn and Nicodème (2009) make one of the first attempt to evaluate the consequences of the Savings Taxation Directive. They first underline the several loopholes of this Directive:

- it is limited to the EU, so other foreign services of tax evasion are still available;

- it applies only to individuals not to companies, so individuals can easily avoid this Directive thanks to shell companies;

- it does not cover income from other forms of savings.

Data reveal that the Directive has not changed the composition of savings incomes of European households. Luxembourg and Switzerland are the main sources of withholding tax revenues (70% of them). The authors concluded that the Directive did not induce substantial shifts in international savings, but they had only few data.

Johannesen (2014) finds a different result: the Saving Directive did not induce repatriation of international savings but rather a reallocation. He does a difference-in-difference regression over the period before and after the implementation, comparing EU and non-EU countries. The outcomes are robust, but biased toward 0. He highlights that the growth rate of Swiss deposits became negative around the period of implementation. This reduction is potentially the result of two effects: the anticipatory behavioural effect and the learning effect. On average the Saving Directive explains 44% of the change in funds' allocation. Then the author computes the elasticity of Swiss bank deposits to the net-of-tax rate applied to undeclared interest income: it lies around 2.75. Three reasons let the author thinks that what he estimated is rather an elasticity of substitution between strategies of evasion: especially no higher compliance would be induced by such a directive. First, evaders are better off facing the withholding tax than complying. Second, no amnesty tax was led at the same time, making compliance risky. Third, other evasion strategies are available.

Roussille (2015) focuses on the consequences of the Saving Directive implemented on Swiss accounts held by Europeans. She analyses the consequences of this Directive on the behavior of evaders. The Directive has induced a four-time increase of offshore wealth's declaration. But it represents only 20% of the European offshore wealth held in Switzerland. Then this Directive has been efficient mostly for the less wealthy tax evaders. This author also acknowledges the inherent problems of the Directive. It focuses only on interests, it applies only to European residents and the mechanism is based on the Swiss bank's good faith while Swiss banks are used to protecting their clients.

2.2 Theoretical literature

To better understand the mechanisms at work in the different policies fighting tax evasion, some authors have developed theoretical models. To start, we review some relevant models of tax competition.

Janeba and Peters (1999) analyze the outcomes of political proposals in EU to fight tax evasion. They use a game-theoretical approach with two countries. They focus on a non-coordinated situation: governments do not cooperate and choose whether they dis-

criminate against non-residents or not. Having decided if they discriminate, both countries set their tax rates. In case of discrimination, the governments choose different tax rates for foreigners and residents. Both governments have incentives to discriminate to maximize their payoff. In the case of no discrimination, the government that can reduce further its unique tax rate wins. But this solution is not sustainable. Both governments will prefer to maximize their revenue by taxing only the residents rather than risking a race to the bottom inducing a loss of all tax revenue. When both countries discriminate, they maximally exploit their immobile tax base and compete on the mobile base which leads to a zero taxation. If only one of the government discriminates, a potential satisfying Nash equilibrium regarding tax evasion exists. The country that discriminates exploits both tax bases by setting a tax on mobile base that the other country cannot sustain. The current situation of the EU is quite similar to the situation where both countries discriminate: countries choose to discriminate and end up unable to tax the mobile base. This situation is also similar to the prisoner's dilemma in the sense that the European countries choose their fiscal policy without coordination leading to a non-optimal outcome.

Kanbur and Keen (1991) work on the competition that occurs between tax havens and developed countries. Therefore, they build a model of tax competition in which two countries are involved. One is much smaller than the other in terms of population. This feature represents well the current situation where tax havens are small countries. They show that the negative consequences of tax competition are even worse when the countries differ in size. They recover the common outcome that complete tax competition results in very low tax rates that are not Pareto-optimal. In this case, the big country is more harmed than the small country. Then they show that harmonization negatively affects the smaller country while a minimum tax rate is Pareto-improving. The harmonization would induce losses to the small countries that could not be offset by the increase of the tax rate.

Both theoretical and empirical outcomes describe how harmful tax evasion is. Some authors have found solutions that seem sustainable.

Solutions to fight against tax evasion

Models try to describe what one should expect when implementing a specific solution. First, we underline the outcomes of the withholding taxes. Second, we review the theoretical results of the automatic information exchange. Third, we describe the theory that focuses on voluntary disclosure policy which has often been led in the USA. Finally, we review a more drastic solution: the possibility of closing tax havens.

Withholding taxes: Chisik and Davies (2004) develop a model of bargaining over the treaty-specified withholding tax rates. The bargaining of the treaty will define the tax rate set in the two countries. The tax rate tends to be higher when countries are asymmetric. The key element to determine the tax rate after an agreement is the relative size of Foreign Direct Investment (henceforth FDI) activity. Tax treaties do not eliminate all the inefficiencies created by tax evasion. But they reduce the administrative and the enforcement costs. These are the sources of the mutual gains engendered by a treaty. The country must agree on how to share these gains. The treaty should enable the countries to define a common rate of withholding tax (t). The authors find a Nash bargaining solution by maximizing the weighted product of the two countries' net gains from the treaty. The solution is such that the non-revenue gains are split according to the country's bargaining power. They observe several elements: an increase in the initial tax rate of the largest[5] country should induce a lower t [6]; larger non-tax gains for a country should induce a redistribution of this gain equal to the power of the country; the more asymmetric the countries are in terms of FDI, the bigger t should be; the FDI of the biggest country are positively correlated with tax treaties, while the FDI of the smallest are negatively correlated with the common tax rate. Their results are confirmed by the data. We will use this model to describe how the coalition of countries could choose its common tax rate.

Huizinga and Nielsen (1997) focus on withholding taxes in a different framework. They consider a situation of tax competition between three countries: a major European country, a European tax haven and a foreign tax haven. An EU-minimum withholding tax would

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[5]in terms of FDI.
[6]Foreign country gains more thanks to the treaty, it should redistribute to home by lowering t.

be beneficial for major European countries, but detrimental for European tax havens: they would be less competitive. Nevertheless the winner would be able to compensate these little countries, so as to have a welfare-enhancing outcome.

Automatic information exchange: Another hope to fight tax evasion in Europe is to implement an automatic exchange of information in the Union. However, the theoretical outcomes as the empirical ones are quite mitigated. Bacchetta and Espinosa (1995) determine the optimal share of information exchanged between governments in a tax competition framework. They model this situation thanks to a two-stage game. The first stage consists in defining the amount of information shared. At the second stage, governments observe the amount shared and then decide on their tax rate simultaneously. There are two effects to information sharing: the direct and the strategic effects. The first is always non-positive; there is no direct gain from information exchanges. The strategic effect is positive under some tax policies. In the pure residence based system, the optimal level of information exchange is indeterminate. When both domestic investments and foreign investments are taxed, exchange of information may be welfare-improving. In this framework, if the foreign tax rate increases, the strategic revenue effect is ambiguous. It could be negative because of a higher tax burden: domestic funds invested in the foreign country face a higher tax rate. But it also increases the level of public good provided in the domestic country thanks to repatriation of some domestic funds and to new foreign investments. Nevertheless, if the foreign investments are elastic to the net tax return, the final strategic revenue effect should be positive. If government fully cooperate to determine the tax rates, then full exchange of information should be optimal. When governments do not cooperate on tax setting, they under-provide public goods. This negative effect might be reduced thanks to an increase in information shared. So the success of the implementation of information exchange depends deeply on the tax policy.

While automatic information exchange is potentially welfare enhancing according to Bacchetta and Espinosa (1995), Dharmapala (2016) shows that a unilateral information sharing such as the Foreign Account Tax Compliance Act (henceforth FATCA) may not reduce tax evasion in the World. FATCA was implemented in the USA in 2010. The aim

was to induce foreign financial institutions to participate in the automatic exchange of information. This agreement is unilateral: no information from American institutions is given in exchange. Dharmapala (2016) shows that this unilateral information exchange is likely to increase cross-border tax evasion for foreign countries. Therefore he models the utility of agents taking into account the natural willingness of agent to comply with the law and the fee retained by the financial institution. The introduction of FATCA induced an additional cost for foreign financial institutions: they have to allocate resources to create a mechanism of automatic information exchange. This translates into a higher fee for account-holders. Then it becomes too expensive for US residents to evade through a foreign bank. For foreign residents it becomes more costly to report their income at home, while the price of evading through American institutions does not change. This change induces more cross-border tax evasion for foreigners. The model is also completed with the introduction of a tax haven but the result is not significantly different. Foreigners choose to evade first through tax haven, but when FATCA is implemented, the evasion is realized through US banks.

Gérard et al. (2013) try to determine the most efficient way to reduce tax evasion. Therefore, they model different means to do it: they explore the consequences of automatic information exchange and also of withholding tax. A key element in this paper is that they allow the investor to allocate his wealth across different countries but also among several types of assets. The authors consider that a tax regime is effective if tax revenue is maximized and if taxes do not distort the allocation of savings (across countries and assets). According to this definition they find that only three regimes are efficient. The first consists in a pure residence-based taxation. The second is a perfect information exchange concerning all assets. The third is a withholding taxation defined by each country and all the revenue from this tax is transferred to the residence country. Then, due to loopholes the European Saving Directive is not efficient: since all types of capital revenue are not taxed, it generated a distortion in the allocation of capital.

Voluntary disclosure: Several policies of voluntary disclosure have been implemented in the USA. In the short term these policies enable governments to recover some revenues

at a low cost. But what about the incentives given to the individuals with such a policy? Langenmayr (2017) provides a theoretical proof that voluntary disclosure increases tax evasion. She models the decision of individuals thanks to a four-step game between government and individuals. When probability of being caught is low, individuals evade more than in a high probability situation. But when voluntary disclosure is available, individuals assume low probability. If the probability turns out to be high, then the agents may become more compliant only if they have a high tax moral. So, a voluntary disclosure policy does not improve compliance. All the same, the government chooses to display voluntary disclosure because it is less costly to provide such a possibility than recover all the evaded taxes. The study of German data shows that the administrative cost of fining tax evaders is significant compared to the amount of evaded taxes. In such a case, voluntary disclosure is desirable. Finally, thanks to the voluntary disclosure implemented in the USA in 2009, the author realizes a difference-in-difference estimation that enables her to assess that her theoretical results are empirically verified.

Closing tax havens: Some economists go further: they model how one could force tax havens to close down and what the consequences would be. Elsayyad and Konrad (2012) develop a model to observe the consequences of different methods to force tax havens to close down. Their model is similar to a model of price competition where the price is the tax rate. They show that closing all the tax havens at the same time is the best solution. Otherwise, the remaining tax havens would have higher revenues since the clients of the closing tax havens would send their revenues in the remaining tax havens. So, by closing them sequentially, the market concentration increases giving more power and resources to them to counter the effect of fighting tax evasion policies. Besides, deactivating several tax havens (or at least 2) is less costly than deactivating only one. The authors recommend a "big-bang policy": a policy initiative, which "tries to form a simultaneous multilateral agreement between all non-tax-haven countries and all tax havens". This would be the most efficient method. We will use a similar framework to explore the desirability of imposing tariffs on a tax haven.

Since closing all tax havens at the same time seems quite demanding in terms of

cooperation, Slemrod and Wilson (2009) point out that closing some tax havens could be satisfactory for a start. This contradicts the conclusions of Elsayyad and Konrad (2012). This paper provides a simple model where tax evasion is presented as a service offered by tax havens. Companies may evade taxes by shifting income, but they incur a cost if they do so. This cost differs across companies. Thus only some of them are willing to evade. It is also costly for governments to fight tax evasion. The authors show that the elimination of tax havens is desirable since it is welfare enhancing for each country. The presence of tax havens induces a higher cost for collecting any given amount of capital income tax. If closing all tax havens is impossible, at least reducing the number of tax havens is desirable. Less tax havens induce an increase of the price of evasion services and make them less attractive. Finally the authors underline that countries would be even better off if they cooperate to fight tax havens. The reduction of the tax haven number would also make the remaining small ones better off.

Insights on Zucman's ideas: One of Zucman (2015)'s idea was to force tax havens to cooperate thanks to a coalition among some countries that would set a joint tariff on the exchanges of the targeted haven. Here, some insights why such a solution is likely to be sustainable are summarized.

First, to implement such an idea, it implies that the countries from the coalition agree on a joint tariff and potentially on a common capital tax rate. This can be formalized through a treaty. A multilateral treaty would be much more efficient than a bilateral one. Thuronyi (2000) underlines several reasons why multilateral treaty is a robust solution when it deals with tax agreements. First the absence of a global agreement reduces the incentives of a country to implement some types of taxes, like taxes on interest or foreign revenues. By implementing a global treaty, countries ensure that the others do the same and that their tax base does not erode. The second consists in the possibility of fiscal optimization facilitated by the multiplicity of tax treaties. The third reason concerns the approach of multilateral treaty: a global approach is required for such a treaty in order to take into account the issues concerning different countries and differences among them. It will particularly solve triangular problems where a company locates its subsidiaries in

more than two countries. Another reason concerns the possibility of tax shopping which joins the idea of triangular problems. Companies allocate resources where it is optimal in terms of taxation, a multilateral treaty removes this possibility as it generates a unique and homogeneous tax regulation. For European countries, multilateral treaties seem quite logic: there are a rational way to reinforce the common market and to follow the European rules concerning this unique market.

Because coordination among several countries may be complicated, a multilateral treaty between as many countries as possible may be more efficient. European countries have allowed subgroup of countries to further collaborate on some topics thanks to the Enhanced Cooperation Agreement[7]. This solution seems quite efficient regarding the setting of a common capital tax.

Conconi et al. (2008) demonstrate that partial tax harmonization is both desirable and sustainable compared to no harmonization or global harmonization. The authors explain that capital taxes are exposed to two main distortions that work in opposite directions. The first consists in the competition between countries. Since capital is mobile, governments decrease the capital tax rate in order to attract more capital. This results in too low corporate taxes. The second distortion is that, once the capital has been invested in their country, governments are tempted to increase the tax *ex post*. The model consists in a welfare maximization resolution, where the authors focus on a representative agent. There are two periods: in the first one, the agent decides how much to consume and the government sets the tax rates (on labor and on capital); second the agent decides where to invest, the capital is footloose. The agent suffers from a cost when investing abroad. Thanks to this set-up, the authors show that if governments are unable to commit to a fiscal policy then global harmonization is never beneficial: the capital tax rate will end up too high. If only a subset of countries cooperates then it will set a higher capital tax rate and a lower labor tax rate inducing a higher welfare. The remaining countries outside the coalition dissuade the coalition to implement a discretionary policy that would increase

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[7]"Enhanced Cooperation is a procedure where a minimum of nine EU member states are allowed to establish advanced integration or cooperation in an area within EU structures but without the other members being involved." https://eur-lex.europa.eu/summary/glossary/enhanced_cooperation.html

excessively capital tax rate.

Considering a representative company and its FDI instead of a representative consumer, Haufler and Wooton (1999) show the advantages of being in a coalition. They assume that three countries are competing for the location of a corporation and two of them are members of the same coalition. The coalition is attractive for both countries because it permits to transfer rent from the corporation to the regional government thanks to an increase in tax rate. Agreeing on a collective reduction of taxes when the company is indifferent to where to locate helps the coalition to attract the company which improves its welfare. In this model, there are conflicting interests between the coalition and the third country: when the coalition decreases its tax rate it redirects FDI toward the coalition and the third country is the looser. The second country of the coalition that does not host the company benefits from spillover effects related to the decrease of transportation costs. The company has also advantages in settling in the coalition so as to save trade costs. The coalition renders the members competitive and able to attract the company, which would not be the case without cooperation.

Cooperation between countries seems efficient for at least the members of the union. Nevertheless it raises several issues: the coalition formation, its stability and the allocation of the gain induced by the coalition. The two first issues may be solved by the existence of other common policies that can be used as tools for punishment in case of defection (e.g. the agricultural policy in EU). Regarding the last problem, Konrad and Schjelderup (1999) demonstrate that the tax harmonization will be beneficial for either the coalition countries and the rest of the World if and only if the tax rate of the coalition and the others are complementary. When harmonization is at work three effects appear. The first effect is called *fiscal externalities*: the country losses tax revenue because of the increase of its tax rate, but it also attracts some capital because the other countries do the same. The second effect is the *direct tax effect* which consists in an increase of the tax revenue if we consider an unchanged allocation of capital. The third is called the *factor terms of trade*, this effect is twofold. It includes the impact of a variation in the coalition's tax rate on the net return of capital and the indirect effect of the variation of non-member tax rate on the equilibrium. The capital tax rates of the coalition and the other countries have

to be complementary to be beneficial for all the countries, otherwise tax harmonization is beneficial only for the members of the group. This supports the idea that a regional tax agreement is advantageous.

Since cooperation to set a common capital tax rate tends to be welfare enhancing, one may wonder if implementing a common tariff would be the right solution to fight tax evasion. Only the question of whether a country is likely to win a tariff war has been explored. This question is of interest because a tariff war may be triggered. Indeed, if the coalition decides to punish a tax haven by implementing a tariff the tax haven may answer by setting tariffs too. Is a coalition likely to win a tariff war against a *small* country ? Kennan and Riezman (2013) show that even with potential retaliation the biggest country[8] is likely to win tariff war.

Using a neoclassical framework, Syropoulos (2002) demonstrates how the size of a country may change the outcome of a tariff war. He links tariff war to a non cooperative Nash equilibrium of a single period tariff game between two welfare maximizer governments. He defines a change of country size when all the countries' factor supplies increase by the same proportion. Under free trade, when a country grows compared to its trade partner, it immiserises. It benefits its partner which terms of trade improve. The size growth of a country has two main effects. The first consists in a rise of partners' imports which induces an increase in tariff revenues and therefore in welfare. This effect is direct in the sense that it directly changes welfare without a change of policy. The second is indirect: the growing country may change its tariffs. The authors compute general outcomes taking extreme sizes of country. A very small country has better terms of trade under free trade, while a big has a monopoly/monopsony power that can be used under retaliation. Then free trade is optimal for the small country while it is not for the big one. It prefers to levy a positive but not prohibitive tariff. The welfare of the big country converges to the level of autarky. Then the author shows that if the relative size of a country exceeds a given threshold, it will necessarily win the tariff war.

But concerning region's size regarding the number of countries, Zissimos (2009) is more

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[8]Big country in the sense of the more endowed in the commodities that are traded.

skeptical. Indeed, he points out that enlarging the region cooperation may have negative consequences for its members. Especially if the asymmetries between the two groups of countries are large, then the smallest region is more likely to *win* a tariff war.

Then, triggering a tariff war may be risky, but trade agreements with tax havens have sometimes heavy drawbacks. Raff (2004) underlines that trade agreements and custom unions were favorable for FDI for both countries if and only if tax competition between these countries is small.

Moreover, Rodrik (2018) underlines that trade agreements have changed. A large part of the trade literature argues that trade agreements are positive for the economy[9]. With trade agreement, the economy gets closer to free trade. Rodrik (2018) tells another story: he highlights that these agreements are more likely to favour powerful companies such as international banks, multinational companies... In this case, treaties may be welfare-reducing. For example, Drutman (2013), using the data from the Sunlight Foundation for Trans-Pacific Partnership, reveals that many companies were lobbying to get an advantage in the Trans-Pacific Partnership negotiations. Rodrik (2018) emphasizes that trade agreements erode tax bases: the influence of groups of interests also have consequences on tax competition. By allowing freer mobility of capital, trade agreements favour a decrease of capital taxes.

Therefore triggering a tariff war is harmful but leaving unchanged trade agreements is not the right solution either.

Aside from the risk of tariff war, one may worry about the incidence of tariffs, which country will suffer from the tariff, the tax haven or the coalition of countries ? Within the country, will producers or final consumers pay this tariff? Tokarick (2004) is one of the few authors who investigate the theoretical consequences of a tariff increase. In this paper, he explores who bears the burden of a tariff: the country that sets it or the other country. Tariffs' effects on welfare depend on the elasticity of demand for imports and the share of imports in GDP. Empirically, it has been found that the country who sets the tariff is the most impacted by it[10]. Tokarick (2004) weakens this result thanks to a theoretical

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[9] Smith (1776), Ricardo (1891), Krugman (1979), in a more reserved way Caliendo and Parro (2015).
[10] Anderson et al. (2001a).

demonstration. He focuses on the marginal change of a tariff and the cumulative effect relative to free trade. He found that small economies bear the entire burden of the tariffs they set. The distribution of welfare cost induced by tariffs depends on the elasticity of the foreign supply and on the level of the tariff. The home country does not suffer from its own tariffs as long as it does not go over the optimal level (from 0 to t^*) [11], its welfare is improved thanks to a variation of its terms of trade. Over this optimal level, a negative distortionary effect appears. There exists a rate of tariff, equal to twice the optimal tariff, at which the burden is equally shared between both countries. A tariff higher than this level would worsen the welfare of the foreign country, due to the global welfare effect of the home country. The terms of trade and the distortionary effect constitute the global welfare effect of the home country, while the welfare effect of the foreign country is only made of a variation in terms of trade. To balance the cumulative welfare effect, the tariff should be even bigger.Tokarick (2006) found similar results when focusing on the marginal burden repartition when elasticity is constant.

Inside the country, De Anderson et al. (2001b) describe which agent is likely to bear the tax burden in an oligopolistic framework with heterogeneous products. The incidence of both *add valorem* and excise unit taxes is explored. The framework is that of Bertrand competition. In the short run, the authors find that in both cases the consumer price increases and taxes are likely to be over-shifted. Taxes are over-shifted if and only if the ratio between the company i's demand elasticity to its price (dd[12] curve) and to the market price (DD[13] curve) is sufficiently large. Under similar conditions, *add-valorem* taxes have greater incidence on the producer than excise unit taxes. With stricter conditions, the profit raises with these taxes and this is even true with unit tax. This is also true in the long run. The increase in profit is smaller in the long run because profits attract companies which reduces the price increase.

After having summarized the works related to tax evasion and how to fight it, a model inspired from Zucman (2015)'s ideas is presented.

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[11]The optimal tariff is equal to $\frac{1}{1-\epsilon^*}$, where ϵ^* is the elasticity of the foreign offer curve.

[12]This curve is the change in demand for the company i when its own price change.

[13]This curve is the change in demand for the company i when all prices change.

3 Model

After having described the framework, the definition of the optimal tariff and its consequences are detailed. Following the method of Chisik and Davies (2004), we model how the countries of the coalition bargain to define their common capital tax rate. Finally, taking an approach similar to Elsayyad and Konrad (2012), we verify that implementing a common tax on capital while threatening the tax haven is the right solution.

The proofs of propositions and lemmas can be found in appendix.

3.1 Description of the game

Our model is similar to an extensive form game where there are two players: the coalition (denoted C) which includes France, Italy and Germany and Switzerland (S), the targeted tax haven.

3.1.1 Framework

We assume that the total quantity of capital sums up to 1 and is owned by the residents of the coalition. A share s of capital is immobile[14], an amount x $(= 1 - s)$ of capital is shifted to the tax haven. The capital has the same return wherever it is located, the return is normalized to r. The tax haven retains a fraction ρ of capital as fees while the coalition levies a tax T.

Concerning trade, $Z_i = X_i^j - I_j^i$ is the commercial balance of country i. We denote X_i^j the exports from i to j and I_j^i are the imports from j to i. We assume that the exports from the coalition to Switzerland (X_C^S) are negligible while the Swiss imports to the coalition are substantial (I_S^C): $Z_C = X_C^S - I_S^C < 0$. A tariff δ_i is set on imports by country i.

The coalition's payoff is made of four elements. The first corresponds to the net return of domestically invested capital: $(1 - T)(1 + r)s$. The second is the net income of capital located in the tax haven: $(1 - \rho)(1 + r)x$. The third is the social valuation of the capital revenue: $(1 + \lambda)T(1 + r)s$ with $(1 + \lambda)$ that accounts for the shadow price of public funds. According to Elsayyad and Konrad(2011), it is the "marginal social cost of an additional

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[14]The capital is invested only in the home country.

unit of tax revenue from other sources of taxation.". The net gain from tariff $\delta_C I_S^C - \delta_S X_C^S$ is the fourth element. So the coalition's payoff is:

$$\Pi_C = (1-T)(1+r)s + (1-\rho)(1+r)x + (1+\lambda)T(1+r)s + \delta_C I_S^C - \delta_S X_C^S \quad (1)$$

The payoff of Switzerland is:

$$\Pi_S = \begin{cases} \rho\overline{x} & \text{if } \rho > T \\ \rho(1+r)(x+\overline{x}) + \delta_S I_C^S - \delta_C X_S^C & \text{if } \rho < T \end{cases} \quad (2)$$

If ρ exceeds the capital tax rate of the coalition T nobody from the coalition will shift his capital to the tax haven, it is not profitable. Then only capital from other countries denoted $\overline{x}$ is shifted.

If $\rho < T$ the profit of Switzerland is made of the fees paid by the tax evaders $(\rho(x+\overline{x}))$ minus the net cost incurred by the tariffs. Switzerland can offset the effect of the tariffs by increasing the fees (ρ), but this solution is limited: capital may flee to other tax havens. We assume that the profit of the tax haven when it cooperates is constant $\overline{\overline{\Pi}}_S > 0$.

3.1.2 Timing of the game

We define the game in three steps:

1. The coalition evaluates whether it is socially valued to implement a capital tax rate while threatening the tax haven. Then the members of the coalition have to agree on a common capital tax rate T.

2. Switzerland is asked to cooperate. If it accepts, the Swiss payoff is $\overline{\overline{\Pi}}_S$ and the coalition suffers no more from the tax evasion. The game ends. If it refuses the coalition responds.

3. If Switzerland refuses to cooperate, the coalition has to define a tariff on Swiss imports (δ_C) that should force Switzerland to cooperate. *A priori* Switzerland should be deterred from sheltering coalition capital. But it can also trigger a tariff war.

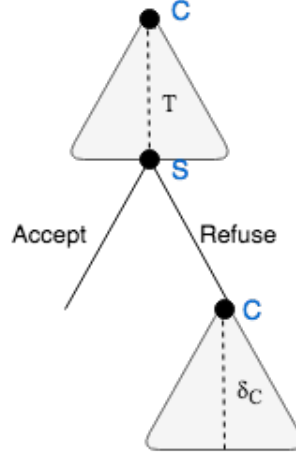Figure 1 is an illustration of the game proceedings.

Figure 1: The timing of the game. *The coalition (C) defines its common capital tax rate (T). Then it asks Switzerland (S), whether it is willing to cooperate. If Switzerland accepts to cooperate the game ends. Otherwise, the coalition defines the optimal tariff (δ_C) to set on Swiss imports and implements it.*

Since this framework is similar to an extensive form game, it should be solved by backward induction. We will focus on the situation in which Switzerland refuses to cooperate.

A tariff on Swiss imports in the coalition may impact more the consumers than the producers. In this case, it would not be optimal for the coalition to set a tariff on Swiss imports. So, we will first define the optimal tariff and explore its incidence. The incidence of the tariff should be evaluated before choosing the tariff rate, but doing so would imply less precise predictions. The definition of the tariff and its incidence are tightly related. Then, depending on the tariff effects, Switzerland accepts or refuses to cooperate. Anticipating its reaction, the coalition determines the optimal capital tax rate to set.

3.2 Choosing the tariff on Swiss exports

3.2.1 The optimal tariff

Recall that exports from Switzerland to the coalition are substantial (35% of Swiss exports) while imports from the coalition to Switzerland are negligible (less than 5% of the coalition

exports)[15].

Then, the demand for Swiss goods is elastic and depends on the tariff: $I_S^C(\delta_C)$, to simplify notations it will be denoted I. The derivatives of the imports with respect to a parameter are denoted as follows: $I'_a = \frac{\partial I}{\partial a}$ and $I''_{ab} = \frac{\partial^2 I}{\partial a \partial b}$. We assume that Switzerland may respond by setting a tariff on the imports from the coalition. This response depends on the tariff set by the coalition on Swiss imports: $\delta_S(\delta_C)$[16]. $\delta'_S(\delta_C)$ denotes the derivative of the Swiss tariff with respect to the coalition tariff. We suppose that exports to Switzerland are inelastic because they are negligible in the share of coalition exports. The Swiss tariff would have too small an impact to change the coalition producer's behavior. Thus taking these elements into account the coalition determines the optimal tariff.

Proposition 1 *When the demand for Swiss imports is elastic and the tariff set by Switzerland depends on that of the coalition, the optimal tariff satisfies the following relationship:*

$$\frac{\delta_C - \delta'_S(\delta_C)\frac{X}{I'_{\delta_C}(.)}}{\delta_C} = -\frac{1}{\xi_{\delta_C}} \tag{3}$$

Where $\xi_{\delta_C} = \frac{\partial I(\delta_C)}{\partial \delta_C}\frac{\delta_C}{I(.)}$, it is the elasticity of the coalition imports from Switzerland with respect to the tariff. $\delta'_S(\delta_C)\frac{X}{I'_{\delta_C}(.)}$ can be interpreted as the marginal cost of the tariff scaled by the the variation of the imports induced by the tariff. The more elastic the demand, the closer to the marginal cost the tariff.

This result is similar to a Lerner index (Lerner (1995)) in the sense that it describes how strong the power of the coalition is regarding the exchanges with Switzerland. This power comes from the unbalanced trade relationship between the coalition and Switzerland.

Once the tariff has been chosen by the coalition, we have to explore whether this tariff is effective to combat tax evasion. First, we have to verify that the tariff reached the targeted population: the Swiss producers. Otherwise, the coalition tariff is harmful for itself. Second, the capacity of the tariff to cover the losses and/or to close the tax haven is determined.

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[15]according to Zucman (2015).

[16]$\delta_S(\delta_C)$ can be seen as the best reply function of Switzerland.

3.2.2 Who bears the tariff burden?

The price of Swiss imports in the coalition is p increased by a tariff δ_C. The tax inclusive price is therefore $q = p + \delta_C$. We focus on the incidence of the optimal tariff. From proposition 1, we assume that the tariff set by the coalition is:

$$\delta_C^* = \frac{\delta_S'(\delta_C^*)X - I(p + \delta_C^*)}{I_{\delta_C}'(p + \delta_C^*)} \tag{4}$$

with $\delta_S'(\delta_C)$ being the derivative of the Swiss tariff with respect to the coalition tariff. $I_{\delta_C}'(.)$ is the derivative of the coalition imports with respect to the tariff of the coalition.

First, the shape of the demand curve is explored, then the incidence of the tariff is identified.

- **The shape of the demand for Swiss goods:**

The demand for Swiss imports is given by:

$$D(p + \delta_C^*) = I_S^C \left(p + \frac{\delta_S'(\delta_C^*)X - I(p + \delta_C^*)}{I_{\delta_C}'(p + \delta_C^*)} \right) \tag{5}$$

The demand for Swiss goods is the import from Switzerland to the coalition, it depends on the price p and the tariff implemented by the coalition on Swiss imports δ_C^*.

Lemma 1 *The shape of the demand for Swiss imports is defined by:*

$$A \equiv \frac{\partial D}{\partial p} = -\delta_C^* I_{\delta p}''(p + \delta_C^*) \tag{6}$$

The shape of the demand defines the type of goods imported from Switzerland. The Swiss imports are defined as normal goods if we suppose that $I_{\delta p}''(p + \delta_C^*)$ is positive. So, if Swiss goods are normal, the level of imports decreases when the price increases.

If we posit that Swiss imports are luxury goods, we should rather assume that $I_{\delta p}''(p + \delta_C^*)$ is negative since the tariff may increase the price offered to consumers. In this case, the partial derivative of imports with respect to the price is positive: a rise in price induces a higher demand. This result can be supported empirically: one of the major export of Switzerland to Europe is jeweler's crafts and luxury watches[17].

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[17]The other major share of Swiss exports is made of pharmaceutical products, according to the Swiss Department of European Affair (DEA).

- **The tariff incidence:**

The tariff burden is shared between coalition consumers and Swiss producers. We use a partial equilibrium analysis similar to that of Kotlikoff and Summers (1987) to determine who effectively pays the tariff.

Lemma 2 *The effect of the coalition tariff on Swiss producers is given by:*

$$\frac{dp}{d\delta_C} = \frac{A}{\frac{\partial S}{\partial p} - A} \tag{7}$$

where $S(p)$ is the supply of Swiss goods, thus $\frac{\partial S}{\partial p}$ is the variation of the supply relative to the price. If Swiss imports are normal goods, we have $\frac{dp}{d\delta_C} < 0$. When the tariff on Swiss imports increases the price set by producers decreases.

If Swiss imports are luxury goods, we have $\frac{dp}{d\delta_C} < 0$ if and only if $\frac{\partial S}{\partial p} - A < 0$. This condition implies that the demand is more elastic than the supply. When the tariff on Swiss imports increases, the price set by producers decreases.

Lemma 3 *The effect of the coalition tariff on the consumers is given by:*

$$\frac{dq}{d\delta_C} = \frac{\frac{\partial S}{\partial p}}{\frac{\partial S}{\partial p} - A} \tag{8}$$

If Swiss imports are normal goods, we have $\frac{dq}{d\delta_C} > 0$. When the tariff on Swiss imports increases, the price faced by consumers increases too.

If Swiss imports are luxury goods, we have $\frac{dq}{d\delta_C} > 0$ if and only if $\frac{\partial S}{\partial p} - A > 0$. This condition implies that the demand is less elastic than the supply side. When the tariff on Swiss imports increases, the price offered to consumers increases too.

By defining ξ_D the price elasticity of the demand and ξ_S the price elasticity of the supply, we can rewrite the results of the lemmas as follows:

$$\frac{\partial p}{\partial \delta_C} = \frac{\xi_D}{\xi_S - \xi_D} \tag{9}$$

$$\frac{\partial q}{\partial \delta_C} = \frac{\xi_S}{\xi_S - \xi_D} \tag{10}$$

So, the side of the market that will suffer the most from the tariff is the least elastic side. If the supply is more elastic than the demand, the suppliers will be able to shift the burden on the consumers since they will not change their spendings much.

From these equations, two cases are possible:

- $|\xi_D| \geq \xi_S$ the consumers are more sensitive to price changes, the companies bear the tariff. The goal of the tariff is reached: Switzerland is hurt by the tariff implemented by the coalition;

- $|\xi_D| \leq \xi_S$ the supply is more elastic than the demand, the tariff is shifted to the consumers. In this case, the coalition is harmed by its own tariff.

Facing the first case, Switzerland may be tempted to trigger a tariff war.

Proposition 2 *The tax burden is mostly borne by:*

- *consumers, if Swiss imports are luxury goods;*

- *both consumers and producers, if Swiss imports are normal goods. The tariff incidence is not clearly determined.*

Luxury goods account for only 19.6% of Swiss exports to Europe in 2017[18]. So, the tariff will not impact most of the consumers, only a few of them. Moreover, the other goods exported[19] by Switzerland to Europe are normal goods that may be substituable.

The coalition demand for Swiss imports is in majority a demand for normal goods, implying that when the price increases the demand decreases. Then, the consumers of the coalition are for most of the Swiss goods able to find substitutes in other countries. So, the coalition demand for Swiss imports is likely to be more elastic than the supply.

For the rest of the paper, we will assume that Swiss imports are normal goods. Therefore, most of the tariff burden falls on Swiss producers. Thus, the tariff should be implemented. Note, that these imply that: $I'_p, I'_{\delta_C} < 0$ and $I''_{\delta_C p} > 0$.

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[18]according to AFD, Swiss-Impex.

[19]The Swiss exports to Europe in terms of goods are made of: agricultural products (5.8%), energy products (1.9%), chemical products (50.6%), vehicles (3.9%) and equipments (18.2%).

3.2.3 How effective is this tariff?

We have seen that the optimal tariff is most likely to impact Swiss producers. Now, we may wonder if it will permit to cover the losses induced by evasion and to force the tax haven to stop its capital sheltering activities.

We have to identify the losses induced by tax evasion.

Lemma 4 *To cover its losses, the tariff revenue of the coalition should be such that:*

$$\delta_C I \geq (\rho + (1 + \lambda)T)(1 + r)x \tag{11}$$

The revenue from the tariff set on Swiss imports is larger or equal than the total amount of losses. The losses are made of the share of capital spent on fees (Slemrod and Wilson (2009)) and the tax that should have been paid by capital owners.

Proposition 3 *The tariff set by the coalition covers the losses incurred by the sheltering activities of Switzerland if and only if:*

$$I \geq \frac{\delta'_S(\delta_C^*)X_C^S + \sqrt{(\delta'_S(\delta_C^*)X_C^S)^2 - 4(\rho + (1 + \lambda)T))I'_{\delta_C}(.)(1 + r)x}}{2} \tag{12}$$

If the imports from Switzerland to the coalition are too small, the tariff set by the coalition is inefficient. This threshold increases with the level of tax evasion x and the cost of evasion $\rho + T(1 + \lambda)$. Indeed, when the amount of evaded taxes increases, so do the losses of the coalition. When the level of taxes rises, the level of evasion may increase. This must be due to the fact that tax evasion is even more profitable: individuals save even more by evading. Thus, these two elements make the level of imports required to balance the losses rise.

Then, Switzerland would be deterred from evasion if its payoff becomes negative.

Lemma 5 *Switzerland should be deterred from sheltering capital if it expects that:*

$$\rho(x + \overline{x}) + \delta_S X_C^S \leq E_{NC}[\delta_C]I \tag{13}$$

with $E_{NC}[\delta_C]$ the expected tariff in case of non-cooperation.

The losses induced by the tariff that Switzerland expects to have should be larger than the profit that it makes. So, to force Switzerland to cooperate, the tariff revenue of the coalition should verify this inequality.

Proposition 4 *The tariff set by the coalition induces Switzerland to cooperate if and only if:*

$$I \geq \frac{\delta_S'(\delta_C^*)X_C^S + \sqrt{(\delta_S'(\delta_C^*)X_C^S)^2 - 4I_{\delta_C}'(.)[\rho(1+r)(x+\overline{x}) + \delta_S(\delta_C^*)X]}}{2} \tag{14}$$

If the imports from Switzerland to the coalition are too small, the tariff set by the coalition is not optimal. The lower-bound increases with the level of exports to Switzerland and the fees retained by the tax haven. This is explained by the fact that these two elements are Switzerland's source of revenue. Thus, the higher they are, the harder it is to close the tax haven.

Proposition 5 *If the coalition tax evasion level is large enough, recovering the losses induced by tax evasion is sufficient to force Switzerland to cooperate. This is true if and only if the coalition level of tax evasion is so that:*

$$x > \frac{\rho(1+r)\overline{x} + \delta_S X}{(1+\lambda)T(1+r)} \tag{15}$$

If the capital from the coalition sheltered in Switzerland is large, the cost incurred by the tariff over-balances the profit generated by the sheltering activities. This threshold lowers with T since a larger capital tax rate implies larger losses induced by tax evasion. And this losses gets closer to the tax haven payoff. On the other hand, this threshold rises when the evaded taxes of other countries increases. The tax haven is less dependent on the coalition capital.

To summarize, the less elastic the demand for Swiss imports, the larger the tariff. The tariff will force Switzerland to cooperate or will at least cover the losses if and only if the imports are sufficiently large.

The tariff implemented in the following sections is that of defined from proposition 2 denoted δ_C^*.

3.3   Defining the capital tax rate in the coalition

In section 4, we describe different methods to solve this stage. Here, we develop the one that we find the most relevant and insightful.

In this section, a different framework is used because each member of the coalition is modeled as a player. In fact, this section focuses on the definition of the common capital tax rate in the coalition. Therefore, the tax haven is not represented here as a player and the evaded amount of tax is not taken into account. France, Germany and Italy negotiate their common capital tax rate. The capital of country $i \in \{F, G, F \cap G, I\}$ comprises: immobile capital s_i and i's capital that is invested in country j β_{ij}. We posit that the amount of capital is normalized to 1: $s_i = 1 - \beta_{ij}$.

We consider a withholding tax t_i that is implemented on the foreign mobile capital when their is no agreement between the countries. When the coalition is formed, the withholding tax becomes T. We hypothesize that investment does not directly depends on the capital tax rate. According to Hartman (1985) withholding tax does not affect the size of foreign investments.

Without treaty, the tax revenue of country i is:

$$\overline{R}_i = t_i(1+r)s_i + t_i(1+r)\beta_{ji} - t_j(1+r)\beta_{ij} \tag{16}$$

The net revenue of country i is made of the taxes levied on the immobile and the foreign capital minus the taxes paid to the other countries where the capital is invested.

With treaty, the payoff of country i is:

$$R_i = t_i(1+r)s_i + T(1+r)(\beta_{ji} - \beta_{ij}) + \Phi_i(\beta_{ij}) \tag{17}$$

$\Phi_i(\beta_{ij})$ are the mutual gains of implementing a tax treaty, especially gains from the reduction of enforcement costs. We assume that $\Phi_i(\beta_{ij})$ is a non-decreasing function of β_{ij}. To simplify notations, we will write Φ_i instead of $\Phi_i(\beta_{ij})$. $-T(1+r)\beta_{ij}$ is the loss due to the tax paid to country j by country i; while $T(1+r)\beta_{ji}$ is the tax earned on the foreign capital invested in i.

We assume that France initiates the treaty and first negotiates with Germany. This assumption is in line with the spirit of the European construction. Indeed, several major

European treaties started by a cooperation between France and Germany[20]. Nowadays the links between these two countries remain strong. That is why we suppose that France and Germany form a coalition. Once they have agreed on a common capital tax rate, they propose and bargain with Italy. In this framework, France is similar to a Stackelberg leader.

So, the treaty construction is made of two key steps:

1. The negotiation between France and Germany about a common capital tax rate $T_{F \cap G}$. These two countries form first a small coalition (denoted $F \cap G$) that will expand by including Italy (I);

2. France and Germany behave as a unique country and negotiate with Italy to define the capital tax rate T^* that will be set in the grand coalition.

We model these two steps in the following sections.

3.3.1 France bargains with Germany

France initiates the treaty and first discusses with Germany the basis of the treaty. They determine together a common capital tax rate. So, this section focuses only on the negotiation between France and Germany. We assume that France has more capital invested in Germany than Germany has in France[21]: $\beta_{FG} > \beta_{GF}$.

First, each country's payoff generated by a common tax is derived.

Lemma 6 *The net gain of the treaty for France and Germany are respectively:*

$$R_F - \overline{R}_F = t_G(1+r)\beta_{FG} - t_F(1+r)\beta_{GF} - T_{F \cap G}(1+r)(\beta_{FG} - \beta_{GF}) + \Phi_F(\beta_{FG}) \quad (18)$$

$$R_G - \overline{R}_G = t_F(1+r)\beta_{GF} - t_G(1+r)\beta_{FG} + T_{F \cap G}(1+r)(\beta_{FG} - \beta_{GF}) + \Phi_G(\beta_{GF}) \quad (19)$$

The net gain of the treaty is made of the change in net tax revenue, the difference of what is earned now (R_i) and what was earned before ($\overline{R}_i$), and the non-tax gains from

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[20]like the Coal and steel agreement (1952) or the Elysée Treaty (1963).

[21]This assumption is empirically justified in terms of investment positions. According to the OECD, the outward FDI position from France to Germany was 75,785 million euros, while from Germany to France it represents 41,590 million euros in 2010.

the treaty $(\Phi_i(.))$[22]. A large common capital tax rate (T) benefits more to Germany than France. Indeed, the German tax burden will be lower since it has less capital invested in France than France in Germany.

Then, the common capital tax rate should be such that each country has a positive or null payoff.

Lemma 7 *The common capital tax rate to be acceptable for each country should be such that:*

$$T_{F \cap G} \in \left[\frac{(1+r)[t_G \beta_{FG} - t_F \beta_{GF}] - \Phi_G}{(\beta_{FG} - \beta_{GF})(1+r)}; \frac{(1+r)[t_G \beta_{FG} - t_G \beta_{GF}] + \Phi_F}{(\beta_{FG} - \beta_{GF})(1+r)} \right] \quad (20)$$

A common capital tax rate in this interval makes the treaty mutually beneficial.

The upper bound makes the payoff of France null and maximizes the payoff of Germany and vice versa for the lower bound. This can be explained by the fact that France has more FDI than Germany. Indeed, France is willing to agree on a common capital tax rate to save on enforcement costs, but if this common capital tax is too high it will balance these gains.

By choosing the optimal capital tax rate, the coalition enables to shift a share of tax revenue from a country to another, making both of them better off and thus willing to agree.

The bargaining outcome is derived thanks to the Nash bargaining solution[23]. It consists in maximizing the weighted product of countries' net gain. The problem can be written as follows:

$$\max_{T_{F \cap G}} \ (R_F - \overline{R}_F)^{\alpha_F} (R_G - \overline{R}_G)^{\alpha_G} \quad (21)$$

$\alpha_i \in [0,1]$ represents the bargaining power of the country and sums to one. The bargaining power of a country is its capacity to impose its preferences. The solution to this problem gives the optimal capital tax rate that is set in Germany and France.

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[22]Denoted Φ_i to simplify notations.

[23]following the methodology of Binmore et al. (1986).

Lemma 8 *The optimal common capital tax rate defined in the first step of the treaty construction is such that:*

$$T_{F \cap G} = \frac{\alpha_G \Phi_F - \alpha_F \Phi_G + (1+r)[t_G \beta_{FG} - t_F \beta_{GF}]}{(1+r)[\beta_{FG} - \beta_{GF}]} \tag{22}$$

Note that, the bigger the bargaining power of a country, the closer to its preferred tax rate the common tax rate is. Indeed, if $\alpha_G = 1$ and $\alpha_F = 0$, $T_{F \cap G}$ is equal to the upper bound of the acceptable condition (equation 20) which makes the German payoff maximal.

The denominator is positive, since we assumed that $\beta_{FG} > \beta_{GF}$. Then, the tax rate is positive if and only if the numerator is positive. The numerator is likely to be positive since the capital invested in Germany by France is larger than that of invested in France by Germany. Indeed larger investment induces larger enforcement and administrative costs ($\Phi_F > \Phi_G$). Then, we may assume that France and Germany have approximatively the same bargaining power in Europe ($\alpha_F \approx \alpha_G$). *A priori* the numerator should be positive.

Having determined a common capital tax rate, the Franco-German coalition is now able to bargain with Italy in order to enlarge the coalition. The enlargement enables the coalition to have sufficient power regarding Switzerland cooperation. Indeed, the tariff threat is more credible when it concerns more Swiss trade partners.

3.3.2 The Franco-German coalition bargains with Italy

France and Germany now behave as a unique country. They receive a common payoff. Italy's payoff is similar to that of Germany and France described in the previous section.

Lemma 9 *The net gain of the treaty for the Franco-German ($F \cap G$) coalition and Italy (I) are respectively:*

$$R_{F \cap G} - \overline{R}_{F \cap G} = t_I(1+r)\beta_{(F \cap G)I} - t_{F \cap G}(1+r)\beta_{I(F \cap G)} \tag{23}$$

$$- T^*(1+r)(\beta_{(F \cap G)I} - \beta_{I(F \cap G)}) + \Phi_{F \cap G}(\beta_{(F \cap G)I}) \tag{24}$$

$$R_I - \overline{R}_I = t_{F \cap G}(1+r)\beta_{I(F \cap G)} - t_I(1+r)\beta_{(F \cap G)I} \tag{25}$$

$$+ T^*(1+r)(\beta_{(F \cap G)I} - \beta_{I(F \cap G)}) + \Phi_I(\beta_{I(F \cap G)}) \tag{26}$$

Similarly, the net gain of the treaty is made of the change in net tax revenue and the non-tax gains from the treaty[24]. Here, $\beta_{(F\cap G)I}$ accounts for the capital from the Franco-German coalition capital invested in Italy.

We could also define an interval in which the common capital tax rate has to be in order to make the agreement acceptable by each part.

The bargaining outcome is also derived thanks to the Nash bargaining solution. It consists in maximizing the weighted product of the country's net gain. This time the weighted product is made of the Italian and the the Franco-German coalition net gains. The problem that the coalition and Italy seek to solve can be written as follows:

$$\max_{T^*} \ (R_{F\cap G} - \overline{R}_{F\cap G})^{\alpha_{F\cap G}} (R_I - \overline{R}_I)^{\alpha_I} \tag{27}$$

with T^* being the optimal tax rate of the grand coalition. The solution to this problem gives the optimal capital tax rate that should be set in the grand coalition (among France, Germany and Italy). This capital tax rate will be the one set by the coalition in the model.

Proposition 6 *Assuming that France initiates the agreement with Germany the chosen capital tax rate in the grand coalition is such that:*

$$T^* = \frac{\alpha_I \Phi_{F\cap G} - \alpha_{F\cap G}\Phi_I + (1+r)[t_I \beta_{(F\cap G)I} - T_{F\cap G}\beta_{I(F\cap G)}]}{(1+r)[\beta_{(F\cap G)I} - \beta_{I(F\cap G)}]} \tag{28}$$

with $T_{F\cap G}$ as previously defined.

We assume that $\beta_{(F\cap G)I} - \beta_{I(F\cap G)} > 0$, which is empirically verified in terms of FDI[25]. The bargaining power of the Franco-German coalition is larger than that of Italy since the coalition is made of two countries ($\alpha_{F\cap G} > \alpha_I$). But the non-tax gain generated by the treaty should be greater for the small coalition since they have larger foreign investments ($\phi_{F\cap G} > \phi_I$). Thus, the first part of the numerator is positive or null. Then, we have $t_G < T_{F\cap G} < t_F$ and empirically, $t_G < t_I < t_F$. Thus, we may assume that the tax rates

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[24]The non-tax gains can here summarize the advantages of multilateral treaty underlined by Thuronyi (2000).

[25]The amount of French and German investments in Italy sums to 77,429 million euros according to the OECD in 2010. The investments of Italy in the small coalition is equal to about 60,000 million euros.

are slightly different: $t_I \approx T_{F \cap G}$. This implies that the second part of the numerator is positive.

So, the treaty induces a positive tax on capital in the coalition. The tax rate reflects both the asymmetry regarding capital between countries but also the difference of bargaining power. The larger the asymmetries between countries, the larger the capital tax rate.

This agreement around the capital tax is mutually beneficial if and only if the net gain induced by the common rate is positive.

Proposition 7 *The net gain of each member of the coalition are the following*[26]:

$$R_{F \cap G} - \overline{R}_{F \cap G} = \alpha_{F \cap G}[\phi_I + \phi_{F \cap G}] = \alpha_{F \cap G}[\phi_I + \phi_F + \phi_G] \tag{29}$$

$$R_I - \overline{R}_I = \alpha_I[\phi_I + \phi_{F \cap G}] = \alpha_I[\phi_I + \phi_F + \phi_G] \tag{30}$$

Thus, the net gain of each country is positive. It depends on the global non-tax gains and on the bargaining power of each member. The larger they are, the larger the net gain. A similar result is obtained for the Franco-German coalition. Similarly to Chisik and Davies (2004), we find that if there is no non-tax gain, the countries are indifferent between being part of the coalition and not participating.

We may wonder how the coalition capital tax rate evolves when one of the country characteristic varies. Therefore, we do a comparative static of T^*.

Proposition 8 *A variation in the initial capital tax rate induces the following effects:*

$$\frac{\partial T^*}{\partial t_I} = \frac{\beta_{(F \cap G)I}}{\beta_{(F \cap G)I} - \beta_{I(F \cap G)}} > 0 \tag{31}$$

$$\frac{\partial T^*}{\partial t_F} = \frac{\beta_{I(F \cap G)}\beta_{GF}}{(\beta_{(F \cap G)I} - \beta_{I(F \cap G)})(\beta_{FG} - \beta_{GF})} > 0 \tag{32}$$

$$\frac{\partial T^*}{\partial t_G} = \frac{-\beta_{I(F \cap G)}\beta_{FG}}{(\beta_{(F \cap G)I} - \beta_{I(F \cap G)})(\beta_{FG} - \beta_{GF})} < 0 \tag{33}$$

[26]We assume that $\phi_{F \cap G} = \phi_G + \phi_F$, meaning that the non-tax gain of the Franco-German coalition is equal to the non-tax gain of Germany plus that of France.

An increase of the Italian initial tax rate implies that the coalition saves more thanks to the agreement. To redistribute the gains, the tax rate induced by the treaty should be higher. If the initial German capital tax rate rises, the Franco-German coalition has a higher initial capital tax rate ($T_{F \cap G}$). Similarly, a higher $T_{F \cap G}$ implies that Italy saves more thanks to the treaty. To keep the bargaining solution sustainable, it requires that the tax treaty decreases. The reasoning is similar for the French tax rate.

Proposition 9 *A change in the bargaining power induces the following effects:*

$$\frac{\partial T^*}{\partial \alpha_I} = \frac{\Phi_{F \cap G}}{(1+r)(\beta_{(F \cap G)I} - \beta_{I(F \cap G)})} > 0 \tag{34}$$

$$\frac{\partial T^*}{\partial \alpha_F} = \frac{\Phi_G \beta_{I(F \cap G)}}{(\beta_{(F \cap G)I} - \beta_{I(F \cap G)})(\beta_{FG} - \beta_{GF})(1+r)} > 0 \tag{35}$$

$$\frac{\partial T^*}{\partial \alpha_G} = \frac{-\Phi_F \beta_{I(F \cap G)}}{(\beta_{(F \cap G)I} - \beta_{I(F \cap G)})(\beta_{FG} - \beta_{GF})(1+r)} < 0 \tag{36}$$

The larger the bargaining power of Italy or France, the larger the grand coalition tax rate. Italy receives more investment than it invests, thus an increase of the common tax rate induces a net increase of its tax revenues. Consequently, if Italy has a higher bargaining power, it seeks to increase the final capital tax rate. On the contrary, a larger German bargaining power reduces the final capital tax. This is due to the fact that a larger bargaining power of Germany induces a larger Franco-German capital tax rate which reduces the final capital tax.

Proposition 10 *A variation in the amount of capital invested induces the following effects:*

$$\frac{\partial T^*}{\partial \beta_{I(F \cap G)}} = -\frac{(1+r)(T_{F \cap G} - T^*) + \alpha_{(F \cap G)} \Phi_I'}{(1+r)(\beta_{(F \cap G)I} - \beta_{I(F \cap G)})} < 0 \tag{37}$$

$$\frac{\partial T^*}{\partial \beta_{FG}} = -\frac{\beta_{I(F \cap G)}}{\beta_{(F \cap G)I} - \beta_{I(F \cap G)}} \frac{\partial T_{F \cap G}}{\partial \beta_{FG}} < 0 \tag{38}$$

$$\frac{\partial T^*}{\partial \beta_{GF}} = -\frac{\beta_{I(F \cap G)}}{\beta_{(F \cap G)I} - \beta_{I(F \cap G)}} \frac{\partial T_{F \cap G}}{\partial \beta_{GF}} > 0 \tag{39}$$

with Φ_i' denotes $\frac{\partial \Phi_i}{\partial \beta_{ij}}$.

Recall that Φ_i is a non-decreasing function of β_{ij}. When the investment of Italy in the coalition increases, it increases its gain from the implementation of the new tax rate. This requires a compensation from Italy to the small coalition that is realized through a decrease of the final tax rate. The same mechanism is at work regarding the sign of the partial derivatives of the Franco-German capital tax.

Finally, a common capital tax rate in the coalition is possible. We notice that any change in the German parameters except its level of investment has a negative impact.

3.4 Implementing the tax on capital and threatening the tax haven

In this section, the efficiency of implementing a tax on capital while threatening the tax haven is explored.

The three European countries want to cooperate to fight tax evasion. They want to check whether setting a common capital tax rate while threatening the tax haven would be efficient. The threat consists in implementing the optimal tariff that was defined earlier on Swiss imports to the coalition.

In this section, we get back to the situation where the coalition is considered as a unique player. The two players are the coalition and the tax haven. The conditions under which the scenario we just described is achievable are derived.

The amount of capital held by the coalition is considered in a comprehensive manner. Only the capital invested in tax haven x and that of invested in the coalition $1 - x$ are distinguished.

The coalition of countries seeks to maximize its payoff while covering at least the cost of tax evasion[27]:

$$\max_{T} \Pi_C(T) \text{ s.t } \delta_C I_S^C \geq (\rho + T(1 + \lambda))(1 + r)x \tag{40}$$

---

[27] Remind that, $(1 - T)(1 + r)(1 - x)$ corresponds to the net return of domestically invested capita; $(1 - \rho)(1 + r)x$ is the income of capital located in tax haven; and $(1 + \lambda)T(1 + r)(1 - x)$ is the social valuation of the capital revenue. $(1 + \lambda)$ accounts for the shadow price of public funds.

From the previous section (3.2), we know that the constraint is satisfied when:

$$\delta_C = \frac{\delta'_S(\delta_C)X - I(p + \delta_C)}{I'_{\delta_C}(p + \delta_C)} \tag{41}$$

$$\text{and } I^C_S \equiv I \geq \frac{\delta'_S(\delta_C)X^S_C + \sqrt{(\delta'_S(\delta_C)X^S_C)^2 - 4(\rho + (1 + \lambda)T))I'_{\delta_C}(.)(1 + r)x}}{2} \tag{42}$$

Assuming that these conditions are satisfied and thus that the coalition tariff revenue covers the losses, the first order condition of the problem 40 is:

$$\frac{\partial \Pi_C}{\partial T} = \lambda(1 + r)s + \delta_C \frac{\partial I}{\partial T}(T) \tag{43}$$

With

$$\frac{\partial I}{\partial T} = -4(1 + r)x[\frac{\partial I'_{\delta_C}}{\partial T}(\rho + (1 + \lambda)T) + (1 + \lambda)I'_{\delta_C}(.)] \tag{44}$$

This partial derivative could be positive. Indeed, if the coalition capital tax increases, we expect that the coalition's capital flees to other countries such as Switzerland which is a border country. In this case, we may think that to balance the losses induced by the leak of companies or capital the imports will rise[28].

It has already been assumed that $I'_{\delta_C}(.) < 0$. Regarding $\frac{\partial I'_{\delta_C}}{\partial T}$, when the capital tax rate increases, the level of tariff should increase to balance the losses induced by tax evasion. Thus, we can say that a variation of T is similar to a variation of δ_C. From this assumption we can say that $\frac{I'_{\delta_C}}{\partial T} \approx I''_{\delta_C \delta_C}$ is similar to $I''_{p\delta_C}(.)$ since it was also assumed that a tariff change is similar to a price change. Moreover, at the beginning of the model, it was finally assumed that most of the imported goods are normal and thus $I''_{p\delta_C}(.) > 0 \Leftrightarrow \frac{\partial I'_{\delta_C}}{\partial T} > 0$. In this case, the partial derivative of our interest is effectively positive if and only if:

$$\frac{\partial I}{\partial T} \geq 0 \Leftrightarrow \frac{\partial I'_{\delta_C}}{\partial T} \leq \frac{-(1 + \lambda)I'_{\delta_C}(.)}{(\rho + (1 + \lambda)T)} \tag{45}$$

Then, as Elsayyad and Konrad (2012) underlined, a positive λ is the basis of the theory of optimal taxation. Then the payoff of the coalition is increasing in T (equation 43 is positive). Thus, in this setting, the coalition is willing to set the maximal capital tax rate that is achievable.

---

[28]Assume that the goods or services produced by the company are consumed in the home country. Then, if the company relocates because of a tax increase, the consumers will still consume these goods and thus import them.

So, no constraint regarding the valuation of public funds is required to have a welfare-improving tax on capital. This results contrasts with that of Elsayyad and Konrad (2012). In their model, closing tax havens while implementing a positive capital tax benefits to the non-tax-haven country if and only if λ is large enough.

Since it has been verified that setting a positive capital tax rate is efficient, we can derive the payoffs. We have showed that the optimal tax on capital in the coalition is T^*, it represents the interest of each member. Thus, this is the rate set.

Proposition 11 *Whatever the social valuation of public goods, a positive tax on capital is welfare improving when the tax haven is threatened of tariff retaliation. The payoffs of each player depends on whether the tax haven cooperates:*

- *if the tax haven does not cooperate, the respective profits are:*

$$\Pi_C = (1 - T^*)(1 + r)(1 - x) + (1 - \rho)(1 + r)x + (1 + \lambda)T^*(1 + r)(1 - x) \quad (46)$$

$$+ \delta_C^* I_S^C - \delta_S^* X_C^S \quad (47)$$

$$\Pi_S = \rho(1 + r)(x + \overline{x}) + \delta_S^* I_C^S - \delta_C^* X_S^C \quad (48)$$

The optimal values for δ_C^* and T^* are obtained by solving respectively equation 3 and 28. $\delta_S^* = \delta_S^*(\delta_C^*)$ is the best response of Switzerland to the coalition tariff.

- *if the tax haven cooperates, the respective payoffs are:*

$$\Pi_C = (1 - T^*)(1 + r) + (1 + \lambda)T^*(1 + r) \quad (49)$$

$$\Pi_S = \overline{\overline{\Pi}}_S \quad (50)$$

In case of non-cooperation, the coalition of countries is able to recover the losses induced by tax evasion if its imports from Switzerland are sufficiently high. The tax haven still shelters capital but has to pay the tariff on its exports. Its payoff remains positive if and only if the fees levied on the other capital ($\rho\overline{x}(1 + r)$) and the tariff on coalition imports are greater than the burden induced by the coalition tariff.

Proposition 12 *In case of non-cooperation, the coalition payoff changes as follows with respect to different parameters:*

$$\frac{\partial \Pi_C}{\partial \delta_C} > 0 \text{ if and only if } I_C^S > \delta_C I_{\delta_C}' \tag{51}$$

$$\frac{\partial \Pi_C}{\partial \lambda} = T(1+r)s + \delta_C \frac{\partial I_C^S}{\partial \lambda} > 0 \tag{52}$$

The condition regarding the variation of the coalition payoff when the tariff varies must be verified since we assumed that Swiss imports are substantial. The coalition payoff should increase when the valuation of public funds increases. Indeed, when public funds are more valued, the taxes are more accepted by the citizens. Then, we may assume that *a priori* there is no link between the valuation of public goods and the level of imports ($\frac{\partial I}{\partial \lambda} = 0$). λ impacts the threshold above which the tariff revenue covers the losses induced by tax evasion but it does not directly impact the imports. So, the payoff of the coalition increases with the valuation of public funds.

The coalition could increases its payoff by increasing its capital tax rate, but this may induce higher tax evasion, which has a negative effect on its payoff. So, raising a tariff on Swiss imports could be a solution.

4   Alternative approaches

There are many alternative routes to reach similar conclusions as the one we present in section 4, we describe a few of them in the following section. Especially, we develop another approach to the optimal tariff set on Swiss imports and we derive other methods to solve the bargaining problem regarding the coalition capital tax rate. We also use this section to justify the approach that we chose.

4.1   Choosing the tariff on inelastic Swiss imports

In section 3.2, it was assumed that the demand for Swiss goods was elastic. We should also consider the case in which the demand for Swiss good is not elastic. Since, different types of goods are imported some might have an inelastic demand.

The idea is still to set a tariff on Swiss imports that will deter Switzerland from sheltering capital. Here, the imports do not depend on the tariff set by the coalition ($\frac{\partial I_S^C}{\partial \delta_C} = 0$). For simplicity, we assume a tit-for-tat situation meaning that Switzerland sets exactly the same tariff on coalition imports to Switzerland.

Thus, the coalition wants to solve the following problem:

$$
\begin{cases}
\max_{\delta_C} \Pi_C(\delta_C, I_S^C) \\
\text{s.t } \delta_C I_S^C \geq (\rho + T(1+\lambda))(1+r)x
\end{cases}
\tag{53}
$$

The coalition wants to find the tariff (δ_C) that will force Switzerland to stop its sheltering activities. The constraint comes from the lemma 3. .

In this situation, since Swiss imports are inelastic the coalition has no upper bound to set the optimal tariff. Therefore, it may be tempting to sets a confiscatory tariff ($\delta_C = 1$). But this can be badly perceived by other governments and especially Switzerland could make a complaint against the coalition to the World Trade Organization (henceforth WTO). On the other hand, if the coalition set a tariff sufficiently high to cover its losses induced by the Swiss sheltering activities, the WTO would allow this tariff as it authorized the USA to set a confiscatory tax on some European goods in 1997. This is what Zucman (2015) underlined.

Proposition 13 *Assuming that the demand for Swiss good is totally inelastic, that the WTO will not accept a higher tariff than that of required to cover the losses induced by tax evasion and a tit-for-tat situation, the optimal tariff is such that:*

$$
\delta_C = \frac{(\rho + (1+\lambda)T)(1+r)x}{I_S^C}
\tag{54}
$$

This level of tariff makes Switzerland indifferent between sheltering capital or becoming a non-tax-haven country if x is sufficiently large according to proposition 5. This tariff decreases with the level of Swiss imports. At a given tariff revenue, an increase of Swiss imports must be balanced by a tariff decrease.

We preferred to define the optimal tariff in the game considering an elastic demand for Swiss goods rather than this approach. There are two main reasons. The first is that

there are only few goods that have inelastic demand. The second is that the result with elastic demand are more insightful and can generalize to an inelastic demand. So, the solution presented in the model is more general than this one.

4.2 Alternative definitions for the coalition's capital tax rate

We expose other ways to model the negotiation between the three members of the coalition. First, we still focus on the Nash bargaining solution but we assume that the members negotiate all together at the same time. Second, we briefly review what the solution is if the maximization of the common profit is considered. Finally, we discuss which framework seems the most realistic.

4.2.1 The Nash Bargaining Solution.

We have a similar framework to the previous, but it is more complete: perfectly mobile capital is considered. The capital of country $i, j, k \in \{F, G, I\}$ comprises: immobile capital (s_i), i's capital that is invested in country j (β_{ij}), i's capital that is invested in country k (β_{ik}) and i's capital that is fully mobile (γ_i) between the two other countries. It is invested where the capital tax rate is the lowest. We normalize the amount of capital to 1: $s_i = 1 - \beta_{ij} - \beta_{ik} - \gamma_i$. Let's denote the mobile capital by $\beta_i = \beta_{ij} + \beta_{ik} + \gamma_i$.

We assume that the capital has the same capital return r wherever it is invested. We consider a capital tax t_i that is implemented on the foreign mobile capital when there is no agreement between the three countries. When the coalition is formed, the tax becomes T.

Lemma 10 *The net gain of the treaty is given by:*

$$R_i - \overline{R}_i = t_j(1+r)\beta_{ij} + t_k(1+r)\beta_{ik} - t_i(1+r)(\beta_{ji} + \beta_{ki}) + \min\{t_j, t_k\}(1+r)\gamma_i \quad (55)$$

$$+ T(1+r)(\beta_{ji} + \beta_{ki} + \mathbf{1}_{t_i < t_k}\gamma_k + \mathbf{1}_{t_i < t_j}\gamma_j - \beta_i) + \Phi_i(\beta_i) \quad (56)$$

This net gain is positive if the new tax set and the mutual gain ($\Phi_i(.)$) are greater than the loss of the tax revenue that was earned before the coalition. If the country i receives more investment than it does, its net gain increases with the coalition tax rate. If the

44

country i used to have the smaller capital tax rate, then the fully mobile capital (γ) of other countries is invested in i. Thus, country i levies a tax on this capital.

We use the Nash bargaining solution to derive the result from the bargaining process. Therefore we look for T so that:

$$T \in \arg\max[(R_F - \overline{R}_F)^{\alpha_F}(R_G - \overline{R}_G)^{\alpha_G}(R_I - \overline{R}_I)^{\alpha_I}] \tag{57}$$

α_i corresponds to the relative bargaining power of country i. We have $\alpha_F + \alpha_G + \alpha_I = 1$

One of the weaknesses of such a solution is that it does not account for the possibility of sub-coalition inside the grand coalition. But this issue is no longer one when the coalition is made of the three players, meaning that the grand coalition is able to negotiate effectively. Negotiating effectively means that the countries of the coalition agree to make a change that will be beneficial to all of them without compromising the agreements that they have with outsider countries. So, we should assume that the coalition of the three countries is able to negotiate effectively.

Then, two cases are distinguished: the one in which the three countries are assumed perfectly symmetric and the one in which only one country differs in its initial capital tax rate.

- **Assuming that the three countries are perfectly symmetric**

Since the three countries are perfectly symmetric, we assume that: each country has the same bargaining power $\alpha_i = \frac{1}{3}$ $\forall i$, they have the same initial capital tax rate $t_i = t_j = t$ $\forall i, j$ $i \neq j$ and the countries are also similar in terms of exchanges $\beta_{ij} = \beta_{ji} = \beta$ $\forall i, j$. Thus, they have the same benefit from the treaty: $\Phi_i = \Phi_j = \Phi$ $\forall i, j$ $i \neq j$.

Proposition 14 *Under the perfectly symmetric country assumption, the optimal tax on capital is:*

$$T = \frac{\Phi + \gamma t(1+r)}{\gamma(1+r)} \tag{58}$$

The capital tax rate depends positively on the non-tax gains and on the initial capital tax rate. An increase of the perfectly mobile capital γ has a negative impact. This could be

explained by the fact that larger mobile capital implies greater downward pressure on T. Indeed, this mobile capital is footloose. So, a decrease of T would be a solution to keep this perfectly mobile capital in the coalition.

It should be noted that the capital tax rate set by the coalition is higher than the unilateral initial rate. This means that even if the countries had the same tax before forming the coalition, it is beneficial for them to cooperate.

- **The three countries are symmetric and only Germany has a different initial tax rate:**

The assumptions regarding the terms of exchange, the bargaining power and the benefits from the treaty still hold. Only two differ: Germany has the smallest capital tax rate, France and Italy have the same, denoted t ($t_G < t_I = t_F = t$), the perfectly mobile capital of Germany which is footloose, remains in Germany since it has the lowest capital tax rate[29]

Proposition 15 *Under perfectly symmetric countries in terms of exchanges and similar tax rates between France and Italy, but higher than that of Germany, the optimal tax on capital is:*

$$T = \frac{(t_G - t)(1 + r)\beta + t_G(1 + r)\gamma + \Phi}{\gamma(1 + r)} \qquad (59)$$

The capital tax rate depends positively on the non-tax gains and on the initial capital tax rate of Germany. An increase of perfectly mobile capital (γ) has a negative impact. The bargaining forces Germany to raise its level of capital tax. When the difference between the initial tax rate ($t_G - t$) widens, the coalition tax rate shrinks (($t_G - t$) being negative). This can be explained by the fact that, having the lowest capital tax rate, Germany is more reluctant to increase its rate. Thus, the German downward pressure in the bargaining is likely to strengthen when its initial tax rate is low.

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[29]The German net gain is sightly different: $R_G - \overline{R}_G = t(1 + r)(\beta_{GF} + \beta_{GI}) - t_G(1 + r)(\beta_{FG} + \beta_{IG}) + T(1 + r)(\beta_{FG} + \beta_{IG} + \gamma_F + \gamma_I - \beta_G) + \Phi_G(\beta_G)$. with $\beta_G = \beta_{GF} + \beta_{GI}$.

4.2.2 Maximizing the common profit

Another possibility to determine the optimal tax is to maximize the sum of the coalition members' payoffs:

$$T \in \arg\max[\overline{\Pi}_F + \overline{\Pi}_G + \overline{\Pi}_I] \tag{60}$$

Lemma 11 *The condition that the optimal tariff should verify is the following:*

$$\frac{\partial(\overline{\Pi}_F + \overline{\Pi}_G + \overline{\Pi}_I)}{\partial T} = (\beta_{GF} + \beta_{IF} - \beta_F) + (\beta_{GI} + \beta_{FI} - \beta_I) + (\beta_{IG} + \beta_{FG} - \beta_G) \tag{61}$$

The result depends on the terms of trade of each country. The outcome is binary, the optimal tax is either equal to 0 or 1. This result is due to the linearity of the payoff functions. It is not possible to get a closed form for T depending on the parameters.

4.2.3 Discussion

Different situations of negotiation have been presented. Regarding the capital tax rate, the assumption of perfectly symmetric countries seems the least plausible. The incentive to cooperate would be weak since the members of the coalition have already the same capital tax rate. Furthermore, it is observed that the real corporate income tax rates are as follows: 15% in Germany, 30% in France and 27.5% in Italy[30]. Therefore, it is reasonable to assume that Italy and France have the same capital tax rate.

Regarding the level of exchanges, it is also quite realistic to assume that exchanges between the three countries are similar. Indeed, Germany and Italy are respectively the first and the third France's export trade partners. Italy mostly exports to Germany and France. Germany has a weaker relationship with Italy but France is the second destination for its exports. In term of imports, the trade relationship are less strong, Germany is the first country of imports for France and Italy, but the reverse is not true. France is only the third German partner of imports.[31]

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[30] According to Deloitte, International tax, *Corporate tax rates 2018*.

[31] According to Eurostat, imports and exports of goods in the European Union in 2017.

Regarding the method used to solve the problem, the Nash bargaining solution gives interesting results but is based on strong assumptions regarding the exchanges to make the derivation tractable. Nevertheless, when we assume that the treaty is built step by step, we get a closed form solution for the capital tax rate without restriction on the exchanges. As we have already said, the assumption made on the fact that France and Germany initiate the treaty is in line with the spirit of the European construction. Nowadays the links between these two countries remain strong. Then, the maximization of the common profit is not insightful in this model since the payoff formulas are linear.

As a consequence, the preferred model is the model in which we hypothesize that the treaty is built step by step and that France and Germany initiate the coalition.

5 Conclusion

To conclude, we have underlined that creating a coalition is effective to fight tax evasion. Indeed, threatening to impose a tariff on tax haven imports should be effective when the trade relationship is unbalanced and favorable to the coalition. If the tax haven refuses to cooperate and prefers to absorb the tariff burden, it risks a paralysis. Either its exports may drop or their costs will offset the profit made by the capital sheltering activities. In both cases, the tax havens is exposed to significant losses in the absence of cooperation. The larger the coalition of countries fighting tax evasion, the greater the retaliation.

Our model also showed that a coalition of countries is able to find a common capital tax rate that is Pareto-improving. Then we underlined that regardless of the valuation of public funds, a positive capital tax and tariff threat are desirable for the coalition.

From these theoretical results, we should expect that countries can effectively fight tax evasion. Then, the larger the coalition of countries, the more credible the tariff threat is. Regarding the coalition described in this model, Switzerland might be tempted to refuse to cooperate for two reasons. First, fighting this way tax evasion has never been observed. Thus it can be perceived as non-credible. Second, Switzerland may hope not to be stifled by such a retaliation. Therefore, if the coalition is larger, for example adding the participation of Great-Britain, we should not expect to enter the stage of tariff implementation.

To have better idea of the tariff effects on Swiss imports, a numerical simulation would be helpful. It would enable us to quantify the losses incurred by the tax haven and to compare them to the profit made thanks to tax evasion. Then, precise estimations of imports elasticities would permit us to clearly identify the incidence of the tariff.

Finally, the tariff war possibility is not negligible, thus this should be explored. A tariff war could be as harmful as tax evasion.

A Defining the tariff on Swiss imports

A.1 The optimal tariff

Proof of the proposition 1: The coalition chooses the tariff that maximizes its payoff taking into account a possible response of Switzerland:

$$\max_{\delta_C} \Pi_C(\delta_C) = (1-T)(1+r)(1-x) + (1-\rho)(1+r)x + (1+\lambda)T(1+r)(1-x) \quad (62)$$

$$+ \delta_C I_S^C(\delta_C) - \delta_S(\delta_C)X_C^S \quad (63)$$

For simplicity, here we write $I_S^C = I$ and $X_C^S = X$. The first order condition is:

$$\delta_C I'_{\delta_C}(\delta_C) + I(\delta_C) - \delta'_S(\delta_C)X = 0 \quad (64)$$

It can be rewritten as:

$$\delta_C I'_{\delta_C}(\delta_C) - \delta'_S(\delta_C)X = -I(\delta_C) \quad (65)$$

$$\Leftrightarrow \delta_C - \delta'_S(\delta_C)\frac{X}{I'_{\delta_C}(.)} = -\frac{I(.)}{I'_{\delta_C}(.)} \quad (66)$$

$$\Leftrightarrow \frac{\delta_C - \delta'_S(\delta_C)\frac{X}{I'_{\delta_C}(.)}}{\delta_C} = -\frac{1}{\xi_{\delta_C}} \quad (67)$$

This is the result of the proposition.

A.2 Who bears the tariff burden?

Proof of lemma 1:

$$A = \frac{\partial D}{\partial p} = \left(1 + \frac{I'_\delta(.)(-I'_p(.)) + I''_{\delta p}(.)[I(.) - \delta'_S(\delta_C)X]}{(I'_\delta(.))^2}\right)I'_p(.) \quad (68)$$

Recall that $I'_p(.) = \frac{\partial D}{\partial p}$:

$$I'_\delta(.)\frac{\partial D}{\partial p} = I''_{\delta p}(.)[I(.) - \delta'_S(\delta_C)X] \quad (69)$$

$$\frac{\partial D}{\partial p} = \frac{I''_{\delta p}(p+\delta_C)[I(p+\delta_C) - \delta'_S(\delta_C)X]}{I'_\delta(p+\delta_C)} \quad (70)$$

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Proof of equation 9 and 10: At the equilibrium, the supply of Swiss goods equals the coalition's demand, we have:

$$S_S(p) = D_C(p + \delta_C) \tag{71}$$

At the initial state there is no tariff, so we start from $\delta_C = 0$. Then a tariff is introduced, and it is assumed that a change of tax is equivalent to a change of price, meaning that $dp \approx dq$. It follows that by differentiating $S_S(p) = D_C(q)$ gives[32] :

$$\frac{\partial S}{\partial p} dp = A dp + A d\delta_C \tag{72}$$

Then, from equation 7:

$$\frac{dp}{d\delta_C} = \frac{A\frac{p}{I}}{(\frac{\partial S}{\partial p} - A)\frac{p}{I}} = \frac{\epsilon_D}{\epsilon_S - \epsilon_D} \tag{73}$$

And since $q = p + \delta_c$, we have:

$$\frac{dq}{d\delta_C} = 1 + \frac{A}{\frac{\partial S}{\partial p} - A} = \frac{\frac{\partial S}{\partial p}\frac{p}{I}}{(\frac{\partial S}{\partial p} - A)\frac{p}{I}} = \frac{\epsilon_S}{\epsilon_S - \epsilon_D} \tag{74}$$

These are the results of the section 3.1.

Proof of the proposition 2: If we assume that Swiss imports are luxury goods, we have $A > 0$. Then, if we assume $\frac{\partial S}{\partial p} - A > 0$, it implies that:

$$\frac{\partial S}{\partial p} > A \tag{75}$$

$$\frac{\frac{\partial S}{\partial p}}{\frac{\partial S}{\partial p} - A} > \frac{A}{\frac{\partial S}{\partial p} - A} \tag{76}$$

$$\frac{dq}{d\delta_C} > \frac{dp}{d\delta_C} \tag{77}$$

The tax is more shifted to consumers. Similar results are found with $\frac{\partial S}{\partial p} - A < 0$.

Proof of the lemma 4: The coalition wants to set a tariff on Swiss exports such that the tariff covers the losses induced by capital shifting. Losses due to tax evasion are twofold: the loss in tax revenue $(T(1+r)x(1+\lambda))$ increased by the shadow price of public funds $(1 + \lambda)$ and the waste of resources used to pay the tax haven fees $(\rho(1 + r)x)$.

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[32]To get these formula, we should assume small tariff.

Proof of the proposition 3: To cover the losses the tariff should be such that:

$$I(.)\delta_C \geq [\rho + (1 + \lambda)T](1 + r)x \tag{78}$$

We replace δ_C by its value, then:

$$I(.)\frac{\delta'_S(\delta_C)X - I(p + \delta_C)}{I'_{\delta_C}(p + \delta_C)} \geq [\rho + T(1 + \lambda)](1 + r)x \tag{79}$$

$$I(.)[\delta'_S(\delta_C)X - I(.)] \leq I'_{\delta_C}(.)[\rho + T(1 + \lambda)](1 + r)x \tag{80}$$

$$-I(.)^2 + \delta'_S(\delta_C)XI(.) + I'_{\delta_C}(.)[(\rho + T(1 + \lambda))(1 + r)x] \leq 0 \tag{81}$$

The inequality changes because $I'_{\delta_C}(.) < 0$. The discriminant of this equation is:

$$\Delta = (\delta'_S(.)X)^2 - 4I'_{\delta_C}(.)[\rho + T(1 + \lambda)](1 + r)x > 0 \tag{82}$$

It is positive since $I'(.) < 0$. The only positive root is:

$$I_1 = \frac{\delta'_S(.)X + \sqrt{(\delta'_S(.)X)^2 - 4I'_{\delta_C}[\rho + T(1 + \lambda)](1 + r)x}}{2} \tag{83}$$

Then if $I(.) > I_1$ the inequality is verified and the tariff covers the losses.

Proof of the lemma 5: The tax haven chooses to cooperate if and only if it expects a negative profit:

$$E_{NC}[\Pi_S] \leq 0 \Leftrightarrow \rho(1 + r)(x + \overline{x}) + \delta_S I_C^S - E_{NC}[\delta_C]X_S^C \leq 0 \tag{84}$$

The expectation remains only on δ_C which is the only element on which the country has no power.

Proof of the proposition 4: To force Switzerland to cooperate, the tariff should be such that:

$$\delta_C \geq \frac{\rho(1 + r)(x + \overline{x}) + \delta_S I_C^S}{X_S^C} \tag{85}$$

Remember that $I_C^S = X_C^S = X$ and $X_S^C = I_S^C = I$. We replace δ_C by its value, then:

$$\frac{\delta_S'(\delta_C)X - I(p + \delta_C)}{I_{\delta_C}'(p + \delta_C)} \geq \frac{\rho(1 + r)(x + \overline{x}) + \delta_S X}{I} \tag{86}$$

$$I(.)[\delta_S'(\delta_C)X - I(.)] \leq I_{\delta_C}'(.)[\rho(1 + r)(x + \overline{x}) + \delta_S(\delta_C)X] \tag{87}$$

$$-I(.)^2 + \delta_S'(\delta_C)X I(.) - I_{\delta_C}'(.)[\rho(1 + r)(x + \overline{x}) + \delta_S(\delta_C)X] \leq 0 \tag{88}$$

The inequality changes because $I_{\delta_C}'(.) < 0$. the determinant of this equation is:

$$\Delta = (\delta_S'(.)X)^2 - 4I_{\delta_C}'[\rho(1 + r)(x + \overline{x}) + \delta_S X] > 0 \tag{89}$$

It is positive since $I_{\delta_C}'(.) < 0$. The only positive root is:

$$I_2 = \frac{\delta_S'(.)X + \sqrt{(\delta_S'(.)X)^2 - 4I_{\delta_C}'(.)[\rho(1 + r)(x + \overline{x}) + \delta_S X]}}{2} \tag{90}$$

Then if $I(.) > I_2$ the inequality is verified and the tariff forces the tax haven to cooperate.

Proof of the proposition 5: The level of imports required to cover the losses is bigger than the one required to force the tax haven to close if and only if:

$$I_1 > I_2 \tag{91}$$

$$[\rho + T(1 + \lambda)](1 + r)x > [\rho(1 + r)(x + \overline{x}) + \delta_S X] \tag{92}$$

$$x > \frac{\rho(1 + r)\overline{x} + \delta_S X}{T(1 + \lambda)(1 + r)} \tag{93}$$

$$\tag{94}$$

B   Defining the capital tax rate

B.1   France bargains with Germany

Proof of lemma 7:   The profit of each country is equalized to 0, and the coalition tax rate is isolated.

Proof of lemma 8:

$$T_{F \cap G} \in \arg\max[(\Pi_F - \overline{\Pi}_F)^{\alpha_F}(\Pi_G - \overline{\Pi}_G)^{\alpha_G}] \tag{95}$$

The first order condition is:

$$\alpha_F[t_F(1+r)\beta_{GF} - t_G(1+r)\beta_{FG} + T(1+r)(\beta_{GF} - \beta_{FG}) + \Phi_G] \tag{96}$$

$$- \alpha_G[t_G(1+r)\beta_{FG} - t_G(1+r)\beta_{GF} - T(1+r)(\beta_{FG} - \beta_{GF}) + \Phi_F] = 0 \tag{97}$$

The solution is:

$$T_{F\cap G} = \frac{\alpha_F\Phi_G - \alpha_G\Phi_F + (1+r)[t_G\beta_{FG} - t_F\beta_{GF}]}{(1+r)[\beta_{FG} - \beta_{GF}]} \tag{98}$$

B.2 The Franco-German coalition

Proof of proposition 6: The first order condition is similar to the previous one.

$$T^* \in \arg\max[(\Pi_I - \overline{\Pi}_I)^{\alpha_I}(\Pi_{F\cap G} - \overline{\Pi}_{F\cap G})^{\alpha_{F\cap G}}] \tag{99}$$

A similar fist order condition to the previous one is obtained. The solution is:

$$T^* = \frac{\alpha_I\Phi_{F\cap G} - \alpha_{F\cap G}\Phi_I + (1+r)[t_{F\cap G}\beta_{I(F\cap G)} - t_I\beta_{(F\cap G)I}]}{(1+r)[\beta_{I(F\cap G)} - \beta_{(F\cap G)I}]} \tag{100}$$

Proof of propositions 8,9 and 10: The comparative static of the grand coalition tax rate comes from the following results:

A change in the bargaining power induces the following effects:

$$\frac{\partial T_{F\cap G}}{\partial \alpha_G} = \frac{\Phi_F}{(1+r)(\beta_{FG} - \beta_{GF})} > 0 \tag{101}$$

$$\frac{\partial T_{F\cap G}}{\partial \alpha_F} = \frac{-\Phi_G}{(1+r)(\beta_{FG} - \beta_{GF})} < 0 \tag{102}$$

$$\tag{103}$$

A change in the initial tax rate induces the following effects:

$$\frac{\partial T_{F\cap G}}{\partial t_G} = \frac{-\beta_{FG}}{(1+r)(\beta_{FG} - \beta_{GF})} < 0 \tag{104}$$

$$\frac{\partial T_{F\cap G}}{\partial t_F} = \frac{\beta_{GF}}{(1+r)(\beta_{FG} - \beta_{GF})} > 0 \tag{105}$$

A change in the level of investment induces the following effects:

$$\frac{\partial T_{F\cap G}}{\partial \beta_{GF}} = -\frac{(1+r)(t_F - T_{F\cap G}) + \alpha_F \Phi'_G}{(1+r)(\beta_{FG} - \beta_{GF})} < 0 \tag{106}$$

$$\frac{\partial T_{F\cap G}}{\partial \beta_{FG}} = \frac{(1+r)(t_G - T_{F\cap G}) + \alpha_G \Phi'_F}{(1+r)(\beta_{FG} - \beta_{GF})} > 0 \tag{107}$$

These results explain the comparative static of T^*.

C   Alternative approaches

C.1   Defining the capital tax rate

Proof of Lemma 10   Without treaty, the tax revenue of country i is:

$$\overline{R}_i = t_i(1+r)s_i + t_i(1+r)(\beta_{ji} + \beta_{ki}) - t_j(1+r)\beta_{ij} - t_k(1+r)\beta_{ik} - \min\{t_j, t_k\}\gamma_i \tag{108}$$

With treaty, the payoff of country i is:

$$R_i = t_i(1+r)s_i + T(1+r)(\beta_{ji} + \beta_{ki} + \mathbf{1}_{t_i < t_k}\gamma_k + \mathbf{1}_{t_i < t_j}\gamma_j - \beta_i) + \Phi_i(\beta_i) \tag{109}$$

Solving the Nash bargaining problem: The first order condition of problem 57 can be written as follows:

$$T^2(1+r)^2 b_F b_G b_I \tag{110}$$

$$+ T(1+r)[\alpha_F b_F(b_G d_I + b_I d_G) + \alpha_G b_G(b_F d_I + b_I d_F) + \alpha_I b_I(b_F d_G + b_G d_F)] \tag{111}$$

$$+ \alpha_F b_F d_I d_G + \alpha_G b_G d_I d_F + \alpha_I b_I d_F d_G = 0 \tag{112}$$

with $b_i = \beta_{ji} + \beta_{ki} + \mathbf{1}_{t_i < t_k}\gamma_k + \mathbf{1}_{t_i < t_j}\gamma_j - \beta_i$
and $d_i = t_j(1+r)\beta_{ij} + t_k(1+r)\beta_{ik} - t_i(1+r)(\beta_{ji} + \beta_{ki}) + \min\{t_j, t_k\}(1+r)\gamma_i + \Phi_i$

Proof of proposition 14:   The first order condition can be rewritten in this manner:

$$aT^2(1+r)^2 + bT(1+r) + c = 0 \tag{113}$$

In our case we have:

$$a = (-\gamma)^3 \tag{114}$$

$$b = 2\gamma^2[t(1+r)\gamma + \Phi] \tag{115}$$

$$c = -\gamma[t(1+r)\gamma + \Phi]^2 \tag{116}$$

The discriminant is equal to:

$$\Delta = 0 \tag{117}$$

It implies that the only solution is T.

Proof of Proposition 15: The first order condition can be rewritten in this manner:

$$aT^2(1+r)^2 + bT(1+r) + c = 0 \tag{118}$$

In this case we have:

$$a = 3(\gamma)^3 \tag{119}$$

$$b = \gamma^2[6(t - t_G)\beta - 4(1+r)\gamma t_G - 3\Phi] \tag{120}$$

$$c = \gamma[3(t_G - t)\beta(1+r) + \gamma t_G(1+r)][(t_G - t)(1+r)\beta + t_G(1+r)\gamma + \Phi] \tag{121}$$

The discriminant of this equation is positive, so the only solution that is positive for sure is the one we stated.

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