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Migrant smuggling to Europe: A two-sector model with directed search*

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Abstract

In the last decade, combating migrant smuggling has emerged as a top priority for the European Union (EU). The market for smuggling services to the EU is characterized by (i) a dual structure, comprising both a segment of organized criminal cartels and one of smaller, self-employed smugglers, (ii) significant trading frictions, and (iii) the ability of smugglers to set fees. A directed search model is well-suited to analyze this market. Comparative statics on the equilibrium solution, along with numerical simulations, allow for a detailed examination of various policies aimed at reducing irregular migration and disrupting the smuggling business. Results indicate that general-purpose policy measures effectively curb migration but may inadvertently bolster cartel profits by pushing self-employed smugglers out of the market. Conversely, policies that specifically target criminal organizations may increase the number of self-employed smugglers, potentially leading to higher irregular border crossings.

Keywords - Migrant smuggling, Directed search, Irregular migration, Organized crime, Migration policy.

JEL Classification - J61, L13, D83

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1 Introduction

In the last decade, the large number of irregular migrants crossing the EU border every year has become an essential policy challenge for the European member countries and the EU itself. After reaching a peak of 1,822,000 illegal border crossings in 2015, the flow has significantly declined, to edge up again after 2021; illegal border crossings reached 330,000 in 2022 and 380,000 in 2023, to fall in 2024 according to preliminary data.[1] Irregular migration can only reach such significant numbers and level of resilience with the support of smugglers (Europol, 2016; Lyuten and Smialowski, 2021). The European Border and Coast Guard Agency (Frontex)[2] reports annual detection of 11,700 smugglers on average between 2014 and 2022 (Frontex, 2019, 2022, 2023). At the peak of the migratory crisis, in 2015, the turnover of the European smuggling market was estimated between 3 and 6 billion euros (Europol, 2016); between 2017 and 2019, it was estimated at some 330 million euros on the Western and Central Mediterranean routes only.[3]

The UN Protocol Against the Smuggling of Migrants (2000) defines migrant smuggling as "the procurement, in order to obtain, directly or indirectly, a financial or other material benefit, of the illegal entry of a person into a State Party of which the person is not a national or a permanent resident".[4] Smugglers provide migrants with the logistics for their long and risky journey, including planning (based on their knowledge of the routes and risks), minimal shelter and food, means of transport, and fake documents; they provide protection against robbery and other crimes, sometimes bribe officials to close their eyes when they cross the controls (Salt and Stein, 1997; IOM, 2019; UNODC, 2018; Frontex, 2021; MacKellar, 2020).

As any illegal market, smuggling involves large trading frictions, resulting from a structural shortage of information and trust, with potential migrants deploying significant efforts to search, gather information, and choose a smuggler (Campana and Gelsthorpe, 2020; Campana, 2020). Smugglers use various channels to advertise their business in railway stations, cafes or bazaars,

[1] See Frontex News Release, January 26, 2024, "Significant rise in irregular border crossings in 2023, highest since 2016", and Frontex News Release, October 15, 2024, "EU external borders: Detections down 42% in first 9 months of 2024".

[2] The European Border and Coast Guard Agency, Frontex, created in 2004, provides operational enforcement services to protect the EU borders and fight against cross-border crime.

[3] See The European Commission, September 2020, "Migration - Acting together to deepen international partnerships".

[4] Art. 3(a), UN Protocol Against the Smuggling of Migrants by Land, Sea and Air, supplementing the United Nations Convention against Transnational Organized Crime, 2000.

through Internet-based social media and world-of-mouth communication (UNODC, 2018; Frontex, 2019; Campana and Gelsthorpe, 2020).

Besides, ethnology and criminology studies that analyzed the substantial irregular migration flows to the EU in the last decade reveal that the market for smuggling services is complex, with both large criminal organizations and smaller fuzzy small businesses involved (Europol, 2016; UNODC, 2018; Campana, 2018; Campana and Gelsthorpe, 2020; Sanchez, 2020; Achilli, 2022; Aziani, 2023). For example, Watt (2024) conducted an ethnological study that provides insights into the market for smuggling services to cross the Channel from the French coast to the United Kingdom (UK). In 2023, this researcher spent time with irregular migrants near Calais, France, who were seeking to cross the Channel to reach the UK. She reveals the trade-off facing migrants: either paying more for the safer service provided by the Kurdish criminal cartel (who often provides services along the entire route), or opting for the easier-to-find and cheaper but riskier small smugglers from Sudan or Northern Africa. These autonomous smugglers charge lower fees but use unfit boats, increasing the risk of death at sea.

This paper provides an analysis of the market for smuggling services that takes into account its dual supply-side structure, consisting of both a cartelized segment dominated by a few large criminal organizations and a competitive segment made up of many small businesses. We model the smuggling market with a directed search approach, well-suited to analyzed opaque markets with substantial trade frictions, where the power to set the fee sits with one side of the market (the smugglers). The analysis reveals complex interactions between the two sectors in the provision of the smuggling service, and cross-sector consequences of various policies.

The study of markets with large trade frictions is the core topic of the search and matching literature. In these models, buyers and sellers spend time and effort to collect information about the other side of the market. They spend time searching (a buyer for a seller, and a seller for a buyer), before a successful match occurs. This contrasts sharply with the elementary neoclassical framework, in which all that buyers and sellers need to know in order to make their optimal choice, is the price of the good or service. In the matching literature, a successful match results from the efforts made by both agents (buyer and seller) to find one another, and from the search technology they use. A successful match generates a positive surplus, to be shared between the buyer and the seller. In early models, inspired by the seminal work of Pissarides (2000), prices have no effect on the matching process: they are determined only after the buyer and the seller meet, and only allow to share the surplus between the two parties.[5] An alternative approach, known

[5]Most papers use the Nash bargaining solution (Nash, 1950) to determine the price and the surplus allocation.

as competitive search equilibrium or directed search, was introduced by Moen (1997) and Peters (1991, 2000) (see Rogerson et al. (2005) and Wright et al. (2021) for surveys). In this framework, markets are divided into smaller sub-markets, or "islands", with perfect mobility of buyers and sellers across these islands. In each sub-market, prices posted by sellers allow buyers to direct their search toward their preferred price offer. Therefore, directed search combines elements of the neoclassical approach where prices have (full) informational value, and traditional matching models, where agents search for a good match in an indiscriminate way and prices just help sharing the surplus. A notable property of the directed search mechanism is the guarantee of Pareto efficiency of the resulting allocation. The directed search mechanism is efficient because it allows buyers and sellers to find their optimal match based on posted prices, unlike the bargaining mechanism, which requires a hard to justify alignment of parameters for efficiency to hold (Hosios, 1990).

In the directed search framework one can represent the smuggling market as including many sub-markets, where smugglers post their fees, and migrants direct their search toward the most attractive offer. A low smuggling fee attracts more migrants to a smuggler, yet reduces the probability of a migrant to meet a smuggler. Therefore, in a market hosting many "small" smugglers, the smuggler chooses an optimal fee in order to maximize its profits given migrants' contract acceptance constraint. In a model with homogeneous migrants and a linearly homogeneous matching function, if smugglers were homogeneous (in terms of the quality of the service provided), then a single smuggling fee would prevail, resulting in a single migrants-to-smuggler ratio (Cahuc et al., 2014; Wright et al., 2021).

However, in the market for smuggling services to the EU, smugglers significantly differ based on their employment status. While a continuum of business arrangement can be observed, in this paper we adopt a simplified perspective and assume that smugglers may either work for a large criminal organization (sector 1), or operate independently as small-business owners (sector 2). Travel conditions and the likelihood of success are sector specific. Migrants can choose to search for cartelized smugglers or opt for self-employed smugglers, depending on the price, quality and matching probability for each type of service provider. With two sectors and cross-sector mobile homogeneous migrants, for both sectors to coexist, migrants must be indifferent to choosing either type of smuggler; in equilibrium the expected utility of traveling with a cartel-employed smuggler or a self-employed one should be equal. Our analysis reveals the (endogenous) proportions of smugglers and migrants directing their search toward each sector, and how the sector-specific smuggling fees are determined.

For EU member states and the EU as a supranational organization, curbing irregular migration and fighting human smuggling is a key policy goal (von der Leyen, 2023), as shown by the implementation of two successive Action Plans against Migrant Smuggling for the periods 2015-2020 and 2021-2025 (European Commission, 2015, 2021).

Official documents also express high concern especially about the criminal cartel segment of the human smuggling market. The renewed EU Action Plan against Migrant Smuggling (European Commission, 2021) highlights the significant threat posed by organized crime, stating:

> "Organised crime structures capable of carrying out sophisticated operations that cover the full range of migrant smuggling services along the entire route constitute a high risk to Europe's security."

Understanding how European policies impact the smuggling market, and especially the cartelized sector of this market, is then crucial for assessing the effectiveness of these action plans.

Using the model for comparative statics and numerical simulations allow us to study the consequences of various policies devised to fight irregular migration and smuggling. Results point to significant and likely unintended cross-sector effects associated to various policies under consideration by the EU and EU-member country governments.

We show that "general-purpose" policies - such as higher penalties for smugglers, increased arrest rates, greater operational costs, improved alternative income for smugglers, or higher migrant push-back rates - would effectively reduce irregular migration, against the background of a lower total number of smugglers. However, these general purpose measures primarily deter smugglers in the small-business segment; on the other hand, the induced "scarcity" of smugglers increases cartel profits. This is obviously at odds with the EU stated goal of combating organized crime in the first place. Measures specifically aimed at making the cartel activity more expensive will help containing the cartels profits. However, these actions might backfire by providing incentive to the expansion of the small-firm segment of the market, potentially leading to an increase in irregular border crossings.

Our paper contributes to the emerging literature on the economics of human smuggling. As noted by MacKellar (2020), while the role of smugglers as facilitators of irregular migration has been well-documented in many policy, legal, and sociological studies, investigations of this activity in economics remain relatively scarce.[6] In particular, the industrial organization of the market for smuggling services presents a challenge to economists.

With evidence existing at that time, Gathmann (2008) acknowledges that the market for smuggling services might be characterized by either perfect competition or a collusive oligopoly model. The latter perspective is explored by Auriol and Mesnard (2016). They assume that smuggling services are provided by a closed oligopoly comprising a limited number of large criminal organizations, similar to drug cartels. Within this framework, the authors find that a combination of tight border controls with the sale of a large number of visas would be an optimal policy, as it would limit the number of irregular migrants while preventing excessive concentration of the smuggling market. In an extension of this work, Auriol et al. (2023) reveal that temporary visas can also irrevocably push smugglers out of the market. A competitive approach to smuggling services is developed by Charlot et al. (2024), who build on the small-firm matching model in the labor market (Pissarides, 2000). A matching model, while allowing for substantial bargaining power for smugglers, presents key characteristics of a competitive market, such as free entry for self-employed smugglers, which drives the asset value of vacant offers to zero. Keita et al. (2023) use the 2015 massive migration to Europe to provide rigorous empirical evidence to the assumption that the supply side of the smuggling market is highly responsive to large demand shocks. In particular, they find that smuggling fees did not significantly increase during the large demand period. They suggest that this is at odds with the closed oligopoly assumption; instead, they show that a simple model of monopolistic competition with product differentiation and free entry of smugglers seem to match well the data.

The analysis in this paper considers the special case of forced migrants, which represents an emerging strand in the migration literature.[7] According to the IOM (2019), forced migration is "a migratory movement which, although the drivers can be diverse, involves force, compulsion, or coercion". The case of forced migrants can be seen as a first level of the analysis, where the number of migrants is predetermined. It must also be acknowledged that the frontier between refugees fleeing conflict, and migrants escaping extreme poverty or climate-related disasters can be thin.

[6] Several papers have analyzed the financial relationship between migrants and the criminal smuggling organization as a provider of transport services as well as financial resources (Friebel and Guriev, 2006; Tamura, 2010, 2013; Djajic and Vinogradova, 2013; Djajic and Michael, 2014; Djajic and Vinogradova, 2014).

[7] For surveys on the economics of forced migration, see Ruiz and Vargas-Silva (2013); Fasani (2016); Maystadt et al. (2019).

In Charlot et al. (2024), we focus on the stages of migration as emphasized in Salt and Stein (1997). Therefore we develop a dynamic analysis, albeit considering a simple market structure (one-sector, small firms, free-entry). In this paper, the essential of the analysis is the interaction between the cartelized and the competitive segment of the smuggling market, and the cross-sector effects of various policies. On a Occam razor principle, we adopt here a static framework, like Auriol and Mesnard (2016); Auriol et al. (2023); Keita et al. (2023), but, differently from them, we allow for trade frictions.

To our knowledge, this paper presents the first analysis of the smuggling market that *(a)* acknowledges its dual structure, as documented by the criminology and ethnography literature on migration to Europe, and *(b)* uses directed search to explain the determination of smuggling fees and tensions in the market. Our two-sector setting may bridge the gap between the two competing assumptions regarding the industrial organization of the smuggling market.

The remainder of the paper is organized as follows. The main assumptions of the model are introduced in section 2. Section 3 determines the equilibrium of the model. Section 4 analyses the policy implications of the model, backed by comparative statics and numerical simulations. Section 5 presents our conclusions.

2 Main assumptions

We analyze the interactions between potential migrants searching for a smuggler, and smugglers - either self-employed or working for criminal organizations - who provide the smuggling service. Because the fee and the quality of the service (probability of finding a smuggler, travel quality, risks) differ from one segment of the market to another, potential migrants will direct their search toward the market that fits best their preferences.

2.1 Numbers of migrants and smugglers

Number of smugglers. Based on evidence from the field as summarized in the introduction, we assume that the smuggling service can be provided either by large criminal organizations, or by self-employed smugglers organized as small businesses.

The two segments of the smuggling market are:

- The cartel-dominated segment, or sector 1. It comprises N identical criminal organizations ($N \geqslant 1$), each hiring s smugglers. The number of smugglers per firm is optimally chosen to maximize the profit of the organization. The total number of smugglers in sector 1 is then $S_1 = Ns$. Barriers to entry are large, thus the number of criminal cartels, N, can be considered as a constant (Auriol and Mesnard, 2016; Auriol et al., 2023).

- The competitive segment, or sector 2. It comprises many self-employed smugglers or "entrepreneurs". The number of smugglers in sector 2 is S_2. We assume free entry of (individual) smugglers in this sector (Charlot et al., 2024).

The total number of smugglers then is:

$$S = S_1 + S_2. \tag{1}$$

Numbers of migrants. Let M be the number of potential migrants. Migrants are assumed to be identical in all respects: they are refugees, fleeing their area of origin to save their lives and that of their families from violence and war. They have no choice but to leave their area of origin. M is therefore an exogenous variable.

In equilibrium, a migrant should be indifferent between directing their search toward the competitive or the cartelized sector; in other words, we study a situation where the two sectors co-exist. Let M_1 and M_2 be the numbers of migrants directing their search respectively towards sector 1 and sector 2. We then can write:

$$M = M_1 + M_2. \tag{2}$$

2.2 Trading frictions and the meeting technology

In the smuggling market, evidence from the field reveals that smugglers have an important control over the smuggling fee, that they advertise via different channels, including social media. We therefore assume that smugglers post fees, while migrants search for a smuggler, directing their search toward a specific sector.[8] To keep the analysis simple, we assume that trading frictions follow the same process in both the cartel and the competitive sector.[9] More precisely, the encounter between migrants and smugglers is characterized by the same meeting technology:

$$H_i = H(M_i, S_i), \text{ with } i = (1, 2). \tag{3}$$

[8]Moen (1997) proves that such a market mechanism is more likely to occur if sellers have a large market power, which is probably the case in the smuggling market.

[9]This means that smugglers in both sectors rely on the same communication and advertising tools and channels. The structure of the problem would not change much if we assume that the meeting technology differs from one sector to another.

In line with the traditional labor market model (Pissarides, 2000), the meeting (or matching) function H is twice continuously differentiable, increasing and concave in both of its arguments, and linearly homogeneous (constant returns to scale). It is such that $H(M_i, S_i) \leqslant \min(M_i, S_i)$ with $i = (1, 2)$. It satisfies the Inada conditions and the boundary conditions ($H(0, S_i) = H(M_i, 0) = 0$ for $M_i, S_i \geqslant 0$ with $i = (1, 2)$).

For the resolution of the model, it is convenient to introduce the concept of market tension, defined as the migrants-to-smugglers ratio in each sector:

$$\theta_1 = \frac{M_1}{S_1} \tag{4}$$

$$\theta_2 = \frac{M_2}{S_2} \tag{5}$$

We can now define the (sector-specific) probability for a smuggler to meet a migrant as h, and the (sector-specific) probability for a migrant to meet a smuggler as g:

$$h(\theta_i) = \frac{H(M_i, S_i)}{S_i} \tag{6}$$

$$g(\theta_i) = \frac{H(M_i, S_i)}{M_i}, \tag{7}$$

with $h, g \in [0, 1], h(0) = 0, h' > 0, h'' < 0$ and $g' < 0$.

The constant-return-to-scale property of the meeting function ensures that:

$$h(\theta_i) = \theta_i g(\theta_i). \tag{8}$$

We denote by ε the elasticity of the likelihood h with respect to θ:

$$\varepsilon(\theta_i) = \frac{\theta_i h'(\theta_i)}{h(\theta_i)}. \tag{9}$$

Because $h(0) = 0$ and $h(\theta)$ is concave, $\varepsilon < 1$. We further assume that $\varepsilon' \leqslant 0$, which is standard in this literature (see Wright et al., 2021).

2.3 Behavior of migrants

As already mentioned in the introduction, in this paper we focus on the case of forced migration. Because potential migrants have no choice but to leave the area of origin, this rules out the important discussion about the self-selection of migrants. In our setting, potential migrants search for a smuggler, which they can find or not. If they find one, they are exposed to multiple risks, during the journey and beyond. To keep the analysis as simple as possible, we assume that migrants are risk-neutral individuals, thus, subject to risky alternatives, they are concerned by the expected income from migration.[10]

The net expected income of the migrant *directing search* towards a smuggler in sector i, with $i = (1, 2)$, is:

$$V_i = g(\theta_i)(\bar{y}_i - p_i) + [1 - g(\theta_i)]\, z, \tag{10}$$

where $g(\theta_i)$ was defined as the likelihood to find a smuggler in sector i, $\bar{y}_i$ is the expected income after contracting with a smuggler in sector i, p_i is the smuggling fee and z is the migrants' income in the area of origin. In areas subject to extreme hardship (war, extreme poverty, drought and climate strain), z is extremely low, and might even tend to zero.

The expected income $\bar{y}_i$ depends on many exogenous variables, related to the possible outcomes of the risky journey from the origin to the destination area. Based on evidence from the field (see UNODC, 2018; Campana and Gelsthorpe, 2020; Brausmann and Djajic, 2022; Charlot et al., 2024), we consider that the migrant can: (a) be intercepted by the border police with a probability η_i; he is then sent back to his origin area (where he obtains z); (b) die during the sea crossing with a probability δ_i; this risky event is associated with a loss $D > 0$; (c) reach the destination and apply for asylum; in this case, with a probability μ he is granted the refugee status and receives the income r, and with probability $(1 - \mu)$ his asylum demand is rejected and he is sent back to his origin area (where he obtains z).[11] The migrant's expected income from migration can then be written as:

$$\bar{y}_i = \eta_i z - \delta_i D + (1 - \eta_i - \delta_i)\left[\mu r + (1 - \mu) z\right]. \tag{11}$$

Most of these parameters have an impact on $\bar{y}_i$ only; however, a parameter such as η_i has direct consequences for the smuggler too.

[10]Migrant's decision under risk is a complex problem, that so far has not been fully elucidated, given the multiplicity of situations, cultural differences and theoretical perspectives on decision making. Some scholars argued that migrants distinguish themselves by a taste for risk (Jaeger et al., 2010; Gibson and McKenzie, 2011), or, in a departure from expected utility theory (EUT), tend to underestimate the likelihood of extreme adverse events or overstate losses (Auriol et al., 2023; Mendogo and Bocquého, 2024). Using quantile maximization, Ceriani and Verme (2018) find that among forced migrants, those who manage to leave the conflict area are the loss-averse individuals. Introducing a utility function to model specific preferences toward risk in a standard EUT framework would not challenge our main results.

[11]We assume that those who have their application rejected are sent back and effectively return to the origin area. To relax that assumption, we could add an additional parameter to take into account the fact that some of those who see their asylum status denied manage to stay as irregular migrants in the destination area, where they could earn a discounted income.

In the following, we will assume that the criminal organization provides a service of better quality than the self-employed smuggler, a situation depicted by Watt (2024) and summarized in the introduction: $\bar{y}_1 \geqslant \bar{y}_2$. This condition is not required to determine the equilibrium of the problem; it is useful for the sensitivity analysis.

2.4 Behavior of smugglers

Smugglers are individuals specialized in facilitating migrant illegal transit and border-crossing. They can be either self-employed entrepreneurs, or work for a large criminal organization. We further assume that the supply of smugglers to both sectors is infinitely elastic for what would be their alternative wage in a honest activity, denoted by $\bar{w}$.

Sector 1 - Criminal organizations. A large criminal organization or a crime cartel is a hierarchy that has many features of a corporation, with tasks assigned to its members by a centralized command team, according to well-designed governance, aiming for efficient steering of resources toward achieving a specific goal. By contrast with the corporation, the criminal organization and the service it produces are illegal.[12]

According to the UNODC (2018), "linkages between smuggling networks and other criminal markets appear to be exceptions rather than the rule." We can then assume that criminal organizations offer only smuggling services, and are not involved in any other criminal activities. Our analysis takes as given the number of smuggling cartels, N.[13]

Following a line of reasoning that can be traced back to the seminal paper by Becker (1968) and was incorporated in the UN definition of transnational crime (UN General Assembly, 2000), we will assume that the main goal of the smuggling cartel is to make the largest profit out of its criminal activity.

The cartel employs a given number of identical smugglers, denoted by s_1. Within the firm, every smuggler can meet and guide h migrants, and generates a fee p_1 per migrant. On the other hand, there is a (constant) marginal cost of smuggling one migrant, denoted by c_1. Thus the

[12]One important international regulation and definition of transnational international crime is the UN Convention Against Transnational Organized Crime, that entered into force in 2003 (UN General Assembly, 2000).

[13]Schelling (1971) noticed that, in general, the number of crime cartels should tend to one, since violent action often leads to absorption of the weaker groups. On the other hand, in European drugs markets, several large criminal organizations appear to be active (Allum and Sands, 2004). In the smuggling market, the number of large criminal organizations tends to be small.

profit margin per smuggler is simply $(p_1 - c_1)h$. Other important costs for the organization are smugglers' wages, hiring costs and organizational costs (a fixed cost).

Turning to wages first, we acknowledge that potential smugglers can work in the legal sector for a (predetermined) wage $\bar{w}$, create their own smuggling business, or work for the cartel on a fixed wage contract.

Because of the large size of the organization, the cartel can submit a "take-or-leave-it" wage offer (Cooper et al., 2007). This wage, denoted by w_1, is paid irrespective of whether or not the smuggler finds a migrant or is intercepted by the border police. Any smuggler working for a cartel can be intercepted at rate η_1 and sent to jail (implying a cost k for him). The zero trade-off condition of the smuggler writes as:

$$(1 - \eta_1)w_1 + \eta_1(w_1 - k) = \bar{w}. \tag{12}$$

It turns out that the cartel must compensate the smuggler for the risk of being intercepted and sent to jail. Thus the smuggler's wage incorporates an arrest risk premium:

$$w_1 = \bar{w} + \eta_1 k. \tag{13}$$

Hiring smugglers also involves trading frictions. A firm that hires smugglers will first open vacancies. In a general model, the probability to fill a vacant job would be endogenous, and would depend on the numbers of available smugglers and open vacancies. In this paper, we make a simplifying assumption according to which the probability to fill a vacancy, ψ, is exogenous.[14] In this case, we can consider that the firm decides directly on the number of smugglers, and adjusts the stock of posted vacancies.[15]

Furthermore, the cost of hiring is assumed to be increasing and convex in the number of vacant jobs (Cooper et al., 2007; Kaas and Kircher, 2015): hiring one more smuggler requires additional effort and expenses, like in any professional organization searching for experienced professionals.

These assumptions pin down to a simple cost of hiring smugglers, denoted $C(s_1/\psi)$. The hiring-cost function is increasing and convex in s_1.

Finally, the functioning of a large criminal organization involves a fixed cost F_1, related to the coordination of the network, headquarters, communication and equipment.

[14]The higher the frictions in the market for smugglers, the lower this probability.

[15]It is the same as considering that the firm decides on the number of posted vacancies and obtains a given number of hires. If the number of posted vacancies is J and the probability to fill one of them is ψ, then the number of smugglers hired by the firm will be just $s = \psi J$.

The profit function of the representative criminal organization is thus:

$$\pi_1 = (p_1 - c_1)\, h\,(\theta_1)\, s_1 - w_1 s_1 - C\,(s_1/\psi) - F_1, \text{ with } w_1 = \bar{w} + \eta_1 k. \tag{14}$$

The key control variables for the profit-maximizing cartel are the number of smugglers working for it (s_1) and the smuggling fee (p_1).

Finally, the number of cartels, N, critically depends on the fixed cost of doing business. Similar to Auriol and Mesnard (2016), we assume that this number is exogenous.

Sector 2 - Self-employed smugglers. In the entrepreneurial sector, any individual can enter the smuggling business as a self-employed person. In this sector, small firms can be freely created, and provide the smuggler with a positive profit.

Denoting by p_2 the smuggling fee in sector 2, by c_2 the marginal cost of smuggling, and by η_2 the probability to be intercepted by the police or coast guards, the expected profit function of a self-employed smuggler is:

$$\pi_2 = (p_2 - c_2)\, h\,(\theta_2) - \eta_2 k. \tag{15}$$

In this expression we acknowledge that both the fee and the cost are delivered upfront (the smuggler obtains the fee even if he is intercepted later on). We expect the criminal organization to provide a better service than the self-employed smuggler. To ensure a higher level of quality, we can assume that the cartel incurs a higher marginal cost than the individual smuggler: $c_1 \geqslant c_2$.

Finally, under free entry, firms enter this market until the expected profit becomes identical to the income (wage) in an alternative activity (legal work):

$$\pi_2 = \bar{w}. \tag{16}$$

The key control variable for the profit-maximizing self-employed smuggler is the smuggling fee (p_2).

3 Solving the model

Within a directed search framework, the smuggling fee (or price) is endogenously determined in each sector. In each market i, the smuggling service is sold against a smuggling fee p_i, and smugglers offer a specific travel contract (the travel contract specifies, for instance, the risks of interception and death during the journey).

3.1 Sector 1 - Criminal organizations

Under directed search, the representative cartel chooses the number of posted vacancies (s_1/ψ) and the smuggling fee (p_1), taking as a constraint the requirement to provide the reserve utility V_1 to migrants searching for a smuggler in sector 1. At the time of the decision, the cartel takes the reserve utility as given.[16]

Using the profit function (eq. 14) and the migrants' utility constraint (eq. 10), the decision problem of the cartel can then be written:

$$\max_{(p_1,s_1)} \quad \{\pi_1 = (p_1 - c_1)\, h(\theta_1)\, s_1 - (\bar{w} + \eta_1 k)\, s_1 - C(s_1/\psi) - F_1\} \tag{17}$$

$$\text{s.t.} \quad g(\theta_1)(\bar{y}_1 - p_1) + [1 - g(\theta_1)]\, z = V_1. \tag{18}$$

The constraint gives us:

$$p_1 = (\bar{y}_1 - z) - \frac{V_1 - z}{g(\theta_1)}. \tag{19}$$

After substitution, the problem becomes:

$$\max_{(\theta_1,s_1)} \quad \{\pi_1 = (\bar{y}_1 - z - c_1)\, h(\theta_1)\, s_1 - [(V_1 - z)\,\theta_1 + \bar{w} + \eta_1 k]\, s_1 - C(s_1/\psi) - F_1\} \tag{20}$$

From the two First Order Conditions (FOCs), we obtain:

$$h^{'}(\theta_1) = \frac{V_1 - z}{\bar{y}_1 - z - c_1} \tag{21}$$

$$\frac{C'(s_1/\psi)}{\psi} = (\bar{y}_1 - z - c_1)\, h(\theta_1) - [(V_1 - z)\,\theta_1 + \bar{w} + \eta_1 k] \tag{22}$$

Equation (21) is equivalent to:

$$V_1 = (\bar{y}_1 - z - c_1)\, h^{'}(\theta_1) + z \tag{23}$$

Using equation (23) to eliminate V_1 from equations (19) and (22), we obtain:

$$C'(s_1/\psi) = \psi\,\{(\bar{y}_1 - z - c_1)\, h(\theta_1)\,[1 - \varepsilon(\theta_1)] - (\bar{w} + \eta_1 k)\} \tag{24}$$

$$p_1 = \bar{y}_1 - z - \varepsilon(\theta_1)(\bar{y}_1 - z - c_1) \tag{25}$$

Equation (23) allows us to determine the tension in the market θ_1, depending on the reserve utility V_1. For this tension, we obtain the number of smugglers working for the cartel $s_1(\theta_1)$

[16] We show later that the reserve utility V_1 is an equilibrium variable, essentially determined in the competitive segment of the smuggling market.

(eq. 24), and the smuggling fee charged by the cartel $p_1(\theta_1)$ (eq. 25). The total number of smugglers in sector 1 is $S_1(\theta_1) = Ns_1(\theta_1)$.

Then, the number of potential migrants directing their search toward the criminal organization is $M_1(\theta_1) = \theta_1 S_1(\theta_1)$.

The maximum profit of the cartel is:

$$\pi_1(\theta_1) \quad = \quad [(p_1(\theta_1) - c_1) h(\theta_1) - (\bar{w} + \eta_1 k)] s_1(\theta_1) - C(s_1(\theta_1)/\psi) - F_1. \tag{26}$$

3.2 Sector 2 - Self-employed smugglers

In sector 2, smugglers can be represented as "small firms": they freely enter this market as long as they obtain a gain larger than their alternative income.

Under directed search, the self-employed smuggler chooses a fee (p_2) to maximize profit, taking as given the requirement to provide the reserve utility V_2 to migrants searching for smugglers in sector 2. At the stage of the decision, the smuggler takes this utility as given.

The decision problem of the entrepreneur is:

$$\max_{p_2} \quad \{\pi_2 = (p_2 - c_2) h(\theta_2) - \eta_2 k\} \tag{27}$$

$$s.t. \quad g(\theta_2)(\bar{y}_2 - p_2) + [1 - g(\theta_2)] = V_2. \tag{28}$$

The constraint allows us to write:

$$p_2 \quad = \quad (\bar{y}_2 - z) - \frac{V_2 - z}{g(\theta_2)}. \tag{29}$$

After substitution, we obtain the equivalent maximization problem:

$$\max_{\theta_2} \quad \{\pi_2 = (\bar{y}_2 - z - c_2) h(\theta_2) - (V_2 - z)\theta_2 - \eta_2 k\}. \tag{30}$$

The FOC implies:

$$h'(\theta_2) \quad = \quad \frac{V_2 - z}{\bar{y}_2 - z - c_2}. \tag{31}$$

For a given tension in the market θ_2, equation (31) allows to determine the reserve utility V_2. Substituting in equation (29), we obtain the optimal fee as a function of θ_2:

$$p_2 \quad = \quad \bar{y}_2 - z - \varepsilon(\theta_2)(\bar{y}_2 - z - c_2). \tag{32}$$

The maximum profit of the self-employed smuggler then is:

$$\pi_2 \quad = \quad (\bar{y}_2 - z - c_2)[1 - \varepsilon(\theta_2)] h(\theta_2) - \eta_2 k. \tag{33}$$

Furthermore, we assume that self-employed (risk neutral) smugglers can freely enter this market. The indifference condition yields $\pi_2 = \bar{w}$ (eq. 16).

Using the profit expression, we obtain an implicit definition of θ_2^*:

$$h(\theta_2^*)[1 - \varepsilon(\theta_2^*)] = \frac{\bar{w} + \eta_2 k}{\bar{y}_2 - z - c_2}. \tag{34}$$

We assume that this equation has a solution. Then, it can easily be shown that this solution is unique, since the function $G(\theta_2) = h(\theta_2)[1 - \varepsilon(\theta_2)]$ is positive (with $\lim_{\theta_2 \to 0} G(\theta_2) = 0$) and increasing in θ_2.

With solution θ_2^* in hands, we can then determine V_2^* and p_2^* from equations (31) and (32):

$$V_2^* = (\bar{y}_2 - z - c_2) h'(\theta_2^*) + z \tag{35}$$

$$p_2^* = \bar{y}_2 - z - \varepsilon(\theta_2^*)(\bar{y}_2 - z - c_2) \tag{36}$$

3.3 The competitive search equilibrium

So far, we analyzed the optimal choices of the firms in sectors 1 and 2 in relative isolation, taking as given the utility constraint of the migrants in each market. However, as long as the two sectors co-exist, in the equilibrium of the smuggling market, identical migrants should be indifferent between taking the journey with a cartel-employed smuggler or an independent one. This leads to the following indifference condition:

$$V_1^* = V_2^* = V^*. \tag{37}$$

Thus the reserve utility in sector 1 depends on the terms of the contracts in sector 2, revealing cross-sector effects.

The competitive search equilibrium can then be defined as an n-tuple $[V^*, \theta_1^*, \theta_2^*, p_1^*, p_2^*, S_1^*, S_2^*, M_1^*, M_2^*]$. Indeed, combining condition (37) with equations (23), (24) and (25), we can determine θ_1^*, p_1^*, s_1^*, and then, the total number of smugglers in sector 1, $S_1^* = Ns_1^*$ as well as the number of migrants directing search toward the cartels, $M_1^* = \theta_1^* S_1^*$.

Then, we obtain the number of smugglers directing their search towards the competitive sector, $M_2^* = M - M_1^*$, and the number of self-employed smugglers:

$$S_2^* = \frac{M_2^*}{\theta_2^*} = \frac{M - M_1^*}{\theta_2^*}. \tag{38}$$

We can thus solve the model and find all the endogenous variables as implicit functions of the parameters. The main optimization and equilibrium equations are presented in Appendix A.1, A.2 and A.3.

Finally, an important variable for policy purposes is the number of migrants reaching the borders of the EU (asylum seekers):

$$M_{dest} = g\left(\theta_1^*\right) M_1^* \left(1 - \eta_1 - \delta_1\right) + g\left(\theta_2^*\right) M_2^* \left(1 - \eta_2 - \delta_2\right). \tag{39}$$

Note that in the special case where anti-cartel policies succeed in driving all crime cartels out of the market (profits fall below the lowest fixed cost), the full market will be occupied by the self-employed smugglers. Then equation (34) defines the tension θ; the number of self-employed smugglers is simply $S = M/\theta$.

3.4 Comparing the sectors

In the introduction we explained why it is plausible to assume that the criminal organization, with its strong network and advanced logistic, would provide a better service than the self-employed smuggler, or $\bar{y}_1 \geqslant \bar{y}_2$. This improved service implies a higher marginal cost ($c_1 \geqslant c_2$). However, we assume that the difference in terms of expected incomes overcomes the difference in terms of marginal costs, so that the surplus can be ordered as $\bar{y}_1 - c_1 \geqslant \bar{y}_2 - c_2$. This allows us to show two interesting properties that will be verified in the numerical simulation later on.

Proposition 1. *The tension in the cartel sector is higher than the tension in the competitive sector.*

Proof. The equality of reserve utilities in both sectors implies that $\left(\bar{y}_1 - z - c_1\right) h'\left(\theta_1^*\right) = \left(\bar{y}_2 - z - c_2\right) h'\left(\theta_2^*\right)$. Since h' is decreasing, if $\bar{y}_1 - c_1 \geqslant \bar{y}_2 - c_2$, then $\theta_1^* \geqslant \theta_2^*$. □

Proposition 2. *The fee charged by smugglers in the cartel sector is higher than the fee charged by smugglers in the competitive sector.*

Proof. Combining the fee equations (25) and (36), the gap between the fees in the different sectors can be written: $p_1^* - p_2^* = \left(\bar{y}_1 - z - c_1\right)\left[1 - \varepsilon\left(\theta_1^*\right)\right]\left\{1 - \left(\frac{\bar{y}_2 - z - c_2}{\bar{y}_1 - z - c_1}\right)\left[\frac{1-\varepsilon\left(\theta_2^*\right)}{1-\varepsilon\left(\theta_1^*\right)}\right]\right\} + \left(c_1 - c_2\right)$.

If $\bar{y}_1 - c_1 \geqslant \bar{y}_2 - c_2$, then $\theta_1^* \geqslant \theta_2^*$. Since ε is a decreasing function, then $\frac{1-\varepsilon\left(\theta_2^*\right)}{1-\varepsilon\left(\theta_1^*\right)} \leqslant 1$ and $p_1^* - p_2^* \geqslant 0$ (we assume that $c_1 \geqslant c_2$). □

The service provided by the criminal organization is of better quality, leading to a higher price. However, the probability to which a migrant meets a smuggler is lower in the cartel sector than in the competitive one.

3.5 Comparative statics

Building on the definition of the competitive search equilibrium, we analyze the consequences of various policy measures on a set of key variables of interest for policy-making: the migrants' expected utility $V^* = V_1^* = V_2^*$, the smuggling fees p_1^* and p_2^*, the profits in each sector π_1^* and π_2^*, the number of smugglers in each sector S_1^* and S_2^*, the number of migrants directing their search toward each sector M_1^* and M_2^* and the number of migrants reaching destination M_{dest}^*.

Equilibrium tensions θ_1^* and θ_2^* are essential for understanding the equilibrium of this market, since the key variables of interest are functions of parameters and of these market tensions, which also depend on the parameters of the problem. A change in parameters has therefore a direct and an indirect effect (via changes in θ_i^*) on the policy variables.

The following propositions summarize the effects of changes in policy-related parameters on the smuggling market tensions and on the other variables of interest as resulting from elementary comparative statics (calculations are presented in Appendix A.4; in the same Appendix, Table A.1 provides a synthesis of all comparative statics results).

Hereafter we just emphasize the main results, and also point out the absence of results when this information is relevant. The thorough analysis of real-life policies and the explanations related to the mechanisms driving the important effects will be presented in the next section, which will introduce a numerical simulation to remove the ambiguity surrounding the undetermined effects.

Proposition 3. ***Impact of a change in the conviction penalty.***
An increase in the conviction penalty (k) *leads to:*

- *an increase in the market tensions* (θ_1^*, θ_2^*) *and the smuggling fees* (p_1^*, p_2^*)*,*
- *a decrease in the migrants expected utility* V^**,*
- *no changes in the profits in the competitive sector* (π_2^*)*,*
- *an unknown change in the profits in the competitive sector* (π_1^*)*, the numbers of searching smugglers and migrants in each sector* $(S_1^*, S_2^*, M_1^*, M_2^*)$*, and the number of migrants reaching destination* (M_{dest}^*)*.*

Proposition 4. ***Impact of a change in the arrest rate in the cartel sector.***
An increase in the arrest rate in the cartel sector (η_1) *leads to:*

- *a decrease in the market tension, the smuggling fee, the profits and the number of smugglers in the cartel sector (θ_1^*, p_1^*, π_1^*, S_1^*),*

- *no changes in the migrants expected utility V^*, the market tension, the smuggling fee and the profits in the competitive sector (θ_2^*, p_2^*, π_2^*),*

- *an unknown change in the number of smugglers in the competitive sector (S_2^*), the total number of smugglers (S^*), the numbers of searching migrants in each sector (M_1^*, M_2^*), and the number of migrants reaching destination (M_{dest}^*).*

Proposition 5. ***Impact of a change in the alternative income of smugglers.***
An increase in the alternative income of smugglers, $\bar{w}$, leads to:

- *an increase in the market tensions (θ_1^*, θ_2^*), the smuggling fees (p_1^*, p_2^*) and the profits of self-employed smugglers (π_2^*),*

- *a decrease in the migrants expected utility V^*,*

- *an unknown change the profits in the cartel sector (π_1^*), the numbers of searching smugglers and migrants in each sector ($S_1^*, S_2^*, M_1^*, M_2^*$), and the number of migrants reaching destination (M_{dest}^*).*

Proposition 6. ***Impact of a change in the rate of granting asylum.***
An increase in the asylum-granting rate, μ, leads to:

- *an increase in the migrants expected utility V^* and the smuggling fee in the competitive sector p_2^*,*

- *a decrease in the market tensions (θ_1^*, θ_2^*),*

- *no changes in the profits in the competitive sector (π_2^*),*

- *an unknown change in the smuggling fee and profits in the cartel sector (p_1^*, π_1^*), the numbers of searching smugglers and migrants in each sector ($S_1^*, S_2^*, M_1^*, M_2^*$), and the number of migrants reaching destination (M_{dest}^*).*

4 Policy impact analysis

One important goal of our analysis is to determine the consequences of various policies on the variables of interest. The policies under consideration reflect the current EU action. The renewed EU Action Plan against Migrant Smuggling (2021-2025) (European Commission, 2021) provides an almost exhaustive list of policies undertaken during the first Action Plan (2015-2021), of its achievements and limits. It sets out concrete actions in four main pillars: "improving the law enforcement and judicial response to migrant smuggling; gathering and sharing information; improving the prevention of migrant smuggling and the assistance to vulnerable migrants; and reinforcing cooperation with partner countries". In general, these measures aim at shifting smuggling from a "high profit, low risk" activity to a "high risk, low profit" business, while ensuring the full respect and protection of migrants' human rights.

In a nutshell, a first set of policy measures strives to increase the interception rate and the sanctions for human smuggling; a second set of development measures aims at increasing the alternative income of smugglers in legal occupations, drawing them away from illegal activities. A third set of measures, documented in the New Pact on Migration and Asylum aims at reducing the attractiveness of the EU area for economic migrants, while protecting the asylum rights of refugees.

This section provides an in-depth policy impact analysis, combining the theoretical results from the previous section, with the results from a numerical simulation. To carry out this simulation, we must first introduce specific functions, and then choose a set of parameters.

4.1 Calibration and benchmark solution

The meeting technology and the hiring cost function. Following the traditional matching literature in labor economics, we assume that the migrant/smuggler encounter is driven by the Cobb-Douglas technology:

$$H_i = \nu M_i^{1-\alpha} S_i^{\alpha} \text{ , with } i = (1, 2), \tag{40}$$

where $\nu < 1$ is the search efficiency parameter, and $1 - \alpha$ and α are the meeting elasticities with respect to M and S, with $\alpha < 1$.

The contact probabilities in each sector become: $h(\theta_i) = \nu\theta_i^{1-\alpha}$ and $g(\theta_i) = \nu\theta_i^{-\alpha}$.

The elasticity $\varepsilon(\theta_i)$ as defined in equation (9), is constant: $\varepsilon(\theta_i) = 1 - \alpha$. As a consequence, smuggling fees are independent of the market tensions.

We further assume that the non-wage hiring cost function of the cartel is quadratic (Kaas and Kircher, 2015):

$$C\left(\frac{s_1}{\psi}\right) = b\left(\frac{s_1}{\psi}\right)^2, \tag{41}$$

with $b > 0$ and $\psi \leqslant 1$.[17]

Choice of parameters. Parameters are chosen within an economically meaningful set, but not all of them rely on a precise economic calibration, which would be extremely difficult to implement given the criminal thus hidden nature of smuggling, and the documented lack of data. Therefore the results of the simulation should be seen as a simple attempt to support intuitive reasoning about possible consequences, when theory alone cannot provide a clear answer.

The migrant's income in the area of origin is set to a normalized 10 consumption units ($z = 10$).[18] The income of a migrant who receives the refugee status in the destination area is assumed to be much higher and set to 300 consumption units ($r = 300 = 30z$). The number of potential migrants is set to a normalized 1000 ($M = 1000$) (in the light of actual numbers of irregular migrants, the unit of measure could be one thousand persons).

The alternative income for a smuggler (in a legal occupation) is set to 20 ($\bar{w} = 20$). We choose a penalty for the arrested smuggler equal to 40 ($k = 40 = 2\bar{w}$), which represents a relatively large disutility of the latter from imprisonment.

To keep the model simple, we assume that the detection probability is the same for migrants and smugglers. Hoffmann Pham and Komiyama (2024) estimated the probability of the Libyan Border Police to intercept migrants' ships to something close to 15% before 2016, to approximately 50% after 2018. The probability of the border police to intercept and arrest smugglers in the self-employed sector is set at 25% ($\eta_2 = 0.25$). On the other hand, the probability to intercept smugglers under the control of the organized crime cartel is much lower, as the latter can corrupt the administration, so we set it to a lower 10% ($\eta_1 = 0.1$).

The parameter defining the acceptance rate of incoming irregular migrants (μ) is difficult to infer. According to the report of the EUAA (2023), in 2022, the EU granted a "stay" decision (asylum and humanitarian) to 50% of the migrants arriving. However, with more granularity, this ratio increases to approximately 90% for migrants arriving from known war areas (Syria,

[17] With these specific functions, the model presents explicit analytical solutions, as shown in Appendix A.1, A.2 and A.3. This does not remove the need for numerical simulations insofar as the explicit solutions do not resolve the indeterminacy of the impact of policy-parameters on key variables as emphasized by the general case.

[18] A solution can be obtained for a wide range of z including zero.

Eritrea). For the benchmark, since we focus on the case of forced migrants, we therefore set $\mu = 0.9$, and study the consequences of making it vary around this value.

Every year many migrants die while attempting to cross the Mediterranean sea, as their overloaded makeshift boats break during the journey, often lacking fuel. The most dangerous route is the Central Mediterranean one; the IOM reports that at least 20,000 people died there between 2014 and 2022, and calls attention on this dramatic humanitarian crisis. On the other hand, Frontex recorded some 765,000 illegal border crossings on the same route over the same period (probably many other migrants crossed the border without being noticed). This hints to a probability to die during the journey that can be as high as 2.5% of total crossings.[19] In our simulations, we set to 2.5% the death risk associated to the cartel ($\delta_1 = 0.025$), and to a higher 5% rate the risk to die with the self-employed sector ($\delta_1 = 0.05$) as the latter will use wrecked, smaller boats, with limited fuel (Watt, 2024). We set the ex-ante utility loss of dying during the sea crossing to a relatively large number, $D = 1000$.

In line with the remark in Section 3.1 that the number of criminal organizations is low, for the purpose of this numerical analysis we set the number of crime cartels to 2 ($N = 2$), and set the fixed cost for each of the cartels to 250 ($F = 250$).[20] For the hiring cost function, we set the parameter b to 0.5 and assume that hiring frictions are such that the parameter ψ is equal to 0.9 (the firm must post 1.1 vacant jobs to hire one smuggler).

The parameter of the meeting technology are such that the meeting elasticities with respect to M and S are the same ($\alpha = 0.5$), and the search efficiency parameter is quite low, in line with the important trading frictions on this market ($\nu = 0.33$).

Finally, we also assume that the marginal cost of smuggling one migrant is the same for the cartel and for the self-employed smuggler ($c_1 = c_2 = c$). We set this cost to 5, or 25% of $\bar{w}$.

Parameter values for the benchmark are summarized in Table 1.

[19] See the IOM News on April 2023 and the Frontex data; data reported by Hoffmann Pham and Komiyama (2024) reveal a similar ratio.

[20] Fixed cost heterogeneity could be used to explain cartels quitting this market in a predetermined order as a result to various anti-cartel policies.

Table 1: Parameter values in the benchmark case

$M = 1000$	$z = 10$	$r = 300$	$\mu = 0.9$
$\nu = 0.33$	$\alpha = 0.5$	$b = 0.5$	$\psi = 0.9$
$N = 2$	$F = 250$	$c_1 = 5$	$c_2 = 5$
$\eta_1 = 0.1$	$\eta_2 = 0.25$	$k = 40$	$\bar{w} = 20$
$\delta_1 = 0.025$	$\delta_2 = 0.05$	$D = 1000$	

The benchmark solution. For these parameter values and specific functions, an equilibrium exists; the equilibrium variables are displayed in the second column of Table 2. The migrant's expected gain from successful migration with the cartel is approximately equal to 200 ($\bar{y}_1 = 213.1$), while migrating with the individual smuggler grants him an expected income approximately equal to 140 ($\bar{y}_2 = 142.2$). With identical marginal costs, these income differences translate into a higher smuggling fee in the cartel sector.

There are on average 2 migrants per smuggler in the cartel sector, and almost 5 in the competitive sector. However, the number of smugglers is much larger in the competitive sector compared to the cartel sector (307 vs. 79), so that the likelihood for a migrant to find a smuggler in the competitive sector (0.24) is higher than in the cartel sector (0.15). Due to the many frictions and risks, only 152 migrants out of 1000 migrants searching for a smuggler manage to reach the EU borders.

Building on this *benchmark*, we can now analyze - one by one - the effects of various policies. We will distinguish between "general purpose" policies, aiming at making smugglers' activity more difficult regardless of the sector, and "targeted measures", which focus on the business of the large criminal organizations and their specific operation channels.

4.2 Higher sanctions for smugglers

With the adoption of the renewed EU Action Plan against Migrant Smuggling (2021-2025) in September 2021, a "Facilitators package" required EU member states "to appropriately sanction anyone who intentionally assists a non-EU national to enter or transit through an EU country or, for financial gain, to reside there". Many states followed-up by adopting stricter definition of human smuggling and criminalizing this activity, while standardizing sanctions across EU states (Sanchez et al., 2024).

The EU also implemented many agreements with migrant transit countries, in particular those on the Southern board of the Mediterranean sea (Egypt, Libya, Tunisia, Mauritania), providing financial support, advice and various incentives for these countries to strengthen their own border policy and fight human smuggling. The Financial Times provides information about the agreement between the EU and Tunisia which is the showcase for other agreements.[21] After the signature of the agreement in 2022, interceptions of people at sea by the Tunisian authorities doubled in 2023 to 81,000. Two-thirds of the €105 mn pledged under the deal are dedicated to border management. Overall, the EU is projected to spend €278 mn on migration in Tunisia until 2027.

All these actions can be represented in our analysis by a higher penalty k, and eventually a homogeneous increase in the probability to intercept smugglers in both sectors. Table 2 reveals the effects of a higher penalty.

As expected, the higher penalty entails a lower number or irregular border crossings, associated to a lower total number of smugglers, in line with one of the EU policy goals. However, when k increases, the number of smugglers decreases in the small-business sector while the number of smugglers hired by the criminal organization increases, as well as the number of migrants per cartelized smuggler. As a consequence, the total profit of the cartel increases (at constant fees), which is at odds with the policy goal of fighting in priority large criminal organizations. Actually, the cartel will benefit from the shortage of self-employed smugglers, by increasing its activity.

The mechanism leading to this result is relatively complex, even in the case of the Cobb-Douglas meeting technology that "sterilizes" the effect of changes in the market tensions on the smuggling fees. With a higher penalty, some self-employed smugglers will leave the market, which deteriorates migrants' utility in both sectors. The cartel in sector 1 must pay a higher wage, yet, due to the deterioration of the utility, can offer a higher probability for the smuggler to meet a migrant (i.e., more migrants per smuggler). This effect offsets the higher wage, and brings about a higher profit to the cartel. Migrants are now exposed to a lower likelihood to meet a smuggler in both sectors, thus the total number of irregular border crossings decline (for an invariant number of candidates to migration).

[21] See the Financial Times, April 10, 2024, How Europe is paying other countries to police its borders, by Laura Dubois and Adam Samson.

Table 2: Simulation results for policies impacting convicted smugglers' penalty

	(1) $k = 35$			(2) Benchmark $k = 40$			(3) $k = 45$		
	Cartel	Comp.	Total	Cartel	Comp.	Total	Cartel	Comp.	Total
Migr. exp. income y	213.1	142.2		213.1	142.2		213.1	142.2	
Tension θ^*	4.46	1.83		4.86	2.00		5.27	2.17	
Smug. contact prob. $h(\theta^*)$	0.70	0.45		0.73	0.47		0.76	0.49	
Mig. contact prob. $g(\theta^*)$	0.16	0.25		0.15	0.24		0.14	0.23	
Smuggling fee p^*	104.0	68.6		104.0	68.6		104.0	68.6	
Expected utility V^*	25.6	25.6		25.0	25.0		24.4	24.4	
Profit per smuggler π^*	16.6	20		18.0	20		19.6	20	
Cartel total profit Π^*	616.3			713.8			816.0		
Smugglers S^*	75	361	436	79	307	386	83	258	341
Potential migrants M^*	334	666	1000	384	616	1000	438	562	1000
Total border crossings M^*_{dest}			161			152			145

Note: Column (2) reports benchmark results, with parameters values summarized in Table 1.

This then raises the following question: what would be the consequence of policy actions targeting the criminal organization and making only its activity more difficult? In Table 3, we analyze the consequences of increasing the risk of intercepting the cartel-related smugglers only, keeping constant the interception rate of the self-employed smugglers.

Table 3: Simulation results for policies impacting smugglers' arrest probability

	(1) $\eta_1 = 0.05$			(2) Benchmark $\eta_1 = 0.10$			(3) $\eta_1 = 0.15$		
	Cartel	Comp.	Total	Cartel	Comp.	Total	Cartel	Comp.	Total
Migr. exp. income y	226.2	142.2		213.1	142.2		200	142.2	
Tension θ^*	5.51	2.00		4.86	2.00		4.23	2.00	
Smug. contact prob. $h(\theta^*)$	0.78	0.47		0.73	0.47		0.68	0.47	
Mig. contact prob. $g(\theta^*)$	0.14	0.24		0.15	0.24		0.16	0.24	
Smuggling fee p^*	110.6	68.6		104.0	68.6		97.5	68.6	
Expected utility V^*	25	25		25	25		25	25	
Profit per smuggler π^*	25.0	20		18.0	20		10.5	20	
Cartel total profit Π^*	1241.0			713.8			319.8		
Smugglers S^*	98	228	326	79	307	386	61	370	431
Potential migrants M^*	543	457	1000	384	616	1000	258	742	1000
Total border crossings M^*_{dest}			146			152			157

Note: Column (2) reports benchmark results, with parameters values summarized in Table 1.

This measure appears to be extremely effective in cutting the cartel's total profit; yet, it leads to a larger number of irregular border crossings. The intuition behind this results lies in the market frictions. The increase in the arrest probability in sector 1 leads to a lower expected income from being smuggled by a cartel, in turn leading to a lower smuggling fee in that sector. The cartel's profit is sensible to the decrease in the smuggling fee. For lower profit margins and a convex cost of hiring smugglers, the cartel will cut down employment, which reduces migrants chances to find a smuggler in this sector, and prompt some of them to search for a smuggler in the competitive sector. With more migrants directing their search toward the competitive sector, more smugglers enter this sector (the market tension θ_2 does not vary). As a consequence, the number of irregular border crossings edges up, despite the higher arrest rate for cartel smugglers.

We provide in Appendix A.5 the simulation for higher smuggling costs, both as a general purpose measure rising costs in both sectors in an undiscriminate way (Table A.2), or as a targeted measure, rising costs for the criminal organizations only (Table A.3). The outcome of these policies is similar to that of the above-mentioned measures. A higher and undifferentiated variable cost c contributes to cut down irregular migration, but pushes up the cartel's profits. A measure that targets the variable cost of the cartel only pushes down the cartel's profits, but supports expansion of smuggling in the small business sector, ultimately leading to more irregular migrants reaching the EU borders.

4.3 The alternative income of the smugglers

The new migration strategy of the EU relies on partnerships with several countries of origin and transit to the EU (European Commission, 2021), including recent initiatives with Tunisia, Mauritania and Egypt. Migration is addressed as a chapter within multi-purpose actions in other key areas such as economy and trade, investments in green energy, security and people-to-people relations.[22] Many of these measures aim to improve living standards and job opportunities in the origin and transit countries, in order to decrease the incentives for potential migrants to come to Europe. In our framework, these actions can be represented by an increase in the alternative income of smugglers in the formal sector (a higher $\bar{w}$).

The theoretical calculations show that an increase in the alternative income for smugglers leads to an increase in the market tensions in both sectors, and a decrease in the expected utilities from migration. The latter is essentially the outcome of a lower likelihood to meet a smuggler.

[22] See EU Commission Press Release, 12 March 2024, "Commission takes stock of key achievements on migration and asylum".

As shown in Table 4, the simulation shows that overall, this measure appears to be quite effective in decreasing the number of illegal border crossings.

However, in this context too, the fall in the total number of smugglers hides disparity across sectors: the number of smugglers in sector 1 actually increases while the number of individual smugglers decreases more rapidly. In the end, the cartel sector expands, both in terms of number of smugglers and profit levels, while the competitive sectors shrinks despite the increase in profits.

These contrasting results (a lower number of irregular migrants, *cum* higher profits for the cartel) are also grounded in the complex dynamics of this dual-market. All other things being equal, an increase in the alternative income makes the hiring of smugglers more expensive for the cartel, and the smuggling business less attractive for self-employed smugglers who can find a job in the official market. With less smugglers in the market (and an invariant smuggling fee), the likelihood to meet a smuggler in each sector as well as the expected utility of a migrant decline. The fall in migrants' expected utility allows the cartel to offer journeys with more migrants per smuggler, which ultimately brings about higher profits, despite a higher wage per smuggler.

Table 4: Simulation results for policies impacting the alternative income of the smugglers

	(1) $\bar{w} = 15$			(2) Benchmark $\bar{w} = 20$			(3) $\bar{w} = 25$		
	Cartel	Comp.	Total	Cartel	Comp.	Total	Cartel	Comp.	Total
Migr. exp. income y	213.1	142.2		213.1	142.2		213.1	142.2	
Tension θ^*	3.37	1.39		4.86	2.00		6.61	2.72	
Smug. contact prob. $h(\theta^*)$	0.61	0.39		0.73	0.47		0.86	0.55	
Mig. contact prob. $g(\theta^*)$	0.18	0.28		0.15	0.24		0.13	0.20	
Smuggling fee p^*	104.0	68.6		104.0	68.6		104.0	68.6	
Expected utility V^*	28	28		25	25		22.8	22.8	
Profit per smuggler π^*	13.4	15		18.0	20		22.4	25	
Cartel total profit Π^*	452			713.8			1016.0		
Smugglers S^*	67	555	622	79	307	386	90	147	237
Potential migrants M^*	228	772	1000	384	616	1000	599	401	1000
Total border crossings M^*_{dest}			189			152			124

Note: Column (2) reports benchmark results, with parameters values summarized in Table 1.

4.4 The rate of granting asylum

With the rise in irregular migration after 2015, and the difficulties encountered by the arrival countries in managing these large flows of people (Greece, Italy, Spain), many voices called for new restrictions on asylum rights and were followed by the European Commission in the proposal for a New Pact on Migration and Asylum, adopted in May 2024.[23] This Pact includes a mechanism for redistributing refugees between the EU member countries, provisions for examining the demands out of the EU borders, improved monitoring and control of the applications, better security checks, and measures to smooth the process of sending back migrants who do not qualify for the asylum status.

In our analysis, these measures can be represented by a decrease in the parameter μ. We represent in Table 5 the effect of this change.

Table 5: Simulation results for policies impacting the probability of being granted the refugee status

	(1) $\mu = 0.80$			(2) Benchmark $\mu = 0.90$			(3) $\mu = 0.95$		
	Cartel	Comp.	Total	Cartel	Comp.	Total	Cartel	Comp.	Total
Migr. exp. income y	187.8	121.9		213.1	142.2		225.8	152.4	
Tension θ^*	7.4	2.8		4.86	2.00		4.04	1.71	
Smug. contact prob. $h(\theta^*)$	0.91	0.56		0.73	0.47		0.67	0.44	
Mig. contact prob. $g(\theta^*)$	0.12	0.20		0.15	0.24		0.17	0.25	
Smuggling fee p^*	91.4	58.4		104	68.6		110.4	73.7	
Expected utility V^*	20.6	20.6		25	25		27.5	27.5	
Profit per smuggler π^*	21.4	20		18.0	20		16.7	20	
Cartel total profit Π^*	946.0			713.8			632.0		
Smugglers S^*	88	123	211	79	307	386	76	404	480
Potential migrants M^*	652	348	1000	384	616	1000	306	694	1000
Total border crossings M^*_{dest}			118			152			167

Note: Column (2) reports benchmark results, with parameters values summarized in Table 1.

As expected, this general purpose measure (cutting μ) as applying to migrants coming through both channels, leads to a lower number of irregular border crossings; unfortunately, the same undesired effect as in the previous analysis - a higher profit for cartels - is at work.

The intuition of this outcome follows the same logic as before. The first consequence of a lower μ is a reduction in the migrant expected income, which in turn brings about a lower smuggling fee in both sectors. The expected utility of a migrant searching for a smuggler can only decline. While in the competitive sector the lower smuggling fee push some smugglers out of the illegal business, the cartel takes advantage of the looser utility constraint to offer journeys with more migrants per smuggler (tantamount to additional trading frictions for the migrant). This allows the cartel to increase its profits, despite the lower smuggling fee. Migrants drop their search for a

[23]See Promoting our European way of life - Protecting our citizens and our values.

smuggler in the competitive sector (more congested) and redirect their search towards the cartel sector.

5 Conclusion

Criminology and ethnographic studies on migrant smuggling to Europe over the last decade have revealed a complex dynamic wherein a few large criminal organizations coexist with numerous small businesses, all aiming to facilitate migrant mobility in high-risk environments, spanning from their places of origin to European borders.

Economists have encountered challenges in modeling this structural duality. Some studies have focused on the dominance of large criminal organizations, conceptualizing the market as a closed oligopoly (Auriol and Mesnard, 2016; Auriol et al., 2023), while others have emphasized the significance of small businesses and highlighted smuggler free-entry in a competitive approach (Charlot et al., 2024; Keita et al., 2023).

This paper introduces two innovations in modeling the market for smuggling services. First, it employs a competitive search equilibrium model to incorporate the significant trading frictions inherent to these criminal activities. Second, the model explicitly considers the dual structure of the market: the cartel segment includes a fixed number of large firms, while the competitive segment includes many small-firm governed by a free-entry condition. This framework accommodates both persistent profits and supply flexibility, aligning with findings from the empirical study by Keita et al. (2023).

The model is solved to determine the cross-sector equilibrium, and changes in parameters are linked to various policy measures implemented by the EU to tackle irregular migration and curb smuggling activities. In the fight against smuggling, the European Commission has prioritized combating criminal organizations, which, in their view, pose a threat to EU security.

Our analysis reveals that general purpose measures such as increasing sanctions for smugglers, improving the alternative income of smugglers and reducing the asylum rate, would indeed reduce the influx of irregular migrants, associated to a decline in the total number of smugglers. However, this reduction primarily affects self-employed smugglers, while criminal organizations thrive and even hire more smugglers. On the other hand, cartel-targeted measures can help containing the cartel's profit, to the expense of expanding the small-business smuggling sector, ultimately leading to an increase in irregular border crossings. Therefore our analysis underscores the difficult policy dilemma to which the EU is subjected.

These results were obtained under a set of simplifying assumptions, of which some were more restrictive than others. A primary limitation of our analysis lies in its static nature. Migrant smuggling involves a significant flow dimension, as many migrants who are turned back in destination areas may attempt to re-enter multiple times. Developing a dynamic model with directed search, akin to the single-sector analysis conducted by Charlot et al. (2024), could address this aspect. However, it is likely that the conclusions of a dynamic model would not differ significantly from those of the static analysis, at least as long as they rely on the same fee determination mechanism.

Another limitation of our analysis is the focus on forced migration. The model could be extended to the case of voluntary migration, where potential migrants are in the position to arbitrate between the benefit of staying and the benefit of migrating net of migration costs, along the traditional rationale put forward by Harris and Todaro (1970). The problem would require to introduce additional assumptions about migrants heterogeneity with respect to the psychological cost of migration, or their ability to pay the smuggling fee. In this context, policy measure to improve living standards in the country of origin should curb irregular migration. Obviously this is another interesting path for future research.

Finally, in our analysis, cartels and self-employed smugglers compete to attract potential migrants as they provide a similar smuggling service, i.e. helping migrants reach the EU borders by providing planning and logistics. Reports by international organizations and studies mentioned in the introduction reveal an extreme degree of complexity of the smuggling market. Many activities are horizontally segmented, as assumed in this paper; however, in some other cases, independent smugglers would provide upstream and downstream services for the cartel (Europol, 2016; UNODC, 2018). This supply chain perspective is not present in our paper, and could be addressed in future research.

Despite these limitations, our analysis can be seen as a first attempt to model the structural complexity of the market for smuggling services, in a directed search framework that allows to take into account the substantial matching frictions specific to this activity.

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A Online Appendix

A.1 Sector 1 - Criminal cartels

A.1.1 The general case

Summary of the main optimization equations for Sector 1:

$$\bar{y}_1 = \eta_1 z - \delta_i D + (1 - \eta_1 - \delta_1)\left[\mu r + (1-\mu)z\right] \tag{A.1}$$

$$V_1 = (\bar{y}_1 - z - c_1)\, h^{'}(\theta_1) + z \tag{A.2}$$

$$C'(s_1/\psi) = \psi\left[(\bar{y}_1 - z - c_1)\, h(\theta_1)\left[1 - \varepsilon(\theta_1)\right] - (\bar{w} + \eta_1 k)\right] \tag{A.3}$$

$$p_1 = \bar{y}_1 - z - \varepsilon(\theta_1)(\bar{y}_1 - z - c_1) \tag{A.4}$$

$$\pi_1 = \left[(p_1 - c_1)\, h(\theta_1) - (\bar{w} + \eta_1 k)\right] s_1 - C(s_1/\psi) - F_1 \tag{A.5}$$

A.1.2 The Cobb-Douglas case

Summary of the main optimization equations for Sector 1 in the case of a Cobb-Douglas meeting technology:

$$\bar{y}_1 = \eta_1 z - \delta_1 D + (1 - \eta_1 - \delta_1)\left[\mu r + (1-\mu)z\right] \tag{A.6}$$

$$V_1 = \nu(1-\alpha)(\bar{y}_1 - z - c_1)(\theta_1)^{-\alpha} + z \tag{A.7}$$

$$s_1 = \frac{\psi^2}{2b}\left[\alpha\nu(\bar{y}_1 - z - c_1)(\theta_1)^{1-\alpha} - (\bar{w} + \eta_1 k)\right] \tag{A.8}$$

$$p_1 = \alpha(\bar{y}_1 - z) + (1-\alpha)\, c_1 \tag{A.9}$$

$$\pi_1 = \left[\nu(p_1 - c_1)(\theta_1)^{1-\alpha} - (\bar{w} + \eta_1 k)\right] s_1 - \frac{b}{\psi^2}(s_1)^2 - F_1 \tag{A.10}$$

A.2 Sector 2 - Self-employed smugglers

A.2.1 The general case

Summary of the main optimization equations for Sector 2:

$$\bar{y}_2 = \eta_2 z - \delta_2 D + (1 - \eta_2 - \delta_2)\left[\mu r + (1-\mu)z\right] \tag{A.11}$$

$$h(\theta_2) = \frac{\bar{w} + \eta_2 k}{(\bar{y}_2 - z - c_2)\left[1 - \varepsilon(\theta_2)\right]} \tag{A.12}$$

$$V_2 = (\bar{y}_2 - z - c_2)\, h'(\theta_2) + z \tag{A.13}$$

$$p_2 = \bar{y}_2 - z - \varepsilon(\theta_2)(\bar{y}_2 - z - c_2) \tag{A.14}$$

$$\pi_2 = \bar{w} \tag{A.15}$$

A.2.2 The Cobb-Douglas case

Summary of the main optimization equations for Sector 2 in the case of a Cobb-Douglas function:

$$\bar{y}_2 = \eta_2 z - \delta_2 D + (1-\eta_2-\delta_2)\left[\mu r + (1-\mu)z\right] \tag{A.16}$$

$$\theta_2 = \left[\frac{\bar{w}+\eta_2 k}{\alpha\nu\left(\bar{y}_2 - z - c_2\right)}\right]^{\frac{1}{1-\alpha}} \tag{A.17}$$

$$V_2 = (1-\alpha)\,\nu\left(\bar{y}_2 - z - c_2\right)\left(\theta_2\right)^{-\alpha} + z \tag{A.18}$$

$$= (1-\alpha)\left[\nu\left(\bar{y}_2 - z - c_2\right)\right]^{\frac{1}{1-\alpha}}\left[\frac{\alpha}{\bar{w}+\eta_2 k}\right]^{\frac{\alpha}{1-\alpha}} + z \tag{A.19}$$

$$p_2 = \alpha\left(\bar{y}_2 - z\right) + (1-\alpha)\,c_2 \tag{A.20}$$

$$\pi_2 = \bar{w} \tag{A.21}$$

A.3 Cross-sector interactions and equilibrium

A.3.1 The general case

Summary of the main equilibrium equations:

$$h\left(\theta_2^*\right) = \frac{\bar{w}+\eta_2 k}{\left(\bar{y}_2 - z - c_2\right)\left[1-\varepsilon\left(\theta_2^*\right)\right]} \tag{A.22}$$

$$p_2^* = \bar{y}_2 - z - \varepsilon\left(\theta_2^*\right)\left(\bar{y}_2 - z - c_2\right) \tag{A.23}$$

$$p_1^* = \bar{y}_1 - z - \varepsilon\left(\theta_1^*\right)\left(\bar{y}_1 - z - c_1\right) \tag{A.24}$$

$$V^* = V_1^* = V_2^* = \left(\bar{y}_2 - z - c_2\right)h'\left(\theta_2^*\right) + z \tag{A.25}$$

$$h'\left(\theta_1^*\right) = \frac{V^* - z}{\bar{y}_1 - z - c_1} \tag{A.26}$$

$$C'\left(s_1^*/\psi\right) = \psi\left[\left(\bar{y}_1 - z - c_1\right)h\left(\theta_1^*\right)\left[1-\varepsilon\left(\theta_1^*\right)\right] - \left(\bar{w}+\eta_1 k\right)\right] \tag{A.27}$$

$$\pi_1^* = \left[\left(p_1^* - c_1\right)h\left(\theta_1^*\right) - \left(\bar{w}+\eta_1 k\right)\right]s_1^* - C\left(s_1^*/\psi\right) - F_1 \tag{A.28}$$

$$\pi_2 = \bar{w} \tag{A.29}$$

$$S_1^* = N s_1^* \tag{A.30}$$

$$M_1^* = S_1^*\theta_1^* \tag{A.31}$$

$$M_2^* = M - M_1^* \tag{A.32}$$

$$S_2^* = \frac{M_2^*}{\theta_2^*} \tag{A.33}$$

$$M_{dest}^* = g\left(\theta_1^*\right)M_1^*\left(1-\eta_1-\delta_1\right) + g\left(\theta_2^*\right)M_2^*\left(1-\eta_2-\delta_2\right) \tag{A.34}$$

A.3.2 The Cobb-Douglas case

Summary of the main equilibrium equations in the case of a Cobb-Douglas meeting technology:

$$\theta_1^* = \left[\frac{\bar{w} + \eta_2 k}{\alpha}\right]^{\frac{1}{1-\alpha}} \left[\frac{\nu\left(\bar{y}_1 - z - c_1\right)}{\left[\nu\left(\bar{y}_2 - z - c_2\right)\right]^{\frac{1}{1-\alpha}}}\right]^{\frac{1}{\alpha}} \quad (A.35)$$

$$\theta_2^* = \left[\frac{\bar{w} + \eta_2 k}{\alpha\nu\left(\bar{y}_2 - z - c_2\right)}\right]^{\frac{1}{1-\alpha}} \quad (A.36)$$

$$V^* = V_1^* = V_2^* = (1-\alpha)\left[\nu\left(\bar{y}_2 - z - c_2\right)\right]^{\frac{1}{1-\alpha}} \left[\frac{\alpha}{\bar{w} + \eta_2 k}\right]^{\frac{\alpha}{1-\alpha}} + z \quad (A.37)$$

$$p_1^* = \alpha\left(\bar{y}_1 - z\right) + (1-\alpha)\, c_1 \quad (A.38)$$

$$p_2^* = \alpha\left(\bar{y}_2 - z\right) + (1-\alpha)\, c_2 \quad (A.39)$$

$$s_1^* = \frac{\psi^2}{2b}\left[\left(\frac{\bar{y}_1 - z - c_1}{\bar{y}_2 - z - c_2}\right)^{\frac{1}{\alpha}} \left(\bar{w} + \eta_2 k\right) - \left(\bar{w} + \eta_1 k\right)\right] \quad (A.40)$$

$$\pi_1^* = \frac{b}{\psi^2}\left(s_1^*\right)^2 - F_1 \quad (A.41)$$

$$= \frac{\psi^2}{4b}\left[\left(\frac{\bar{y}_1 - z - c_1}{\bar{y}_2 - z - c_2}\right)^{\frac{1}{\alpha}} \left(\bar{w} + \eta_2 k\right) - \left(\bar{w} + \eta_1 k\right)\right]^2 - F_1 \quad (A.42)$$

$$\pi_2 = \bar{w} \quad (A.43)$$

$$S_1^* = N s_1^* \quad (A.44)$$

$$M_1^* = S_1^* \theta_1^* \quad (A.45)$$

$$M_2^* = M - M_1^* \quad (A.46)$$

$$S_2^* = \frac{M_2^*}{\theta_2^*} \quad (A.47)$$

$$M_{dest}^* = \nu\left(\theta_1^*\right)^{-\alpha} M_1^* \left(1 - \eta_1 - \delta_1\right) + \nu\left(\theta_2^*\right)^{-\alpha} M_2^* \left(1 - \eta_2 - \delta_2\right) \quad (A.48)$$

A.4 Comparative statics

A.4.1 The general case

Differentiation of the main equilibrium equations:

$$d\bar{y}_1 = -\mu\left(r - z\right) d\eta_1 - \left[D + z + \mu\left(r - z\right)\right] d\delta_1 + \left(1 - \eta_1 - \delta_1\right)\left(r - z\right) d\mu \quad (A.49)$$

$$d\bar{y}_2 = -\mu\left(r - z\right) d\eta_2 - \left[D + z + \mu\left(r - z\right)\right] d\delta_2 + \left(1 - \eta_2 - \delta_2\right)\left(r - z\right) d\mu \quad (A.50)$$

$$d\theta_2^* = \frac{1 - \varepsilon\left(\theta_2^*\right)}{\bar{y}_2 - z - c_2} \frac{\left(\bar{y}_2 - z - c_2\right)\left(d\bar{w} + \eta_2 dk + k d\eta_2\right) - \left(\bar{w} + \eta_2 k\right)\left(d\bar{y}_2 - dc_2\right)}{\left(\bar{y}_2 - z - c_2\right)\left[1 - \varepsilon\left(\theta_2^*\right)\right]^2 h'\left(\theta_2^*\right) - \left(\bar{w} + \eta_2 k\right)\varepsilon'\left(\theta_2^*\right)} \quad (A.51)$$

$$dp_2^* = \left[1 - \varepsilon\left(\theta_2^*\right)\right] d\bar{y}_2 + \varepsilon\left(\theta_2^*\right) dc_2 - \left(\bar{y}_2 - z - c_2\right)\varepsilon'\left(\theta_2^*\right) d\theta_2^* \quad (A.52)$$

$$dV^* = h'\left(\theta_2^*\right)\left(d\bar{y}_2 - dc_2\right) + \left(\bar{y}_2 - z - c_2\right) h''\left(\theta_2^*\right) d\theta_2^* \quad (A.53)$$

$$d\theta_1^* = \frac{(\bar{y}_1 - z - c_1)\, dV^* - (V^* - z)\,(d\bar{y}_1 - dc_1)}{(\bar{y}_1 - z - c_1)^2\, h''(\theta_1^*)} \quad (A.54)$$

$$dp_1^* = [1 - \varepsilon(\theta_1^*)]\, d\bar{y}_1 + \varepsilon(\theta_1^*)\, dc_1 - (\bar{y}_1 - z - c_1)\, \varepsilon'(\theta_1^*)\, d\theta_1^* \quad (A.55)$$

$$\frac{C''(s_1^*/\psi)}{\psi^2} ds_1^* = [1 - \varepsilon(\theta_1^*)]\, h(\theta_1^*)\,(d\bar{y}_1 - dc_1) - \theta_1^* h''(\theta_1^*)\,(\bar{y}_1 - z - c_1)\, d\theta_1^* \quad (A.56)$$

$$- (d\bar{w} + k d\eta_1 + \eta_1 dk) \quad (A.57)$$

$$d\pi_1^* = \frac{C''(s_1^*/\psi)}{\psi^2} s_1^* ds_1^* \quad (A.58)$$

$$d\pi_2 = d\bar{w} \quad (A.59)$$

$$dS_1^* = s_1^* dN + N ds_1^* \quad (A.60)$$

$$dM_1^* = S_1^* d\theta_1^* + \theta_1^* dS_1^* \quad (A.61)$$

$$dM_2^* = -dM_1^* \quad (A.62)$$

$$(\theta_2^*)^2\, dS_2^* = \theta_2^* dM_2^* - M_2^* d\theta_2^* \quad (A.63)$$

$$dM_{dest}^* = (1 - \eta_1 - \delta_1)\left[M_1^* g'(\theta_1^*)\, d\theta_1^* + g(\theta_1^*)\, dM_1^*\right] - g(\theta_1^*)\, M_1^*\,(d\eta_1 + d\delta_1) \quad (A.64)$$

$$+ (1 - \eta_2 - \delta_2)\left[M_2^* g'(\theta_2^*)\, d\theta_2^* + g(\theta_2^*)\, dM_2^*\right] - g(\theta_2^*)\, M_2^*\,(d\eta_2 + d\delta_2) \quad (A.65)$$

A.4.2 The Cobb-Douglas case

Differentiation of the main equilibrium equations in the case of a Cobb-Douglas meeting technology:

$$\bar{d}y_1 = -\mu(r - z)\, d\eta_1 - [D + z + \mu(r - z)]\, d\delta_1 + (1 - \eta_1 - \delta_1)(r - z)\, d\mu \quad (A.66)$$

$$d\bar{y}_2 = -\mu(r - z)\, d\eta_2 - [D + z + \mu(r - z)]\, d\delta_2 + (1 - \eta_2 - \delta_2)(r - z)\, d\mu \quad (A.67)$$

$$d\theta_1^* = \frac{1}{\alpha}\left[\frac{\bar{w} + \eta_2 k}{\alpha}\right]^{\frac{1}{1-\alpha}} \left[\frac{\nu(\bar{y}_1 - z - c_1)}{[\nu(\bar{y}_2 - z - c_2)]^{\frac{1}{1-\alpha}}}\right]^{\frac{1}{\alpha}}$$
$$\left\{\frac{\alpha}{1-\alpha}\frac{d\bar{w} + \eta_2 dk + k d\eta_2}{\bar{w} + \eta_2 k} + \frac{d\bar{y}_1 - dc_1}{\bar{y}_1 - z - c_1} - \frac{1}{1-\alpha}\frac{d\bar{y}_2 - dc_2}{\bar{y}_2 - z - c_2}\right\} \quad (A.68)$$

$$d\theta_2^* = \frac{1}{1-\alpha}\left[\frac{\bar{w} + \eta_2 k}{\alpha\nu(\bar{y}_2 - z - c_2)}\right]^{\frac{1}{1-\alpha}} \left[\frac{d\bar{w} + \eta_2 dk + k d\eta_2}{\bar{w} + \eta_2 k} - \frac{d\bar{y}_2 - dc_2}{\bar{y}_2 - z - c_2}\right] \quad (A.69)$$

$$dV^* = \left[\frac{\alpha}{\bar{w} + \eta_2 k}\right]^{\frac{\alpha}{1-\alpha}} [\nu(\bar{y}_2 - z - c_2)]^{\frac{1}{1-\alpha}} \left(\frac{d\bar{y}_2 - dc_2}{\bar{y}_2 - z - c_2} - \alpha\frac{d\bar{w} + \eta_2 dk + k d\eta_2}{\bar{w} + \eta_2 k}\right) \quad (A.70)$$

$$dp_1^* = \alpha d\bar{y}_1 + (1 - \alpha)\, dc_1 \quad (A.71)$$

$$dp_2^* = \alpha d\bar{y}_2 + (1 - \alpha)\, dc_2 \quad (A.72)$$

$$\frac{2b}{\psi^2} ds_1^* = \left(\frac{\bar{w} + \eta_2 k}{\alpha}\right)\left(\frac{\bar{y}_1 - z - c_1}{\bar{y}_2 - z - c_2}\right)^{\frac{1}{\alpha}} \left(\frac{d\bar{y}_1 - dc_1}{\bar{y}_1 - z - c_1} - \frac{d\bar{y}_2 - dc_2}{\bar{y}_2 - z - c_2} + \alpha\frac{d\bar{w} + \eta_2 dk + k d\eta_2}{\bar{w} + \eta_2 k}\right)$$
$$- (d\bar{w} + \eta_1 dk + k d\eta_1) \quad (A.73)$$

$$d\pi_1^* = \frac{2b}{\psi^2} s_1^* ds_1^* \tag{A.74}$$

$$d\pi_2^* = d\bar{w} \tag{A.75}$$

$$dS_1^* = s_1^* dN + N ds_1^* \tag{A.76}$$

$$dM_1^* = \theta_1^* dS_1^* + S_1^* d\theta_1^* \tag{A.77}$$

$$dM_2^* = -dM_1^* \tag{A.78}$$

$$\left(\theta_2^*\right)^2 dS_2^* = \theta_2^* dM_2^* - M_2^* d\theta_2^* \tag{A.79}$$

$$\begin{aligned} dM_{dest}^* = {} & \left(1-\eta_1-\delta_1\right)\nu\left(\theta_1^*\right)^{-\alpha} M_1^* \left(\frac{dM_1^*}{M_1^*} - \alpha\frac{d\theta_1^*}{\theta_1^*} - \frac{d\eta_1 + d\delta_1}{1-\eta_1-\delta_1}\right) \\ & + \left(1-\eta_2-\delta_2\right)\nu\left(\theta_2^*\right)^{-\alpha} M_2^* \left(\frac{dM_2^*}{M_2^*} - \alpha\frac{d\theta_2^*}{\theta_2^*} - \frac{d\eta_2 + d\delta_2}{1-\eta_2-\delta_2}\right) \end{aligned} \tag{A.80}$$

A.4.3 Results in the general case

Table A.1: Comparative static results

		Alternative income $\bar{w}$	Convicted penalty k	Cartel fat. rate δ_1	Comp. fat. rate δ_2	Cartel arrest rate η_1	Comp. arrest rate η_2	Asylum-status rate μ	Cartel mg. cost c_1	Comp. mg. cost c_2	Both mg. cost c	Cartel firms N
Cartel migr. exp. income	$\bar{y}_1$	0	0	-	0	-	0	+	0	0	0	0
Comp. migr. exp. income	$\bar{y}_2$	0	0	0	-	0	-	+	0	0	0	0
Cartel tension	θ_1^*	+	+	-	+	-	+	-	-	+	+	0
Comp. tension	θ_2^*	+	+	0	+	0	+	-	0	+	+	0
Expected utility	V^*	-	-	0	-	0	-	+	0	-	-	0
Cartel fee	p_1^*	+	+	-	-	-	+	?	+	+	+	0
Comp. fee	p_2^*	+	+	0	-	0	?	+	0	+	+	0
Cartel smugglers per firm	s_1^*	?	?	-	+	-	+	?	-	+	?	0
Cartel profit	π_1^*	?	?	-	+	-	+	?	-	+	?	0
Comp. profit	π_2^*	+	0	0	0	0	0	0	0	0	0	0
Cartel smugglers	S_1^*	?	?	-	+	-	+	?	-	+	?	+
Cartel migrants	M_1^*	?	?	-	+	?	+	?	-	+	?	+
Comp. migrants	M_2^*	?	?	+	-	?	-	?	+	-	?	-
Comp. smugglers	S_2^*	?	?	+	-	?	-	?	+	-	?	-
Total smugglers	S^*	?	?	?	?	?	?	?	?	?	?	-
Migrants reaching dest.	M_{dest}^*	?	?	?	?	?	?	?	?	?	?	?

A.5 Simulation: impact of an increase in the marginal costs

We provide in this Appendix the simulation for a higher marginal cost of smuggling, both as a general purpose measure rising costs in an indiscriminate way (Table A.2), or as a targeted measure rising costs for the criminal organizations only (Table A.3).

Table A.2: Simulation results for policies impacting marginal costs in both sectors

	(1) $c_1 = c_2 = 2.5$			(2) Benchmark $c_1 = c_2 = 5$			(3) $c_1 = c_2 = 7.5$		
	Cartel	Comp.	Total	Cartel	Comp.	Total	Cartel	Comp.	Total
Migr. exp. income y	213.1	142.2		213.1	142.2		213.1	142.2	
Tension θ^*	4.6	1.92		4.86	2.00		5.12	2.08	
Smug. contact prob. $h(\theta^*)$	0.71	0.46		0.73	0.47		0.75	0.48	
Mig. contact prob. $g(\theta^*)$	0.15	0.24		0.15	0.24		0.15	0.23	
Smuggling fee p^*	102.8	67.4		104.0	68.6		105.3	69.9	
Expected utility V^*	25.6	25.6		25	25		24.4	24.4	
Profit per smuggler π^*	17.4	20		18.0	20		18.7	20	
Cartel total profit Π^*	674.6			713.8			755.6		
Smugglers S^*	77	334	411	79	307	386	81	281	362
Potential migrants M^*	357	643	1000	384	616	1000	414	586	1000
Total border crossings M^*_{dest}			157			152			148

Note: Column (2) reports benchmark results, with parameters values summarized in Table 1.

Table A.3: Simulation results for policies impacting the cartel's marginal cost

	(1) $c_1 = 2.5$			(2) Benchmark $c_1 = 5$			(3) $c_1 = 7.5$		
	Cartel	Comp.	Total	Cartel	Comp.	Total	Cartel	Comp.	Total
Migr. exp. income y	213.1	142.2		213.1	142.2		213.1	142.2	
Tension θ^*	4.98	2.00		4.86	2.00		4.73	2.00	
Smug. contact prob. $h(\theta^*)$	0.74	0.47		0.73	0.47		0.72	0.47	
Mig. contact prob. $g(\theta^*)$	0.15	0.24		0.15	0.24		0.15	0.24	
Smuggling fee p^*	102.8	68.6		104.0	68.6		105.3	68.6	
Expected utility V^*	25	25		25	25		25	25	
Profit per smuggler π^*	19.2	20		18.0	20		16.9	20	
Cartel total profit Π^*	788.2			713.8			643.0		
Smugglers S^*	82	295	377	79	307	386	76	319	395
Potential migrants M^*	409	591	1000	384	616	1000	360	640	1000
Total border crossings M^*_{dest}			151			152			154

Note: Column (2) reports benchmark results, with parameters values summarized in Table 1.