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A two-sector model with directed search

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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 analysis in this paper accounts for the dual structure of the market for smuggling services, including a criminal cartel segment and a segment of small self-employed smuggler. The large trading frictions specific to this criminal activity justify the use of a directed search model of fee determination. Comparative statics for the equilibrium solution and numerical simulations show that while general-purpose policy measures demonstrate efficiency in curbing irregular migration, they might inadvertently bolster cartel profits as they push self-employed smugglers out of the market.

Keywords - Migrant smuggling, Directed search, Dual smuggling market, Irregular migration.
JEL Classification - J61, L13, D83

1 Introduction

In the last decade, the large number of irregular migrants crossing the EU border every year became an essential policy challenge for the European member countries and the EU itself. As shown in Figure A.1, after a peak of 1.822.000 illegal border crossings in 2015, the flow has somehow tarnished, to edge up again after 2021; illegal border crossing reached 330.000 in 2022, and 380.000 in 2023.[1] As an established fact, irregular migration can only reach such a level 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 in the period 2014-2022 (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). According to data communicated by the European Commission, smuggling generated some 330 million euros in profits on Western and Central Mediterranean routes during 2017-2019.[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 transports, and fake documents; they assure their 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).

Ethnology and criminology studies that analyzed the substantial irregular migration flows to the EU in the last decade revealed that the market for smuggling services has a polymorphic structure, where large criminal organizations coexist with a network of fuzzy small businesses (Europol, 2016; UNODC, 2018; Campana, 2018; Campana and Gelsthorpe, 2020; Sanchez, 2020; Achilli, 2022). As a showcase, reference can be made to an ethnological study conducted by

[1] See Frontex News Release, January 26, 2024, "Significant rise in irregular border crossings in 2023, highest since 2016".

[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.

Watt (2024). In 2023, this researcher spent time with irregular migrants near Calais, France, who were aiming to illegally cross the Channel to reach the UK. She reveals the trade-off facing migrants between utilizing the safer yet more costly service provided by the Kurdish criminal cartel (who often provides services along the entire route) or opting for the easier-to-find but riskier small smugglers from Sudan or Northern Africa, who charge a lower fee but employ unfit boats, increasing the death risk at sea.

This paper provides an analysis of the market for smuggling services that takes into account its dual structure, including both a cartelized segment and a segment of many small business that compete to provide smuggling services. A directed search approach allows us to bring into the picture the substantial trading frictions specific to this criminal activity. The analysis reveals complex interactions between the two sectors in the provision of the smuggling service. Comparative statics and numerical simulations allows us to study the consequences of various policies devised to fight irregular migration and smuggling. Results point out to significant and probably unintended cross-sector effects associated to "general purpose" policies.

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

The analysis 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 what 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 generates a positive surplus, to be shared between the buyer and the seller. In the early matching models inspired by the seminal work of Pissarides (2000), the price emerges as the outcome of a bargaining process between the buyer and the seller once the match occurred (Nash, 1950). An alternative, the competitive search equilibrium or directed search approach, 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 organized in sub-markets with perfect mobility of buyers and sellers across these "islands"; in each sub-market, prices posted by one side of the market allow agents from the other side 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.[5] A remarkable property of the directed search mechanism is the guaranty of efficiency of the allocation, by contrast with the bargaining mechanism where efficiency requires a hard to justify alignment of parameters (Hosios, 1990). In the context of a two-sector market, the directed search approach is quite appealing, since it allows for neat segmentation of the search process.

In the directed search framework, the market of interest is made up of many sub-markets or islands; on each sub-market, smugglers post 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. With homogeneous migrants and a linearly homogeneous matching function, if smugglers were homogeneous, then only one fee would prevail, so the migrants-to-smuggler ratio would also be unique (Wright et al., 2021; Cahuc et al., 2014).

However, in the market for smuggling services to the EU, smugglers are heterogeneous with respect to their employment status. Smugglers can work either as employees of a criminal organization (sector 1), or establish their own self-employed business (sector 2). Travel conditions and the likelihood of success are sector specific. Migrants can either search for cartelized smugglers or for small autonomous smugglers, depending on the price, quality and waiting line for each type of service provider.

With two sectors and cross-sector mobile homogeneous migrants, if both sectors co-exist, migrants must be indifferent to which smuggler to apply; in equilibrium the expected utility of traveling with one or the other type of smuggler should be the same. The proportions of smugglers and migrants targeting each sector are endogenously determined within the model, as well as the smuggling fees. The migrants-to-smuggler ratios and the fees are then sector-specific.

The analysis considers the special case of forced migrants, which represents an emerging strand in the migration literature.[6] 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

[5]As mentioned by Cahuc et al. (2014), one important assumption, and a known limitation of this model, is that sellers (firms) can make a strong commitment on the posted price, which might not be true.

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

refugees fleeing war areas, and migrants fleeing areas of extreme poverty driven by climate change or natural catastrophes can be thin.

Solving the model, we show how policy interventions represented by changes in the main parameters, contribute to changes in variables of interest for policymakers: the number of irregular migrants arriving in Europe, the total number of smugglers, smuggling fees, the number of smugglers working for the cartel, the migrants utility and the cartel's profits.

For EU member states and the EU as a supranational organization, fighting human smuggling is a key policy goal (von der Leyen, 2023), aligned with the goal of curbing irregular migration to the EU. Two successive Action Plans against Migrant Smuggling were adopted by the EU for the periods 2015-2020 and 2021-2025 (European Commission, 2015, 2021). The 2021-2025 plan 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 transforming smuggling from a "high profit, low risk" activity into a "high risk, low profit" business, while ensuring the full respect and protection of migrants' human rights.

The new strategy for migration of the EU relies on partnerships with many of the countries of origin and transit to the EU, 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.[7] Many of these measures aim at improving living standards and job opportunities in the origin and transit countries, in order to decrease the incentives of potential migrants to come to Europe.

While the European Commission has a broad action against migrant smuggling, official documents express high concern especially about the criminal cartel segment of this market. In the renewed EU Action Plan against Migrant Smuggling (European Commission, 2021), one can read:

> "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 affect the smuggling market, and in particular the cartelized sector of this market, is then key to assessing the efficiency of these action plans.

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

Comparative statics from our model and simulations show that "general-purpose" policies - higher penalties for smugglers, higher arrest rates, higher costs of "doing business", a better alternative income for smugglers, higher migrant push-back rates - would efficiently cut down irregular migration, against the background of a lower total number of smugglers. However, these general purpose measures primarily dissuade smugglers in the small-business segment; on the other hand, the induced "scarcity" of smugglers bolsters the cartel's profits. This is obviously at odds with the stated goal of combating organized crime in the first place.

Measures specifically aimed at making the cartel activity more expensive will help containing the cartel's profits. Yet they might backfire by providing incentive to a strong expansion of the small firm segment of the market, with more irregular border crossings.

Our paper contributes to the emerging literature on the economics of human smuggling. As noted by MacKellar (2020), despite the documented importance of the smugglers as facilitators of irregular migration in many policy, legal and sociological studies, investigations of this activity in economics are relatively scarce.[8] In particular, the industrial organization of the market for smuggling services was and still is a challenge to economists. With evidence existing at that time, Gathmann (2008) acknowledges that the organization of the market for smuggling services might be represented either by the perfect competition model, or by a collusive oligopoly model.

The latter perspective can be found in the analysis by Auriol and Mesnard (2016). They assume that smuggling services are provided by a closed oligopoly including a relatively small 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 at the same time limit the number of irregular migrants and prevent 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 was developed by Charlot et al. (2024) building on the small-firm matching model in the labor market (Pissarides, 2000). A matching model, while it allows for substantial bargaining power on behalf of the smugglers, presents fundamental characteristics of the competitive market since it allows for free entry of entrepreneurial smugglers on the market, which drives to zero the asset value of vacant offer. Keita et al. (2023) use the 2015 massive migration to Europe to bring rigorous empirical evidence to the assumption that the

[8] 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; Djajić and Vinogradova, 2013; Djajić and Michael, 2014; Djajić and Vinogradova, 2014).

supply side of the smuggling market is highly responsive to large demand shocks. In particular, smuggling fees did not raise in a substantial way during the large demand period. They suggest that this is at odds with the closed oligopoly assumption; they show that a simple model of monopolistic competition with product differentiation and free entry of smugglers seem to match well the data.

To our knowledge, the model in this paper is the first analysis of the smuggling market that *(a)* uses directed search to explain the determination of smuggling fees and tensions in the market, and *(b)* acknowledges the duality of the market, as documented by the criminology and sociology literature on migration to Europe. Our dual market setting might close the gap between the two competing assumptions about 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 presents the model; Section 4 determines the equilibrium of the model. Section 5 analyses the policy implications of the model, backed by comparative statics and several numerical simulations. Section 6 presents our conclusions.

2 Main assumptions

We analyze the interaction between potential migrants searching for a smuggler, and smugglers - either self-employed or working for a criminal organization - who provide the smuggling service.

2.1 The smugglers

Based on evidence from the field as summarized in the introduction, we assume that the smuggling market has a dual structure. The smuggling service can be provided either by large criminal organizations, or by autonomous smugglers organized as small businesses. Because the fee and the quality of the service (waiting time, travel quality, risks) differ from one market to another, potential migrants will direct their search toward the market that fits best their preferences.

The two markets are:

- The cartel-dominated market, 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 market, 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:

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

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; smugglers offer a specific travel contract (the travel contract specifies, for instance, the risks of interception and death during the journey).

Given this dual market structure, the analysis must include both a small firm and a large firm sub-model.

2.2 The migrants

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

In equilibrium, a migrant should be indifferent between traveling with a cartel-employed smuggler or with a self-employed smuggler; in other words, we study a situation where the two sectors co-exist. With identical migrants, the indifference condition allows to determine the numbers of migrants using the service of smugglers in each sector, M_1 and M_2 respectively.

The total number of migrants then is:

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

2.3 Trading frictions

We define the "queue length" as the migrants-to-smuggler ratio in each sector:

$$\theta_1 = \frac{M_1}{S_1} \tag{3}$$

$$\theta_2 = \frac{M_2}{S_2} \tag{4}$$

We assume that smugglers post fees, while migrants search for their preferred price offer, depending on the sector.[9] To keep the analysis simple, we assume that trading frictions follow the same process in both the cartel and the competitive sector.[10] More precisely, the encounter between migrants and smugglers is characterized by the same meeting technology:

$$H_i = H\left(M_i, S_i\right), \tag{5}$$

with $i = (1, 2)$.

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

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:

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

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

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

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

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

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

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

We assume that $\varepsilon' \leqslant 0$, which is standard in this literature (see Wright et al., 2021).

3 The model

In Charlot et al. (2024), we focus on the stages of migration as emphasized in Salt and Stein (1997), and develop a dynamic analysis in the context of a simple (one-sector) market structure

[9] 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.

[10] 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.

(small firms, free entry). On a Occam razor principle, we adopt here a static framework, where all the potential outcomes of the migration process boil down to a single variable, the migrant's expected income.[11]

3.1 The migrants

Let z be the migrants' monetary utility in the home country. In areas subject to extreme hardship (war, extreme poverty, drought and climate strain), z may even take a negative value.

The expected utility of the migrant searching for a smuggler in sector i, with $i = (1, 2)$, is:

$$V_i = g(\theta_i)(\bar{y}_i - p_i), \tag{10}$$

where $\bar{y}_i$ is the expected income from contracting with a smuggler in sector i.

$\bar{y}_i$ depends on many exogenous variables, related to the possible outcomes of the migration decision. Based on evidence from the field (see Charlot et al., 2024), we consider that the migrant can:

- be intercepted by the border police with a probability η_i; he is then sent back home (where he obtains z);
- die in the sea with a probability δ_i; this risky event is associated with a loss D;
- 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 home (where he obtains z).[12]

The migrant's expected income from migration then is:

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

Obviously, whether $\bar{y}_1 \geqslant \bar{y}_2$ or the opposite depends on the parameters of the problem.

[11] A dynamic analysis could be developed by replacing the expected income with the appropriate asset values for each stage of the migration process.

[12] 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 illegal migrants in the destination area, where they could earn a decreases income.

3.2 The 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 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 cartels A large criminal organization is a hierarchy that has many features of a corporation. Its aim is to make the largest profit out of its criminal activity, by choosing the optimal number of smugglers working for it (s_1) and the smuggling fee (p_1).

To determine the profit function, we make several additional assumptions. Within the firm, the marginal productivity of a hired smuggler is constant - every additional smuggler hired can meet and guide h migrants, and generates a fee p_1 per migrant. The marginal cost of smuggling one migrant is c_1.

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 "take-or-leave-it" wage offer (Cooper et al., 2007). This wage, denoted 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.[13]

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

In this case, we can consider that the firm decides directly on the number of smugglers, and adjusts the stock of posted vacancies.[14]

Furthermore, the cost of hiring is assumed to be increasing and convex in the number of vacant jobs (Cooper et al., 2007; Jaeger et al., 2010): 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. The number of large organizations, N, critically depends on this fixed cost: if the fixed cost is very large, at most one criminal organization can exist in this market. Similar to Auriol and Mesnard (2016), we assume that this number is exogenous.

The profit function of the representative criminal organization is thus:

$$\pi_1 = (p_1 - c_1)\, h(\theta_1)\, s_1 - w_1 s_1 - C(s_1/\psi) - F_1, \tag{14}$$

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

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).

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

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

[14] 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 $s = \psi J$.

4 Solving the model

4.1 Sector 1 - Criminal cartels

There are $N \geqslant 1$ identical criminal cartels involved in the smuggling business. To keep the analysis simple, these criminal organizations are assumed to offer only smuggling services, and are not involved in other criminal activities. According to the UNODC (2018), "linkages between smuggling networks and other criminal markets appear to be exceptions rather than the rule." 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 migrants searching for a smuggler in sector 1 with the reserve utility V_1. We further assume that at the moment of the decision, the representative cartel takes the reserve utility as given.[15]

The decision problem of the cartel can then be written:

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

$$\text{s.t.} \qquad g(\theta_1)(\bar{y}_1 - p_1) = V_1 \tag{18}$$

The constraint gives us:

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

After substitution, the problem becomes:

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

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

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

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

Using equation (21) to eliminate V_1 from equations (19) and (22), we get:

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

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

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

[15] We show later that the reserve utility V_1 is endogenous, since it is an equilibrium variable; our "binded-rationality" assumption involves that the cartel lacks the information to incorporate the multiple feedback effects into the optimal choice, or alternatively, that a cartel is "small" with respect to the size of the market.

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 $s_1(\theta_1)$ (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:

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

4.2 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 migrants searching for smugglers in sector 2 with the reserve utility V_2. At the stage of the decision, the (small) smuggler takes this utility as given.

The decision problem of the entrepreneur is:

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

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

The constraint allows us to write:

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

After substitution, we obtain the equivalent maximization problem:

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

The FOC implies:

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

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:

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

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

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

Furthermore, we assume that self-employed (risk neutral) smugglers can freely enter this market. The indifference condition yields:

$$\pi_2 = \bar{w} \tag{34}$$

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

$$h(\theta_2)[1 - \varepsilon(\theta_2)] = \frac{\bar{w} + \eta_2 k}{\bar{y}_2 - c_2}. \tag{35}$$

We assume that this equation has a solution θ_2^*. 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):

$$V_2^* = (\bar{y}_2 - c_2)\,h'\,(\theta_2^*) \tag{36}$$

$$p_2^* = \bar{y}_2 - \varepsilon\,(\theta_2^*)\,(\bar{y}_2 - c_2) \tag{37}$$

4.3 Cross-sector interactions

So far, we analyzed the optimal choices of the firms in sectors 1 and 2 in relative isolation. However, in the equilibrium of the smuggling market, as long as the two sectors co-exist, 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:

$$V_1^* = V_2^* = V^*. \tag{38}$$

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

We can then determine θ_1^*, p_1^*, s_1^* and $S_1^* = N s_1^*$ as well as $M_1^* = \theta_1^* S_1^*$.

Then, we obtain $M_2^* = \bar{M} - M_1^*$, and the number of smugglers in sector 2:

$$S_2^* = \frac{M_2^*}{\theta_2^*} = \frac{\bar{M} - M_1^*}{\theta_2^*}. \tag{39}$$

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

$$M_{dest} = g\,(\theta_1^*)\,M_1^*\,(1 - \eta_1 - \delta_1) + g\,(\theta_2^*)\,M_2^*\,(1 - \eta_2 - \delta_2)\,. \tag{40}$$

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.2, A.3 and A.4.

4.4 Comparing the sectors

It can further be shown that the differences in tensions and smuggling fees across sectors depend on whether $\bar{y}_1 - c_1 \geqslant \bar{y}_2 - c_2$ or the opposite.

Tensions The equality of reserve utilities in both sectors implies that $(\bar{y}_1 - c_1)\, h^{'}(\theta_1^*) = (\bar{y}_2 - c_2)\, h'(\theta_2^*)$. Since h' is decreasing, if $\bar{y}_1 - c_1 \geqslant \bar{y}_2 - c_2$ then $\theta_1^* \geqslant \theta_2^*$. Under that assumption, the tension in the cartel sector is higher than the tension in the competitive sector; the probability to which a smuggler meets a migrant is thus higher in the cartel sector than in the competitive one.

Smuggling fees Combining the fee equations (25) and (37), the gap between the fees in the different sectors can be written:

$$p_1^* - p_2^* = (\bar{y}_1 - c_1)\left[1 - \varepsilon(\theta_1^*)\right]\left\{1 - \left(\frac{\bar{y}_2 - c_2}{\bar{y}_1 - c_1}\right)\left[\frac{1 - \varepsilon(\theta_2^*)}{1 - \varepsilon(\theta_1^*)}\right]\right\} + (c_1 - c_2) \qquad (41)$$

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 $\frac{1-\varepsilon(\theta_2^*)}{1-\varepsilon(\theta_1^*)} \leqslant 1$ and $p_1^* - p_2^* \geqslant 0$ (we assume that $c_1 \geqslant c_2$).

As expected, if the net gain of migrating is higher with the cartel ($\bar{y}_1 - c_1 \geqslant \bar{y}_2 - c_2$), then the fee paid to smugglers in the cartel sector is higher than the fee paid in the competitive sector.

In the following, we will assume that the net gain of using the cartel service is larger than the net gain of using the individual service, a situation depicted by Watt (2024) and summarized in the introduction.

5 Predicting policy effects

5.1 Comparative statics

As summarized in Table 1, the equilibrium smuggling market tightness θ_1^* and θ_2^* increase with $\bar{w}$, k, δ_2, η_2 and c_2, and decrease with δ_1, η_1, c_1 and μ. They are independent from N. Calculations are presented in Appendix A.5.

These equilibrium properties of the smuggling market tightness are summarized in the following proposition.

Proposition 1 ***Properties of the equilibrium smuggling market tightness*** θ^****.***
The equilibrium smuggling market tightness θ_1^* *and* θ_2^* *are increasing in the alternative income* $\bar{w}$*, the penalty for convicted smugglers* k*, the fatality rate in the competitive smuggling sector* δ_2*, the arrest rate in the competitive smuggling sector* η_2 *and the competitive sector marginal cost* c_2*. They are decreasing in the fatality rate in the cartel sector* δ_1*, the cartel arrest rate* η_1*, the cartel sector marginal cost* c_1*, and the asylum-status rate* μ*. They are independent from the number of cartel organizations* N*.*

Variables θ_1^* and θ_2^* are essential for determining the equilibrium of this market. However, the main purpose of the analysis is to reveal the consequences of various policy measures on a small 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 searching migrants in each sector M_1^* and M_2^* and the number of migrants reaching destination M_{dest}^*.

These variables are functions of parameters and of the equilibrium tightness (θ_1^*, θ_2^*), which also depend on the parameters of the problem. A change in parameters has therefore a direct and an indirect effect on the policy variables.

Table 1 summarizes the total effects of the parameters of our model on those variables (calculations are presented in Appendix A.5).

Table 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 tightness	θ_1^*	+	+	-	+	-	+	-	-	+	+	0
Comp. tightness	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}^*	?	?	?	?	?	?	?	?	?	?	?

The theoretical analysis allows us to point out how changes in parameters modify the equilibrium solutions. In general, these parameters are representative of the various policies aiming at containing the smuggling business. If many effects are clearly identified within the theoretical framework, some other important effects are not. In the next section, we introduce a numerical simulation, to provide additional intuition relative to the effects of various policies.

5.2 A specific meeting technology

To obtain numerical solutions, we need to make specific assumptions about the frictions on the market for smuggling services, and the hiring cost function faced by the cartel.

Following the traditional matching literature in labor economics, we assume that the migrant/smuggler encounter is driven by the Cobb-Douglas technology:

$$H_i = \nu M_i^{1-\alpha} S_i^{\alpha} \text{ , with } i = (1, 2), \tag{42}$$

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

The contact probabilities in each sector become:

$$h(\theta_i) = \frac{H_i}{S_i} = \nu\theta_i^{1-\alpha} \tag{43}$$

$$g(\theta_i) = \frac{H_i}{M_i} = \nu\theta_i^{-\alpha}, \tag{44}$$

with $h(\theta_i) = \theta_i g(\theta_i)$, $h'(\theta_i) = \nu(1-\alpha)\theta_i^{-\alpha} \geqslant 0$ and $h''(\theta_i) = -\nu\alpha(1-\alpha)\theta_i^{-1-\alpha} \leqslant 0$.

The elasticity becomes:

$$\varepsilon(\theta_i) = \frac{\theta_i h'(\theta_i)}{h(\theta_i)} = (1-\alpha) \tag{45}$$

We further assume that the non-wage hiring cost function is quadratic: $C(s_1/\psi) = b\left(\frac{s_1}{\psi}\right)^2$, with $b > 0$ and $\psi < 1$.

With these specific functions, the model presents explicit solutions, as shown in Appendix A.2, A.3 and A.4. The elasticity ϵ is a constant (it does not depend on the tension θ) thus the smuggling fees are independent of the tensions.

5.3 Parameters

Parameters are chosen within an economically meaningful set, but do not rely on a precise economic calibration, which would be extremely difficult to implement given the criminal thus hidden nature of smuggling. 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 alternative income for a smuggler (in a legal occupation) is set to 20 ($\bar{w} = 20$), and the number of potential migrants to a normalized 1000 ($\bar{M} = 1000$). The income in the home country is set to 10 ($z = 10$), while the income of a migrant in the destination area is assumed to be much higher and set to 300 ($r = 300$).

We choose a penalty for the arrested smuggler equal to 40 ($k = 40$), which involves a 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, 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.[16] 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,

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

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, $D = 1000$.

We set the number of cartelized firms to 1 ($N = 1$), the fixed cost for the cartel to 0 ($F = 0$) and the marginal cost of doing business c to 5 ($c = c_1 = c_2 = 5$). For the hiring cost function, we set the parameter $b = 0.9$ 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 ($\nu = 0.25$).

Parameter values for the benchmark are summarized in Table 2. The equilibrium variables obtained for these parameters are displayed in the second column of Table 3.

Table 2: Parameter values in the benchmark case

$\bar{w} = 20$	$\bar{M} = 1000$	$r = 300$	$\mu = 0.9$
$\nu = 0.25$	$\alpha = 0.5$	$\psi = 0.9$	$b = 0.9$
$F = 0$	$c = 5$	$N = 1$	
$\delta_1 = 0.025$	$\delta_2 = 0.05$	$D = 1000$	
$\eta_1 = 0.1$	$\eta_2 = 0.25$	$k = 40$	$z = 10$

With these parameters, 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 sector one.

5.4 Policy implications

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 achievement and limits. It also sets a clear agenda for the years to come.

On the one hand, policy measures strive to increase the interception rate and the sanctions for smuggling; on the other hand, development measures, aiming at increasing the alternative income of smugglers in legal occupation could prompt entrepreneurs to shun their illegal activities.

Other measures, documented in the New Pact on Asylum and Migration aim at reducing the attractiveness of the EU area for economic migrants, while protecting the asylum rights of the refugees.

Our simulations show that a simple cost/benefit logic, guided by intuition and common sense, can sometimes backfire in a two-sector environment. We 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.

5.4.1 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 smuggling. The Financial Times provides information about the agreement between the EU and Tunisia which is the showcase for other agreements.[17] 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 sanction cost k, and eventually a homogeneous increase in the probability to intercept smugglers in both sectors. Table 3 reveals the effects of higher sanctions.

As expected, the higher sanction 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 num-

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

ber of smugglers hired by the criminal organization increases, as well as the number of migrants per cartel 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 smugglers, by increasing its activity.

Table 3: Simulation results for policies impacting convicted smugglers' penalty

	(1)			(2)			(3)		
	$k = 35$			Benchmark $k = 40$			$k = 45$		
	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	
Tightness θ^*	6.46	2.81		7.04	3.05		7.64	3.32	
Smug. contact prob. $h(\theta^*)$	0.63	0.42		0.66	0.43		0.69	0.46	
Mig. contact prob. $g(\theta^*)$	0.09	0.14		0.09	0.14		0.09	0.14	
Smuggling fee p^*	109.1	73.6		109.1	73.6		109.1	73.6	
Expected utility V^*	10.23	10.23		9.8	9.8		9.41	9.41	
Profit per smuggler π^*	21.3	20		22.5	20		23.7	20	
Cartel total profit Π^*	409			456.3			505.7		
Smugglers S^*	19	311	330	20	280	300	21	252	273
Potential migrants M^*	124	876	1000	143	857	1000	163	837	1000
Total border crossings M^*_{dest}			102.1			97.5			93.3

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

This then raises the following question: what would be the consequence of targeting the criminal organization and making only its activity more difficult?

In Table 4, we analyze the consequences of increasing the risk of intercepting the cartel-related smugglers only, keeping constant the interception rate of the small smugglers.

Table 4: Simulation results for policies impacting smugglers' arrest probability

	(1)			(2)			(3)		
	$\eta_1 = 0.075$			Benchmark $\eta_1 = 0.10$			$\eta_1 = 0.15$		
	Cartel	Comp.	Total	Cartel	Comp.	Total	Cartel	Comp.	Total
Migr. exp. income y	219.6	142.2		213.1	142.2		200	142.2	
Tightness θ^*	7.49	3.05		7.04	3.05		6.18	3.05	
Smug. contact prob. $h(\theta^*)$	0.68	0.43		0.66	0.43		0.62	0.46	
Mig. contact prob. $g(\theta^*)$	0.09	0.14		0.09	0.14		0.09	0.14	
Smuggling fee p^*	112.3	73.6		109.1	73.6		102.5	73.6	
Expected utility V^*	9.8	9.8		9.8	9.8		9.8	9.8	
Profit per smuggler π^*	25.2	20		22.5	20		17.3	20	
Cartel total profit Π^*	572			456.3			270		
Smugglers S^*	23	271	294	20	280	300	16	295	311
Potential migrants M^*	170	830	1000	143	857	1000	96	904	1000
Total border crossings M^*_{dest}			97			97.5			98.4

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

This measure appears to be extremely effective in cutting the cartel's total profit, and the number of hired smugglers. On the other hand, the small-business sector will take advantage of this opportunity to expand their business, such that the total number of smugglers actually increases. As a consequence, the number of irregular border crossings is edging up, despite the higher arrest rate for cartel smugglers.

We provide in Appendix A.6 the simulation for higher smuggling costs, both as a general purpose measure rising costs in both sectors in an undiscriminate way (Table A.1), or as a targeted measure, rising costs for the criminal organizations only (Table A.2). 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 would push 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.

5.4.2 The smuggler alternative income

The economic development of migrant transit countries (for instance Libya, Tunisia, Turkey) should increase the alternative income of smugglers in the formal sector (a higher $\bar{w}$). The EU has signed many development agreements with these countries, and offers them interesting trade and investment opportunities (European Commission, 2021). All other things being equal, an increase in the alternative income would make the hiring of smugglers more expensive for the cartel, and the smuggling business less attractive for self-employed smugglers.

The theoretical calculations show that an increase in the alternative income for smugglers leads to similar changes in both sectors: an increase in the market tensions and the fees paid to smugglers, and a decrease in the expected utilities from migration. (In the Cobb-Douglas case, the fees does not depend on the alternative income for smugglers).

Additionally, as shown in Table 5, the simulation shows that overall, this measure appears to be effective in decreasing the number of illegal border crossings. This reduction is the outcome of a drastic fall in the number of smugglers.

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.

Table 5: 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	
Tightness θ^*	4.89	2.12		7.04	3.05		9.5	4.16	
Smug. contact prob. $h(\theta^*)$	0.55	0.36		0.66	0.43		0.77	0.51	
Mig. contact prob. $g(\theta^*)$	0.11	0.17		0.09	0.14		0.08	0.12	
Smuggling fee p^*	109.1	73.6		109.1	73.6		109.1	73.6	
Expected utility V^*	11.76	11.76		9.8	9.8		8.43	8.43	
Profit per smuggler π^*	19.2	15		22.5	20		25.8	25	
Cartel total profit Π^*	334			456.3			597.6		
Smugglers S^*	17	430	447	20	280	300	23	186	209
Potential migrants M^*	87	913	1000	143	857	1000	222	778	1000
Total border crossings M^*_{dest}			118.3			97.5			82.3

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

5.4.3 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.[18] The new Pact on Asylum and Migration was adopted in April 2024. It 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 analyse, these measures can be represented by a decrease in the parameter μ. We represent in Table 6 the effect of this change.

Table 6: Simulation results for policies impacting the probability of being granted the refugee status

	(1)			(2)			(3)		
	$\mu = 0.8$			Benchmark $\mu = 0.9$			$\mu = 0.95$		
	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	
Tightness θ^*	10.3	4.21		7.04	3.05		5.95	2.65	
Smug. contact prob. $h(\theta^*)$	0.8	0.51		0.66	0.43		0.61	0.41	
Mig. contact prob. $g(\theta^*)$	0.07	0.12		0.09	0.14		0.1	0.15	
Smuggling fee p^*	96.4	63.5		109.1	73.6		115.4	78.7	
Expected utility V^*	7.11	7.11		9.8	9.8		11.3	11.3	
Profit per smuggler π^*	24.7	20		22.5	20		21.6	20	
Cartel total profit Π^*	547			456.3			423		
Smugglers S^*	22	183	205	20	280	300	20	333	353
Potential migrants M^*	229	771	1000	143	857	1000	116	884	1000
Total border crossings M^*_{dest}			81.3			97.5			105.4

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

As expected, this general purpose measure, applying to migrants coming though both channels, leads to a lower number of irregular border crossings. This is explained by a reduction in the expected income, a lower smuggling fee, and a lower number of smugglers in the small-business sector.

On the other hand, the profit in the organized crime sector is edging up, as well as the number of smugglers in this sector (although this increase is smaller than the decrease in the number of smugglers in sector 2). This can be explained by the reallocation of migrants, from searching a smuggler in sector 2 (more congested) toward searching one in sector 1.

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

6 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 monopoly (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 was solved to determine the cross-sector equilibrium, and changes in parameters were 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 penalties for smugglers, improving smugglers alternative income 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. 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, as both rely on the same fee determination mechanism. Further research could aim at refining such a dynamic analysis.

Another limitation of our analysis is the focus on forced migration. The model can 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 migrant 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 organisations 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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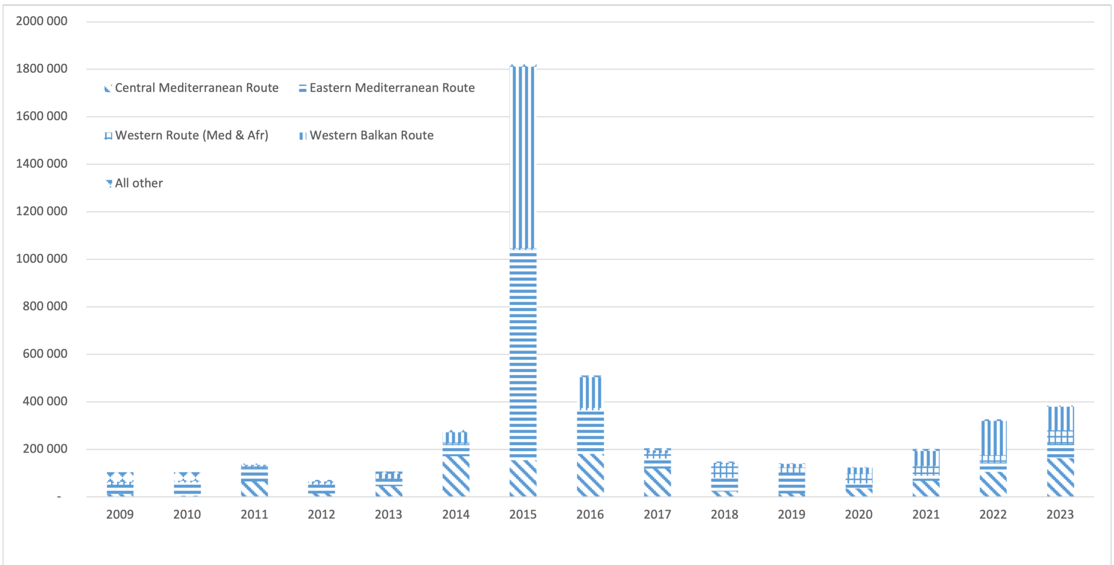
A Online Appendix

A.1 Irregular Border Crossings in the EU

Figure A.1: Detections of Irregular Border Crossings to the EU - 2009-2023



Source: Frontex Risk Analysis Network (FRAN) data as of 4 April 2024.

Notes: Data reported on a monthly basis by Member States and Schengen Associated Countries on detections of illegal border-crossing on entry between BCPs of the external borders of the Member States of the EU and Schengen Associated Countries, and aggregated by routes. The data refer to detections of illegal border-crossing rather than the number of persons, as the same person may cross the external border several times.

A.2 Sector 1 - Criminal cartels

A.2.1 The general case

Summary of the main optimization equations for Sector 1:

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

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

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

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

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

A.2.2 The Cobb-Douglas case

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

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

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

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

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

$$\pi_1 = \left[\alpha\nu\left(\bar{y}_1 - c_1\right)\left(\theta_1\right)^{1-\alpha} - \left(\bar{w} + \eta_1 k\right)\right] s_1 - \frac{b}{\psi^2}\left(s_1\right)^2 - F_1 \tag{A.10}$$

A.3 Sector 2 - Self-employed smugglers

A.3.1 The general case

Summary of the main optimization equations for Sector 2:

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

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

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

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

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

A.3.2 The Cobb-Douglas case

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

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

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

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

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

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

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

A.4 Cross-sector interactions and equilibrium

A.4.1 The general case

Summary of the main equilibrium equations:

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

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

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

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

$$h^{'}\left(\theta_1^*\right) = \frac{V_1^*}{\bar{y}_1 - c_1} \tag{A.26}$$

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

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

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

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

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

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

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

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

A.4.2 The Cobb-Douglas case

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

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

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

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

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

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

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

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

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

$$\pi_2 = \bar{w} \tag{A.43}$$

$$S_1^* = N s_1^* \tag{A.44}$$

$$M_1^* = S_1^* \theta_1^* \tag{A.45}$$

$$M_2^* = \bar{M} - M_1^* \tag{A.46}$$

$$S_2^* = \frac{M_2^*}{\theta_2^*} \tag{A.47}$$

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

A.5 Comparative statics

A.5.1 The general case

Differentiation of the main equilibrium equations:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

A.5.2 The Cobb-Douglas case

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

$$d\bar{y}_1 = -\mu(r-z)\,d\eta_1 - [D+z+\mu(r-z)]\,d\delta_1 + (1-\eta_1-\delta_1)(r-z)\,d\mu \tag{A.66}$$

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

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

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

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

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

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

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

$$-(d\bar{w}+\eta_1 dk+kd\eta_1) \tag{A.74}$$

$$d\pi_1^* = \frac{2b}{\psi^2}s_1^* ds_1^* \tag{A.75}$$

$$d\pi_2^* = d\bar{w} \tag{A.76}$$

$$dS_1^* = s_1^* dN + N ds_1^* \tag{A.77}$$

$$dM_1^* = \theta_1^* dS_1^* + S_1^* d\theta_1^* \tag{A.78}$$

$$dM_2^* = -dM_1^* \tag{A.79}$$

$$(\theta_2^*)^2\, dS_2^* = \theta_2^* dM_2^* - M_2^* d\theta_2^* \tag{A.80}$$

$$dM_{dest}^* = (1-\eta_1-\delta_1)\,\nu\left[(\theta_1^*)^{-\alpha}dM_1^* - \alpha(\theta_1^*)^{-(1+\alpha)}M_1^* d\theta_1^*\right] - \nu(\theta_1^*)^{-\alpha}M_1^*(d\eta_1+d\delta_1) \tag{A.81}$$

$$+\nu(1-\eta_2-\delta_2)\left[(\theta_2^*)^{-\alpha}dM_2^* - \alpha(\theta_2^*)^{-(1+\alpha)}M_2^* d\theta_2^*\right] - \nu(\theta_2^*)^{-\alpha}M_2^*(d\eta_2+d\delta_2) \tag{A.82}$$

A.6 Simulation: impact of an increase in the marginal costs

We provide in this Appendix the simulation for a higher marginal cost of smuggling (c), both as a general purpose measure rising costs in an undiscriminate way (Table A.1), or as a targeted measure, rising costs for the criminal organizations only (Table A.2).

Table A.1: 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	
Tightness θ^*	6.7	2.95		7.04	3.05		7.39	3.17	
Smug. contact prob. $h(\theta^*)$	0.64	0.43		0.66	0.43		0.68	0.45	
Mig. contact prob. $g(\theta^*)$	0.09	0.14		0.09	0.14		0.09	0.14	
Smuggling fee p^*	107.8	72.3		109.1	73.6		110.3	74.8	
Expected utility V^*	10.16	10.16		9.8	9.8		9.45	9.45	
Profit per smuggler π^*	22.1	20		22.5	20		22.9	20	
Cartel total profit Π^*	439			456.3			474.2		
Smugglers S^*	20	293	313	20	280	300	21	267	288
Potential migrants M^*	134	866	1000	143	857	1000	153	847	1000
Total border crossings M^*_{dest}			99.5			97.5			95.5

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

Table A.2: 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	
Tightness θ^*	7.21	3.05		7.04	3.05		6.87	3.05	
Smug. contact prob. $h(\theta^*)$	0.67	0.43		0.66	0.43		0.65	0.43	
Mig. contact prob. $g(\theta^*)$	0.09	0.14		0.09	0.14		0.09	0.14	
Smuggling fee p^*	107.8	73.6		109.1	73.6		110.3	73.6	
Expected utility V^*	9.8	9.8		9.8	9.8		9.8	9.8	
Profit per smuggler π^*	23.4	20		22.5	20		21.7	20	
Cartel total profit Π^*	490.7			456.3			423.5		
Smugglers S^*	21	277	298	20	280	300	19	283	302
Potential migrants M^*	152	848	1000	143	857	1000	134	866	1000
Total border crossings M^*_{dest}			97.2			97.5			97.8

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