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Fighting Mobile Crime

Abstract

Two countries set their enforcement non-cooperatively to deter native and foreign individuals from committing crime in their territory. Crime is mobile, ex ante (migration) and ex post (fleeing), and criminals hiding abroad after having com- mitted a crime in a country must be extradited back. When extradition is not too costly, countries overinvest in enforcement: insourcing foreign criminals is more costly than paying the extradition cost. When extradition is sufficiently costly, in- stead, a large enforcement may induce criminals to flee the country whose law they infringed. The fear of paying the extradition cost enables the countries coordinating on the efficient outcome.

JEL-Codes: K140, K420.

Keywords: crime, enforcement, extradition, fleeing, migration.

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1. Introduction

Globalization has substantially contributed to improving living standards over the last decades. At the same time, however, it has also influenced the way in which criminals behave, by availing them the possibility to move some of their illegal interests in foreign countries. For example, many criminal organizations, including Mafia, have progressively expanded their sphere of influence and relocated some activities abroad (Varese, 2006, 2011). Sociologists have long debated about crime mobility, and recognized that it is a salient aspect to be taken into account when designing policies aimed at deterring crime (see, e.g., Bernasco, 2014, and Morselli and Royer, 2008, among others). Governments have also realized that crime mobility is a common threat and decided to react accordingly by signing international conventions to coordinate collective responses to it.[1] The empirical evidence on the correlation between immigration and crimes is abundant — see, e.g., Butcher and Piehl (1998), Moehling and Piehl (2009), Borjas, Grogger and Hanson (2010), Alonso-Borrego, Garoupa and Vázquez (2012) and Bell, Fasani and Machin (2013) among many others.

Surprisingly, despite the existence of an established literature on the economics of crime, no formal economic model exists that studies the effects of crime mobility on optimal enforcement. Although many papers have investigated the decision by criminals about whether to commit a crime (extensive margin) and about the amount of crime to commit (intensive margin), little is known about the effects of crime mobility in settings in which countries or states in a federal country design their enforcement systems in a non-cooperative fashion. How should enforcement policies be designed when crime is mobile? What type of mobility matters? Do countries make inefficient choices when they behave non-cooperatively? If so, why? Answering these questions is of paramount importance to better understand the bright and the dark side of enforcement policies, to interpret the existing patterns of crime mobility, and to help governments better coordinate their efforts to fight crime.

The *mobility margins* studied in this paper differ from the usual extensive margin, in that they are intrinsically associated with the idea of competition (see, e.g., Lehman et al., 2014). Crime mobility is a special phenomenon, which could involve not only ex-ante mobility — i.e., felons moving across borders to perpetrate crimes (*migration*) — but also ex-post mobility — i.e., felons escaping from the country where they have perpetrated crimes, in order to shield themselves against the risk of apprehension (*fleeing*). Extraditing

[1] For example, the United Nations Convention against Transnational Organized Crime entered into force in 2003 with this objective.

back fugitives often involves in real life cumbersome bureaucratic procedures, which make extradition very costly for the demanding country.[2] These costs could be related to the Governments' strategic behavior in the process of setting up their enforcement systems, over and above the standard effects. Why should civilized nations pose similar obstacles to the implementation of extradition?

The lack of theoretical work on fugitives is striking given that warrants represent a pervasive, and perhaps fundamental, aspect of justice systems especially in the US. The work by Bierie (2014) provides the first comprehensive research identifying how many fugitives exist in the US, the distribution of their offenses, the demographics of the fugitive population, etc. The phenomenon appears to be important and undervalued. It is argued that 'fugitives are the Achilles heel of law enforcement today' (Fugitives, 2001).[3] More than one million active felony warrants existed in the United States in 2004 (Helland and Tabarrok, 2004), with this number reaching approximately two millions in April 2011 (Bierie, 2014). Evidence supporting the idea that fugitives are an important concern for law enforcers, has been previously collected by Guynes and Wolff (2004) showing that half of all arrests in the counties that they surveyed derived from warrants. Similar patterns were found in federal policing. Over half of all arrests by the U.S. Department of Justice are made by the U.S. Marshals Service (USMS), an agency which almost exclusively arrests fugitives (Fugitives, 2001). These patterns translate into large numbers of arrests each year. For example, the USMS made over 130,000 fugitive arrests in fiscal year 2013 alone (U.S. Marshals Service, 2014). A few case studies, focusing on serious crimes, also confirm the importance of fleeing and the link between enforcement strengthening and the population of fugitives. For example, by studying the effects of targeted enforcement in high-crime places in Philadelphia, Goldkamp and Vilcica (2008) argue that fleeing is indeed an unintended negative consequence of strengthened and targeted law enforcement against drug trafficking. According to their study, in the Philadelphia criminal court system there were on average approximately 40,000 fugitive defendants on any given day in the years from 1998 to 2000 (see, e.g., also Goldkamp et al., 2005). During the same period, in relative terms, the fugitives' backlog represented the equivalent of well over 1 year's total criminal caseload of the Philadelphia courts.

To study these issues, we set up a model in which two countries (or states) choose their enforcement levels non-cooperatively, in order to deter native and foreign individuals from

[2] See, e.g., People ex rel. Westbrook v. O'Neill, 378 Ill. 324 (Ill. 1941). Extradition is the act by which one nation delivers up an individual, accused or convicted of an offense outside its own territory to another nation or state, which is competent to try and punish the criminal and demands him.

[3] See also https://www.state.gov/s/l/16163.htm

committing crimes in their territory. Criminals are heterogeneous along two migration-related dimensions: a migration cost, which is borne when individuals decide to commit the crime abroad (ex-ante mobility); and a fleeing cost, which is borne when individuals hide abroad after having committed a crime (ex-post mobility). Upon observing the countries' enforcement decisions, individuals choose whether to commit the crime, where to operate, and whether to flee the country whose law they have infringed.

Before characterizing the equilibrium of the non-cooperative game in which both countries behave strategically, we first characterize the optimal behavior of small open economy that takes as given the level of enforcement abroad, and study its incentive to set an enforcement level above or below the international standard. The analysis builds on the following trade-off. On the one hand, if a country sets an enforcement level higher than the international standard, it will outsource crime — i.e., natives with a relatively low migration cost will decide to perpetrate crime abroad. However, criminals that do not migrate, will subsequently flee and hide abroad. As a consequence, the country will have to pay the cost of extraditing them back. On the other hand, if the country sets an enforcement level lower than the international standard, it will be targeted by foreign criminals (i.e., it will insource crime). However, the country will save on extradition costs since fewer natives will flee after having infringed the law. We show that the magnitude of the enforcement and extradition costs are important drivers of this trade off. Specifically, countries with higher enforcement costs are more likely to choose enforcement levels below the international standard, and are thus more exposed to immigration by foreign criminals both ex ante and ex post. Moreover, countries facing high extradition costs are more likely to underperform relative to the international standard.

Building on these insights, we then turn to study the non-cooperative version of the game in which both countries set strategically their enforcement. We show that, as long as extradition is costly, the game features a continuum of symmetric equilibria, in which both countries choose the same enforcement level. In these equilibria, there is neither migration nor fleeing. Each equilibrium must be robust to two types of deviations. First, no country must have an incentive to set enforcement above the equilibrium level with the aim of outsourcing criminals (upward deviation). Second, no country must have an incentive to set enforcement below the equilibrium level with the aim of saving on extradition costs (downward deviation). A symmetric equilibrium featuring a (too) large enforcement level is likely to be undercut, since a downward deviation would allow the deviating country to save on enforcement costs. On the other hand, an equilibrium featuring a (too) low enforcement level is not robust to upward deviations, which allow the deviating country to save on extradition costs. The tension between these two opposing forces shapes the equilibrium set. Interestingly, when extradition is costless, only upward deviations matter, since the migration effect is not balanced by the presence of a fleeing concern. Hence, a race to the top takes place and there is a unique symmetric equilibrium in which both countries set the highest enforcement level in the set mentioned before.

Next, we study the efficiency properties of these equilibria. We first characterize the cooperative (efficient) solution, which minimizes the sum of the two countries' loss function. We show that this solution is symmetric (and, as such, it features neither migration nor fleeing) and corresponds to the autarkic benchmark. Moreover, we show that the cooperative solution can be decentralized only when the extradition cost is sufficiently large. The intuition is as follows. When the extradition cost is too low, countries tend to overinvest in enforcement when playing non-cooperatively, since insourcing foreign criminals is more expensive than paying the extradition cost. By contrast, when the extradition cost is sufficiently large, setting a high enforcement level may induce fleeing, which requires countries to pay for the extradition procedures. The fear of incurring the extradition cost enables countries to coordinate on equilibria featuring an enforcement level even lower than the cooperative (efficient) solution. As a result, in this region of parameters, the cooperative solution can be decentralized as an equilibrium of the non-cooperative game.

Interestingly, this result implies that, when extradition is relatively cheap, international agreements setting a common enforcement standard are necessary to achieve the cooperative solution. With a sufficiently high extradition cost, instead, these agreements may not be necessary. Hence, a policy implication of our analysis is that countries which are under the threat of mobile crime may wish to commit to costly and long extradition procedures in order to achieve efficiency without the need of setting up an explicit enforcement treaty. In this sense, our model offers a novel rationale for the controversially costly and cumbersome extradition procedures observed around the world (see, e.g., Bassiouni, 2014, Margolies, 2011, and Moore, 1911, among others).

The previous results hold true even when we extend our analysis to consider an endogenous extradition decision (i.e., chosen non-cooperatively) and countries or states within the same federal country care enough about their reputation. The latter condition arises when policy makers are exposed to a strong internal political pressure not to let criminals run away or when not honoring a pre-existing international treaty can lead to foreign retribution. Instead, with mild reputation concerns the cooperative outcome cannot be decentralized, even though choosing low extradition costs improves the welfare of both countries. Finally, with very low reputation concerns there is no extradition in equilibrium, migration occurs only ex post and the countries overinvest in enforcement. Extending the model to encompass the possibility of reneging on the promise of taking fugitives back is empirically relevant. For instance, in the US an exceptional number of warrants lack extradition authority: in 2011 only fewer than 614,000 of the nearly 2 million warrant allowed full extradition (Bierie, 2014).

Our final extension considers asymmetries between countries. Specifically, we assume that countries feature different enforcement costs and study the conditions under which the more efficient country chooses (in a pure strategy equilibrium) an enforcement level higher than the less efficient country. We show that such an asymmetric equilibrium may fail to exist when the cost asymmetry between the two countries is sufficiently small and when extradition is sufficiently costly. The reason being that, even if more efficient countries can better deter crime, their cost advantage is mitigated by the presence of the extradition cost — i.e., in contrast to the symmetric case, in this equilibrium criminals flee the most efficient country, which has to bring them back. By contrast, an asymmetric equilibrium exists as long as the cost asymmetry between the two countries is large enough and the extradition cost is not too high. Hence, with relatively high extradition costs, countries with different enforcement costs do not necessarily choose different enforcement levels.

Our analysis is mainly related to the literature studying the relation between expected penalties on an illegal activity and the harm that it inflicts to society (see, e.g., Becker, 1968; Landes and Posner, 1975; Polinsky and Shavell, 1984; Friedman, 1981; Stigler, 1970; Friedman and Sjostrom, 1991; Mookherjee and Png, 1992, 1994; Polinsky and Shavell, 1992; Shavell, 1991, 1992, and Wilde, 1992).[4] However, since all these models have overlooked the role of crime out-sourcing and criminal fleeing, they are silent on how potential mobility by criminals may affect the design of optimal enforcement policies by competing governments. This is the starting point of our analysis.

The paper is also connected to, and motivated by, the empirical literature on migration and crime. Buonanno and Pazzona (2014) and Scognamiglio (2018) look at the effect of the geographical relocation of Mafia members on crime. These studies find evidence that the geographical mobility of Mafia members has contributed to the diffusion of organized crime in Italy. There is also a growing body of evidence on the relationship between foreign immigration and crime. Butcher and Piehl (1998) and Moehling and Piehl (2009) document, for the US, that immigrants were less likely than the native-born to be institutionalized in correctional facilities and much less likely to be institutionalized than native-born men with similar demographic characteristics. Although all immigrant cohorts appear to have assimilated toward the higher institutionalization rates of the

[4] See also Crinò, Immordino and Piccolo (2017) for empirical evidence on this relationship.

native-born as their time in the country increased. Borjas, Grogger and Hanson (2010) and Alonso-Borrego, Garoupa and Vázquez (2012) find that immigration increased crime in the US and Spain, respectively. Bell, Fasani and Machin (2013) find that the wave of asylum seekers in the UK caused a significant increase in crime, whereas the post-2004 inflow of people from the EU accession countries did not. Baker (2015), Mastrobuoni and Pinotti (2015) and Pinotti (2017) have tested the effects of a change in the legal status of immigrants while Bianchi et al. (2012) document that the size of the immigrant population is positively correlated with the incidence of property crimes and with the overall crime rate.[5]

The rest of the paper is organized as follows. Section 2 sets up the baseline model. Section 3 determines criminals' behavior for given enforcement policies. Section 4 characterizes the optimal policy in a small open economy. Section 5 studies the noncooperative version of the game and highlights the welfare properties of the equilibrium. Section 6 discusses the case in which extradition is endogenous and in which countries feature different enforcement costs. Section 7 concludes. All proofs are in the Appendix.

2. The model

Players. Consider two countries — or two states within the same federal country — denoted by $i \in \{A, B\}$. In each country there is a continuum of potential criminals, which can move across the border to carry out an illegal activity (crime). The crime imposes an harm $h > 0$ to the country where it is perpetrated. Conditional on the target (home or foreign) country, agents decide whether to commit the crime. If they do so, they obtain a random (monetary) benefit $\pi \in [0, 1]$. This can be interpreted as the result either of ability or of some contingencies (unknown to Governments when enforcement is set) that can make a crime relatively more or less profitable.[6] Agents are heterogeneous along two migration-related dimensions: (i) a random migration cost $m \in [0, M]$, which they bear when deciding to commit the crime abroad; and (ii) a random fleeing cost $l \in [0, L]$, which they bear if they decide to flee the country after having committed the crime.

Mobility costs and crime profitability. For simplicity, we assume that the three (random) characteristics described above are identically and independently distributed

[5] Also of interest are the papers by Blanes i Vidal and Mastrobuoni (2018), which estimates the effects of police street deployment on crime and Mastrobuoni (2017), which shows that the use advanced statistical methods by police departments in Italy has improved their productivity in fighting crimes.

[6] For simplicity, we ignore the possibility for agents to also choose among different types of crime. See, e.g., Mookerjee and Png (1994) for a model (without crime mobility) in which this possibility is taken into account.

across individuals and countries. The ex ante mobility cost corresponds to a loss in utility due, for instance, to the need of setting up a new illegal network, transporting people and weapons, learning a different language, and adapting to another culture. Denote by $G(m)$ the cumulative distribution function of the migration cost — i.e., the mass of criminals with migration costs below m — whose density is $g(m)$. We also consider the possibility that an individual who commits a crime in country A might choose to flee that country and hide abroad (in country B) to avoid the sanction imposed by country A. When this happens, country B has to help catching the criminal and extradite him back to country A. In this case, country A incurs the extradition cost $x > 0$.[7] We denote by $Z(l)$ the cumulative distribution function of the fleeing cost — i.e., the mass of criminals with fleeing costs below l — whose density is $z(l)$. Finally, the cumulative distribution function of returns from crime is $F(\pi)$, with density $f(\pi)$.

Sanctions and enforcement. In keeping with the 'territorial principle' in criminal law (see, e.g., Perkins, 1971), we assume that the country where the crime is committed has jurisdiction on the offence. We assume that each Government always sanctions the offense with the highest possible penalty. This is without loss of generality in our model, since each individual chooses whether to commit a single harmful act (see, e.g., Becker, 1968; Landes and Posner, 1975; Polinsky and Shavell, 1984; Friedman, 1981) and Governments always set the sanction at the maximum possible level. For simplicity, and to save on notation, we also normalize the maximum possible penalty in each country to 1. The (endogenous) probability of apprehension in country i is denoted by $p_i \in [0, 1]$. The cost of enforcement is linear and given by cp_i for every country (see, e.g., Mookherjee and Png, 1994). All players are risk neutral. Following the literature, all sanctions will be interpreted as the monetary equivalent of the imprisonment terms, fines, damages, and so forth, to which criminals expose themselves. We assume that governments are unable or unwilling to base sanctions on migration cost, fleeing status, benefit from crime or native country.

Timing. The timing of the game is as follows:

t = 0 Governments simultaneously commit to an enforcement level p_i.

t = 1 Knowing each country's enforcement level, the crime profitability and the migration cost (but being uncertain about the fleeing cost) agents decide whether to commit the crime and in which country.

[7] For instance, this is the case in the US, where the extradition cost is borne by the demanding State.

t = 2 Criminals learn their fleeing cost and decide whether to flee the country.

t = 3 Sanctions are imposed to criminals who get caught. Extradition costs (if any) are paid.

The idea that criminals learn their fleeing costs after committing the crime seems natural. Indeed, various contingencies, unexpected at the time a criminal decides to break the law, can influence these costs (e.g., the ability of the police officers in charge of the case, the possibility of getting injured during the crime, an unexpected reaction by the victims, and the presence of a witness on the crime scene). In line with an intuitive reputation argument, we assume that countries always extradite back criminals (see Section 6.1 for a simple treatment of extradition as a strategic decision).

Equilibrium. Each Government chooses the enforcement level that minimizes a loss function determined by the sum of: (*i*) the expected harm from domestic crime (which can be caused both by residents and immigrants); (*ii*) the cost of extraditing back criminals who have fled to the other country after having committed the crime; and (*iii*) the enforcement costs, taking as given the enforcement level chosen by the other government. Criminals make decisions along three margins: whether to commit the crime, where to operate, and whether to flee the country after having committed the crime. The solution concept is Subgame Perfect Nash Equilibrium.

Assumptions. We impose the following technical assumptions:

A1 $f'(\cdot) < 0$ and $f(1) < \frac{c}{h} < f(0)$.

This assumption ensures that the cooperative benchmark — i.e., the enforcement level that minimizes the joint loss function of the two countries — has a unique interior solution.

In the rest of the paper it will be useful to define

$$\Phi_H(p) \triangleq \underbrace{h[f(p) + (1 - F(p)) g(0)]}_{\text{Marginal benefit of higher deterrence}} \geq \Phi_L(p) \triangleq \Phi_H(p) - \underbrace{xp(1 - F(p)) z(0)}_{\text{Marginal cost of extradition}}.$$

As it will be explained shortly, the function $\Phi_H(\cdot)$ captures the marginal benefit for a country to increase its enforcement level (slightly) above that of the other country (say p). Indeed, the term $hf(p)$ reflects the benefit of strengthening deterrence on natives (who have a weaker incentive to infringe their home country's law), while $h(1 - F(p)) g(0)$ measures the benefit of outsourcing crime (relatively more criminals migrate abroad). In addition to these (marginal) benefits, the function $\Phi_L(\cdot)$ also encompasses the marginal cost of taking fugitives back — i.e., strengthening deterrence increases the number of fugitives that must be taken back at cost x once they are captured abroad (with probability p). In the following we assume that these functions are both non-increasing in p — i.e.,

A2 $\Phi'_H(p) \leq 0$ and $\Phi'_L(p) \leq 0$.

This assumption reflects the standard idea of decreasing marginal benefits and increasing marginal costs. As we will explain, this implies that the equilibrium set is connected — i.e., a set which cannot be partitioned into two non-empty subsets with no points in common.[8]

In the Appendix, we impose additional technical requirements by studying the (sufficient) conditions on the primitives of the model under which the countries' objective functions are well-behaved (i.e., they are strictly convex). Finally, only for simplicity, we assume that fugitives do not commit crimes in the country where they hide.

3. Preliminaries

Before characterizing the equilibrium of the game, it is useful to determine criminals' behavior for given enforcement policies. The game is solved by backward induction. Hence, we begin with the analysis of the fleeing decisions occurring in stage $t = 2$.

Lemma 1. *An agent who has committed a crime in country i flees that country and hides in country j if and only if*

$$p_i \geq p_j + l \quad \Leftrightarrow \quad l \leq l_i \triangleq p_i - p_j. \tag{3.1}$$

As intuition suggests, criminals flee a country if the cost of doing so is sufficiently small and only if the destination country sets a lower enforcement level.

Moving backward, we can now determine criminals' expected utilities and optimal decisions in stage $t = 1$. Suppose (without loss of generality) that $p_i \geq p_j$. Then, the expected utility of a criminal who is resident in i and decides to commit the crime in his home country is

$$u_{ii}(p_i, p_j) \triangleq \pi - p_i(1 - Z(l_i)) - p_j Z(l_i) - \int_0^{l_i} l dZ(l). \tag{3.2}$$

[8] The qualitative insights of the analysis do not change if A2 does not hold, even though the equilibrium set could be slightly more complex to describe — e.g., it could be the union of two or more disjointed compacts.

This expression takes into account the expected cost of fleeing. Notice that, even if a criminal does not migrate, the enforcement of the foreign country affects his utility through the ex post fleeing decision. Hence, fleeing criminals are also responsive to the enforcement policy set abroad.

By contrast, the expected utility of a criminal who is resident in country i and migrates to country j is

$$u_{ij}(p_i, p_j) \triangleq \pi - p_j - m. \tag{3.3}$$

Moreover, as implied by Lemma 1, such a criminal will not return back to country i since $p_i \geq p_j$.

Comparing (3.2) with (3.3), we can show the following result.

Lemma 2. *A criminal who is resident in country i migrates to country j if and only if*

$$u_{ii}(p_i, p_j) \leq u_{ij}(p_i, p_j) \quad \Leftrightarrow \quad m \leq m_i \triangleq (1 - Z(l_i))\, l_i + \int_0^{l_i} l dZ(l)\,. \tag{3.4}$$

The threshold m_i identifies the marginal migrant — i.e., the criminal who is indifferent between migrating and committing the crime in his home country. Similarly to the fleeing decision (condition 3.1), the decision to migrate also depends on the difference between the two enforcement levels. Specifically, when $p_i = p_j$, there is no migration (and, of course, no fleeing), because expected sanctions are the same in the two countries. Notice that, the effect of p_i on the marginal migrant is ambiguous, as stated in the following lemma.

Lemma 3. $\frac{\partial m_i}{\partial p_i} \geq 0$ *while* $\frac{\partial m_i}{\partial p_j} \leq 0$.

As intuition suggests, the effect of a change in p_i on the marginal migrant m_i is positive: since the expected sanction in that country is higher (other things being equal) more natives migrate to country j. By contrast, as p_j increases less natives migrate to country j.

Let π_i be the level of π above which criminals who do not migrate (but flee with some probability) commit the crime in country i,

$$u_{ii}(\cdot) \geq 0 \quad \Leftrightarrow \quad \pi \geq \pi_i \triangleq p_i (1 - Z(l_i)) + p_j Z(l_i) + \int_0^{l_i} l dZ(l) = p_j + m_i. \tag{3.5}$$

Similarly, since we assumed $p_i \geq p_j$ (offenders who commit the crime in country j will never flee that country), let π_j be the level of π above which natives of country j commit

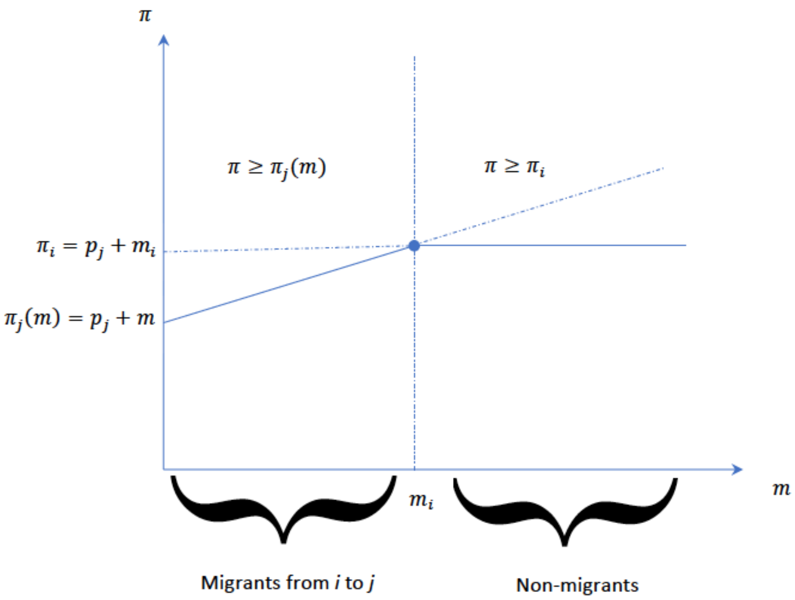

Figure 3.1: Criminal Behavior for $p_i > p_j$

the crime at home,

$$u_{jj}\left(\cdot\right) \geq 0 \quad \Leftrightarrow \quad \pi \geq p_j. \tag{3.6}$$

Finally let $\pi_j\left(m\right)$ be the level of π above which an offender who is resident in country i and has migration cost $m \leq m_i$ commits the crime in country j — i.e.,

$$u_{ij}\left(\cdot\right) \geq 0 \quad \Leftrightarrow \quad \pi \geq \pi_j\left(m\right) \triangleq m + p_j. \tag{3.7}$$

Clearly, the higher is the migration cost, the higher the benefit π has to be for the crime to be profitable for a migrant. Moreover, the higher is the enforcement level p_j implemented by country j, the less profitable is migration to that country.

Summing up, under the hypothesis that $p_i \geq p_j$, conditions (3.1), (3.4), (3.5), (3.6) and (3.7) describe criminals' optimal response to the enforcement policies implemented by the two countries (see Figure 3.1).

4. Basic insights: small economy

In order to better understand the forces driving a country's choice of enforcement, it is useful to start with the analysis of a small economy, which takes as given the enforcement level in the rest of the world. Building on the insights offered by this analysis, we will then extend the logic to the case of strategic interaction between the two countries. Hence, without loss of generality, in the rest of the section we focus on the decision making problem solved by country A and take as given p_B, which can be interpreted as the average enforcement level taken worldwide.

As explained before, the difference $p_A - p_B$ determines the flows of criminals that migrate ex ante and flee ex post. Hence, country A's loss function is

$$\mathcal{L}^A(p_A, p_B) \triangleq cp_A + \begin{cases} \underbrace{(1 - G(m_A))(1 - F(\pi_A))}_{\text{Amount of crime}} \times \underbrace{[h + xZ(l_A)p_B]}_{\text{Harm + Extradition cost}} & \text{if } p_A \geq p_B \\ \underbrace{h\int_{p_A}^{1} dF(\pi)}_{\text{Harm by natives}} + \underbrace{h\int_0^{m_B}(1 - F(\pi_A(m)))\,dG(m)}_{\text{Harm by immigrants}} & \text{if } p_A < p_B. \end{cases}$$

This loss function reflects how criminals move across the borders as a best response to A's policy. When $p_A \geq p_B$, country A sets a tougher policy than the rest of the world (country B). Hence, A is the outsourcing country, while the rest of the world is insourcing country: some criminals resident in A migrate to B ($m < m_A$), while others commit the crime at home and flee afterwards ($m \geq m_A$ and $l \leq l_A$). This implies that A will have to bring the latter criminals back, which costs $xZ(l_A)$. By contrast, when $p_A < p_B$, country A sets a more lenient policy than the rest of the world, so it saves on the fleeing cost but bears the additional harm produced by foreign criminals. Notice that this function is continuous and piecewise differentiable, with a kink at $p_A = p_B$ (see the Appendix). Hence, in order to characterize A's optimal policy we have to consider each case in turn. From now on, we assume that $\mathcal{L}^A(\cdot)$ is (strictly) convex in either case (we will derive in the Appendix sufficient conditions on the primitives of the model under which this conjecture holds).

Suppose first that $p_A \geq p_B$. In this case, country A solves the following minimization problem:

$$\min_{p_A \geq p_B} \{(h + xp_BZ(l_A))(1 - G(m_A))(1 - F(\pi_A)) + cp_A\}. \tag{4.1}$$

Differentiating with respect to p_A we have

$$\left.\frac{\partial \mathcal{L}^A(p_A, p_B)}{\partial p_A}\right|_{p_A \geq p_B} = c + \underbrace{x p_B (1 - G(m_A))(1 - F(\pi_A)) z(l_A) \frac{\partial l_A}{\partial p_A}}_{\text{Fleeing effect } (+)} +$$

$$\underbrace{-(h + x p_B Z(l_A))(1 - G(m_A)) f(\pi_A) \frac{\partial \pi_A}{\partial p_A}}_{\text{Deterrence on natives } (-)} \underbrace{-(h + x p_B Z(l_A)) g(m_A) \frac{\partial m_A}{\partial p_A}(1 - F(\pi_A))}_{\text{Migration effect } (-)}.$$

When A is the outsourcing country, increasing p_A has the following effects over and above the obvious direct cost of enforcement: first, a higher enforcement induces more criminals to flee ex post, which is detrimental to country A because extradition is costly; second, a higher enforcement reduces the amount of crime by deterring natives to commit the crime at home; third, a higher level of enforcement p_A tends to increase the marginal migrant m_A.

Therefore, A's problem features an interior solution $p_A > p_B$ if and only if the derivative of the (convex) loss function is negative at $p_A \to p_B^+$,

$$\lim_{p_A \to p_B^+} \frac{\partial \mathcal{L}^A(\cdot)}{\partial p_A} < 0 \quad \Leftrightarrow \quad \underbrace{c + x p_B (1 - F(p_B)) z(0)}_{\text{Marginal cost}} < \underbrace{h[f(p_B) + (1 - F(p_B)) g(0)]}_{\text{Marginal benefit}}. \tag{4.2}$$

Otherwise, the function is minimized for some $p_A \leq p_B$. In brief, country A has an incentive to set an enforcement level tougher than the rest of the world if the sum of the enforcement and fleeing (marginal) costs is small compared to the (marginal) benefit in terms of deterrence that such a policy would generate for p_A sufficiently close to p_B.

Next, suppose that $p_A \leq p_B$. In this case, country A's minimization problem is

$$\min_{p_A \leq p_B} \left\{ h(1 - F(p_A)) + h \int_0^{m_B} (1 - F(\pi_A(m))) \, dG(m) + c p_A \right\}. \tag{4.3}$$

Differentiating with respect to p_A we have

$$\left.\frac{\partial \mathcal{L}^A(p_A, p_B)}{\partial p_A}\right|_{p_A \leq p_B} = c - \underbrace{h f(p_A)}_{\text{Deterrence on natives } (-)} +$$

$$\underbrace{-h \int_0^{m_B} f(\pi_A(m)) \, dG(m)}_{\text{Deterrence on immigrants } (-)} + \underbrace{h(1 - F(\pi_A(m_B))) g(m_B) \frac{\partial m_B}{\partial p_A}}_{\text{Migration effect } (-)}.$$

When A is the insourcing country increasing p_A has the following intuitive effects over and above the direct cost of enforcement: first, it clearly deters native committing crime; second, it reduces the number of migrants (extensive margin) and makes the crime less profitable for them (intensive margin).

A's problem features an interior solution $p_A < p_B$ if and only if the derivative of the (convex) loss function is positive at $p_A \to p_B^-$,

$$\lim_{p_A \to p_B^-} \frac{\partial \mathcal{L}^A(\cdot)}{\partial p_A} > 0 \quad \Leftrightarrow \quad c > \underbrace{h\left[f(p_B) + (1 - F(p_B))\, g(0)\right]}_{\text{Marginal benefit}}. \tag{4.4}$$

In brief, A has an incentive to set an enforcement level more lenient than the rest of the world if the marginal cost of enforcement (c) is larger than the marginal benefit in terms of deterrence that such a policy would generate when p_A is sufficiently close to p_B.

Gathering (4.2) and (4.4), we can state the following result:

Proposition 1. *There exist two thresholds $p_L^* \in (0,1)$ and $p_H^* \in (0,1)$, with $p_L^* < p_H^*$, such that country A's optimal enforcement level, say p_A^*, has the following features:*

- *$p_A^* > p_B$ if and only if $p_B < p_L^*$. The threshold p_L^* is the unique solution of $c = \Phi_L(p)$.*
- *$p_A^* < p_B$ if and only if $p_B > p_H^*$. The threshold p_H^* is the unique solution of $c = \Phi_H(p)$.*
- *$p_A^* = p_B$ for every $p_B \in P \triangleq [p_L^*, p_H^*] \subseteq [0,1]$.*

This result illustrates how country A sets its enforcement level when it takes as given the enforcement in the rest of the world. There are two main forces that shape this choice. On the one hand, country A would like to shield itself against migration of foreign criminals, which requires a relatively high enforcement level (high p_A). On the other hand, such a strong enforcement may induce natives to flee ex post, which would raise extradition costs. This novel trade-off determines the optimal enforcement level set by A and the extent to which a small country is tougher or more lenient with criminals compared to the rest of the world.

In order to better understand the logic behind the result, consider first the case where p_B is sufficiently low: in this case, A has an incentive to raise its enforcement level above p_B. The reason is that saving on the extradition cost would require p_A smaller than p_B. This would both attract foreign criminals and (since p_B is already small) sensibly weaken the deterrence on natives. Hence, it is relatively too costly for A to avoid paying the extradition cost, and it is optimal to strengthen deterrence above p_B in order to induce as many natives as possible to perpetrate their crimes abroad, while also lowering natives' incentive to commit crimes.

By contrast, when p_B is sufficiently large, A has an incentive to lower its enforcement level below p_B. In this region of parameters, it is relatively too costly for A to avoid migration (say by setting p_A above p_B). Hence, A is mainly concerned with discouraging native criminals from fleeing the home country, thus avoiding paying the extradition cost.

Finally, when p_B takes intermediate values, the two forces described above offset each other, so that it is optimal for a small country to keep up with the international standard — i.e., it is optimal for A to set $p_A^* = p_B$.

The following comparative statics offers some interesting implications of the model.

Proposition 2. *The optimal enforcement chosen by Country A is such that:*

- *the region of parameters in which $p_A^* < p_B$ expands as c grows large and shrinks as h grows large — i.e., p_H^* is decreasing in c and increasing in h.*
- *the region of parameters in which $p_A^* = p_B$ expands as x grows large; the effect of h is ambiguous.*
- *the region of parameters in which $p_A^* > p_B$ shrinks as c and x grow large and expands as h grows large — i.e., p_L^* is decreasing in c and x and increasing in h.*

The intuition behind this comparative statics is straightforward. When the cost of enforcement increases (higher c), country A is less willing to invest public funds into enforcement activities; hence, the region of parameters in which p_A^* falls short of p_B expands, while the region of parameters in which p_A^* exceeds p_B shrinks. The comparative statics on h is also rather intuitive. As the harm produced by the crime becomes more serious (higher h), country A is ceteris paribus more willing to deter both native and foreign individuals from breaking the law; hence, the region of parameters in which p_A^* falls short of p_B shrinks, while the region of parameters in which p_A^* exceeds p_B expands. The comparative statics on x is the most interesting. When extraditing criminals becomes more costly (e.g., because of long bureaucratic procedures) country A has a lower incentive to choose a policy more lenient than the rest of the world. Indeed, if it does so, criminals committing the crime in A will be more likely to flee the country, which is costly because they will need to be extradited back.

Testable implications. Although developed in a non-strategic framework, these results yield interesting testable implications for small open economies which take the enforcement system abroad as given. Specifically, since the region of parameters in which $p_A^* < p_B$ expands as c grows large, countries with higher enforcement costs are more likely to choose enforcement levels below the international standard. Moreover, these countries are more exposed to immigration both ex ante and ex post. On the contrary, countries with lower enforcement costs are more likely to outperform the international standard since the region of parameters in which $p_A^* > p_B$ shrinks as c grow large. These countries should be also a less suitable target for immigrants and fugitives. Finally, countries facing high extradition costs are more likely to underperform relative to the international standard since the region of parameters in which $p_A^* < p_B$ shrinks as x grows large and that in which $p_A^* > p_B$ shrinks as x grows large.

5. Strategic Interaction

We now turn to study the strategic interaction between countries — i.e., the case in which p_A and p_B are both endogenous and determined simultaneously in equilibrium. We first characterize the cooperative solution in which the two enforcement levels maximize the countries' joint welfare (i.e., minimize their joint loss function) and then turn to the non-cooperative solution. The objective of the analysis is to study the efficiency properties of the equilibria, the role played by the model's underlying parameters (e.g., fleeing costs) and the scope (if any) for international cooperation between countries.

5.1. Cooperative benchmark

Suppose that p_A and p_B are chosen cooperatively — i.e., as a solution of the following problem

$$\min_{(p_A,p_B)\in[0,1]^2} \sum\nolimits_{i=A,B} \mathcal{L}^i \left(p_i, p_{-i}\right).$$

We can show the following preliminary result.

Lemma 4. *The cooperative solution never features asymmetric enforcement levels — i.e., the optimal policy is such that* $p_i^c = p^c$ *for every* $i \in \{A, B\}$.

Intuitively, when the countries choose cooperatively, it is never optimal to set two different enforcement levels, because an asymmetric solution would generate fleeing and thus extradition costs, which are a pure waste from a joint welfare point of view. By contrast, the enforcement of a symmetric outcome rules out both fleeing and ex ante migration. Therefore, the enforcement level (say p^c) that maximizes the countries' joint welfare solves

$$\min_{p\in[0,1]} 2\left[h\left(1-F\left(p\right)\right)+cp\right].$$

In words, in a symmetric solution, the joint loss induced by crime is equal to twice the sum of the cost of enforcement and the harm caused by criminals who decide to break the law — i.e., those for whom $\pi \geq p$. We can thus show the following intuitive result.

Proposition 3. *When countries play cooperatively, they choose a symmetric enforcement level $p^c \in (0,1)$ that solves the following first-order condition*

$$hf\left(p\right)=c,$$

with p^c being increasing in h and decreasing in c.

Intuitively, the cooperative solution — like the well-known autarkic solution — must balance the marginal cost of enforcement with the marginal benefit that the reduction in crime driven by the higher enforcement level produces. Clearly, as the crime becomes more serious — i.e., as the harm h increases — the cooperative solution requires both countries to set a more intense enforcement level. The same is obviously true as the cost of enforcement drops.

5.2. Non-cooperative outcome

We now turn to the analysis of the non-cooperative game. Since countries are identical we consider (without loss of generality) symmetric equilibria — i.e., such that $p_A = p_B = p^*$. In order for p^* to be a symmetric equilibrium, it must be immune to upward and downward deviations. Hence, each country must have no incentive either to undercut p^* or to choose an enforcement level above p^*.

Consider, without loss of generality, a deviation by country A, and assume first that $p_A > p^*$, so that criminals flee and migrate from A to B. The best possible deviation is the solution of the minimization problem (4.1) with $p_B = p^*$. Evaluating the first-order condition at $p_A = p_B = p^*$, an upward deviation is never profitable if and only if

$$\lim_{p_A\to p^{*+}} \frac{\partial \mathcal{L}^A\left(\cdot\right)}{\partial p_A} < 0 \quad \Leftrightarrow \quad c + xp^*\left(1-F\left(p^*\right)\right)z\left(0\right) > h\left[\left(1-F\left(p^*\right)\right)g\left(0\right)+f\left(p^*\right)\right]. \tag{5.1}$$

This condition reflects the trade-off discussed in the case of a small economy for $p_A > p_B$. In words, the reduction of crime induced by a marginal increase in the enforcement

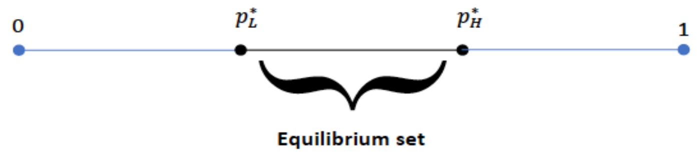

Figure 5.1: Equilibrium

level (above p^*) must not be worth the cost of strengthening enforcement and the waste of public resources needed to extradite back criminals who manage to flee the country.

By the same token, p^* is an equilibrium if it is immune to downward deviations — i.e., such that $p_A < p^*$. The most profitable of such deviations is the solution to the minimization problem (4.3) with $p_B = p^*$. Evaluating the first-order condition at $p_A = p_B = p^*$, deviating downward is never profitable if and only if

$$\lim_{p_A \to p^{*-}} \frac{\partial \mathcal{L}^A(\cdot)}{\partial p_A} > 0 \quad \Leftrightarrow \quad c < h\left[\left(1 - F\left(p^*\right)\right) g\left(0\right) + f\left(p^*\right)\right]. \tag{5.2}$$

Once again, this condition reflects the trade-off discussed in the case of a small economy for $p_A < p_B$. Intuitively, p^* is an equilibrium if the enforcement costs is small compared to the benefit in terms of deterrence that such a deviation would generate.

Summing up, an equilibrium candidate in which both countries choose the same level of enforcement must satisfy simultaneously (5.1) and (5.2), which yields exactly the set P characterized before. Hence:

Proposition 4. *The game features a continuum of symmetric equilibria — i.e., any enforcement $p^* \in P$. The equilibrium is unique when extradition is costless — i.e., if $x = 0$. In this limiting case, $p^* = p_H^*$.*

The set of symmetric equilibria is bounded from below and from above (see Figure 5.1). A symmetric equilibrium featuring too large an enforcement level is likely to be undercut, since such a deviation would lead the deviating country to save on enforcement costs. On the other hand, a symmetric equilibrium featuring too low an enforcement level is not robust to upward deviations, which allow the deviating country to save on the extradition cost.

Notice that as the extradition cost x grows large, the equilibrium set widens (since p_L^* is decreasing in x, as discussed before). Interestingly, when extradition is costless, there is a unique symmetric equilibrium in which both countries set the enforcement level to the highest level within the set P: a race to the top. The reason is that only upward deviations matter when extradition is costless, since the migration effect is not balanced by the presence of a fleeing concern.

5.3. Selection and efficiency

In Proposition 4, we have shown that the game may feature a continuum of symmetric equilibria. One may wonder which equilibrium will be selected. To address this issue, we use a selection criterion based on Pareto dominance. In particular, we assume that countries select the equilibrium that maximizes joint welfare — i.e., the $p^* \in P$ that minimizes the sum of their expected losses. This equilibrium need not be the cooperative outcome p^c, since it is not clear a priori whether this solution lies within the equilibrium set P.

In the next proposition, we show that the cooperative outcome can be decentralized as an equilibrium of the game if and only if the extradition cost is sufficiently large compared to the harm,

Proposition 5. *The cooperative (efficient) outcome is an equilibrium of the non-cooperative game if and only if x is large enough — i.e.,*

$$p^c \in P \quad \Leftrightarrow \quad x \geq x^* \triangleq \frac{hg(0)}{p_L^* z(0)}.$$

In this region of parameters countries coordinate on p^c. By contrast, $p^c < p_L^*$ if $x < x^*$ and the countries coordinate on the least expensive equilibrium p_L^*.

Hence, the cooperative solution cannot be decentralized when the extradition cost is relatively small. Indeed, in this region of parameters, countries tend to overinvest in enforcement when playing non-cooperatively, since insourcing foreign criminals is relatively more costly than paying the extradition cost. By contrast, when the extradition cost is sufficiently large, setting a high enforcement level may induce fleeing, which requires countries to pay for the extradition procedures. The fear of incurring this cost may then lead countries to coordinate on equilibria featuring an enforcement level below the cooperative solution, which does not take extradition costs into account. As a result, in this region of parameters, the cooperative solution can be decentralized as an equilibrium of the non-cooperative game.

Interestingly, this result implies that international agreements that set a common enforcement standard are required to achieve efficiency when extradition is relatively cheap, while these agreements may not be necessary with a sufficiently high extradition cost. Indeed, if the countries could choose x — e.g., by signing a bilateral treaty setting the rules (and therefore the costs) of extradition procedures — they would choose $x = x^*$, which yields $p_L^* = p^c$. This observation yields the following comparative statics:

Corollary 1. *x^* is increasing in c. The effect of h on x^* is ambiguous.*

The fact that x^* is increasing in c, implies that countries where enforcement is more costly, also need to set (relatively) more costly extradition to achieve efficiency. The reason why the impact of h on x^* is ambiguous is as follows. There are both direct and indirect effects of h on x^*. On the one hand, a higher harm tends to increase the cooperative solution, so that (other things being equal) makes it easier to implement the efficient outcome — i.e., ceteris paribus, as h grows large the minimal extradition cost that implements the efficient outcome drops. On the other hand, more harmful crimes (higher h) request a tougher standard p_L^*, which (other things begin equal) tends to make the implementation of the efficient solution harder — i.e., other things being equal, the minimal extradition cost that implements the efficient solution increase. The tension between these two effects is in general unclear, implying that (when set optimally) extradition costs may not be a monotone function of the seriousness of the crime harm.

Policy and testable implications. The non-cooperative version of the game offers a simple and novel rational for the implementation of relatively costly (e.g., long and highly bureaucratized) extradition produces. One interesting point to notice is that extradition treaties may be easier to enforce than international agreements intended to set a common enforcement standard. Indeed, while monitoring whether the commitment to a given enforcement level has been respected may be hard in practice, the action of extraditing back criminals is relatively easy to observe, and therefore defections from these international agreements can be punished more easily. In this sense, a sharp empirical prediction of our model is that high extradition costs should be negatively correlated with the existence of international cooperation (e.g., bilateral or multilateral treaties) between countries with the aim of fighting mobile crime.

6. Extensions

We now extend the baseline model by considering first endogenous extradition decision and next how asymmetries between countries affect the possibility of asymmetric equilibria.

6.1. Endogenous extradition

Up to this point, we have developed the equilibrium analysis under the assumption that countries always extradite back fugitives. Of course, since countries are symmetric, this is optimal from an ex ante point of view because extradition never occurs in equilibrium. Yet, from an ex post perspective, paying the extradition cost may not be optimal for the demanding country (even if this happens only out of equilibrium). Introducing the possibility for a country to renege on its ax ante commitment to extradite back fugitives undermines the equilibrium characterized above, unless renegotiation is costly. In fact, letting criminals run away or defecting from an international treaty may trigger both internal and foreign reactions that can be costly for policy makers. For example, fugitives may feel less exposed to prosecution and eventually return to commit crimes in their home country, the public opinion may pressure the demanding country to honor its duties, the international community may react by sanctioning or boycotting the deviating county, etc. Hence, the ex post decision of reneging the ax ante commitment to extradite back fugitives has benefits, because it allows the demanding country to save on the extradition cost, but it may also have implicit costs. In what follows we will study how the model's results change when the tension between these two forces is taken into consideration.

In order to strip down the analysis, let us assume that countries pay an (exogenous) reputation cost $\delta \geq 0$ for every fugitive that they do not extradite back. This cost is meant to capture in the simplest possible way the loss of reputation and/or the political price paid by policy makers. It is then straightforward to show that as long as $x \leq \delta$ the equilibrium analysis developed before remains valid — i.e., it is never optimal to renege on the promise of taking fugitives back to their home country. Hence, if countries care enough about reputation — i.e., $\delta \geq x^*$ — the cooperative solution can still be reached. Otherwise, countries can achieve a second best solution by choosing the highest possible extradition cost — i.e., $x = \delta$ — and coordinating on the equilibrium with the lowest enforcement. Clearly, the less countries care about their reputation the more they overinvest in enforcement. This shows that the qualitative conclusions of our analysis remain valid even if extradition is endogenous.

To make an additional step ahead, assume now that extraditing criminals back requires a minimum cost $\underline{x} > 0$. Clearly, as long as $\delta \geq \underline{x}$ the equilibrium analysis developed before remains valid. By contrast, if $\delta < \underline{x}$ there cannot exist an equilibrium in which countries can credibly commit to extradite back their fugitives. Hence, in this case, the analysis changes dramatically. Proceeding backward as before, we first consider the incentive to flee. Criminals operating in country i flee abroad if and only if

$$l \leq p_i \quad \forall i = A, B. \tag{6.1}$$

Notice that, differently from before, the cost of becoming a fugitive does not reflect the probability of being caught abroad because, in the region of parameters under consideration, the demanding country never extradites criminals back.

Similarly, migration from country A to country B occurs if and only if

$$m \leq m_A \triangleq p_A \left(1 - Z\left(p_A\right)\right) - p_B \left(1 - Z\left(p_B\right)\right) + \int_{p_B}^{p_A} l dZ\left(l\right).$$

Assuming without loss of generality that $p_A \geq p_B$ and that $m_A \geq 0$ it is possible to show that there is no migration from country B to country A — i.e., a criminal resident in country B migrates to A if and only if $m \leq -m_A \leq 0$. Moreover, criminals resident in country i commit the crime in the home country if and only if

$$\pi \geq \pi_i \triangleq p_i \left(1 - Z\left(p_i\right)\right) + \int_0^{p_i} l dZ\left(l\right) \quad \forall i = A, B.$$

Finally, an offender who is resident in country A and has migration cost $m \leq m_A$ commits the crime in country B if and only if

$$\pi \geq \pi_B\left(m\right) \triangleq m + p_B.$$

Clearly, the higher is the migration cost, the higher has to be the benefit π for the crime to be profitable for a migrant.

Country i's loss function is

$$\tilde{\mathcal{L}}^i\left(p_i, p_j\right) \triangleq cp_i + \begin{cases} h\left(1 - G\left(m_i\right)\right)\left(1 - F\left(\pi_i\right)\right) & \text{if } p_i \geq p_j \\ \\ h(1 - F\left(\pi_i\right)) + h\int_0^{m_j}\left(1 - F\left(\pi_i\left(m\right)\right)\right) dG\left(m\right) & \text{if } p_i < p_j. \end{cases}$$

Differentiating and imposing symmetry (see the Appendix) we have a the following result.

Proposition 6. *When $\delta < \underline{x}$ the game features a unique symmetric equilibrium p^* characterized by the following condition*

$$h\underbrace{\left(1 - Z\left(p^*\right)\right)}_{\textit{Non-fugitives}}\left[f\left(\pi^*\right) + \left(1 - F\left(\pi^*\right)\right) g\left(0\right)\right] = c,$$

with

$$\pi^* = p^* - \underbrace{\int_0^{p^*} (p^* - l)\, dZ(l)}_{\text{Impunity effect}}.$$

In this equilibrium criminals flee ex post. Moreover, p^* is decreasing with c and increasing with h.

Again, in the symmetric equilibrium of this modified game the countries choose their enforcement so to deter both natives and foreigners to commit crimes within their borders. Yet, because fugitives will not be extradited back, the enforcement is effective only on the mass of criminals that does not manage to flee — i.e., the mass $1 - Z(p^*)$ of non fugitives. Notice that because of fleeing this equilibrium features an additional 'impunity effect' that (other things being equal) makes the crime more profitable than before. Intuitively, criminals have a greater ex ante incentive to commit the crime since they (correctly) anticipate that in the equilibrium they will flee with positive probability.

Finally, we study the welfare properties of the equilibrium in order to check whether countries over- or under-invest compared to an efficiency benchmark, which in this case is 'constrained' by the fact that extradition is not feasible. Hence, ruling out the possibility of extradition, the cooperative solution ($\tilde{p}^c$) is still symmetric, and solves

$$\min_{p \in [0,1]} h(1 - F(\pi(p))) + cp,$$

where

$$\pi(p) \triangleq p - \int_0^p (p - l)\, dZ(l).$$

Differentiating with respect to p we then obtain the following first-order condition

$$h(1 - Z(p)) f'(\pi(p)) = c,$$

which yields immediately $\tilde{p}^c < p^*$. Intuitively, since extradition does not take place, countries have only an incentive to over-invest relative to the cooperative benchmark.

Testable implications. Our modified model provides three very interesting and potentially testable empirical predictions. First, other things being equal, countries with higher enforcement costs c will be less exposed to fleeing, since the equilibrium enforcement p^* will be lower and this will decrease the incentives to flee (see condition 6.1); second, people committing more serious crimes will have a greater incentive to flee. The reason being that, ceteris paribus, the equilibrium enforcement p^* will be higher the higher the harm of the crime committed h, and in turn a higher enforcement will increase the incentives to flee (see again condition 6.1); finally, a larger minimal extradition cost $\underline{x}$ — for instance due to the physical distance between states — increasing the probability that will not exist an equilibrium in which countries can credibly commit to extradite back their fugitives ($\delta < \underline{x}$) will increase both the number of fugitives (in the model from zero to a positive amount) and due to the impunity effect also the amount of crimes.

6.2. Asymmetries in the cost of enforcement

Do countries with different enforcement costs set different enforcement levels in equilibrium? If not, why and under which conditions the equilibrium is asymmetric? Is the country with lowest enforcement cost the most aggressive toward crime? What is the implication of this on the flows of criminals both ex-ante and ex-post?

In the baseline model we assumed that the two countries are symmetric. This is clearly a restrictive assumption, which we relax in this section where we focus on asymmetries in the enforcement cost. Of course, there are other dimensions along which countries can differ — e.g., the harm from the crime (or rather the way this is perceived), the distribution of the migration and fleeing costs, etc. However, our choice is driven by the prominent and growing empirical literature establishing that legal institutions, and in particular law enforcement systems, matter for economic development. For example, exploiting cross-country variation in the quality of enforcement systems around the world, La Porta et al. (1997) show that countries with poorer legal rules and quality of law enforcement, have smaller and narrower capital markets (see, e.g., also Acemoglu and Johnson, 2005, La Porta et al., 1999 and Rajan and Zingales, 1998). There exists also a large literature studying the relation between police manpower and crime (see, e.g., Levitt 1997, McCrary 2002, Evans and Owens 2007, Machin and Marie 2011, Chalfin and McCrary 2017).

Let us then assume, without loss of generality, that $c_A < c_B$ with $\Delta c \triangleq c_B - c_A > 0$. Consider an intuitive candidate equilibrium in which $p_A^* > p_B^*$. In what follows we show that such an equilibrium may not exist for small cost asymmetries Δc and for large extradition costs x, provide sufficient conditions under which it exists and study its determinants.

Following the previous analysis it is easy to show that criminals migrate and flee to country B. Hence, A's solves

$$\min_{p_A \in [0,1]} \left\{ \left(h + x p_B^* Z\left(l_A\right)\right)\left(1 - G\left(m_A\right)\right)\left(1 - F\left(\pi_A\right)\right) + c_A p_A \right\},$$

whose first-order condition yields in an interior solution

$$c_A + xp_B^* (1 - G(m_A))(1 - F(\pi_A)) z(l_A) \frac{\partial l_A}{\partial p_A} =$$
$$(h + xp_B^* Z(l_A)) \left[(1 - G(m_A)) f(\pi_A) \frac{\partial \pi_A}{\partial p_A} + g(m_A) \frac{\partial m_A}{\partial p_A} (1 - F(\pi_A)) \right].$$

The intuition for this expression is as before: by increasing its enforcement level country A reduces the amount of offenses perpetrated within its borders, but it has to pay the extradition cost in addition to a higher cost of enforcement. Let p_A^* denote its solution. Then, assuming again convexity of the countries' loss functions, $p_A^* > p_B^*$ if and only if

$$\lim_{p_A \to p_B^{*+}} \frac{\partial \mathcal{L}^A(\cdot)}{\partial p_A} < 0 \quad \Leftrightarrow \quad c_A < h[f(p_B^*) + (1 - F(p_B^*)) g(0)] - xp_B^* (1 - F(p_B^*)) z(0). \tag{6.2}$$

Next, consider B's minimization problem — i.e.,

$$\min_{p_B \in [0,1]} \left\{ h(1 - F(p_B)) + h \int_0^{m_A} (1 - F(\pi_B(m))) dG(m) + c_B p_B \right\}.$$

Differentiating with respect to p_B in an interior solution we have

$$c_B = hf(p_B) + h \int_0^{m_A} f(\pi_B(m)) dG(m) + h(1 - F(\pi_B(m_A))) g(m_A) \frac{\partial m_A}{\partial p_B}. \tag{6.3}$$

The intuition is the same as before: by increasing its enforcement level country B reduces the amount of offenses perpetrated within its borders, but it also pays a higher cost of enforcement. Let p_B^* denote its solution. Then, convexity of the loss functions implies that $p_B^* < p_A^*$ if and only

$$\lim_{p_B \to p_A^{*-}} \frac{\partial \mathcal{L}^B(\cdot)}{\partial p_B} > 0 \quad \Leftrightarrow \quad c_B > h[f(p_A^*) + (1 - F(p_A^*)) g(0)]. \tag{6.4}$$

Hence, as long as p_A^* and p_B^* satisfy simultaneously (6.2) and (6.4) the game features an asymmetric equilibrium with $p_A^* > p_B^*$.

We can show the following

Proposition 7. *For Δc small enough and x large enough an asymmetric equilibrium with $p_A^* > p_B^*$ does not exist. Moreover, there exists a threshold $\Delta c^* > 0$ such that an asymmetric equilibrium with $p_A^* > p_B^*$ exists if $\Delta c > \Delta c^*$, with Δc^* being increasing in x.*

The intuition is simple. Ceteris paribus, country A has a higher incentive than country

B to deter crime (i.e., by setting a higher enforcement level) since $c_A < c_B$. Yet in the equilibrium candidate criminals flee ex post from A to B, then A's cost advantage is mitigated by the presence of the extradition cost — i.e., A bears the cost x of extraditing criminals back. Therefore, an asymmetric equilibrium exists as long as the cost difference between the two countries is not too large and the extradition cost is not too high.

One interesting empirical implication of this result is that with relatively high extradition costs, countries with different enforcement do not necessarily choose different enforcement levels provided that these asymmetries are not too large. On the contrary, other things being equal, different abilities in fighting crime should be reflected by different enforcement standards only when these asymmetries are large enough.

Finally, as intuition suggests, when an asymmetric equilibrium exists it is not efficient since countries do not internalize the effect of their enforcement choice on the other country. On the one hand, other things being equal, the efficient country (A) overinvests in enforcement (compared to the cooperative benchmark) because in the non-cooperative solution of the game it does not take into account the fact that a stronger enforcement creates migration to country B. On the other hand, the inefficient country (B) underinvests in enforcement (compared to the efficient solution) because it does not take into account the beneficial effect of a marginal increase in deterrence on the extradition cost of the most efficient country.

7. Concluding remarks

We have presented the first formal economic model studying the effects of crime mobility both ex ante (migration) and ex post (fleeing) on the optimal enforcement of criminal law. We have shown that, when extradition is not too costly, countries overinvest in enforcement compared to the cooperative outcome since insourcing foreign criminals is more costly than paying the extradition cost. By contrast, when extradition is sufficiently costly, a large enforcement may induce criminals to flee the country after perpetrating a crime. In this case, the fear of extraditing these criminals back enables countries to coordinate on the efficient outcome. These results contribute to better understand how enforcement systems should be designed when crime is mobile.

Specifically, countries may wish to commit to costly and long extradition procedures, in order to achieve efficiency. In this sense, our model offers a novel rationale for the controversially costly and cumbersome extradition procedures observed around the world (see, e.g., Bassiouni, 2014, Margolies, 2011, and Moore, 1911, among others).

Moreover, we have seen that our model provides many empirical predictions which could guide future empirical work trying to assess the link between enforcement systems, migration and crime. The test of those interesting predictions goes beyond the scope of the present work and is left for future research.

To conclude, it should be recognized that our model overlooks some additional and potentially important forces like a temporal dimension and a more game-theoretically grounded role for reputation. However, even if obtained in a stylized model, our results highlight some salient aspects of the relationship between crime mobility, extradition costs and the efficient design of enforcement systems in a noncooperative framework. Indeed, the basic trade offs emphasized here are likely to be at play also in reacher environments explicitly accounting for asymmetries between countries and for repeated interactions among countries and criminals. We hope to analyze in future research the aspects neglected in this work.

Appendix

Proof of Lemma 1. The proof of this result follows immediately from the comparison between the utility that an individual who has committed a crime in country i obtains when he does not leave that country — i.e., p_i — and the utility that he obtains when he flees the country — i.e., $l + p_j$. ■

Proof of Lemma 2. The proof of this result follows immediately from the comparison between $u_{ii}(p_i, p_j)$ and $u_{ij}(p_i, p_j)$. ■

Proof of Lemma 3. The proof of this result is simple. Differentiating we immediately have

$$\frac{\partial m_i}{\partial p_i} = 1 - Z(l_i) \geq 0,$$

and

$$\frac{\partial m_i}{\partial p_j} = -(1 - Z(l_i)) \leq 0. \quad ■$$

Proof of Proposition 1. In order to study the behavior of the optimal enforcement chosen by country A, it is useful to study the sign of the following derivatives

$$\lim_{p_A \to p_B^+} \frac{\partial \mathcal{L}^A(\cdot)}{\partial p_A} = c - h[f(p_B) + (1 - F(p_B))g(0)] + xp_B(1 - F(p_B))z(0).$$

and

$$\lim_{p_A \to p_B^-} \frac{\partial \mathcal{L}^A(\cdot)}{\partial p_A} = c - [f(p_B) + (1 - F(p_B))g(0)].$$

Where clearly, for given p_B, one has

$$\lim_{p_A \to p_B^+} \frac{\partial \mathcal{L}^A(\cdot)}{\partial p_A} > \lim_{p_A \to p_B^-} \frac{\partial \mathcal{L}^A(\cdot)}{\partial p_A}.$$

Hence,

$$\lim_{p_A \to p_B^+} \frac{\partial \mathcal{L}^A(\cdot)}{\partial p_A} < 0 \quad \Rightarrow \quad \lim_{p_A \to p_B^-} \frac{\partial \mathcal{L}^A(\cdot)}{\partial p_A} < 0,$$

and

$$\lim_{p_A \to p_B^-} \frac{\partial \mathcal{L}^A(\cdot)}{\partial p_A} > 0 \quad \Rightarrow \quad \lim_{p_A \to p_B^+} \frac{\partial \mathcal{L}^A(\cdot)}{\partial p_A} > 0.$$

Therefore, since we assumed that the loss function $\mathcal{L}^A(\cdot)$ is strictly convex, it is optimal for country A to set $p_A^* > p_B$ if and only if

$$c < \Phi_L(p_B) = h[f(p_B) + (1 - F(p_B))g(0)] - xp_B(1 - F(p_B))z(0). \quad (.1)$$

Notice that, $\Phi'_L(p_B) < 0$ by assumption **A1**. Moreover, by **A1** it must also be $\Phi_L(1) < c < \Phi_H(0)$. Hence, there exists a unique value $p_L^* \in (0,1)$, which solves $c = \Phi_L(p_B)$, such that (.1) holds for every $p_B < p_L^*$. As a result, $p_A^* > p_B$ for every $p_B < p_L^*$.

By the same token, it is optimal for country A to set $p_A^* < p_B$ if and only if

$$c > \Phi_H(p_B) = h\left[f(p_B) + (1 - F(p_B))\, g(0)\right]. \tag{.2}$$

Notice that $\Phi'_H(p_B) < 0$ by assumption **A1**. Moreover, by **A1** it must also be $\Phi_H(1) < c < \Phi_H(0)$, there exists a unique value $\overline{p} \in (0,1)$, which solves $c = \Phi_H(p_B)$, such that (.2) holds for every $p_B > p_L^*$. Hence, $p_A^* < p_B$ for every $p_B > p_L^*$.

Finally, it is easy to verify that $\Phi_H(p_B) > \Phi_L(p_B)$ so that $p_H^* > p_L^*$. Hence, $p_A^* = p_B$ for every $p_B \in [p_L^*, p_H^*]$. ■

Proof of Proposition 2. The proof of this result follows immediately from the fact that the functions $\Phi_H(p_B)$ and $\Phi_L(p_B)$ are decreasing in p_B, increasing in h and non-increasing in x. ■

Proof of Lemma 4. Consider a point $(p_A, p_B) \in [0,1]^2$, with $p_A \geq p_B$ without loss of generality. Let $\hat{p} = \frac{1}{2}p_A + \frac{1}{2}p_B$, we want to show that

$$\mathcal{L}^A(p_A, p_B) + \mathcal{L}^B(p_B, p_A) \geq \mathcal{L}^A(\hat{p}, \hat{p}) + \mathcal{L}^B(\hat{p}, \hat{p}) = 2\left[h(1 - F(\hat{p})) + c\hat{p}\right].$$

To begin with notice that $\mathcal{L}^A(p_A, p_B) + \mathcal{L}^B(p_B, p_A) \geq$

$$h(1 - F(\pi_A)) + cp_A + h(1 - F(p_B)) + cp_B - hG(m_A)\left[F(\pi_B(m_A)) - F(\pi_A)\right].$$

Next, recall that $\pi_B(m_A) \triangleq m_A + p_B > m_A$ and that $\pi_A \triangleq m_A + p_B$, so that $\pi_B(m_A) \triangleq \pi_A$. Hence,

$$\begin{gathered} h(1 - F(\pi_A)) + cp_A + h(1 - F(p_B)) + cp_B - hG(m_A)\left[F(\pi_B(m_A)) - F(\pi_A)\right] = \\ h(1 - F(\pi_A)) + cp_A + h(1 - F(p_B)) + cp_B. \end{gathered}$$

Moreover, since $\pi_A \triangleq p_A(1 - Z(l_A)) + p_B Z(l_A) = p_A - l_A Z(l_A) < p_A$, it follows that

$$h(1 - F(\pi_A)) + cp_A + h(1 - F(p_B)) + cp_B > \left[h(1 - F(p_A)) + cp_A\right] + \left[h(1 - F(p_B)) + cp_B\right].$$

Finally, since $f'(\cdot) < 0$ by **A1** it follows that

$$\frac{h(1 - F(p_A)) + cp_A + h(1 - F(p_B)) + cp_B}{2} > \left[h(1 - F(\hat{p})) + c\hat{p}\right],$$

which proves the result. ■

Proof of Proposition 3. Differentiating $h(1 - F(p)) + cp$ with respect to p yields immediately the first-order condition $hf'(p) = c$. By assumption **A1** the objective function is strictly convex. Moreover, **A1** also implies that the solution is interior since $hf'(0) > c > hf'(1)$. ■

Proof of Proposition 4. The proof of this result follows immediately from the proof of Proposition 1. Any $p^* < p_L^*$ cannot be a symmetric equilibrium of the game because it is always profitable for a country to deviate by choosing an enforcement level strictly larger than p_L^* since

$$\frac{\partial \mathcal{L}^A(p_L^*, p_L^*)}{\partial p_A} < 0.$$

Similarly, any $p^* > p_H^*$ cannot be an equilibrium because it is always profitable for a country to deviate by choosing an enforcement level strictly lower than p_H^* since

$$\frac{\partial \mathcal{L}^A(p_H^*, p_H^*)}{\partial p_A} > 0,$$

which concludes the proof. ■

Proof of Proposition 5. Let $\mathcal{L}(p) \triangleq h(1 - F(p)) + cp$. Then, using the definition of p_L^*, notice that

$$\frac{\partial \mathcal{L}(p_L^*)}{\partial p} = -hf(p_L^*) + c = h(1 - F(p_B))(hg(0) - xp_L^* z(0)), \tag{.3}$$

which by the convexity of $\mathcal{L}(p)$ directly implies the result — i.e., $p^c > p_L^*$ if and only if $hg(0) < xp_L^* z(0)$.

Next, using the definition of p_H^*, notice also that,

$$\frac{\partial \mathcal{L}(p_H^*)}{\partial p} = -hf(p_H^*) + c = h(1 - F(p_B))\, hg(0) > 0, \tag{.4}$$

implying, again by the convexity of $\mathcal{L}(p)$, that $p^c < p_H^*$. ■

Proof of Corollary 1. First, showing that x^* is increasing in c is immediate since p_L^* is decreasing in c. Second, differentiating with respect to h we have:

$$\frac{\partial x^*}{\partial h} = \frac{g(0)}{z(0)} \frac{p_L^* - h\frac{\partial p_L^*}{\partial h}}{(p_L^*)^2},$$

whose sign is ambiguous since $\frac{\partial p_L^*}{\partial h} > 0$ by Proposition 2. ■

Convexity of the loss function. We now characterize sufficient conditions under which the loss function $\mathcal{L}^A(\cdot)$ is strictly convex in p_A. Consider first $p_A \geq p_B$. Recall that in this case

$$\mathcal{L}^A(p_A, p_B) = cp_A + (1 - G(m_A))(1 - F(\pi_A)) \times [h + xp_B Z(l_A)]$$

with

$$l_A = p_A - p_B,$$

$$m_A = (1 - Z(l_A))\, l_A + \int_0^{l_A} l dZ(l),$$

and

$$\pi_A = p_A (1 - Z(l_A)) + p_B Z(l_A) + \int_0^{l_A} l dZ(l) = p_B + m_A.$$

Notice that,

$$\frac{\partial^2 \pi_A}{\partial p_A^2} = \frac{\partial^2 m_A}{\partial p_A^2} = -z(l_A).$$

Denote now

$$\beta(p_A) \triangleq (1 - G(m_A))(1 - F(\pi_A)),$$

$$\phi(p_A) \triangleq g(m_A)(1 - F(\pi_A)) + f(\pi_A)(1 - G(m_A)),$$

and

$$\varepsilon(p_A) \triangleq [g'(m_A)(1 - F(\pi_A)) - 2f(\pi_A) g(m_A) + f'(\pi_A)(1 - G(m_A))].$$

Then, it is easy to show that

$$\beta'(p_A) = -\frac{\partial m_A}{\partial p_A}\phi(p_A)$$

and

$$\beta''(p_A) = -\frac{\partial^2 m_A}{\partial p_A^2}\phi(p_A) - \left(\frac{\partial m_A}{\partial p_A}\right)^2 \varepsilon(p_A).$$

Similarly, let

$$\alpha(p_A) \triangleq h + x p_B Z(l_A),$$

with

$$\alpha'(p_A) = x p_B z(l_A) > 0$$

and

$$\alpha''(p_A) = x p_B z'(l_A).$$

Hence, we can rewrite

$$\mathcal{L}^A(p_A, p_B) = c p_A + \beta(p_A)\alpha(p_A)$$

and

$$\frac{\partial^2 \mathcal{L}^A(\cdot)}{\partial p_A^2} > 0 \quad \Leftrightarrow \quad \beta''(\cdot)\alpha(\cdot) + 2\alpha'(\cdot)\beta'(\cdot) + \beta(\cdot)\alpha''(\cdot) > 0,$$

Rearranging terms we have

$$-\alpha(\cdot)\varepsilon(\cdot)\left(\frac{\partial m_A}{\partial p_A}\right)^2 - \phi(\cdot)\left[\frac{\partial^2 m_A}{\partial p_A^2}\alpha(\cdot) + 2x p_B z(\cdot)\frac{\partial m_A}{\partial p_A}\right] + \beta(\cdot) x p_B z'(\cdot) > 0,$$

Assume $z'(\cdot) \geq 0 \geq g'(\cdot)$. Then, since $\varepsilon(\cdot) < 0$, it follows that $\mathcal{L}^A(\cdot)$ is convex if

$$\frac{\partial^2 m_A}{\partial p_A^2}\alpha(\cdot) + 2xp_B z(\cdot)\frac{\partial m_A}{\partial p_A} \leq 0,$$

substituting terms we have

$$2xp_B(1 - Z(l_A)) \leq h + xp_B Z(l_A).$$

A sufficient condition for this inequality to hold is $h \geq 2x$. Summing up, $\mathcal{L}^A(\cdot)$ is convex if $z'(\cdot) \geq 0 \geq g'(\cdot)$ and $h \geq 2x$.

Next, consider $p_A \leq p_B$. Recall that in this case

$$\mathcal{L}^A(p_A, p_B) = cp_A + h\int_{p_A}^{1} dF(\pi) + h\int_{0}^{m_B}(1 - F(\pi_A(m)))\,dG(m),$$

with

$$l_B = p_B - p_A,$$

$$m_B = (1 - Z(l_B))\,l_B + \int_0^{l_B} l dZ(l),$$

and

$$\pi_A(m) \triangleq m + p_A.$$

Therefore, differentiating with respect to p_A, we have

$$\frac{\partial m_B}{\partial p_A} = -(1 - Z(l_B)),$$

and

$$\frac{\partial^2 m_B}{\partial p_A^2} = -z(l_B),$$

which is strictly negative. Recall that $\pi_A(m_B) \triangleq m_B + p_A$, hence

$$\frac{\partial \pi_A(m_B)}{\partial p_A} = Z(l_B),$$

and

$$\frac{\partial^2 \pi_A(m_B)}{\partial p_A^2} = -z(l_B).$$

Differentiating $\mathcal{L}^A(\cdot)$ with respect to p_A

$$\begin{aligned}\frac{\partial^2 \mathcal{L}^A(\cdot)}{\partial p_A^2} &= -\underbrace{hf'(p_A)}_{-} - h\underbrace{\int_0^{m_B} f'(\pi_A(m))\,dG(m)}_{-} + \\ &\underbrace{-hf(\pi_A(m_B))\,g(m_B)\frac{\partial m_B}{\partial p_A}(1+Z(l_B)+z(l_B)\,l_B)}_{-} + \\ &+h(1-F(\pi_A(m_B)))\underbrace{\left[g'(m_B)\left(\frac{\partial m_B}{\partial p_A}\right)^2 + g(m_B)\frac{\partial^2 m_B}{\partial p_A^2}\right]}_{?}.\end{aligned}$$

Assume as before $z'(\cdot) \geq 0 \geq g'(\cdot)$. Since $\frac{\partial m_B}{\partial p_A} < 0$, then $\mathcal{L}^A(\cdot)$ is convex if

$$\begin{aligned}|f'(p_A)| &> -\sup\left[g'(m_B)\left(\frac{\partial m_B}{\partial p_A}\right)^2 + g(m_B)\frac{\partial^2 m_B}{\partial p_A^2}\right] \\ &= -\sup\left[g'(m_B)(1-Z(l_B))^2 - g(m_B)\,z(l_B)\right]\end{aligned}$$

In order to show that this inequality does not define an empty set, suppose for example that $G(\cdot)$ and $Z(\cdot)$ are uniform and that $F(\pi) = \pi^{\frac{1}{\lambda}}$, with $\lambda > 2$. The above condition rewrites as

$$p_A^{\frac{1}{\lambda}-2} > \frac{\lambda^2}{ML(\lambda-1)}.$$

Hence, since $p_A^{\frac{1}{\lambda}-2}$ is decreasing in p_A, it is enough to impose

$$1 > \frac{\lambda^2}{ML(\lambda-1)}.$$

Summing up, we have shown that sufficient conditions under which the countries' loss function is strictly convex can be found. ■

Proof of Proposition 7. We first show that a sufficient condition for an asymmetric equilibrium to exist is Δc non too small, and then we argue that for Δc small enough it does not exist.

An asymmetric equilibrium in which $p_A^* > p_B^*$ exists if and only if

$$c_A < h\left[f(p_B^*) + (1-F(p_B^*))\,g(0)\right] - xp_B^*(1-F(p_B^*))\,z(0). \tag{.5}$$

and

$$c_B > h\left[f(p_A^*) + (1-F(p_A^*))\,g(0)\right]. \tag{.6}$$

Let $\hat{p}_B$ and $\hat{p}_A$ be the solution of

$$c_A = h\left[f\left(p_B\right) + \left(1 - F\left(p_B\right)\right) g\left(0\right)\right] - x p_B \left(1 - F\left(p_B\right)\right) z\left(0\right). \tag{.7}$$

and

$$c_B = h\left[f\left(p_A\right) + \left(1 - F\left(p_A\right)\right) g\left(0\right)\right], \tag{.8}$$

respectively.

Notice that since by Assumption A2 the right-hand sides of (.7) and (.8) are decreasing respectively in p_B and p_A, then it must be $p_A^* > \hat{p}_A$ and $p_B^* < \hat{p}_B$. It then follows that $p_B^* > p_A^*$ together with $p_A^* > \hat{p}_A$ imply

$$\begin{aligned} c_A &< h\left[f\left(p_B^*\right) + \left(1 - F\left(p_B^*\right)\right) g\left(0\right)\right] - x p_B^* \left(1 - F\left(p_B^*\right)\right) z\left(0\right) \\ &< h\left[f\left(p_A^*\right) + \left(1 - F\left(p_A^*\right)\right) g\left(0\right)\right] - x p_A^* \left(1 - F\left(p_A^*\right)\right) z\left(0\right) \\ &< h\left[f\left(\hat{p}_A\right) + \left(1 - F\left(\hat{p}_A\right)\right) g\left(0\right)\right] - x \hat{p}_A \left(1 - F\left(\hat{p}_A\right)\right) z\left(0\right) \\ &= c_B - x \hat{p}_A \left(1 - F\left(\hat{p}_A\right)\right) z\left(0\right). \end{aligned}$$

Hence, a sufficient condition for an asymmetric equilibrium to exist is

$$\Delta c > \Delta c^* \triangleq x \max_{p \in [0,1]} p\left(1 - F\left(p\right)\right) z\left(0\right), \tag{.9}$$

with Δc^* being clearly increasing in x.

Next, in order to show that for $\Delta c \to 0$ the asymmetric equilibrium does cannot exist, recall that we can write $c_A = \Delta c - c_B$. Hence, (.5) rewrites as

$$c_B < \Delta c + h\left[f\left(p_B^*\right) + \left(1 - F\left(p_B^*\right)\right) g\left(0\right)\right] - x p_B^* \left(1 - F\left(p_B^*\right)\right) z\left(0\right), \tag{.10}$$

which is compatible with (.6) if and only if

$$\Delta c + \int_{p_A^*}^{p_B^*} \overline{\Phi}'\left(x\right) dx > x p_B^* \left(1 - F\left(p_B^*\right)\right) z\left(0\right).$$

It then follows that as long as

$$\Delta c \leq \Gamma\left(p_A^*, p_B^*\right) \triangleq x p_B^* \left(1 - F\left(p_B^*\right)\right) z\left(0\right) - \int_{p_A^*}^{p_B^*} \overline{\Phi}'\left(x\right) dx,$$

the asymmetric equilibrium cannot exist. Let $\tilde{p}_B$ be the unique solution of $c_B = hf\left(p_B\right)$.

By condition (6.3) it can be readily seen that $p_B^* > \tilde{p}_B$. Hence, we have

$$
\begin{gathered}
x p_B^* \left(1 - F\left(p_B^*\right)\right) z\left(0\right) - \int_{p_B^*}^{p_A^*} |\overline{\Phi}'\left(x\right)| dx > \\
x \tilde{p}_B \left(1 - F\left(p_B^*\right)\right) z\left(0\right) - \int_{\tilde{p}_B}^{1} |\overline{\Phi}'\left(x\right)| dx > \\
x \tilde{p}_B \left(1 - F\left(\hat{p}_B\right)\right) z\left(0\right) - \int_{\tilde{p}_B}^{1} |\overline{\Phi}'\left(x\right)| dx.
\end{gathered}
$$

Then, since $\frac{\partial \hat{p}_B}{\partial x} < 0$ by Assumption A2 it follows that $\lim_{x \to +\infty} \hat{p}_B \to 0$. As a result, for x sufficiently large it must be

$$
x \tilde{p}_B \left(1 - F\left(\hat{p}_B\right)\right) z\left(0\right) - \int_{\tilde{p}_B}^{1} |\overline{\Phi}'\left(x\right)| dx > 0,
$$

Therefore, an asymmetric equilibrium does not exist for $\Delta c \to 0$ and x large enough. ■

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