# Coordination Effects among Global Games: An Application on Tax Havens

by Joan Margalef España

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Supervisor: Prof. Pau Milán.

**Abstract**

Regime change global games are coordination games with incomplete information in which an entity's regime changes if a sufficiently large number of agents take a certain action. This paper extends the game to multiple entities to account for the possible coordination effects among them. To analyze this, I design a model where multiple regime change global games take place simultaneously, and in an ex-ante stage, agents decide which one they play. Then, I compare the effects of altering the public information on the overall coordination. The whole model is conducted using a tax evasion application. My results show that worsening the public information of just one tax haven can increase (ease) or decrease (hinder) evasion (coordination), depending on the relative perception of each one. When the tax haven with the best public perception for evading is threatened, it leads to less evasion. However, if the tax haven with the worst public perception is threatened too harshly, it leads to more evasion due to a Crowding-in effect. Whereas a symmetric worsening always hinders coordination. Therefore, modeling a single entity global game when, in fact, players could choose among several of them, might be missing notorious coordination effects. Indeed, these effects can explain the inefficacy of the international policies to undermine tax evasion. Yet, the oncoming Minimum Global Tax Rate will reduce evasion.

Department of Economics
Universitat Autònoma de Barcelona

# 1 Introduction

Regime change global games are coordination games with incomplete information in which an entity's regime changes, and then, players' payoffs, if a sufficiently large number of agents take an action in favor of (or against) it.[1] These games have been used to model speculation against currency peg, run against a bank, revolution against a dictator, or evade through a tax haven.[2] However, the literature is centered on the change of the regime of just one "entity", meaning one government, currency, bank, or tax haven. This might fit well in applications where agents' coordination is actually limited to one entity (domestic government), however, in most cases, agents have access to several of them (banks, currencies or tax havens).

In the latter case, having different choices to coordinate in, also embodies a coordination concern: among all the different entities, to which one we coordinate in? The purpose of this paper is to extend the game to multiple entities in order to analyze the implications of combining two coordination dimensions: an outer dimension taking place among the entities, and an inner dimension taking place inside them. In other words, one issue is, which entity I would like to coordinate in? And the second is, given I would like to coordinate in entity A, do I finally try to coordinate? Taking into account both coordination dimensions might enrich the game by capturing inter-coordination effects since the properties of one entity might also affect how players coordinate into the rest of the portfolio.

To analyze this, I design a model with a multiple entity structure where each one embodies a separate regime change global game. The game is played in two stages. In the first one, players have to decide, among the different entities, to which one (and only one) they want to get access to, only according to public information. Whereas in the second one, they play the chosen entity's regime change global game using public and private information. In other words, multiple regime change global games are going to take place simultaneously, and in an ex-ante stage, agents decide which one they are going to play. Then, in this setting, I mainly compare the effects of altering the public information on the overall coordination. Note that the first stage captures the outer coordination problem meanwhile the second stage embodies the inner one. How this first stage affects the outcome of the second one, or from the players' point of view, how the inference of the second stage affects their decisions in the first one, will tell us about the possible inter-coordination effects.

The whole model is conducted using a tax evasion application based on Konrad and Stolper (2016). Investors have to decide whether to try to evade or not using tax haven jurisdictions. A tax haven is a state that attracts foreign wealth using a combination of a low tax rate and concealing services. However,

[1] Global games were introduced by Carlsson and Van Damme (1993) which often leads to a unique, iterative dominant equilibrium. See Morris and Shin (2001) for a review.

[2] See Morris and Shin (1998), Goldstein and Pauzner (2005), Angeletos et al. (2007) and Konrad and Stolper (2016) respectively.

a tax haven needs enough evaders to make the low taxation strategy profitable.[3] Then, the coordination problem arises: evaders need to coordinate to make the tax haven instrument available, otherwise, they will be punished for attempting to evade. Then, by distorting the public information about the cost of being a tax haven, I try to replicate the OECD policies to undermine tax evasion. Mainly, they have been public threats of economic sanctions by using blacklists, a policy also taken by the G20, EU, UN, etc.[4] I take the tax haven application for two main reasons, one theoretical and another empirical. First, to extend the model of Konrad and Stolper (2016). The authors designed a regime change global game of a tax haven. However, when they extend the analysis to multiple tax havens they return to the simplest setting of complete information, which is not a global game. And second, because this analysis might explain the inefficacy of the mentioned international policies and also it can assess the recently proposed Minimum Global Tax Rate. Nonetheless, the model could be easily extended to more applications that can fit even better the model.

My results show that worsening the public information of just one tax haven can increase (ease) or decrease (hinder) evasion (coordination), depending on the relative perception of each one. On the one hand, investors have less incentive to evade since the information set is worse-off than before. But, on the other hand, they have more incentive because they anticipate a concentration into the alternative tax haven which increases the likelihood of overcoming the risk. I called the former effect "Global Effect", whereas the second one "Crowding-in Effect". When the tax haven with the best public information for evading is threatened, the Global Effect dominates, leading to less evasion. However, if the tax haven with the worst public information for evading is threatened too harshly, the Crowding-in effect accomplishes to overthrown the Global one leading to more evasion. Considering a symmetric threat, the Crowding in effect does not manifest and the Global one always hinders coordination, which is, indeed, the result when modeling just one entity. Therefore, in the study of global games, analyzing single entities as if they would be completely independent might be missing notorious coordination effects. In fact, if we consider that the OECD policies have been applied too heterogeneously, these effects can explain why the leak of wealth has not stopped from increasing in spite of the measures. However, if the oncoming minimum global tax rate is as global as pretended, it will reduce evasion.[5]

Regarding the organization of this document, in the next chapter, I discuss the connection with the literature. In chapter 3, I explain in more detail the international strategies and their results. In chapter 4, I describe the theoretical model. In chapter 5, I some policy implications. And finally, in chapter 6, I lay out the conclusions.

[3] The reader is advised to read the tax competition literature to know more about the underlying incentives and more properties of tax havens. Especially, the two main models which are the ZMW (Zodrow and Mieszkowski, 1986)(Wilson, 1986) and the KK model (Kanbur and Keen, 1991) whose results are summarized in Keen and Konrad (2013).

[4] A more detailed explanation of the international strategies is located in Section 3.

[5] A more detailed explanation of the policy results is located in Section 3.

## 2 Related Literature

This paper contributes to the literature of the global games by extending the analysis of the information effects in a multiple entity structure; and to the tax haven literature by studying the role of information policies, taking also into account the multiple tax haven setting.

Regarding the literature in global games, to the best of my knowledge, this is the first attempt to model a game with multiple and simultaneous regime change global games. Nonetheless, one could relate this paper to the dynamics global games such as Morris and Shin (1999), Chamley (1999) and Angeletos et al. (2007) among many, since their setting can be thought of as several regime change global games taking place. In short, they study when to act, whereas I study where. Their games are played sequentially whereas mine is played simultaneously. They modeled the same entity over time whereas I model different entities once. Their entities are connected through time, whereas mines are connected by being simultaneously in the choice set. Therefore, this paper is weakly related to theirs, although some connections could be found.

Moreover, I analyze the effects of affecting the information, which has also been studied in the literature. Angeletos and Pavan (2007) and Angeletos et al. (2006) show that, given that the entity is a player in the game, the regime's ability to manipulate the information leads to multiple equilibria. However, Edmond (2013) demonstrates that uniqueness is preserved if the signals are manipulated directly. Although the information is affected directly in my model, neither the tax haven nor the OECD are active players in the game. My concerns are based on the information policy effects through the different stages on the overall coordination. If the policies belong to a general equilibrium or not, I leave it to further research.

Regarding the literature analyzing the fight against tax havens, besides Konrad and Stolper (2016) mentioned above, Elsayyad and Konrad (2012) designed a sequential game where the OECD offers a compensation (or punishment) to tax havens in exchange for stopping their activity. The authors find that the offer should be carried out simultaneously and not sequentially since the remaining tax havens become more costly to persuade, due to an imperfect competition effect. A similar result is found in Slemrod and Wilson (2009) which models the tax havens as juridical entrepreneurs that sell protection from national taxation. Therefore, a policy that treats differently tax havens is not optimal, which is also the result of this paper. However, their outcomes are driven by a timing difference in bargaining, whereas my results come from a difference in the public information, which I believe replicates better the international policies based on blacklisting.

# 3 History of the fight against tax havens

In 1998, the OECD published a report called Harmful Tax Competition (OECD, 1998) in which tax evasion is recognized as a global concern. This document represented the first international initiative for identifying tax haven countries and also the first compromise for taking measures against them. The OECD established a series of qualitative characteristics in order to identify these jurisdictions which would be put on a blacklist in 2000. To be whitelisted, an official compromise was required to implement an appropriate system of exchange of information. To the remaining uncooperative, the OECD recommended, and hence internationally approved, a set of country individual economic sanctions which were neither coordinated nor mandatory. A remarkable controversy of this first blacklist is that the commonly known tax havens that belonged to the OECD were not into consideration.

In a few years, all the blacklisted tax havens were out of the list. However, as numerous NGOs reported and scandals suggested, the fight was far from being over. As a consequence of the partial success, other international organizations got involved in the fight and created their own blacklists, like the European Union (from 2017) and the G8 and G20 during their corresponding summits (from 2008). The last main coordination event was the G20-OECD summit in London (2008) in which to be whitelisted, the identified tax havens had to sign at least 12 new bilateral TIEAs (Tax Information Exchange Agreement) with the states they preferred. In contrast with the 2000 OECD blacklist, all known tax haven were listed, including the OECD members.

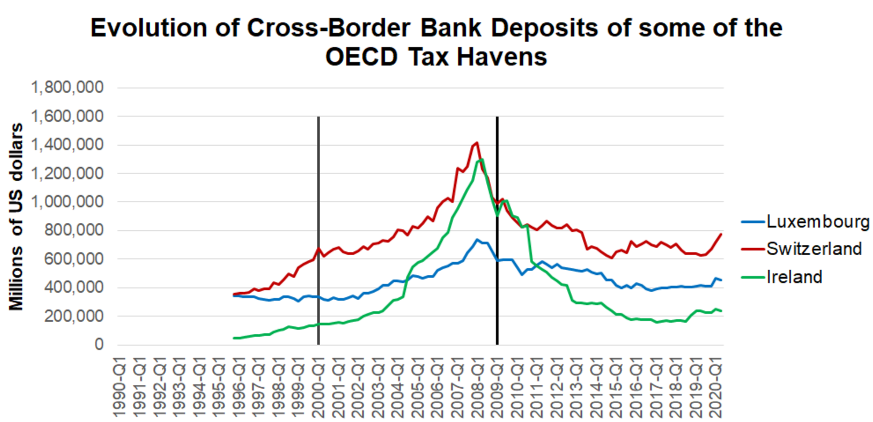


Figure 1: Evolution of the foreign-owned deposits in each BIS-reporting OECD tax haven from 1996-Q1 to 2020-Q1. The grey and black vertical lines represent the time (2001 & 2009) the OECD published its different blacklists.
DATA: Bank for International Settlements, restricted bilateral locational banking statistics.

Each international action, with its own definition of a tax haven, categorical lists and information exchange requirements, increased the international pressure and apparently undermined tax evasion since almost all tax havens in all blacklists were crossed out. Figure 1 shows the evolution of bank deposits of some of the OECD Tax havens which were not listed by the OECD in 2000 but do were in 2009.

The first take from this is that tax havens seem to be responsive to public threats. And the data showed in Figure 1 seem to prove this point. Nonetheless, despite the blacklists' successes, more elaborated empirical results tell a different story. Zucman (2014) analyze the share of profits of US corporations and states that the use of tax havens has steadily increased since the 1980s and continues to rise with no particular sign of slowing down. Johannesen and Zucman (2014) showed that the overall foreign-owned deposits in tax havens have increased despite the OECD measures , as shown in Figure 2.

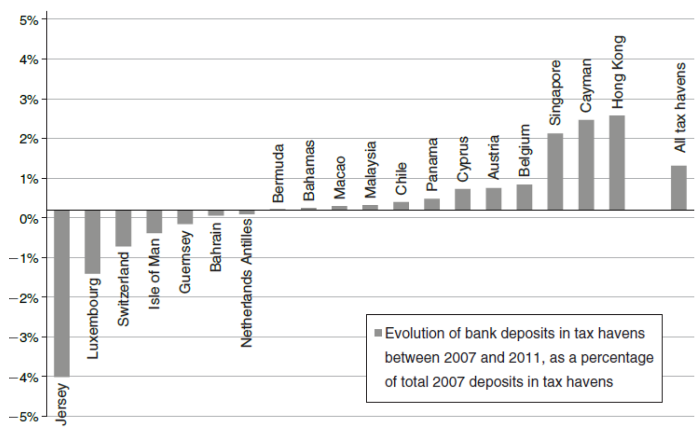


Figure 2: Evolution of the foreign-owned deposits in each BIS-reporting tax haven. The authors compare the first semester of 2011 averages with 2007 averages (except for Cyprus which started reporting in 2008:IV and Malaysia which started in 2007:IV), and express the difference as a fraction of the deposits held in all tax havens in 2007 (2.6 trillion dollars).
DATA: Bank for International Settlements (2002–2011), restricted bilateral locational banking statistics.
SOURCE: Johannesen and Zucman (2014), p.74.

Therefore, although tax havens seem to be responsive to public threats, after decades of blacklisting the overall leak of wealth has not stopped from increasing. Johannesen and Zucman (2014) explains that a TIEA actually reduces foreign-owned deposits between the involved country and the tax haven. However, it produces a deposit shifting to other tax havens with no treaty with the belonging country. Furthermore, in addition to the OECD standards, individual countries are taking their particular treaties with specific tax havens.[6]

Finally, the more recent proposed international policy is the Global minimum tax rate, which the G7 agreed to back it on 2021 (The New York Times, 2021).

This research works will try to explain all the mentioned outcomes by using coordination effects. Even if all tax havens are, to some extent, punished, as long as they are too differently perceived by evaders, coordinating mechanisms can be triggered like the deposit shifting shown in Johannesen and Zucman (2014). In addition, this also might explain part of the tremendous increase of the OECD tax havens plotted in Figure 1 during their privileged period (2000-2009) of not being on the blacklist. In fact, Hines Jr (2005) estimates that 2/3 of the investment from American-based multinationals is located in countries the OECD 1998 report did not consider as tax havens. So apparently, they might have absorbed the deposits of the blacklisted ones. Therefore, given this logic, the policies have not been performed optimally since they have been applied too heterogeneously. This led to coordination effects which ultimately counteracted the policy. However, under the same logic, the global minimum tax rate will be effective if is applied as homogeneously as it pretends to be.

# 4 The model

The model is a two stages sequential game where there are a high tax OECD country and two tax havens indexed by $j \in \{1, 2\}$, also referred to as TH1 and TH2. There is a continuum of homogeneous investors $i \in I$ whose mass is normalized to one. Each investor owns one unit of mobile capital which can be tax either inside the OECD country according to a tax rate $t \in [0, 1]$, or in one of the two tax havens which have the same tax rate $p \in [0, 1]$ s.t. $p < t$. There is incomplete information about the number of investors required to sustain each tax haven, which is represented by $\theta_j$. $\theta_j$ can be interpreted as the economic and political cost of being a tax haven due to, for example, the loss of domestic revenue or/and international sanctions.

Before the game starts, $\theta_1$ and $\theta_2$ are drawn independently by nature from two normal distributions $N(\mu_1, \sigma_\mu)$ and $N(\mu_2, \sigma_\mu)$ respectively, which characterize the public information of each tax haven.

In the first stage, the agent has to decide to which tax haven they want to get specialized, to be able to evade through it according only to public information. All together constitute the number of agents specialized in each tax haven, denoted by $S_j$ s.t. $S_1 + S_2 = 1$. So, all agents get specialized. Denote the decision of specialization as $s_i = \{1, 2\}$. Then, this stage represents an "access stage" to the particular tax haven regime change global game, and can be interpreted as all the tax haven specific requirements to evade, such as discovering the legal loopholes, change of residence/citizenship, creation of shell firms, etc. Importantly, once the investor decides to get specialized in one of the tax haven, she will not be able to use the other one. Furthermore, I assume that the cost

[6]For example, US, Britain and Germany have their own deals with Switzerland and Liechtenstein (The Economist, 2012).

of specialization is negligible compared to the gains of evading, so it is always profitable to get specialized in one of the tax havens before deciding if evade or not.

In the second stage, after specialization took place, agents know the proportion of agents specialized in the chosen tax haven. Thus, considering $s_i = k$, they know $S_k$. Furthermore, they also obtain more information about it in form of a private signal $x_{ik} = \theta_k + \varepsilon_i$ where $\varepsilon_i \sim N(0, \sigma_x)$. Combining it with the public one, each agent decides if finally try to evade or to pay taxes in the OECD country. The number of agents that decide to evade in each tax haven is denoted by $A_j$ s.t. $A_j \leq S_j$ which, by construction, is also bounded between 0 and 1.

At the end of the decisions, if $A_j \geq \theta_j$, the tax haven remains and taxes evaders according to $p$. However, if $A_j < \theta_j$, the tax haven regime changes and reports evaders to the OECD country, which punishes evaders using a tax rate $\tau \in [0, 1]$ s.t. $p < t < \tau$. Therefore, the payoff of an investor is $1 - t$ for not trying to evade and $1 - \tau$ or $1 - p$ for trying, depending on if the regime of the chosen tax haven changes or not. As a final remark, note that the higher is $\theta_j$ the more agents are required to sustain the tax haven, and hence, agents' security decreases in both signals and increases in the number of evaders. So their actions are strategic complements.

For clarification on agent's information, I denote the information set of each agent $i$, in each stage $\xi = \{1, 2\}$, by $\mathcal{I}_i^{\xi}$ s.t. $\mathcal{I}_i^1 = \mathcal{I}^1 = \{\mu_1, \mu_2\}$, $\forall i$; and $\mathcal{I}_i^2|_{s_i=k} = \{\mu_k, S_k, x_{ik}\}$. Note that $\mathcal{I}_i^2|_{s_i=k}$ is conditional on the specialization decision, and since the player is restricted to only consider the chosen tax haven, I dropped the information of the other one since it is irrelevant. The rest of parameters such as volatilities and tax rates are common knowledge.

Finally, notice that the only informative parameter that distinguishes both tax havens in the first stage is $\mu_j$, which is, indeed, what the OECD can affect by means of public threats of economic sanctions. Actually, the OECD does not have to affect the true $\mu_j$ and hence where $\theta_j$ is centered, but only the value of the mean of $\theta_j$ agents beliefs in. Then, analyzing changes on $(\mu_1, \mu_2)$, the inter-coordination effects can be revealed using the fact that the second stage regime change global games are connected by the first stage. More specifically, the decision of specialization that constitutes $(S_1, S_2)$ affects the second stage outcome by bounding the number of evaders in each tax haven $(A_1, A_2)$.

I solve the model by Backward induction.

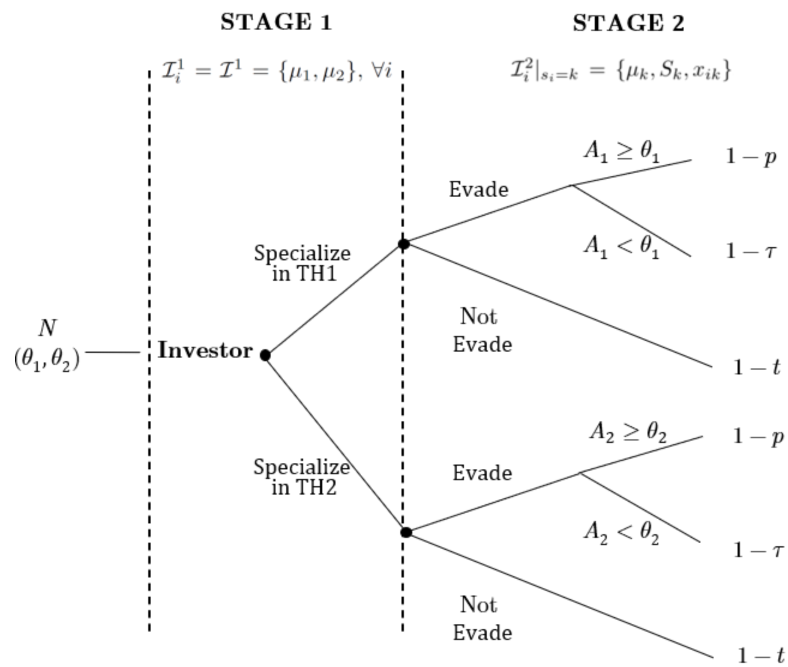


Figure 3: Structure of the game.

## 4.1 STAGE 2: Evade vs. No Evade

In this stage, agents specialized in each tax haven need to decide if they try to evade through it or not evade at all. They face a coordination game with incomplete information between a risky option and a safe one, which I solve as a global game. The process to solve each regime change global game is the same. So, instead of solving separately the regime change global game taking place in TH1 $\forall i : s_i = 1$ and TH2 $\forall i : s_i = 2$, I generalize it using a TH$k$ $\forall i : s_i = k$.

From the previous stage, they inherit the information about the total number specialized in the same tax haven $S_k^*$ which is, in fact, an equilibrium outcome, yet it behaves exogenously in this stage, so to emphasize that $S_k^*$ is decided in the previous period, instead of $S_k^*$ I will use $S_k$.

The agent payoff is $1-t$ if decide not to evade. However, if they decide to evade, her payoff depends on the aggregate of decisions, which is $1-p$ if the chosen tax haven survives ($A_k \geq \theta_k$); or $1-\tau$, if it falls instead ($A_k < \theta_k$). All the possible combination of payoffs depending on the final state are shown in Table 1.

| | TH1 Remains ($A_k \geq \theta_k$) | TH1 Falls ($A_k < \theta_k$) |
|---|---|---|
| Evade | $1-p$ | $1-\tau$ |
| No Evade | $1-t$ | $1-t$ |

Table 1: Stage 2 payoff table $\forall i : s_i = k$.

Considering a simple payoff analysis, a manager finds optimal to evade using TH$k$ if

$$(1-p)\Pr(A_k \geq \theta_k) + (1-\tau)\Pr(A_k < \theta_k) \geq 1-t. \tag{1}$$

Otherwise, it is not profitable to evade (Under indifference, I assume that the agent evades). Each agent can do inference about the state of the world $\theta_k$ using her signals. Since the risk of being reported increases with the public and the private signals, it is strictly dominant to evade if it has sufficiently low signals. According to this, suppose that they will adopt a switching strategy $s(x_{ik})$ around a threshold value of the the private signal $\hat{x}_k$, s.t.:

$$s(x_{ik}) = \begin{cases} \text{Evade} & \text{if } x_{ik} \leq \hat{x}_k \\ \text{No Evade} & \text{if } x_{ik} > \hat{x}_k. \end{cases} \tag{2}$$

Note that the threshold value $\hat{x}_k$ is TH specific. Given a $\hat{x}_k$, the probability of evading can be calculated as the proportion of $S_k$ evading, that is,

$$\Pr(x_{ik} \leq \hat{x}_k | \theta) = \Phi\left(\frac{\hat{x}_k - \theta_k}{\sigma_x}\right) = \frac{A_k(\theta_k)}{S_k}. \tag{3}$$

$\Phi$ is the cumulative distribution function (CDF) of the standard normal. Since $A_k(\theta_k)$ decreases with $\theta_k$, there exist a unique state of $\theta_k$, say $\hat{\theta}_k$, that is equal to $A_k(\hat{\theta}_k)$. Using this fact, a TH will survive if

$$\theta_k \leq \hat{\theta}_k = S_k \cdot \Phi\left(\frac{\hat{x}_k - \hat{\theta}_k}{\sigma_x}\right), \tag{4}$$

which characterizes a fixed point.

Furthermore, given a value of the signals, managers can update their beliefs about $\theta_k$. By Bayesian updating, the posterior belief about $\theta_k$ conditional on the signals is normal with mean $(\sigma_x^2 \mu_k + \sigma_\mu^2 x_{ik})/(\sigma_x^2 + \sigma_\mu^2)$ and variance $(\sigma_x^2 \sigma_\mu^2)/(\sigma_x^2 + \sigma_\mu^2)$. Then, the posterior probability of a regime change is

$$\Pr(\theta_k \leq \hat{\theta}_k | \mathcal{I}_i^2|_{s_i=k}) = \Phi\left(\frac{\hat{\theta}_k - \frac{\sigma_x^2 \mu_k + \sigma_\mu^2 x_{ik}}{\sigma_x^2 + \sigma_\mu^2}}{\sqrt{\frac{\sigma_x^2 \sigma_\mu^2}{\sigma_x^2 + \sigma_\mu^2}}}\right). \tag{5}$$

Now, (1) can be rewritten as a function of known parameter and information i.e., $(1-p)\Pr(\theta_k \leq \hat{\theta}_k | \mathcal{I}_i^2|_{s_i=k}) + (1-\tau)\Pr(\theta_k > \hat{\theta}_k | \mathcal{I}_i^2|_{s_i=k}) \geq 1-t$.

Remember that the incentives to evade decrease in the private signal. Then, when the private signal is exactly the threshold $\hat{x}_k$, an agent should be indifferent between evading and not, and hence, $\hat{x}_k$ can be pinned down as the value of the private signal that solves

$$(1-p)\Phi\left(\frac{\hat{\theta}_k - \frac{\sigma_x^2\mu_k+\sigma_\mu^2\hat{x}_k}{\sigma_x^2+\sigma_\mu^2}}{\sqrt{\frac{\sigma_x^2\sigma_\mu^2}{\sigma_x^2+\sigma_\mu^2}}}\right)+(1-\tau)\left(1-\Phi\left(\frac{\hat{\theta}_k - \frac{\sigma_x^2\mu_k+\sigma_\mu^2\hat{x}_k}{\sigma_x^2+\sigma_\mu^2}}{\sqrt{\frac{\sigma_x^2\sigma_\mu^2}{\sigma_x^2+\sigma_\mu^2}}}\right)\right)=1-t. \quad (6)$$

And using this fact and some algebra, the equilibrium threshold can be pinned down, mores specifically,

$$\hat{x}_k^* = \alpha\hat{\theta}_k - \beta\Phi^{-1}\left(\frac{\tau-t}{\tau-p}\right) - (\alpha-1)\mu_k, \quad (7)$$

$$\text{where } \alpha = \frac{\sigma_x^2+\sigma_\mu^2}{\sigma_\mu^2} \text{ and } \beta = \frac{\sigma_x}{\sigma_\mu}\sqrt{\sigma_x^2+\sigma_\mu^2}$$

A monotone equilibrium ($\hat{x}_k^*$) is thus identified by the joint solution of (4) and (7).

**Proposition 1.** *A Bayesian NE for each tax haven regime change global game exists and is unique if and only if $\sigma_\mu^2 > \sigma_x/\sqrt{2\pi}$.*

The proof is given in the Appendix (see Proof of Proposition 1 in Appendix A). Given that the equilibrium is defined by fixed points, the model needs to be solved computationally. However, we can state some relations between $\hat{x}_k^*$ and some parameters of the model.

**Lemma 1.** *$\hat{x}_k^*$ and $\hat{\theta}_k$ are complements.*

The proof is given in the Appendix (see Proof of Lemma 1 in Appendix A). A higher $\hat{x}_k^*$ translates to a higher probability of evading since the set of $x_{ik}$ below this threshold is larger. Then, the more likely are investors to evade the higher should be the state of $\theta$ to make the tax haven regime change. And the opposite holds, the higher needs to be the state of $\theta$ to make the tax haven regime change, the more likely are agents to evade.

**Lemma 2.** *$\hat{x}_k^*$ is increasing in $S_k$.*

The proof is given in the Appendix (see Proof of Lemma 2 in Appendix A). It is obvious that the more people specialized in this tax haven, the higher is the mass of agents that can evade and then, the more likely investors are going to evade.

**Lemma 3.** *Given a value of $S_k$, $\hat{x}_k^*$ is increasing in $t$; decreasing in $\mu_k$, $p$ and $\tau$; and increasing or decreasing in the volatilities $\sigma_x$ and $\sigma_\mu$.*

The proof is given in the Appendix (see Proof of Lemma 3 in Appendix A). The result is stated in the form of a Lemma because it is not taking into account that the parameters might have an impact on the first stage decisions, and hence on $S_k$, which also has its effect. Therefore, this result will just serve to see how agents will make inference of the second stage for a given value of $S_k$. Then, keeping $S_k$ fixed, agents are going to be more likely to evade the higher is the tax in the OECD country. Contrarily, they are going to be less likely to evade the higher is the public signal (since informs for a higher expected value of $\theta_k$), the higher the tax haven rate, and the punishment. Finally, the effect of the volatility depends on the other parameters. Given that parameters give the idea of being in a "good situation for evading" (low $\mu_k$, $p$, $\tau$ or/and high $t$), an increase in one of the volatilities implies increasing the probability of not being in that situation. And the opposite happens when the parameters give the idea of being in a "bad situation for evading".

## 4.2 STAGE 1: Specialize in TH1 vs. Specialize in TH2

In this stage, agents can only use the public information so as to assess tax havens i.e., $\mathcal{I}_i^1 = \mathcal{I}^1 = \{\mu_1, \mu_2\}$ . Furthermore, the proportion of specialized agents is yet to be formed, and hence, all inference about the second stage equilibrium variables must be written as a function of $S_1$ and $S_2$.

I perform the analysis of the specialization decision, in two different settings. A simple one, where I assume that agents are homogeneous and they just decide according to the same expected payoff analysis; which I also extend to more than 2 tax havens. And a more complex one, where I assume that agents are heterogeneous due to an affinity (or bias) towards one of the tax havens. The latter setting allows me to capture a gradual evolution of the effects from changing the public information, since the shift from specializing in one tax haven to the other one will not be as drastic as in the first setting.

### 4.2.1 Homogeneous Investors

Let's denote the expected payoff of specializing in THj ($s_i = j$) as $E_j$ s.t.

$$\begin{aligned} E_j(\hat{x}_j^*(S_j), \hat{\theta}_j(S_j)|\mathcal{I}^1) =& (1-p)\Pr(x_{ij} \leq \hat{x}_j^*(S_j) \;\; \cap \;\; \theta_j \leq \hat{\theta}_j(S_j)|\mathcal{I}^1) \\ &+ (1-\tau)\Pr(x_{ij} \leq \hat{x}_j^*(S_j) \;\; \cap \;\; \theta_j > \hat{\theta}_j(S_j)|\mathcal{I}^1) \\ &+ (1-t)\Pr(x_{ij} > \hat{x}_j^*(S_j)|\mathcal{I}^1). \end{aligned} \tag{8}$$

Not that, conditional on the information set, the posterior belief about the distribution of $\theta_j$ is normal with mean $\mu_j$ and variance $\sigma_\mu^2$; whereas the one of $x_{ij}$ is normal with the same mean but variance $\sigma_\mu^2 + \sigma_x^2$.

**Lemma 4.** *The expected payoff of specializing in one of the tax haven increases in the number of people that specialize in it, and decreases with the number of people specializing in the other one. Therefore,* $E_j(\cdot)$ *increases in* $S_j$ *and decreases in* $S_{j'} : j' \neq j$.

The proof is given in the Appendix (see Proof of Lemma 4 in Appendix A). This lemma implies that agent actions are strategic complements and hence, they prefer to coordinate. In other words, they prefer to specialize in the tax haven everyone is specializing. Note that by (4) and (7), the effect of $S_j$ on the $E_j(\cdot)$ is through increasing the thresholds $\hat{x}_j^*$ and $\hat{\theta}_j$ of the corresponding CDF.

**Lemma 5.** *Given a value of $S_j$, the expected payoff of specializing in one of the tax havens decreases in its public signal. Therefore, $E_j(\cdot|S_j)$ decreases in $\mu_j$.*

The proof is given in the Appendix (see Proof of Lemma 5 in Appendix A). Without taking into account the possible effect of $\mu_j$ w.r.t. the distribution of $S_j$, the higher is the public signal $\mu_j$ the lower is the payoff. This is due to the fact that the public signal is informing for a higher expected value of $\theta_j$ which makes evading successfully less likely. Note that by (4) and (7), the effect of $\mu_j$ on the $E_j(\cdot)$ is through changing the thresholds $\hat{x}_j^*$ and $\hat{\theta}_j$, and by changing the distribution of the posterior beliefs of $x_{ij}$ and $\theta_j$.

Comparing the expected payoff of each decision, an agent will specialize in TH1 ($s_i = 1$) if

$$E_1(\hat{x}_1^*(S_1), \hat{\theta}_1(S_1)|\mathcal{I}^1) > E_j(\hat{x}_2^*(1 - S_1), \hat{\theta}_2(1 - S_1)|\mathcal{I}^1). \tag{9}$$

Besides $S_1$, which is yet to be formed, the only parameter that can differentiate the tax havens is $\mu_j$. Furthermore, by (4) and (7), the change on $E(\cdot)$ by $S_j$ is limited since $S_1$ and $S_2 = 1 - S_1$ are bounded between (0,1), whereas $\mu_1 - \mu_2 \in (-\infty, \infty)$ can change $\hat{x}_j^*$ from $(-\infty, \infty)$ and $\hat{\theta}_1$ from (0,1). Thus, there exist a unique values of $\mu_1 - \mu_2$ named $\underline{\mu_1 - \mu_2}$ s.t. Specialize in TH1 dominates $\forall S_1$ if $\mu_1 - \mu_2 < \underline{\mu_1 - \mu_2}$. In this case, the unique NE is to Specialize in TH1. To see the intuition behind this, consider a $\mu_1 = -\infty$ and a $\mu_2 = \infty$. $\mu_1 = -\infty$ implies that $\theta_1$ is almost certainly below 0, which means that an agent alone is able to benefit from evading, that is why in this case, $\hat{x}_1^* = \infty$ i.e. always evade regardless of $S_1 = 0$.[7] $\mu_2 = \infty$ implies that almost certain $\theta_2$ is above 1, that is why in this case $\hat{x}_2^* = -\infty$ i.e. never evade regardless of $S_2 = 1$. Therefore, regardless the value of $(S_1, S_2)$, in the TH1 agents almost always evade successfully, whereas in TH2, if they try, they almost surely will be punished.

Then, there also exists a unique value $\overline{\mu_1 - \mu_2}$ s.t. Specialize in TH2 dominates $\forall S_1$ if $\mu_1 - \mu_2 > \overline{\mu_1 - \mu_2}$. In this case, the unique NE is to Specialize in TH2.

However, when $\mu_1 - \mu_2 \in (\underline{\mu_1 - \mu_2}, \overline{\mu_1 - \mu_2})$, for $S_1$ sufficiently high, $E_1(\cdot) > E_2(\cdot)$ but for $S_1$ sufficiently low, $E_2(\cdot) > E_1(\cdot)$. Then, since $S_1$ increase $E_1(\cdot)$ and reduces $E_2(\cdot)$, there exist a unique value of $S_1$, say $\hat{S}_1$, s.t. makes the investors indifferent between both options, and hence, makes previous equation hold with equality, i.e.:

$$E_1(\hat{x}_1^*(\hat{S}_1), \hat{\theta}_1(\hat{S}_1)|\mathcal{I}^1) = E_j(\hat{x}_2^*(1 - \hat{S}_1), \hat{\theta}_2(1 - \hat{S}_1)|\mathcal{I}^1). \tag{10}$$

[7] I have to say almost certainly because $\theta_j$ follows a normal distribution with support $(-\infty, \infty)$, so even the most unlikely states are possible.

Then, for $S_1 > \hat{S}_1$ agents strictly prefers to Specialize in TH1 whereas for $S_1 < \hat{S}_1$ strictly prefer to Specialize in TH2. Using second stage equilibrium equations (4) and (7) with this one, $\hat{S}_1$ can be pinned down.

Therefore, since investors are homogeneous, there are multiple pure strategy NE according to the value of $\hat{S}_1$, which are:

- Specialize in TH1 for $S_1 \geq \hat{S}_1$, which leads to $S_1 = 1$.
- Specialize in TH2 for $S_1 \leq \hat{S}_1$, which leads to $S_1 = 0$.

More interestingly, $\hat{S}_1$ also defines a mixed strategy NE. A mixed strategy NE involves players being indifferent between their pure strategies given that the others are mixing. In this model, with a mass 1 of homogeneous investors, the probability of Specialize in TH1 is equivalent to the number of investors that Specialize in TH1, thus $S_1$. The number of players that makes the agent indifferent between both THs is $\hat{S}_1$, defined by the previous equation. Then, given that other agents play Specialize with probability $\hat{S}_1$, any player is indifferent between both THs. Therefore, $\hat{S}_1$ characterizes a mixed strategy NE ($S_1^*$) that can be also interpreted as the minimum coordination level to get specialized in TH1.

**Proposition 2.** *A mixed Strategy NE exists and it is unique if and only if the difference in public signals is short enough and $\sigma_\mu^2 > \sigma_x/\sqrt{2\pi}$.*

As mentioned above, the mixed Strategy NE exists and it is unique if the public signals are not different enough, and hence, is does not make the decision independent of the number of agents specializing in each tax haven.

Therefore, although the multiplicity of equilibria in Stage 2 is solved by using the global games approach, in Stage 1 we face again multiplicity of equilibria when the public signals are not different enough. However, for the sake of the analysis, I can map public signals into actions using equilibrium refinements.

**Proposition 3.** *When the difference in public signals is short enough, if $\mu_1 < \mu_2$, then everyone specializing in TH1 is the Payoff-Dominant, Basin-Dominant and Centroid-Dominant pure strategy Nash Equilibrium. And the same applies for Specialize in TH2 when $\mu_1 > \mu_2$.*

*Proof.* For notation simplicity, denote the expected payoff of Specializing in THj by $E_j(S_j, \mu_j)$. Given that $\mu_1 - \mu_2 \in (\underline{\mu_1 - \mu_2}, \overline{\mu_1 - \mu_2})$, there two pure strategy NE: Specialize in TH1 $\forall i$ giving $E_1(1, \mu_1)$; and Specialize in TH2 $\forall i$ giving $E_2(1, \mu_2)$. Given that $\mu_1 < \mu_2$, $E(1, \mu_1) > E(1, \mu_2)$ by Lemma 5. So Every one Specialize in TH1 is payoff dominant. And the same applies for Specialize in TH2 when $\mu_1 > \mu_2$.

Remember that $E_j(S_j, \mu_j)$ is increasing in $S_j$ but decreasing in $\mu_j$. When $\mu_1 = \mu_2$, by symmetry, $\hat{S}_1 = 0.5$. When $\mu_1 < \mu_2$, $\hat{S}_1$ decreases to compensate the difference to TH2, i.e. $\hat{S}_1 < 0.5$. Then, given that the NE of everyone specializing in TH1 is played ($S_1 = 1$), the number of agents that needs to jump from equilibrium behavior to make $S_1 < \hat{S}_1$ is bigger than the one that would make switch the equilibrium of everyone Specialize in TH2. Therefore, when $\mu_1 < \mu_2$ Specialize in TH1 is Basin-dominant. And the same applies to Specialize in TH2 when $\mu_1 > \mu_2$.

Finally, when $\mu_1 < \mu_2$, the center $S_1 = 0.5$ leads to everyone play the Specialize in TH1 NE, and hence, is Centroid-dominant; and the same applies to Specialize in TH2 when $\mu_1 > \mu_2$.

■

Therefore, when $\mu_1 \neq \mu_2$, these refinements can be used to predict agents' behavior. Whereas when $\mu_1 = \mu_2$ both NE are symmetric and no refinement that distinguishes them can be applied. In this case, I assume agents play the Mixed Strategy NE which is (1/2, 1/2).

Taking this into account, the mapping of public signals into actions that is followed by all agents is given by:

- If $\mu_1 < \mu_2$, Specialize in TH1 ($S_1 = 1$).
- If $\mu_1 = \mu_2$, Specialize in each TH with probability 0.5 ($S_1 = 0.5$).
- If $\mu_1 > \mu_2$, Specialize in TH2 ($S_1 = 0$)

After having defined equilibrium behavior, the implications of the public signals on overall evasion can be analyzed. Denote by $A$ the total number of evaders at the end of the game s.t. $A = A_1 + A_2$. $A$ will change in each realization of the game since the private signal of each tax haven $x_{ij}$ that agents use to finally decide if evade or not comes from the actual realization of $\theta_j$. However, using the public signal, we can construct a first stage prediction of $A$ by making inference about the distribution of $x_{ij}$.[8] Then,

$$A = S_1 \cdot \Phi_1 \left( \frac{\hat{x}_1 - \mu_1}{\sqrt{\sigma_x^2 + \sigma_\mu^2}} \right) + S_2 \cdot \Phi_2 \left( \frac{\hat{x}_2 - \mu_2}{\sqrt{\sigma_x^2 + \sigma_\mu^2}} \right), \tag{11}$$

I introduce the sub index $j$ in the CDF for future notation simplification. By changing the $\mu_j$ of only one of the tax havens I find the following result.

**Proposition 4.** *Given a finite value of $\mu_{j'}$, the evolution of $A$ as $\mu_j$ increases is the following:*

- *as $\mu_j \to -\infty$, $A$ converges to 1.*
- *when $\mu_j$ increases, as long as $\mu_j < \mu_{j'}$, $A$ decreases.*
- *when $\mu_j = \mu_{j'}$, $A$ jumps to a lower value.*
- *as soon as $\mu_j > \mu_{j'}$, $A$ jumps to a higher value and stays constant.*

[8] This prediction of $A$ can be also thought of as the $\mathbb{E}[A]$ when playing this game repeatedly.

The proof is given in the Appendix (see Proof of Proposition 4 in Appendix A) and a simulation is plotted in Figure 4 (see Calibration of the Simulations in Appendix B for more information). Take for example, that $\mu_1$ is the one increasing meanwhile $\mu_2$ remains constant. When TH1 is almost certainly secure ($\mu_1 \to -\infty$), everyone specializes in TH1 and almost everyone ends up evading ($A \to 1$). Then, the tax haven becomes less as less secure as the public signal of TH1 increases, yet $S_1 = 1$ as before, which produces a gradual decrease in $A$. When the public signals are the same, a minimum is reached because by a marginal change $\epsilon > 0$ s.t. $\mu_1 + \epsilon = \mu_2$, TH1 is infinitesimally as secure as before, but when they are equal it creates a discontinuity due to a sudden shift of $S_1$ from 1 to 0.5. Agents gain from concentrating and now they have been split in a half by an infinitesimal change in the public signal. However, as soon as $\mu_1$ departs from $\mu_2$ by an infinitesimal change, everyone concentrates towards TH2, $S_2 = 0.5$ shift to $S_2 = 1$ which produces a discontinuous jump to a higher $A$. Then, once $\mu_1 > \mu_2$, an increase in $\mu_1$ does not affect $A$ since everyone is already specializing in TH2.

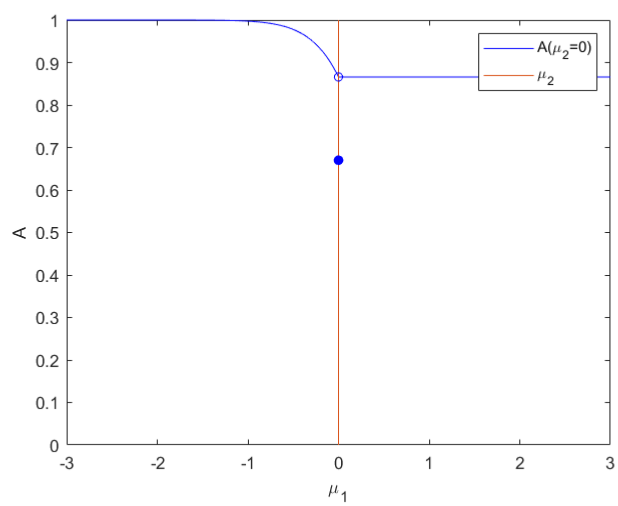


Figure 4: Evolution of A when increasing $\mu_1$ and keep $\mu_2$ fixed.

All these change of behavior of $A$, that come from increasing one $\mu_j$, can be interpreted by the clash of two effects. On the one hand, the public information set is worse off than before, and hence, given that they are getting specialized in the affected tax haven, they lose incentives to evade. On the other hand, the worsening of one public signal can make increase the number of specialized agents in the other one, increasing the incentives to evade. I call the first effect "Global Effect" whereas the second one "Crowding-in Effect". When $\mu_1 < \mu_2 \Rightarrow S_1 = 1$, increasing $\mu_1$ produces the Global Effect, however, since $S_2$ remains equal to 0, the Crowding-in does not manifest and the former effect dominates, leading to less evasion. Around the neighborhood of $\mu_1 = \mu_2$, the dominating effect is interchanged. First, when they are about to become equal, not only $\mu_1$ increases, but also half of the mass of $S_1$ goes to $S_2$. The incentives to evade through TH1 decreases severely, yet the once to use TH2 has increased which is the Crowding-in effect. However, the Global Effect beats the Crowding-in and that is why $A$ decreases, being the minimum $A$. But then, when $\mu_1$ departs from the equality, $A$ jumps drastically because there is a big Crowding-in effect towards TH2, and the Global Effect has dissipated since the public information has no effect on TH2.

In this setting, the effects outweigh each other suddenly, by a marginal increases on $\mu_j$, and this happens because agents are homogeneous and react massively at the same points. In order to analyze how these effects behave in a less volatile setting, I introduce a degree of heterogeneity in section 4.2.3.

By changing the public signals of both tax havens, I obtain the following result.

**Proposition 5.** *Increasing all public signals by the same rate always decreases the number of evaders.*

The proof is given in the Appendix (see Proof of Proposition 5 in Appendix A) and a simulation is plotted in Figure 5. Basically, since the difference between the public signals does not change, $(S_1, S_2)$ are always the same. Then, no matter which is the NE being played, the tax haven which everyone is getting specialized in is getting more and more insecure. Therefore, there is always a Global Effect and the Crowding-in does not manifest since there is no change on $(S_1, S_2)$.

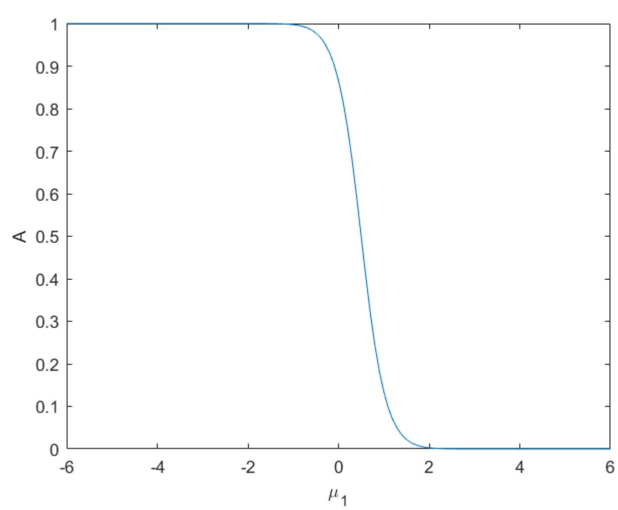


Figure 5: Evolution of A when increasing $\mu_1$ and $\mu_2$ by the same rate. The starting value of $\mu_2$ is -2.

This is in fact, the outcome as if I would model the game with just one entity (tax haven). Increasing the public information of it will always hinder coordination. Whereas, considering the same game with two entities, increasing the public information of the same one can lead to the opposite outcome. Therefore, modeling one entity when agents have access to several of them is missing the Crowding-in effect and misleads the results. And the same applies when modeling multiple entities as if they would be completely independent.

#### 4.2.2 Multiple tax havens with Homogeneous agents

Some features of the model can be extended to more than 2 tax havens. Denote by $J$ the number of tax havens. Equilibrium equations (4) and (7) from previous section remains the same since applies separately to each tax haven. The main change is that agents can specialize in more than two tax haven, which implies that $\sum_{j=1}^{J} S_j = 1$. Note that Lemma 4 applies partially, i.e., $E_j(\cdot)$ increases with $S_j$ but not necessarily with the increase of $S_{j'} : j' \neq j$. This is because an increase of $S_{j'}$ does not necessarily come from a decrease in $S_j$. In addition, Lemma 5 still applies fully, since was formulated independently for each tax haven, so given that $S_j$ remains the same, $E_j(\cdot)$ decreases in $\mu_j$ .

An agent finds optimal to Specialize in THj, i.e., $s_i = j$ if

$$E_j(\hat{x}_j^*(S_j), \hat{\theta}_j(S_j)|\mathcal{I}^1) > E_{j'}(\hat{x}_{j'}^*(S_{j'}), \hat{\theta}_{j'}(S_{j'})|\mathcal{I}^1) \;\; \forall j' \neq j \tag{12}$$

As before, multiple NE equilibrium arises as long as there is not a value of a public signal which is sufficiently lower than all the others. However, for the sake of the analysis, I can map public signals into actions basing on equilibrium refinements.

**Proposition 6.** *The Payoff Dominant NE is everyone specializing in the tax haven that has the lowest public signal.*

*Proof.* Define by $j^*$ the tax haven with the lowest public signal. Given that everyone specializes in TH$j^*$, an unilateral deviation is never profitable since all the other tax havens have a lower $S_j$ and a higher $\mu_j$. So Specializing in TH$j^*$ leads to $S_{j^*} = 1$ and is a NE. Then, according to Lemma 4, even if the rest of NE concentrates all the evaders, the payoff is going to be lower due to a higher $\mu_j$. So this equilibrium is payoff dominant.

∎

The refinements of basin dominant and centroid dominant have dropped since now there are multiple mixed strategy NE.

Then, when there is only one tax haven with the lowest $\mu_j$ the refinement can be applied. In the case that there are several of them, I assume they mixed equally among them. Define by $L$ the set of tax havens that has the lowest value of $\mu_j$. Taking this into account, the mapping of public signals into actions that is followed by all agents is given by

- If $l$ is the only tax haven in $L$, Specialize in TH$l$ ($S_l = 1$).
- If there is multiple tax havens in $L$, Specialize in them with equal probability ($S_{l\in L} = 1/L$, $S_{l\notin L} = 0$ ).

Now, the implications of the public signals on overall evasion can be analyzed.

**Proposition 7.** *Proposition 4 holds when comparing the evolution of the public signal w.r.t. the tax havens s.t.* $\in L$*; and Proposition 5 also holds.*

The proof is the same as in the previous setting. The difference that needs to be taken into account for Proposition 4 is that once the public signal is equal to the lowest public signal, the number of specialized people will split in 1/2 if there is one tax haven in $L$, or in more equal fraction if there are more tax havens. In the latter case, the discontinuous jump will be to a lower value than with 2 tax havens.

#### 4.2.3 Investors with Heterogeneous Affinity

In order to avoid a drastic change in agents' behavior, I analyze the setting of $J = 2$ with heterogeneous agents. Agents differ by an affinity degree towards TH1. The affinity can represent geographical proximity, cultural similarities, country preferences, exposure to tax haven self-promotion, etc. Since the purpose of this setting is to analyze the implication of a gradual change in investors' decisions, no equilibrium analysis will be performed.

Denote by $\delta_i$ the affinity that agent $i$ has towards TH1. $\delta_i$ is identically and independently drawn from a continuous distribution $f(\delta_i)$ which is symmetric around 0. Then, if $\delta_i = 0$ agents have no bias toward any of the tax havens (as before). If $\delta_i > 0$ they are biased towards TH1 and if $\delta_i < 0$ towards TH2.

Assume that affinity affects agents mapping to actions in the following manner:

$$s(\alpha_i) = \begin{cases} \text{Specialize in TH1} & \text{if } \mu_1 - \delta_i < \mu_2 \\ \text{Mix } (1/2,\, 1/2) & \text{if } \mu_1 - \delta_i = \mu_2 \\ \text{Specialize in TH2} & \text{if } \mu_1 - \delta_i > \mu_2. \end{cases} \tag{13}$$

Thus, an agent choose TH1 if its public signal is sufficiently low compared the one of TH2. In fact, this strategy is a disturbed version of the original setting, since when $\delta_i = 0\ \forall i$ the original mapping is obtained. Then, $\delta_i$ can be interpreted as a the miss-perception of the public signal or degree of mistake. Note that by using a pdf which is symmetric around 0, I not only ensure that $\mathbb{E}[\delta_i] = 0$, but also that by using this strategy, when $\mu_1 = \mu_2$ then $S_1 = S_2 = 0.5$.

According to this strategy, the only change in (11) is that $S_1 = \Pr(\mu_1 - \mu_2 < \delta_i) = F_\delta(\mu_2 - \mu_1)$. Therefore, $S_1$ increases gradually as $\mu_1$ decreases or/and $\mu_2$ increases, whereas remain the same if both public signals increases/decreases by the same amount.

Taking the derivative of (11) w.r.t $\mu_1$, I obtain how changing one public signal affects the overall coordination.

$$\frac{\partial A}{\partial \mu_1} = \underbrace{\frac{\partial S_1}{\partial \mu_1}\left[\Phi_1(\cdot) - \Phi_2(\cdot)\right]}_{\substack{<0 \text{ when } \mu_1<\mu_2 \\ >0 \text{ when } \mu_1>\mu_2 \\ =0 \text{ when } \mu_1=\mu_2}} + \underbrace{S_1 \frac{\phi_1(\cdot)}{\sqrt{\sigma_x^2 + \sigma_\mu^2}}\left(\frac{\partial \hat{x}_1^*}{\partial \mu_1} - 1\right)}_{<0} + \underbrace{S_2 \frac{\phi_2(\cdot)}{\sqrt{\sigma_x^2 + \sigma_\mu^2}}\left(\frac{\partial \hat{x}_2^*}{\partial \mu_1}\right)}_{>0} \tag{14}$$

The second term captures the Global Effect, which is the fact that TH1 has become more insecure. The third term captures the Crowding-in one, which is the fact that agents from TH1 shift to TH2, making TH2 more secure. And interestingly, the first term captures the fact that agents are being split/concentrated in one of the tax havens. When the public signal of TH1 is smaller, most of the mass of agents specialize in it, but they move to TH2 balancing the number of agents in each one. However, when the public signal is higher, the term is positive because fewer agents are being specialized in TH1, and they shift towards TH2, unbalancing more the situation between both tax havens. Then, depending on which effect is higher, this leads to more or less evasion. Therefore, the first term will contribute to the Global effect when TH1 has a lower public signal, and to the Crowding-in otherwise.

**Proposition 8.** *The value of $A$ coincides with the one from the setting with homogeneous agents in the extreme cases, which are: $A(\mu_1 \to -\infty, \mu_2)$, $A(\mu_1 = \mu_2)$ and $A(\mu_1 \to \infty, \mu_2)$.*

The proof can be found in the Appendix (see Proof of Proposition 8 in the Appendix). Basically, by using a symmetric function on $\delta_i$, I ensure that when TH1 is almost surely secure, $S_1 = 1$, when they are the same $S_1 = 0.5$ and when it is surely insecure $S_1 = 0$, which is the same outcome of the previous section. In Figure 5 the value of $A$ in both settings is compared. Interestingly, adding affinity to the model makes $A$ always lower or equal than without it. In fact, the more "sticky" is the behavior of agents, the lower the $A$ for all the values of the public signals.[9] Apparently, since agents benefit from concentrating on the best tax haven, the more stickiness the more it takes to concentrates, and hence, the lower the incentives to evade.

[9] The higher the probability mass away from the symmetric point, the higher the degree of stickiness. Assuming $\delta_i \sim N(0, \sigma_\delta)$, this corresponds to a higher volatility.

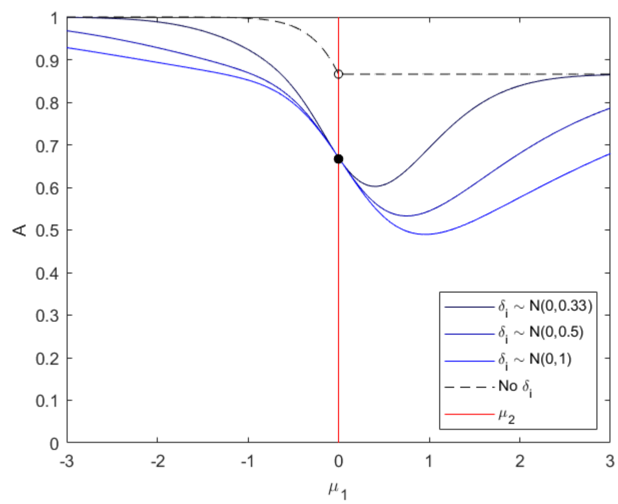


Figure 6: Evolution of A when increasing $\mu_1$ and keeping $\mu_2$ fixed for different affinity distribution functions.

**Proposition 9.** *As in the setting with homogeneous agents, increasing all public signals by the same rate always lead to less evasion. In contrast, when increasing one public signal, A decreases temporarily when departing from the symmetric public information case.*

The proof can be found in the Appendix (see Proof of Proposition 9 in the Appendix). As mentioned above, increasing the public signals of both tax havens does not change $S_1$ and $S_2$ (no Crowding-in Effect), but both tax havens become less secure (Global Effect). However, the second statement represents a relevant difference w.r.t. the original setting, where agents shift specialization drastically. Just by imposing a continuous shift, even if it the fastest one, an infinitesimal departure from the symmetric information case decreases evasion. In this case, the Crowding-in dominated by the Global effect when the difference between tax havens is small. But once this difference is large enough, the Crowding-in achieves to overthrown the Global one leading to more evasion. This was not happening in the original setting because the shift from an infinitesimal change was discontinuous, then the Crowding-in effect was strong enough for a marginal change.

Again, this result highlights the implications of dismissing the idea that agents can coordinate in other entities. Assuming just one entity, increasing its public signal will lead always to less evasion because would miss the Crowding-in effect.

# 5 Policy Implications

Taking into account the stated results which represented in the different figures, some policy implications assessment can be performed.

Policies that try to avoid tax evasion but imply a change in the public perception of the tax havens, like public threats of economic sanctions, can lead to counterproductive outcomes if they are targeted wrongly. As shown in all figures, if the policy threatens the best tax haven for evading (lower $\mu_j$) always brings evasion to a lower value. In a situation where all tax havens are perceived equally, the policy leads to less evasion if all agents do not shift immediately (Figure 4 and Figure 6). However, if the threatened tax haven is sufficiently weak compared to the others, the policy will produce a coordination effect (deposit shifting) towards the stronger tax havens increasing overall evasion (Figure 4 and Figure 6). In contrast, if the policy manage to create an equal threat to all tax havens, it will always reduce evasion (Figure 5).

Therefore, the policies should be either applied homogeneously among tax havens, or focused on the tax havens with the best public perception for evading. Otherwise, they can trigger counteracting coordination effects that lead to even more evasion.

# 6 Conclusions

This paper examined how allowing for multiple entities in a regime change global game affects overall coordination. For this purpose, I construct a game with multiple and simultaneous regime change global games, and then, I analyze the implication of affecting the public information of one or more entities. The whole model has been carried on using a tax evasion game so as to explain the empirical evidence.

The model displays coordination effects among the different entities, which would not appear with just one. Therefore, affecting one of the tax havens can trigger coordination effects on the other tax havens. In particular, the model manifests the clash between two forces I named as Global Effect and Crowding-in effect, that ease and hinders coordination respectively. When the tax haven with the best public information for evading is threatened, the Global Effect dominates leading to less evasion. However, if the tax haven with the worse public information is threatened too harshly, the Crowding-in effect accomplishes to overthrown the Global one leading to more evasion. Finally, when both tax havens are threatened homogeneously, the Crowding-in effect does not manifest leading to less evasion.

Therefore, in the study of global games, when it is reasonable to expect multiple entities in the portfolio choice, the study of one entity as if it would be independent of the others might be missing notorious coordination effects that influence severely the outcomes. In this model, I mainly use changes in the public information, but similar fluctuations are expected for changes in other fundamentals, if not the same.

Furthermore, this paper also carries several policy implications. If the OECD wants to undermine tax evasion, they should not apply policies that treats tax havens too heterogeneously. Because if evaders perceive them too differently, the policy can trigger coordination effects and be counterproductive. In fact, this effect might explain the ineffectiveness of the international policies, yet brings hope to the recently proposed Global Minimum Tax Rate.

As a further research proposal, this model could be extended to a more characterized version which would give more insights about all these coordination effects, e.g., characterize a general equilibrium where the entities and the OECD are active players. Furthermore, some extensions could be studied, like allowing the amount of mobile capital to be separable. Yet, perhaps more interestingly, in the current framework individuals are risk-neutral, so the only reason for the crowding-in effect to appear is the expected payoff of evading being increased by the difference of public signals. Thus, it is actually not about risk-reduction, it is about the expected value, since the risk is measured solely as the variance in payoffs across states. Therefore, it would be interesting to solve the model for risk-averse investors in order to study how the coordination effects behave. And finally, the model can be applied to other scenarios beyond tax havens, which can also bring new insights about coordination games.

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# Appendix A Proofs

## A.1 Proof of Proposition 1

To proof existence and uniqueness I follow Angeletos et al. (2007) methodology.

Using the equilibrium equation (4) and (7), we can create a function named $U(\hat{\theta}_k)$ s.t.:

$$U(\hat{\theta}_k) = \hat{\theta}_k - S_k \cdot \Phi\left(\frac{(\alpha-1)(\hat{\theta}_k - \mu_k) - \beta\Phi^{-1}\left(\frac{\tau-t}{\tau-p}\right)}{\sigma_x}\right). \tag{15}$$

To proof the function is monotonic in $\hat{\theta}_k$ and hence, the FP exist and ! we need that

$$\frac{\partial U(\cdot)}{\partial \hat{\theta}_k} = 1 - S_k \frac{1}{\sigma_x}\phi(\cdot)(\alpha - 1) > 0 \tag{16}$$

To proof this derivative is positive, consider the maximum values of $\phi(\cdot) = 1/\sqrt{2\pi}$ and $S_k = 1$, then

$$\frac{\partial U(\cdot)}{\partial \hat{\theta}_1} > 0 \Rightarrow 1 - \frac{1}{\sigma_x}\frac{1}{\sqrt{2\pi}}\frac{\sigma_x^2}{\sigma_\mu^2} > 0 \Rightarrow \sigma_\mu^2 > \frac{\sigma_x}{\sqrt{2\pi}} \tag{17}$$

Therefore the last condition is both necessary and sufficient for $U(\cdot)$ to be monotonic on $\hat{\theta}_k$, in which case the monotone equilibrium is unique. Finally, to prove that this equilibrium is the only one surviving iterated deletion of strictly dominated strategies, see Morris and Shin (2001). ■

## A.2 Proof of Lemma 1

Using implicit differentiation in (4) ,

$$\frac{\partial \hat{\theta}_k}{\partial \hat{x}_k} = -\frac{\partial U/\partial \hat{x}_k}{\partial U/\partial \hat{\theta}_k} = \frac{S_k \frac{\phi(\cdot)}{\sigma_x}}{1 - S_k\phi_1(\cdot)\frac{\alpha-1}{\sigma_x}} > 0 \tag{18}$$

The latter inequality comes from the condition for existence and uniqueness. Using (7),

$$\frac{\partial \hat{x}_k^*}{\partial \hat{\theta}_k} = \alpha > 0 \tag{19}$$

■

## A.3 Proof of Lemma 2

To see how changes on the different parameters affects $\hat{x}_k^*$, we need to see how affects first the FP $\hat{\theta}_k$, which requires implicit differentiation on (4) . Then,

$$\frac{\partial \hat{\theta}_k}{\partial S_k} = -\frac{\partial U/\partial S_k}{\partial U/\partial \hat{\theta}_k} = \frac{\Phi(\cdot)}{1 - S_k\phi_1(\cdot)\frac{\alpha-1}{\sigma_x}} > 0 \tag{20}$$

The latter inequality comes from the condition for existence and uniqueness. Then, using (7),

$$\frac{\partial \hat{x}_k^*}{\partial S_k} = \alpha \cdot \frac{\Phi(\cdot)}{1 - S_k \phi_1(\cdot) \frac{\alpha - 1}{\sigma_x}} > 0 \tag{21}$$

■

## A.4 Proof of Lemma 3

The procedure is the same as in the Proof of Lemma 2. Given a value of $S_k$, the change of $\hat{\theta}_k$ w.r.t $t$ is

$$\frac{\partial \hat{\theta}_k}{\partial t} = -\frac{\partial U / \partial t}{\partial U / \partial \hat{\theta}_k} = -\frac{S_k \frac{\phi(\cdot)}{\sigma_x} \beta \frac{\partial \Phi^{-1}(\cdot)}{\partial t}}{1 - S_k \phi_1(\cdot) \frac{\alpha - 1}{\sigma_x}} > 0 \quad \text{given that } \frac{\partial \Phi^{-1}(\cdot)}{\partial t} < 0, \tag{22}$$

then

$$\frac{\partial \hat{x}_k}{\partial t} = \alpha \frac{\partial \hat{\theta}_k}{\partial t} - \beta \frac{\partial \Phi^{-1}(\cdot)}{\partial t} > 0. \tag{23}$$

W.r.t. $\mu_k$

$$\frac{\partial \hat{\theta}_k}{\partial \mu_k} = -\frac{\partial U / \partial \mu_k}{\partial U / \partial \hat{\theta}_k} = -\frac{S_k \phi(\cdot) \frac{\alpha - 1}{\sigma_x}}{1 - S_k \phi_1(\cdot) \frac{\alpha - 1}{\sigma_x}} < 0, \tag{24}$$

then

$$\frac{\partial \hat{x}_k}{\partial \mu_k} = \alpha \frac{\partial \hat{\theta}_k}{\partial \mu_k} - (\alpha - 1) = -\alpha \frac{S_k \phi(\cdot) \frac{\alpha - 1}{\sigma_x}}{1 - S_k \phi(\cdot) \frac{\alpha - 1}{\sigma_x}} - (\alpha - 1) < 0. \tag{25}$$

W.r.t. $p$

$$\frac{\partial \hat{\theta}_k}{\partial p} = -\frac{\partial U / \partial p}{\partial U / \partial \hat{\theta}_k} = -\frac{S_k \frac{\phi(\cdot)}{\sigma_x} \beta \frac{\partial \Phi^{-1}(\cdot)}{\partial p}}{1 - S_k \phi_1(\cdot) \frac{\alpha - 1}{\sigma_x}} < 0 \quad \text{given that } \frac{\partial \Phi^{-1}(\cdot)}{\partial p} > 0, \tag{26}$$

then

$$\frac{\partial \hat{x}_k}{\partial p} = \alpha \frac{\partial \hat{\theta}_k}{\partial p} - \beta \frac{\partial \Phi^{-1}(\cdot)}{\partial p} < 0. \tag{27}$$

W.r.t. $\tau$

$$\frac{\partial \hat{\theta}_k}{\partial \tau} = -\frac{\partial U / \partial \tau}{\partial U / \partial \hat{\theta}_k} = -\frac{S_k \frac{\phi(\cdot)}{\sigma_x} \beta \frac{\partial \Phi^{-1}(\cdot)}{\partial \tau}}{1 - S_k \phi_1(\cdot) \frac{\alpha - 1}{\sigma_x}} < 0 \quad \text{given that } \frac{\partial \Phi^{-1}(\cdot)}{\partial \tau} > 0, \tag{28}$$

then

$$\frac{\partial \hat{x}_k}{\partial \tau} = \alpha \frac{\partial \hat{\theta}_k}{\partial \tau} - \beta \frac{\partial \Phi^{-1}(\cdot)}{\partial \tau} < 0. \tag{29}$$

W.r.t. $\sigma_\mu$

$$\frac{\partial \hat{\theta}_k}{\partial \sigma_\mu} = -\frac{\partial U / \partial \sigma_\mu}{\partial U / \partial \hat{\theta}_k} = \frac{S_k \frac{\phi(\cdot)}{\sigma_x} \left( \frac{-2\sigma_x^2}{\sigma_\mu^3} (\hat{\theta}_k - \mu_k) + \frac{\frac{\beta}{\sigma_\mu} + \beta \sigma_\mu}{\sigma_x^2 + \sigma_\mu^2} \Phi^{-1}(\cdot) \right)}{1 - S_k \phi_1(\cdot) \frac{\alpha - 1}{\sigma_x}}, \tag{30}$$

then

$$\frac{\partial \hat{x}_k}{\partial \sigma_\mu} = \frac{-2\sigma_x^2}{\sigma_\mu^3}(\hat{\theta}_k - \mu_k) + \alpha \frac{\partial \hat{\theta}_k}{\partial \sigma_\mu} + \frac{\frac{\beta}{\sigma_\mu} + \beta\sigma_\mu}{\sigma_x^2 + \sigma_\mu^2}\Phi^{-1}(\cdot). \tag{31}$$

It is unclear if the expression is negative or positive. However, since $\hat{\theta}_k$ is decreasing in $\mu_k \in (-\infty, \infty)$, for a sufficient low $\mu_k$ (good state) the derivative is negative. However, for a sufficiently high public signal, the derivative is positive. And the same applies to tax rates inside the inverse CDF that increases the incentives to evade.

And finally, w.r.t. $\sigma_x$

$$\frac{\partial \hat{\theta}_k}{\partial \sigma_x} = -\frac{\partial U / \partial \sigma_x}{\partial U / \partial \hat{\theta}_k} = \frac{S_k \phi(\cdot)\left(\frac{1}{\sigma_\mu^2}(\hat{\theta}_k - \mu_k) - \frac{\sigma_x}{\sigma_\mu\sqrt{\sigma_x^2 + \sigma_\mu^2}}\Phi^{-1}(\cdot)\right)}{1 - S_k\phi_1(\cdot)\frac{\alpha - 1}{\sigma_x}}, \tag{32}$$

then

$$\frac{\partial \hat{x}_k}{\partial \sigma_x} = \frac{1}{\sigma_\mu^2}(\hat{\theta}_k - \mu_k) + \alpha \frac{\partial \hat{\theta}_k}{\partial \sigma_x} + \frac{\sigma_x}{\sigma_\mu\sqrt{\sigma_x^2 + \sigma_\mu^2}}\Phi^{-1}(\cdot). \tag{33}$$

The same argument as with $\sigma_\mu$ applies. ■

## A.5 Proof of Lemma 4**

$1 - p > 1 - t > 1 - \tau$ since $p < t < \tau$. Furthermore, the probability of all the events has to sum up to 1, i.e.:

$$\Pr(x_{ij} \leq \hat{x}_j^*(S_j) \;\cap\; \theta_j \leq \hat{\theta}_j(S_j)) + \Pr(x_{ij} \leq \hat{x}_j^*(S_j) \;\cap\; \theta_j > \hat{\theta}_j(S_j)) + \Pr(x_{ij} > \hat{x}_j^*(S_j)) = 1 \tag{34}$$

Therefore, by proving that by increasing $S_j$ the probability of the event with the best outcome increases, it will imply that the expected payoff increases. In this case, if the probability of getting $1 - p$ (evade successfully) increases with $S_j$, the expected payoff must increase since the probabilities of lower payoffs will decrease proportionally due to the previous equation.

The probability of evading and the tax haven surviving is characterized by the joint distribution of $x_{ij}$ and $\theta_j$, which I denote by $f_{x_{ij},\theta_j}(x_{ij}, \theta_j)$ s.t.

$$f_{x_{ij},\theta_j}(x_{ij}, \theta_j) \sim \text{Bivariate Normal with } \boldsymbol{\mu} = \begin{pmatrix} \mu_j \\ \mu_j \end{pmatrix}, \boldsymbol{\Sigma} = \begin{pmatrix} \sigma_x^2 + \sigma_\mu^2 & \sigma_\mu^2 \\ \sigma_\mu^2 & \sigma_\mu^2 \end{pmatrix}, \rho = \frac{\sigma_\mu}{\sqrt{\sigma_x^2 + \sigma_\mu^2}}; \tag{35}$$

whose CDF w.r.t to the threshold $\hat{x}_j$ and $\hat{\theta}_j$ is

$$\begin{aligned} F_{x_{ij},\theta_j}(\hat{x}_j, \hat{\theta}_j) &= \int_{-\infty}^{\hat{x}_j}\int_{-\infty}^{\hat{\theta}_j} \frac{1}{2\pi\sigma_\mu\sqrt{\sigma_x^2 + \sigma_\mu^2}\sqrt{1 - \rho^2}} e^{-\frac{z}{2(1-\rho^2)}} d\theta_1 dx_{i1} \\ z &= \left(\frac{x_{ij} - \mu_j}{\sqrt{\sigma_x^2 + \sigma_\mu^2}}\right)^2 - \frac{2\rho(x_{ij} - \mu_j)(\theta_j - \mu_j)}{\sigma_\mu\sqrt{\sigma_x^2 + \sigma_\mu^2}} + \left(\frac{\theta_j - \mu_j}{\sigma_\mu}\right)^2 \end{aligned} \tag{36}$$

If $S_j$ increases, the term inside the double integral does not change, yet, the upper bound of the integral increases. Therefore the probability of evading successfully increases and thus the payoff of evading.

For the second statement, since $\sum_j S_j = 1$, an increase in $S_{j'} : j' \neq j$ implies a reduction in $S_j$ and the opposite holds.

■

### A.6 Proof of Lemma 5

By the same argument as in Lemma 4, it is straightforward to see that the joint CDF of the probability of evading and the tax haven surviving is decreasing in $\mu_j$. The mean of both variables is $\mu_j$, and an increase will move the mass of the distribution along the 45 degrees that will decrease the probability mass inside the area below the thresholds. In addition, both thresholds decrease with the public signal by Lemma 1 and Lemma 3. Then, not only the mass of the CDF is moved away from the area limited by the thresholds, but the thresholds shrink, leading to less mass inside.

■

### A.7 Proof of Proposition 4

W.l.g, assume $j = 1$ and $j' = 2$. Denote by $A(\mu_1, \mu_2)$, the total number of evaders as function of the public signals. For $\mu_1 < \mu_2$ remember that $S_1 = 1$. When $\mu_1 \to -\infty$ then using (11)

$$\lim_{\mu_1 \to \infty} A = 1\Phi\left(\frac{\infty + \infty}{\sqrt{\sigma_x^2 + \sigma_\mu^2}}\right) + 0\Phi_2\left(\frac{\hat{x}_2^*(0) - \mu_2}{\sqrt{\sigma_x^2 + \sigma_\mu^2}}\right) = 1 \tag{37}$$

As $\mu_1$ increases and approximates $\mu_2$, $S_1$ continues to be 1. Then,

$$A = A_1 = \Phi_1\left(\frac{\hat{x}_1(1) - \mu_1}{\sqrt{\sigma_x^2 + \sigma_\mu^2}}\right) < 1 \tag{38}$$

which is a function that decreases in $\mu_1$ since also $\hat{x}_1$ decreases too according to Lemma 3. Therefore, form $A = 1$ it will decrease till reaching the value of $A(\mu_1 - \epsilon = \mu_2)$.

For $\mu_1 = \mu_2 = \mu$ remember that $S_1 = 0.5$, then

$$A = 0.5\Phi_1\left(\frac{\hat{x}_1^*(0.5) - \mu}{\sqrt{\sigma_x^2 + \sigma_\mu^2}}\right) + 0.5\Phi_2\left(\frac{\hat{x}_2^*(0.5) - \mu}{\sqrt{\sigma_x^2 + \sigma_\mu^2}}\right). \tag{39}$$

Since tax havens are identical in all the rest of parameters, $\hat{x}_1^*(0.5) = \hat{x}_2^*(0.5)$ and hence

$$A = \Phi_1\left(\frac{\hat{x}_1^*(0.5) - \mu}{\sqrt{\sigma_x^2 + \sigma_\mu^2}}\right) \tag{40}$$

which is lower than (19) because $\hat{x}_1^*(1) > \hat{x}_1^*(0.5)$.

Finally, for $\mu_1 > \mu_2$, remember that $S_1 = 0$, then

$$A = A_2 = \Phi_2 \left( \frac{\hat{x}_2^*(1) - \mu}{\sqrt{\sigma_x^2 + \sigma_\mu^2}} \right) < 1 \tag{41}$$

which is lower than (19) but bigger than (21). And since this function does not depend on $\mu_1$, the same value will remain as long as $\mu_1 > \mu_2$.

■

## A.8 Proof of Proposition 5

Either if $\mu_1 < \mu_2$, $\mu_1 = \mu_2$ or $\mu_1 > \mu_2$, if the increase in both public signals is the same, $S_1$ and $S_2$ remain unchanged. Then, when $\mu_1$ and $\mu_2$ increases the number of evaders in each case decreases by (11) .

■

## A.9 Proof of Proposition 8

The first part of the proof is straightforwards, by substituting the value of the public signals of the extreme cases in (11) and using $F_\delta(\mu_2 - \mu_1)$, we obtain the same expressions as in the Proof of Proposition 4.

■

## A.10 Proof of Proposition 9

If we evaluate (14) at $\mu_1 = \mu_2$, which implies $\hat{x}_1 = \hat{x}_2$, $\hat{\theta}_1 = \hat{\theta}_2$, $S_1 = S_2 = 0.5$, $\Phi_1 = \Phi_2$ and $\phi_1 = \phi_2$, the derivative becomes

$$0.5 \frac{\phi(\cdot)}{\sqrt{\sigma_x^2 + \sigma_\mu^2}} \left( \frac{\partial \hat{x}_1^*}{\partial \mu_1} - 1 \right) + 0.5 \frac{\phi(\cdot)}{\sqrt{\sigma_x^2 + \sigma_\mu^2}} \left( \frac{\partial \hat{x}_2^*}{\partial \mu_1} \right) \tag{42}$$

The fist term is negative whereas the second one it is positive. $\mu_1$ decreases $\hat{x}_1$ through $S_1 = F_\delta$ and directly through (7); whereas it increases $\hat{x}_2$ just through $S_2 = 1 - F_\delta$. Considering only the effect on $\hat{x}_1$ through $S_1$, the expression becomes the following one:

$$0.5 \frac{\phi(\cdot)}{\sqrt{\sigma_x^2 + \sigma_\mu^2}} \left( \frac{\partial \hat{x}_1^*}{\partial S_1} - 1 \right) + 0.5 \frac{\phi(\cdot)}{\sqrt{\sigma_x^2 + \sigma_\mu^2}} \left( \frac{\partial \hat{x}_2^*}{\partial S_2} \right) \tag{43}$$

The symmetry of the problem induces that

$$\frac{\partial \hat{x}_1^*}{\partial S_1} = \alpha \cdot \frac{\Phi(\cdot)}{1 - S_1 \phi(\cdot) \frac{\alpha - 1}{\sigma_x}} = \alpha \cdot \frac{\Phi(\cdot)}{1 - S_2 \phi(\cdot) \frac{\alpha - 1}{\sigma_x}} = \frac{\partial \hat{x}_2^*}{\partial S_2} \tag{44}$$

and using the fact that $\partial S_2 = -\partial S_1$ the remaining term in (43) makes the equation negative, even when ignoring an effect that would reinforce this result.
■

# Appendix B Calibration of the simulations

All the simulations have been carried with the same Calibration, which is summarized in Table 2.

| Parameter | Symbol | Assigned Value |
|---|---|---|
| Tax haven tax rate | $p$ | 0 |
| OECD tax rate | $t$ | 0.5 |
| Punishment | $\tau$ | 1 |
| Public signal volatility | $\sigma_\mu$ | 1 |
| Private signal volatility | $\sigma_x$ | 1 |

Table 2: Calibration parameters for the simulation.