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► **To cite this version:**

Olivier Charlot, Claire Naiditch, Radu Vranceanu. SMUGGLING OF FORCED MIGRANTS TO EUROPE: A MATCHING MODEL. 2023. hal-04316352

HAL Id: hal-04316352

<https://essec.hal.science/hal-04316352>

Preprint submitted on 30 Nov 2023

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ESSEC RESEARCH CENTER

WORKING PAPER 2309

NOVEMBER 30, 2023



Smuggling of Forced Migrants to Europe: A Matching Model

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November 26, 2023

Abstract

This paper¹ develops a matching model *à la* [Pissarides \(2000\)](#) to analyze the smuggling market for forced migrants, building on the empirical evidence related to the smuggling of migrants from the Horn of Africa and the Middle East to the European region in the last decade. Comparative statics for the equilibrium solution reveals that coercion-based measures targeting the smugglers achieve a reduction in the number of irregular migrants and smugglers at the expense of migrants' overall welfare. Slightly increasing legal migration opportunities has the interesting feature of reducing irregular flows, without deteriorating migrants' welfare nor increasing the total number of migrants. An extremely restrictive asylum policy has similar effects in terms of the flows of irregular migrants as a quite loose one, with the largest flows of irregular migrants reached for a "middle-range" policy.

Keywords - Migrant smuggling, Irregular migration, Forced migration, Matching model, Europe.

JEL Classification - F22, O15, J46

¹Pre-print, forthcoming in the *Journal of Population Economics*, Springer, 2024.

1 Introduction

While irregular migration to Europe has expanded since the 1980s ([Angeli and Triandafyllidou, 2016](#)), this dynamics stepped up in the last decade, with European Union (EU) member states recording a surge in the number of irregular migrants arriving from the Middle East and the Horn of Africa against the background of wars and large humanitarian crises in Afghanistan and Syria, among many other tensions and conflicts.²

Figure 1 shows the number of irregular border-crossings between 2009 and 2022 at the external borders of the European Union as reported by the European Border and Coast Guard Agency (or Frontex), depending on whether migrants have reached the EU border by sea or land. Data reveal an all-time-high of 1,822,000 illegal crossings in 2015, during the height of the Syrian crisis ([Frontex, 2019, 2022](#)), a decline during the Covid19 period, followed by a rise in irregular border-crossings after 2020. As reported by the European Commission, Syrian, Afghan, Tunisian, Egyptian and Bangladesh nationals represented 60% of the 330,000 irregular border-crossings in 2022; 15.7% of the border-crossings were by people of unidentified nationality.³ Three out of the five main migration routes to Europe involve crossing of the Mediterranean sea ([Frontex, 2021](#)).

In perfect synchronisation with the rise of irregular migration flows, another phenomenon developed. According to Europol, the EU Agency for Law Enforcement, 90% of those who cross the EU borders in an irregular way do it with the support of smugglers or 'facilitators' ([Europol, 2016; Lyuten and Smialowski, 2021](#)). Frontex reports annual detection of 13,000 smugglers on average in the period 2014-2021 ([Frontex, 2019, 2022](#)). At the peak of the migratory crisis, in 2015, the turnover of the European smuggling market was estimated between 3 and 6 billion euros. In 2019, smuggling turnover on the Mediterranean routes only was estimated at about 190 million euros.

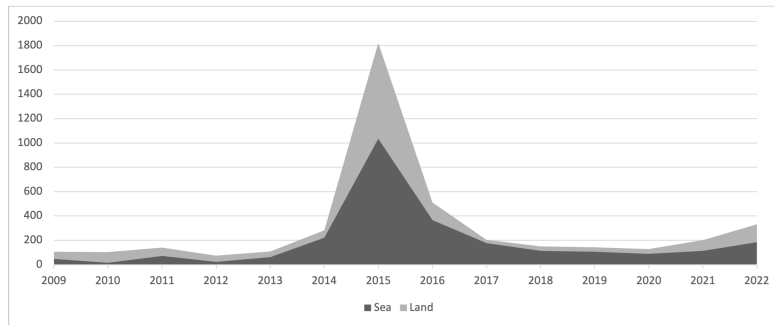
This paper introduces a search and matching model *à la* [Pissarides \(2000\)](#) to study the complex interaction between migrants and smugglers, with the main aim of explaining the consequences of various policies implemented by the EU to discourage smuggling and reduce the number of irregular migrants coming every year. In our analysis, a smuggler searching for a migrant is in the same position as a firm searching for a worker and posting a vacancy. Their

²A significant body of high quality reports by international organizations and research papers provide ethnographic analyses of this new migration-to-EU episode (see, for instance, [Abdel Aziz et al., 2015; Achilli and Sanchez, 2017; UNODC, 2018; Campana, 2018; Campana and Gelsthorpe, 2020; Campana, 2020; Sanchez, 2020](#)).

³The European Commission website for Statistics on Migration, accessed on July 27, 2023.

likelihood to meet and undertake the risky journey reflects the substantial trading frictions in this opaque market.

Figure 1: Illegal border-crossing at the external borders of the EU, on entry (thousands persons)



Sources: Frontex Risk Analysis Reports 2012-2022, Frontex News, Jan. 2023. The same person may cross the border several times in different locations.

The analysis in this paper focuses mainly on forced migration, i.e., on candidates to migration who have no other choice but to flee their country of origin to protect their life and that of their families against the background of wars and natural catastrophes. Once they reach the destination area, they apply for asylum. According to the IOM (2019), *forced migration* is "a migratory movement which, although the drivers can be diverse, involves force, compulsion, or coercion". While it is difficult to isolate the specific migration drivers, several scholars pointed out that human rights violations represented the main determinant of migration to Europe during the high-flow period (2014-2016) (Pignat, 2020).⁴

Our paper therefore brings a new contribution to three strands of the literature.

First, the paper can be seen as a contribution to a growing literature on forced migration or refugees, which for many years evolved in the shadow of mainstream research on voluntary migration. In their surveys of the literature on forced migration, Ruiz and Vargas-Silva (2013); Fasani (2016); Maystadt et al. (2019) and Becker and Ferrara (2019) focus on the impacts of forced migration on the migrants themselves, as well as on host and origin communities. These

⁴In the recent years, the importance of the economic motive as a determinant of migration to Europe might have increased, knowing that people exposed to extreme poverty have no other real choice but to leave the area of residence (see, for instance, The Economist, October 12, 2023, "The EU's endless search for a migration fix"). In an extension of this model (Charlot et al., 2022), we study the case of voluntary migration in a matching framework, where economic migrants follow the same routes as forced migrants, but, additionally, carry on a cost-benefit analysis of migration, along the traditional logic in Harris and Todaro (1970).

studies underline the fact that forced migration differs from voluntary migration not only in nature, but also in its consequences. Our paper contributes to this literature by studying the way forced migrants travel and cross the borders until they can claim asylum in safe destination areas.

Second, it contributes to the literature on human smuggling in general. 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. Among the existing studies, we mention [Salt and Stein \(1997\)](#) who were the first to describe in a systematic way the successive stages of smuggling and the complex nature of the smuggling activities. [Gathmann \(2008\)](#) introduces a cost/benefit analysis to explain smugglers' choice of the crossing border point, and shows that tighter border control leads to geographic substitution and raises migration costs. This prediction is corroborated by the empirical study by [Pham and Komiyama \(2022\)](#) who show that increasing interception rates by the Libyan border police entails a switch to alternative routes for migrants to the EU. [Djajić and Michael \(2014\)](#) investigate how tougher transit cost over a neighboring country can reduce migration. 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, 2014](#)). Closer to our analysis are the papers by [Auriol and Mesnard \(2016\)](#) and [Brausmann and Djajić \(2022\)](#). The former have developed the first industrial organization model of the market for smuggling services. They consider that the smuggling services are provided by a closed oligopoly including a relatively small number of large criminal organizations, similar to the drug cartels. The number of smuggler organizations is given; they engage in monopolistic competition *à la* Cournot, choosing smuggling fees to maximize the profit (rent). 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 (at the cost of drastically increasing the number of legal migrants).⁵ In an interesting extension of this model, [Auriol et al. \(2021\)](#) reveal that temporary visas can also irrevocably push smugglers out of the market. Smuggling activity in the context of forced migration is at the heart of the paper by [Brausmann and Djajić \(2022\)](#). They develop a dynamic macroeconomic model to analyse how the border-control policy of destination countries with a migration target

⁵[Djajić and Vinogradova \(2019\)](#) also show that there may be a trade-off between the policies targeting legal and irregular migration.

should best respond to the pressure from migration flows. The model builds on two differential equations, one for the change in the stock of migrants, and another one for the change in the amount of resources used to control migration. One key result is that the higher the speed of adjustment of the border-control policy, the lower the spending and the amount of time required to get the system to its new steady state.

While the above mentioned migration analyses provide rich and useful insights, they do not take into account two important features of the smuggling market. First, transactions between candidates to migration and smugglers take place in a context of illegality, asymmetric information and low trust ([Campana and Gelsthorpe, 2020](#); [Campana, 2020](#)). Second, the smuggling and migration processes have an essential flow dimension, with many migrants been pushed-back and increasing the stock of candidates to migration. The matching model used in this paper, with its rigorous approach to trading frictions, is well suited to describe such an opaque market with substantial flows.

In this respect, our paper could also be seen as an addition to the substantial body of literature that developed on the foundations of the search and matching model ([Pissarides, 2000](#)). In the migration literature, this framework has already been used for example to study the consequences of irregular migration on rich countries' labor markets (see, for instance, [Chassamboulli and Palivos, 2014](#); [Chassamboulli and Peri, 2020](#); [Chassamboulli and Liu, 2020](#); [Moreno-Galbis and Tritah, 2016](#)). [Docquier and Iftikhar \(2019\)](#) analyze the consequences of brain drain on the welfare of stay-home workers, using a two-sector (formal and informal) matching model of the labor market. Our paper is the first to use the search and matching model to analyse the migration process. By contrast with the traditional labor market model where firms enter the market and pay a wage to workers, in our model smugglers (equivalent of the firms) enter the market but the migrants pay them a wage (the smuggling fee).

We adopt in this paper the "small-firm" version of the labor market matching model, allowing for smuggler free-entry. This assumption covers an important segment of the smuggling market, particularly in the case of Europe. The report by [UNODC \(2018\)](#) indicates that small and family businesses are important players in the human smuggling market, next to the criminal cartels with a strong hierarchical organization. In the case of the smuggling of migrants to Europe, field evidence collected by a number of scholars reveals that most of the smuggling activity is carried out by largely independent and autonomous smuggling facilitators, who compete between them to provide services to a limited number of candidates to migration ([Abdel Aziz et al., 2015](#); [Campana, 2018, 2020](#)). According to [Sanchez \(2020\)](#), who provide an in-depth analysis of the

smuggling activities in Libya, "facilitators of migration were ordinary people, living in border areas along migration pathways and in migrant enclaves in coastal towns and cities".⁶

The model is solved to determine the equilibrium tightness in the market (i.e., the smugglers per migrant ratio), the smuggling fee, the numbers of incoming migrants and smugglers. Changes in the parameters of the model can be related to the various policies implemented by destination, transit or origin countries.

In brief, the results reveal a tension between the goal of reducing the number of irregular migrants and migrants' welfare. Most of the coercion-based measures achieve a reduction in the number of irregular migrants and smugglers at the expense of migrants' overall welfare. On the other hand, slightly increasing legal migration opportunities has the interesting feature of drastically reducing irregular flows, without deteriorating migrants' welfare nor increasing total migration flows. The model reveals that an extremely restrictive asylum policy has similar effects in terms of the flows of irregular migrants as a quite loose one, with the largest flows of irregular migrants reached for a "middle-range" policy.

The remainder of the paper is organized as follows. Some elements of the institutional context of irregular migration to the EU are presented in section 2. The main assumptions of the model are introduced in section 3. Section 4 determines the equilibrium of the model and analyzes the effect of various policies on key equilibrium variables. Section 5 analyses the policy implications of the model, backed by several numerical simulations. Section 6 presents our conclusions.

2 Elements of institutional context

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”.⁷ 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 (IOM, 2019; UNODC, 2018; Frontex, 2021; MacKellar, 2020).

⁶Another segment of the smuggling market relies on large criminal organizations, to which the "large-firm" matching model, also developed in [Pissarides \(2000\)](#), could be a better fit.

⁷Art. 3(a), UN Protocol Against the Smuggling of Migrants by Land, Sea and Air, supplementing the United Nations Convention against Transnational Organized Crime, 2000.

Fighting migrant smuggling and human trafficking is a top priority for the EU, as it was reminded by Ursula von der Leyen, President of the European Commission, in her *State of the Union Address 2023* (von der Leyen, 2023). For EU member states, the key policy goal is to control and curb irregular migration (i.e. decrease the number of migrants reaching the EU and applying for asylum as well as the number of smugglers) through a multitude of policy measures. In turn, these policy measures will have an impact on migrants' welfare, which can be assessed with our framework.

The European Border and Coast Guard Agency (Frontex) was created in 2004, and evolved into the EU operational enforcement service to protect the EU borders and fight against cross-border crime. The agency has a substantial role in preventing irregular border crossings, and fighting smuggling and human trafficking.

In 2015, the EU carried out a comprehensive review of its migratory policy, including the common resources dedicated to improve the situation of the migrants on the one hand, and to fight illegal border crossing on the other hand.⁸ Within this broad set of reforms, on May 2015, the European Commission adopted an [EU Action Plan against Migrant Smuggling](#) designed to transform 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. In September 2021, a [renewed EU Action Plan against Migrant Smuggling \(2021-2025\)](#) has been adopted by the European Commission.

In 2020, the EU issued a [New Pact on Asylum and Migration](#) with the aim of strengthening coordination and cooperation with third countries by creating a common EU system for returns, which includes a stronger role of the European Border and Coast Guard Agency, a newly appointed EU return coordinator, and a voluntary return and reintegration strategy (OECD, 2021; Lyuten and Smialowski, 2021).⁹ More recently, in October 2023, EU member states governments agreed on a mechanism to deal with unforeseen crises.¹⁰

In brief, EU migration policies can be classified as: (1) measures impacting migrants' expected payoff from migration; while these measures have a strong effect on voluntary migrants, they should also influence forced migration indirectly, as they impact the negotiated fee; (2) measures aiming at deterring smugglers, generally involving cooperation with governments of

⁸See the European Commission website: [Towards a Comprehensive European Migration Policy: 20 years of EU Action](#).

⁹See the European Commission webpage [What is the New Pact on Migration and Asylum of the EU?](#); the expected date for final adoption of the Pact is April 2024.

¹⁰See for instance LeMonde, October 6, 2023, ["EU states reach deal on migration reforms"](#).

origin and transit countries; (3) development measures, providing incentives for candidates to migration to abandon the migration project, by improving their living standard at home. Obviously development measures should have only a limited effect on forced migration. Therefore, in this paper, we will not address this topic, and refer instead to a companion text (Charlot et al., 2022) for a complementary analysis of economic migration in a matching framework.

3 The model

As any model-based analysis, we use a simplified framework to describe the extremely complex situation in the field. In the country of origin, a group of candidates to migration searches for smugglers and a group of smugglers searches for candidates to migration. Smugglers and candidates to migration respectively seek to maximize their intertemporal expected profit and utility. Their decision problem is cast in continuous time. Focus is set on the steady state equilibrium. To keep the analysis relatively simple, we assume that only one smuggler is in charge of taking the migrant from the origin to the destination area. In the destination country, authorities aim at curbing irregular migration and deterring the smuggling business.

3.1 The matching function

A fundamental process in the smuggling market is the encounter between candidates to migration who search for smugglers (also referred to as potential migrants), and smugglers who search for potential migrants, what is currently referred to as the matching process. This process takes time as it involves a substantial activity of gathering information and building trust on both sides of the market (Campana and Gelsthorpe, 2020), which are referred to as trading frictions in the traditional search and matching literature.

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). These searching and matching activities are costly.

A standard matching function, as introduced by Pissarides (2000), allows us to bring into the picture these significant trading frictions. Let M_s be the number of potential migrants searching for a smuggler, and S_s the number of smugglers searching for a migrant. The matching function connects the number of successful matches, \mathcal{H} , to the number of searching migrants and smugglers as follows:

$$\mathcal{H} \equiv pH(M_s, S_s), \tag{1}$$

where $p > 0$ is a scale parameter determining the efficiency of the matching process, with $p \rightarrow +\infty$ corresponding to the limit case of a frictionless market where matching is instantaneous.¹¹

The function H is twice continuously differentiable; it is increasing and concave in both of its arguments, linearly homogeneous and satisfies the Inada conditions and the boundary conditions ($H(0, S_s) = H(M_s, 0) = 0$ for $M_s, S_s \geq 0$).

We define the *market tightness* θ as the smuggler per candidate to migration ratio:

$$\theta = \frac{S_s}{M_s}. \quad (2)$$

On average, a smuggler meets a candidate to migration at rate \mathcal{H}/S_s while a candidate to migration meets a smuggler at rate \mathcal{H}/M_s . Linear homogeneity of the matching function allows us to define the two contact rates as a function of the market tightness:

$$\frac{pH(M_s, S_s)}{S_s} = h(\theta), \text{ with } h'(\theta) < 0, \quad (3)$$

and

$$\frac{pH(M_s, S_s)}{M_s} = g(\theta), \text{ with } g'(\theta) > 0. \quad (4)$$

Obviously θ , $h(\theta)$ and $g(\theta)$ are related, since the number of candidates to migration meeting a smuggler must be equal to the number of smugglers meeting a candidate to migration:

$$M_s g(\theta) = S_s h(\theta) \Leftrightarrow g(\theta) = \theta h(\theta). \quad (5)$$

3.2 Key stages of smuggler-facilitated migration

Irregular migration is a long and complex process involving different stages, as first emphasized by [Salt and Stein \(1997\)](#). [Figure 2](#) summarizes these stages, focusing on the status of the migrants. [Figure A.1](#) in the Appendix presents the same stages from a smuggler perspective.

The first block (stage) represents the place where migrants and smugglers strive to meet. There is a stock of candidates to migration, denoted by M_s . Arrivals into this pool of people includes two flows: a flow of N new candidates per period, and a flow of migrants turned back in the different stages of the migration process who try to migrate again. Because we focus on the situation of forced migrants, we take N as an exogenous variable, in line with the literature on forced migration ([Ruiz and Vargas-Silva, 2013](#); [Becker and Ferrara, 2019](#); [Brell et al., 2020](#)).

¹¹As an usual example, used later on for numerical simulations, the matching function can be of the Cobb-Douglas form, $H = pM_s^\alpha S_s^{1-\alpha}$, where $\alpha \in (0, 1)$ is the elasticity of the matching function with respect to M_s .

We assume that asylum-seekers can leave the area of origin either along a legal channel at a (small) exogenous rate σ , or through the irregular channel, via the smuggling market.¹² A candidate finds a smuggler at a rate $g(\theta)$; a smuggler finds a candidate to migration at a rate $h(\theta)$.

A candidate to migration and a smuggler who meet each other enter a tacit "travel contract", involving a smuggling fee w and the obligation for the smuggler to guide and support the journey of the migrant toward a destination country. UNODC (2018) mentions that migrants from sub-Saharan Africa would pay around 1,000 US dollars to be smuggled from Libya to Europe, whereas a Syrian would pay 2,500 US dollars or more for a safer seat. Frontex (2019) documents that the migrants who reached Italy from Turkey spent on average 5,000 euros per person for smuggling services.

The second stage occurs after a successful match; at this stage, the migrant-smuggler pair waits for an opportunity to leave the conflict area; when such an opportunity materializes (at a rate a), the migrant pays to the smuggler the fee as agreed at the previous stage, and they begin their dangerous journey.

The third stage is the travel stage, which, in the context of migration to the EU, involves either a land or a land and sea (Mediterranean) journey (see Fig. 1). During the journey, matched smugglers and migrants can be intercepted by local and border police in countries along their road at a rate η . In this case, migrants are sent back to their origin area, while smugglers are convicted.

For the sea journey, smugglers board migrants on overcrowded, unseaworthy vessels, often short of fuel (Frontex, 2022), and let them sail towards the destination area. The sea journey is extremely dangerous for migrants. The International Organization for Migration (IOM) acknowledges that on the Central Mediterranean route only, 20,000 people died in the attempt to cross the sea in the period 2014-2022, which is a major humanitarian crisis by any standards.¹³ We denote by δ the rate at which migrants (not smugglers) can lose their life during the sea journey.

¹²We implicitly assume that candidates to migration simultaneously search for a smuggler and apply for a visa. Those who have the chance to obtain a visa will leave through the regular channel, the others will use the irregular channel.

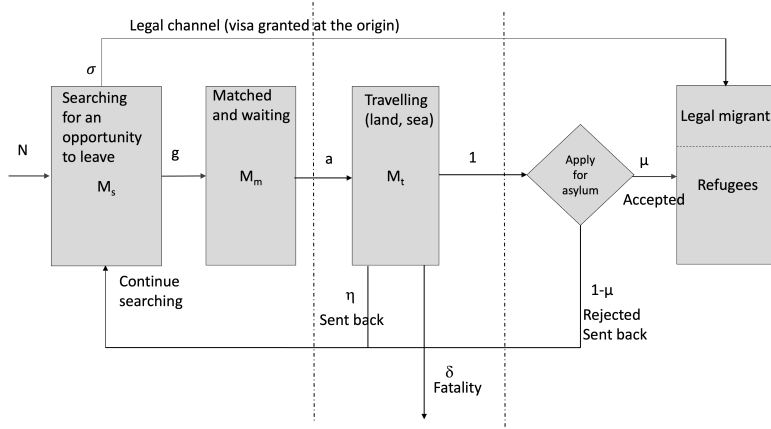
¹³See <https://news.un.org/en/story/2023/04/1135577>.

We assume that the journey to the destination succeeds at a rate equal to 1.¹⁴

The fourth stage of the migration process begins when the migrant reaches the EU border and applies for the refugee status. We assume that the refugee status is granted at a rate μ , representative of the stringency of the EU asylum policy. For the sake of parsimony, we assume that those who have their application rejected are sent back and effectively return to the origin area.¹⁵

All the migrants who are returned to the destination country (either stopped by the border police or with a rejected asylum application) keep on trying to migrate: they apply for a visa and start, one more time, to search for a smuggler. Some witnesses state that some migrants tried to cross border fifteen times or more.¹⁶

Figure 2: Flow diagram for the candidates to migration



3.3 Flows and stocks of migrants and smugglers

The analysis in this paper focuses on the steady state equilibrium, wherein flows in and out of each state offset each other, i.e. $\dot{M}_s = \dot{M}_m = \dot{M}_t = 0$.

¹⁴In a more general framework, this rate could be set equal to a positive parameter λ , to acknowledge that the migration project may also be deterred by other external shocks (natural events, unexpected conflicts, accidents, etc.) and that the duration of the journey may vary from a very few days to weeks or even years (European Commission, 2015). See Charlot et al. (2022) for this extension.

¹⁵An additional parameter might allow us to differentiate between the migrants who see their asylum status denied and accept to be sent back, and those who manage to fall between the cracks and stay as illegal migrants in the destination area.

¹⁶See for instance The Economist, August 8, 2019, "Migrant arrivals in Italy have tumbled" or Deutsche Welle, December 1, 2019, "Germany: Thousands of migrants return after deportation".

According to the flow diagram (Figure 2), the inflow of migrants searching for a smuggler is made up of N new candidates arriving every period from the conflict area, and of the migrants who have either been caught by the border police during their journey or reached the destination country but were denied asylum. All candidates to migration search for a smuggler and apply for a visa. The steady state condition for the pool of candidates to migration then implies:

$$\dot{M}_s = 0 \iff \underbrace{N + [\eta + (1 - \mu)] M_t}_{\text{inflow}} = \underbrace{[g(\theta) + \sigma] M_s}_{\text{outflow}}. \quad (6)$$

Similarly, the flow diagram shows that matched migrants wait for an opportunity to undertake their journey. The steady state condition for matched migrants implies:

$$\dot{M}_m = 0 \iff \underbrace{g(\theta) M_s}_{\text{inflow}} = \underbrace{a M_m}_{\text{outflow}}. \quad (7)$$

Finally, Figure 2 summarizes the fact that travelling migrants can be caught by the police, die during their sea journey, or reach the destination country. The steady state condition for the pool of travelling migrants then implies:

$$\dot{M}_t = 0 \iff \underbrace{a M_m}_{\text{inflow}} = \underbrace{(\eta + \delta + 1) M_t}_{\text{outflow}}. \quad (8)$$

Combining these flow equations, we obtain the expression of the mass of irregular migrants traveling to reach the destination country, M_t :

$$M_t = \frac{N}{\frac{\sigma}{g(\theta)} (\delta + \eta + 1) + \delta + \mu}. \quad (9)$$

The mass of candidates to migration (searching for a smuggler and applying for a visa) is then:

$$M_s = \frac{\delta + \eta + 1}{g(\theta)} M_t. \quad (10)$$

Finally, making use of $S_s = \theta M_s$ and $g(\theta) = \theta h(\theta)$, we obtain the number of active smugglers:

$$S_s = \frac{\delta + \eta + 1}{h(\theta)} M_t. \quad (11)$$

Combining equations (11) and (9), and recalling that $\theta = S_s/M_s$, we obtain a decreasing relationship between the numbers of searching smugglers S_s and searching migrants M_s , similar to the Beveridge-curve in the standard labor market model.

3.4 Asset values

3.4.1 The asset value of a candidate to migration

Let us denote by V_s^M the asset value of a searching candidate to migration, by V_m^M the asset value of a matched migrant waiting for an opportunity to travel, and by V_t^M the asset value of a travelling migrant.

Given the transition rates defined before, and denoting by r the interest rate, for risk neutral agents, these asset values can be written as follows:

$$rV_s^M = g(\theta)(V_m^M - V_s^M) + \sigma(Y - V_s^M) \quad (12)$$

$$rV_m^M = a[-w + (V_t^M - V_m^M)] \quad (13)$$

$$rV_t^M = \delta(-D - V_t^M) + \eta(V_s^M - V_t^M) + [\mu Y + (1 - \mu)V_s^M - V_t^M]. \quad (14)$$

Because we are studying forced migration, we assume that the asset value of a candidate to migration searching for a smuggler to help him/her escape from the high risk area is always higher than his asset value of staying home.

Equation (12) states that a candidate to migration may be granted a visa at rate σ , allowing him/her to obtain a capital gain equal to $Y - V_s^M$, with Y the asset value of living in the destination area. He/she may also find a smuggler at rate $g(\theta)$ and obtain a capital gain equal to $V_m^M - V_s^M$.

Equation (13) summarizes the fact that a matched migrant waits for an opportunity to start travelling, which arrives at rate a ; only when this opportunity materializes, he/she pays the fee w and obtains a capital gain equal to $V_t^M - V_m^M$.

Equation (14) acknowledges that travelling migrants anticipate that they may die during the journey at rate δ ; we further assume that they associate to this risky event a loss D . In this high risk context, the migrant's decision problem is not very different from that of a professional (fireman) who accepts a paid-mission involving a risk of death in action (Viscusi, 1992, 1993). Asset values in the former expressions rely on expected utility theory with risk neutral agents, similar to Aksoy and Poutvaara (2019) who studied forced migrant self-selection with respect to personal characteristics.

Travelling migrants may also be intercepted by the law enforcement authority at rate η . Then, they are sent back to their origin country where they start looking for a smuggler once more; they obtain the asset value V_s^M .

Finally, migrants who overcome these barriers reach the EU border and face EU countries border administrations; they then may be granted the refugee status at rate μ and enjoy the asset value Y . In this model, while irregular migrants cross the border without a visa, they are nonetheless "genuine" asylum-seekers; as a consequence, those who are granted the right to stay actually receive the refugee status, which gives them the same rights as the migrants who obtained a visa. For this reason, we do not consider different income levels depending on the admission channel. Those who are denied the right to stay are returned to their origin country (where they start looking for a smuggler once more).

3.4.2 The asset value of a smuggler

Let us denote by V_s^S the asset value of a searching smuggler, by V_m^S the asset value of a smuggler matched with a candidate before the start of the journey, and by V_t^S the asset value of a smuggler organizing the journey to the destination country. Such asset values can be written as follows:

$$rV_s^S = -c + h(\theta)(V_m^S - V_s^S) \quad (15)$$

$$rV_m^S = a[w + (V_t^S - V_m^S)] \quad (16)$$

$$rV_t^S = \eta(-K - V_t^S) + \delta(V_s^S - V_t^S) + (V_s^S - V_t^S). \quad (17)$$

We assume that the smuggler who has not yet met a migrant incurs a fixed cost c (advertising his business, planning the best route to migrate and maintaining contacts along the route...). When the smuggler is matched with a candidate to migration (at rate $h(\theta)$), he/she obtains a capital gain equal to $V_m^S - V_s^S$.

After a successful match, the smuggler waits for an opportunity to start travelling, which materializes at rate a . Then, he/she receives the smuggling fee w and undertakes the journey.

Once the journey has started, the smuggler may be caught by the local and border police at rate η and sent to jail (he/she is pushed out of the smuggling business); this is tantamount to a cost $K > 0$ incurred by the smuggler. Otherwise, the migrant continues the journey, dying at rate δ or reaching the destination country. In both cases, the smuggler can then resume his/her smuggling activities.

3.5 Free entry of smugglers and smuggling fee determination

With respect to the migration flows to Europe since 2015, we follow the literature mentioned in the introduction ([UNODC, 2018](#); [Abdel Aziz et al., 2015](#); [Campana, 2018, 2020](#)) and represent

smugglers as entrepreneurs, owners of "small firms" made up of a small number of relatives and close friends. These entrepreneurs in criminal activities can freely and rapidly enter the smuggling market. When a smuggler is convicted and pushed out of the smuggling business, another smuggler will enter the market. The free entry assumption implies exhaustion of all rents, i.e. $V_s^S = 0$, in line with the relative economic fragility of the individual smugglers in Libya, as documented in [Sanchez \(2020\)](#).

Information on the way the fees are negotiated or posted by the smugglers is scarce. Several studies have revealed that smugglers have important reputation concerns, which prevent full exploitation of the migrants ([Achilli and Sanchez, 2017](#); [Achilli, 2018](#); [Zhang et al., 2018](#); [Campana and Gelsthorpe, 2020](#)). They argue that smugglers, if they do care about their profits, are not necessarily selfish reckless persons treating migrants as an expandable commodity only. [European Commission \(2015\)](#) and [UNODC \(2018\)](#) argued that smugglers and migrants are in a business relationship that leaves room for a negotiated fee. [Sanchez \(2020\)](#) emphasizes that smugglers and migrants in Libya systematically bargain about the fee.

To account for these elements, we follow the traditional approach in the search and matching literature and model the fee determination process using the standard Nash bargaining solution ([Nash, 1950](#)). While this approach is quite flexible in terms of surplus allocation, in the context of forced migration that involves major strain for the migrants, it is sensible to assume that the bargaining power lies on the side of the smugglers. This assumption will be brought in the simulations we perform in the last section.

In the Appendix [A.2](#), we introduce directed search ([Moen, 1997](#)) as an alternative fee setting mechanism (see [Wright et al., 2021](#), for a survey). In this setting, smugglers have substantial control over the fee (they set the fee), while migrants choose a smuggler depending on the fee and the waiting time before reaching their preferred smuggler. While the two fee determination mechanisms are quite different in nature, we show in the Appendix that they lead to a fee equation with similar properties.¹⁷

Turning back to the fee negotiation problem, the total surplus to be shared between the smuggler and the candidate to migration is:

$$\Sigma = (V_m^M - V_s^M) + (V_m^S - V_s^S). \quad (18)$$

¹⁷Furthermore, the fee equations are identical when the Hosios condition is met ([Hosios, 1990](#)).

The allocation of the surplus between the smuggler and the migrant depends on the value of the fee w , which results from maximizing the Nash product:

$$\max_w (V_m^M - V_s^M)^{1-\beta} (V_m^S - V_s^S)^\beta, \quad (19)$$

where $\beta \in (0, 1)$ captures the relative bargaining power of the smugglers compared to migrants. A value of β close to one is in line with the assumption of smugglers having a dominant position within the bargaining process.

From the First Order Condition (FOC) combined with equations (12) to (17), we obtain:

$$(1 - \beta) (V_m^S - V_s^S) = \beta (V_m^M - V_s^M). \quad (20)$$

Accordingly, smugglers (resp. migrants) receive a share β (resp. $1 - \beta$) of the surplus Σ . Assuming free entry of smugglers ($V_s^S = 0$), using the sharing rule (20) and the asset value equations (12) to (17), we can write the smuggling fee as:

$$w = (1 - \beta) \left(\frac{\eta K}{r + \delta + \eta + 1} \right) + \beta \left(V_t^M - \frac{a + r}{a} V_s^M \right), \quad (21)$$

or equivalently:

$$w = (1 - \beta) \left(\frac{\eta K}{r + \delta + \eta + 1} \right) + \beta \left[\left(\frac{\mu Y - \delta D}{r + \delta + \eta + 1} \right) - V_s^M \left(\frac{r + \delta + \mu}{r + \delta + \eta + 1} + \frac{r}{a} \right) \right]. \quad (22)$$

Due to matching frictions, a surplus is created when a candidate to migration and a smuggler meet. Nash bargaining gives rise to rent sharing and, as a result, migrants pay a share $(1 - \beta)$ of the net expected costs incurred by smugglers for a journey, $\frac{\eta K}{r + \delta + \eta + 1}$, while smugglers capture a share β of migrants' net expected gain.

Rent sharing between smugglers and migrants implies that the fee depends negatively on migrants' outside option V_s^M , as a higher outside option puts them in a better position to negotiate the fee and reduces the surplus to be shared.

4 Equilibrium analysis

In this section, we solve the model for the steady state equilibrium for a given number of new candidates to migration. We proceed in three steps. First, we use the free entry condition to show how market tightness depends on the value of the smuggling fee. Second, the fee negotiation process allows to express the fee itself as a function of market tightness. Finally, we determine the equilibrium by taking into account both relationships, and study its properties. Policy implications are discussed in section 5.

4.1 The smuggler free-entry condition

Under free entry of smugglers, equations (15) to (17) yield:

$$\underbrace{\frac{c}{h(\theta)}}_{\text{expected search costs}} = \underbrace{\frac{a}{a+r} \left(w - \frac{\eta K}{r + \delta + \eta + 1} \right)}_{\text{expected benefit}}. \quad (23)$$

Free entry implies that new smugglers enter the market until expected benefits from smuggling activities, V_m^S , equalize expected search costs, $\frac{c}{h(\theta)}$.

The free entry equation (23) implicitly defines a continuous and increasing relationship between the smuggling fee and the market tightness.

The market tightness θ *increases* with the fee w : all else equal, a higher fee w would attract more smugglers, thereby increasing θ . At a given smuggling fee, it goes down with the costs of providing smuggling services, c , K and η , and up with parameters δ , a and p . It does not directly depend on parameters D , μ , Y , σ and β .

Let us now derive a second relationship between the market tightness and the smuggling fee.

4.2 Migrants' outside option and the fee equation

Combining the free entry condition (eq. 23) with the sharing rule (eq. 20) and the expression of the asset value of the searching migrant (eq. 12), and recalling that $g(\theta) = \theta h(\theta)$, we can express the migrants' outside option in the wage bargain, V_s^M , as a function of the market tightness θ :

$$V_s^M = \frac{1}{r + \sigma} \left(\frac{1 - \beta}{\beta} c\theta + \sigma Y \right). \quad (24)$$

Replacing in the expression of the smuggling fee (eq. 22) and rearranging, the smuggling fee w can be written as a function of the ratio θ , as follows:

$$w = \frac{(1 - \beta)\eta K + \beta(\mu Y - \delta D)}{r + \delta + \eta + 1} - \left(\frac{r + \delta + \mu}{r + \delta + \eta + 1} + \frac{r}{a} \right) \left[\frac{\beta\sigma Y + (1 - \beta)c\theta}{r + \sigma} \right]. \quad (25)$$

The negotiated fee w *decreases* with θ , as a tighter market (e.g. more searching smugglers relative to the number of searching migrants) puts the migrants in a better position to negotiate. At given market tightness, it goes down with δ , D (which reduce the migrants' expected gain from migration) and c (which increases the migrant's outside option), and up with μ (which increases the migrants' expected gain from migration), K (which increases the smugglers' expected cost), a (which increases the surplus to be shared), and β (since increasing the smugglers' bargaining power implies that migrants get a lower share of the surplus). Y , η and σ have an ambiguous impact on w , while p does not have any. All calculations are presented in Appendix A.3.

4.3 The equilibrium

Definition. A steady state equilibrium of the smuggling market is a n-tuple $(\theta^*, w^*, M_s^*, M_m^*, M_t^*, S_s^*, S_m^*, S_t^*)$ such that: (i) the free entry condition (23) holds, (ii) the fee equation (25) is satisfied, (iii) the equilibrium numbers of migrants and smugglers at each step of the migration process, defined by equations (8) to (11), hold.

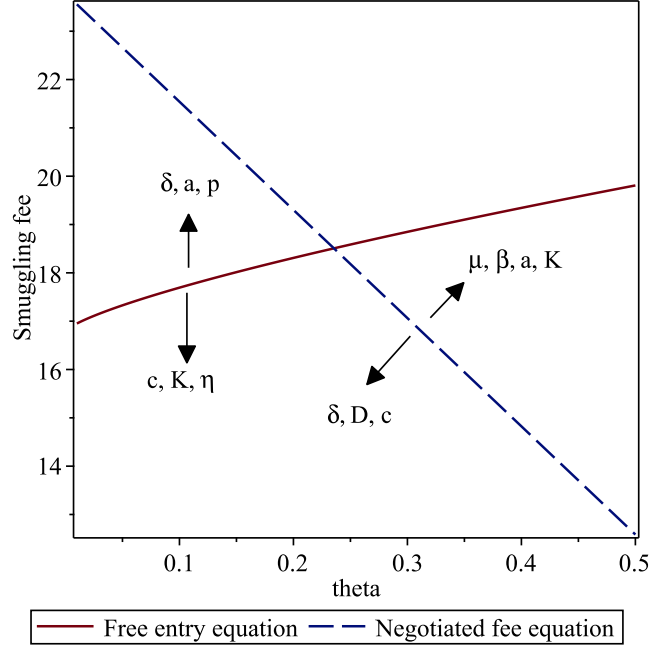
The market tightness. All these variables are themselves a function of the equilibrium market tightness θ^* , which is the main unknown of the model. It can be determined by combining the free entry equation (23) with the smuggling fee equation (25). We then obtain the equilibrium values of the fee w^* and of the market tightness θ^* .

The equilibrium, if it exists, is unique, as according to the first relationship, the tightness θ is increasing in the fee w , whereas according to the second one, the fee w is decreasing in θ . An interior solution exists provided that the two curves cross each other, which requires that the surplus of a match is still positive when the market tightness tends to zero.¹⁸

Figure 3 provides a parametric draw of the two curves as defined in equations (23) and (25). The arrows show how each curve shifts following a positive variation in the key parameters. The equilibrium tightness, θ^* , and equilibrium fee, w^* , are observed at the crossing point between the two curves.

¹⁸This imposes some restrictions on the parameters; see Appendix condition (A.4).

Figure 3: Equilibrium tightness and fee



Note: Plot parameters taken from Table 2. The numerical solutions are $\theta^*=0.24$ and $w^*=18.50$.

Introducing the definition of the negotiated fee (equation 25) into equation (23), we obtain the implicit definition of the equilibrium market tightness:

$$\frac{c}{h(\theta^*)} = \beta \Sigma^*(\theta^*, Z), \quad (26)$$

where Z is the vector of parameters. The explicit expression of the equilibrium surplus, $\Sigma^*(\theta^*)$, is provided in appendix, equation (A.24).

Equation (26) can be interpreted in the following way: given the fee determination process studied in subsections (3.5) and (4.2), smugglers receive a share β of the surplus Σ^* (defined in equation (A.24)), which determines their expected profit when entering the market. Under the free entry assumption, smugglers enter until all profit opportunities are exhausted, namely until their expected profits equalize the expected cost of "doing business".

In the following, we assume that the equilibrium exists and perform a comparative static analysis. For so doing, we proceed by total differentiation of equation (26).

4.4 Key comparative statics

As shown in Appendix A.5 and summarized in Table 1, the tightness θ^* is increasing in μ and a (which raise the size of the expected surplus), in p (which reduces expected search costs), and in β . It is decreasing in c (which reduces the profitability of being a smuggler), and in D and K (which reduce the surplus to be shared). Its variations with regards to η , δ , Y and σ are ambiguous as they all have a twofold effect on the surplus size.

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^ increases with μ , a , β and p ; it decreases with c , K and D ; its variations with respect to η , δ , Y and σ are ambiguous.*

With knowledge of these properties, we can study the comparative statics properties of the equilibrium smuggling fee.¹⁹

Proposition 2 *Properties of the equilibrium smuggling fee w^* .*

The equilibrium smuggling fee w^ increases with K , μ and β ; it decreases with D and p ; its variations with respect to η , δ , Y , a and σ are ambiguous. The fee decreases (increases) with c provided $\epsilon_{\theta^*/c} > -1 (< -1)$, i.e. the elasticity of the tightness with respect to c is not too large (is large).*

Variables θ^* and w^* 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' welfare $V_s^{M^*}$ as defined in equation (24); the number of irregular migrants reaching the EU border M_t^* resulting from equation (9); and the total number of active smugglers S_s^* as defined in equation (11).

These variables are functions of parameters and of the equilibrium tightness and smuggling fee (θ^*, w^*) , 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.7 to A.10). For many parameters and variables, the signs are clearly identified.

¹⁹Calculations are presented in Appendix A.6.

Table 1: Comparative static results

Parameter	Tightness θ^*	Smug. fee w^*	Smug. contact rate $h_i(\theta^*)$	Mig. welfare $V_s^{M^*}$	Incoming irr. mig. M_t^*	Smugglers S_s^*
Fixed cost	c	-	+	-	-	-
Interception and arrest rate	η	?	?	?	?	?
Convicted penalty	K	-	+	-	-	-
Fatality rate	δ	?	?	?	?	?
Death loss	D	-	+	-	-	-
Asylum-status rate	μ	+	-	+	?	?
Migration value	Y	?	?	?	?	?
Travel opportunity rate	a	+	-	+	+	+
Legal migration rate	σ	?	?	?	?	?
Smugglers bargaining power	β	+	-	?	+	+
Matching efficiency	p	+	?	+	+	?

The dynamic framework developed in this paper allows us to study the consequences of various policies on the smuggling fee and the stocks of migrants, and also on migrants intertemporal welfare, the flow of incoming migrants and the number of smugglers. Most of these effects were revealed in the sensitivity analysis in Table 1. However, some effects could not be determined analytically. We therefore complement this analysis by numerical simulations. We assume a Cobb-Douglas matching function, as usual in the literature.

5 Discussion and policy implications

5.1 Parameters

We assume that, in this constrained environment for migrants, smugglers have a much larger bargaining power compared to migrants; more specifically, we assume that 3/4 of the surplus from matching is appropriated by the smuggler.

Then, following a common practice in the matching literature, the [Hosios \(1990\)](#) condition for matching efficiency ($\alpha = \beta$) is assumed to hold, which implies that $\alpha = 0.75$.

The migrant's asset value from successful migration is set to $Y = 200$. We also choose a relatively high asset loss for the arrested smuggler ($K = 75$), which captures a large disutility of the latter from imprisonment.

The probability of the border police to detect the smuggling activity and intervene is set at 30%. As already mentioned, to keep the model simple, we assume that the detection probability is the same for migrants and smugglers. [Pham and Komiyama \(2022\)](#) 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 parameter defining the acceptance rate of incoming irregular migrants (μ) is difficult to infer, given that in the real world, the flow of migrants arriving comprises both "genuine" asylum-seekers and economic migrants that would falsely claim asylum. 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 (Ukraine, Syria, Eritrea). For the benchmark, we therefore set $\mu = 0.90$, 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.²⁰ We set the ex-ante utility loss of dying during the sea crossing to a relatively large number, $D = 1000$.²¹

Finally, the number of new forced candidates to migration per period, N , is set at a "normalized" value $N = 1000$.

For the remaining parameters, we choose values that make economic sense, without resorting to a precise calibration, which would require many observations which, unfortunately, are not available in these opaque markets. In particular, we could not infer from the available publications the number of visas granted to asylum-seekers. Every year, the EU country governments grant a substantial number of visas for students and work permits; however, the number of visas directed to fragile populations in war zone is low, to the best of our knowledge. We also set the cost of doing business c to 5, which is in line with a smuggling fee of approximately 20 in our simulations.

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

$\mu = 0.90$	$Y = 200$	$\sigma = 0.025$	$p = 1$
$\delta = 0.025$	$D = 1000$	$a = 1$	$\beta = 0.75$
$\eta = 0.30$	$K = 75$	$c = 5$	$\alpha = 0.75$
	$r = 0.015$	$N = 1000$	

²⁰See [the IOM News on April 2023](#) and [the Frontex data](#); data reported by [Pham and Komiyama \(2022\)](#) reveal a similar ratio.

²¹In the simulations, a solution exists for $D \in [0, 1500]$.

5.2 Policy consequences

5.2.1 Measures impacting migrants' expected payoff from migration: visa, asylum and labour market policies

Visa policy. The rate of visas granted to asylum-seekers (σ) is an important policy parameter, under the control of EU member states. The effect on the main equilibrium variables of changing σ could not be determined analytically.

Simulations presented in the upper pane of Table 3 reveal the consequences of a small increase in the rate of official visas from 0.025 to 0.03%. An increase in σ increases the flow of regular migrants and, at the same time, reduces the flow of irregular migrants. While these two effects are quite trivial, it should be emphasized that the total number of migrants (regular and irregular) slightly declines.

Furthermore, with less migrants tempted to pay the smuggling fee, the number of smugglers is drastically cut, for a relatively small increase in the visa delivery rate. Finally, this policy not only helps curbing irregular migration but it also improves migrants' welfare (and decrease the expected number of fatalities).

Such results are in line with those obtained by [Auriol and Mesnard \(2016\)](#): an extended visa policy directed to asylum-seekers would undermine the smuggling market; it would lead to an increase in the numbers of legal migrants but to a decrease in the flows of irregular migrants.

Asylum policy. In all EU countries, some voices call for new restrictions on asylum rights, which is tantamount to a reduction in μ . The Pact on Asylum and Migration adopted by the EU in 2020 includes provisions to smooth the process of sending back migrants who do not qualify for the asylum status; this may also imply a decrease in parameter μ .

The reasoning behind these calls relies on a "first-order" effect, according to which, denying the asylum right should deter migrants from leaving in the first stage. This line of reasoning does not take into account the fact that many of the pushed-back migrants will try to migrate again, and will do so several times. In this case, a higher rejection rate only beefs up the flow of incoming migrants, puts additional strain on border control and asylum application bodies, and ultimately nourishes the fears of those calling for tougher immigration policies.

Our simulation reveals a puzzling pattern, grounded in the send-back and return dynamics. As long as the acceptance rate is above 0.76, any further reduction (below the benchmark of 0.90) is only increasing the flows of irregular migrants. To some extent, it is more efficient to have a 100% acceptance rate rather than a 75% one, as shown in Figure 4. On the other hand,

a very strict asylum regime might destroy the equilibrium of this market, with hard to foresee consequences. Our result contrasts with the work of [Piguet \(2020\)](#) who claims that several changes leading to a higher rate of success for asylum seekers explain, to some extent, the surge in irregular migration to Europe.

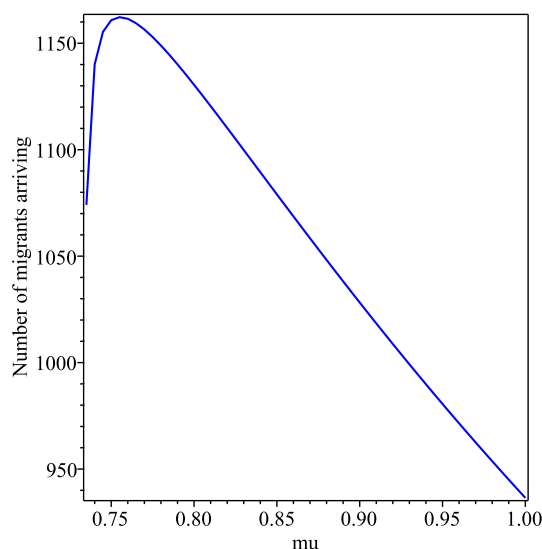
Table 3 also presents the effect of the reduction in μ on the other variables of interest. An increase in the asylum rejection rate has a strong negative effect on the number of active smugglers. All the other effects are in line with the results obtained in the theoretical part.

Table 3: Simulation results for policies impacting migrants' expected payoff from migration

		Benchmark		
		(1)	(2)	(3)
	Visa policy	$\sigma = 0.002$	$\sigma = 0.025$	$\sigma = 0.03$
Tightness θ^*		0.399	0.236	0.086
Smuggling fee w^*		19.33	18.5	19.49
Smuggler contact rate $h(\theta^*)$		1.99	2.96	6.31
Migrants welfare V_s^{M*}		133.3	134.8	136.5
Incoming irregular migrants M_t^*		1043	1028	1001
Legal migrants σM_s^*		35	49	74
Total migrants $M_t^* + \sigma M_s^*$		1078	1077	1075
Expected fatalities δM_t^*		26.1	25.7	25
Smugglers S_s^*		693	460	210
	Asylum policy	$\mu = 0.85$	$\mu = 0.90$	$\mu = 0.95$
Tightness θ^*		0.16	0.236	0.299
Smuggling fee w^*		18.1	18.5	18.84
Smuggler contact rate $h(\theta^*)$		3.81	2.96	2.47
Migrants welfare V_s^{M*}		132	134.8	137.4
Incoming irregular migrants M_t^*		1079	1028	980
Expected fatalities δM_t^*		27	25.7	24.5
Smugglers S_s^*		374	460	525
	Labour policy	$Y = 180$	$Y = 200$	$Y = 220$
Tightness θ^*		0.117	0.236	0.357
Smuggling fee w^*		17.81	18.5	19.13
Smuggler contact rate $h(\theta^*)$		5	2.96	2.16
Migrants welfare V_s^{M*}		117.4	134.8	152
Incoming irregular migrants M_t^*		1019	1028	1033
Expected fatalities δM_t^*		25.5	25.7	25.8
Smugglers S_s^*		269	460	632

Note: Column (2) reports benchmark results, with parameters values summarized in Table 2. Each block of the table provides the results obtained for different policies impacting migrants' expected payoff from migration.

Figure 4: Irregular migrants reaching borders depending on the stringency of the asylum policy



Note: Parameters values are summarized in Table 2.

Labor market policy. EU authorities can control the asset value a migrant may expect to obtain if he/she is granted the asylum status through a couple of restrictions and incentives, such as creating programs promoting migrant integration and raising their employability, or by measures aiming at fighting discrimination in hiring and pay.

Notice that we have assumed that migrants who are denied the refugee status are returned to their country of origin. If some of them manage to stay in the country as now illegal migrants, measures against irregular employment (stricter controls, higher sanctions for the employers) might also have a (negative) impact on the expected economic gains associated with irregular migration, which could be interpreted as a lower asset value Y (Orrenius and Zavodny, 2015; Borjas and Cassidy, 2019; Guriev et al., 2019). In 2021, the European Commission adopted a new directive for fighting the hiring of irregular migrants.

The theoretical analysis did not allow us to determine the effects of changes in Y on the equilibrium variables (Table 1). Simulation results in the lower pane of Table 3 allow us to provide some intuition about these consequences. It turns out that more generous labor market integration programs that are beneficial to migrants will result in more irregular migrants and improve their welfare. On the other side of the market, more smugglers enter this market and

obtain a higher fee (and more migrants risk dying during the journey), two obviously undesirable consequences of this policy.

Our results are in line with those of Djajić and Vinogradova (2013, 2014) who find that a decrease in the expected asset value of migration decreases debt-bonded migration. Contrary to our results, Tamura (2010, 2013) finds that decreasing the asset value from migration through increasing inland apprehension would increase the number of smugglers in the case of perfect information, while it would have no impact in the case of imperfect information.

5.2.2 Making smuggling a high-risk, low-profit activity

Within this category of policy measures, increasing border control and police anti-smuggling actions in both origin and transit countries can: (i) directly deter locals from entering the smuggling business by increasing the direct costs of smuggling (c), (ii) increase the penalty incurred by the smugglers when caught and convicted (K), via the judicial system, (iii) decrease the opportunities to start the journey (equivalent of decreasing the parameter a), thanks to a raise in the number of patrols and improvements in technology used to detect migrants, (iv) throw sand in the matching process, mainly by blocking informal publicity and communication (tantamount to reducing p), (v) set up restrictions that may increase the risk of dying during the journey, which is tantamount to a higher δ , through restrictions of all kinds forcing smugglers to follow longer routes, such as building physical obstacles (fences, walls), or by preventing NGOs to finance search and rescue vessels to patrol next to the Libyan borders, and provide life support to migrants under distress, and finally, (vi) increase the likelihood of being caught by the police during the journey (more border officers, better monitor equipment), equivalent to increasing η .

The theoretical analysis showed that, in general, measures that increase the costs of smuggling deter smugglers entry, and reduce the flow of incoming migrants (see Table 1). However, the theoretical analysis could not determine the effect of increasing the matching frictions (lower p), increasing the risk for migrants of dying on the road (higher δ) or increasing the arrest probability (higher η).

Simulations presented in Table 4 show that these deterrence policies can also efficiently cut irregular migration. A reduced matching efficiency (lower p) brings about a paradoxical outcome, where less irregular migrants arrive, albeit the number of smugglers increases. Simulations also reveal that, by contrast with the official visa policy, these measures entail a reduction of migrants' welfare as they lead to a reduction in market tightness and a rise in the smuggling fee.

Table 4: Simulation results for cooperation policies

	Benchmark		
	(1)	(2)	(3)
	Increase in c or K		$c = 6$ $K = 85$
Tightness θ^*	0.236	0.193	0.205
Smuggling fee w^*	18.5	18.57	19.45
Smuggler contact rate $h(\theta^*)$	2.96	3.42	3.27
Migrants welfare V_s^{M*}	134.8	134.7	133.6
Incoming irregular migrants M_t^*	1028	1025	1026
Expected fatalities δM_t^*	25.7	25.6	25.6
Smugglers S_s^*	460	397	415
	Decrease in a or p		$a = 0.75$ $p = 0.75$
Tightness θ^*	0.236	0.217	0.216
Smuggling fee w^*	18.5	18.41	18.93
Smuggler contact rate $h(\theta^*)$	2.96	3.14	2.36
Migrants welfare V_s^{M*}	134.8	134.05	134.01
Incoming irregular migrants M_t^*	1028	1027	1010
Expected fatalities δM_t^*	25.7	25.7	25.3
Smugglers S_s^*	460	433	566

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

One essential policy parameter is the arrest probability: reinforcing the capacity of the border police to intercept migrants in transit countries is one important target for the EU.

To provide some intuition on this important policy parameter, Table 5 focuses on the impact of η on the key policy variables: increasing the probability of being intercepted and arrested decreases the numbers of smugglers and incoming irregular migrants (as well as the number of expected fatalities), raises the smuggling fee and the smuggler contact rate. It also drastically decreases the migrants welfare, as the fee goes up with η while the market tightness goes down.

Our results are in line with most of the literature: [Friebel and Guriev \(2006\)](#); [Tamura \(2010\)](#) and [Djajić and Vinogradova \(2014\)](#) all find that increasing border controls decreases debt-bonded migration; [Tamura \(2010\)](#) also shows that this would result in a lower number of smugglers (in the case of perfect information). Focusing on migration costs, [Gathmann \(2008\)](#) shows that tighter border controls result in geographic substitution, which leads to an increase in the smuggling fee.

Table 5: Simulation results for border policy

	Benchmark					
	(1)	(2)	(3)	(4)	(5)	
Increases in η	$\eta = 0.10$	$\eta = 0.20$	$\eta = 0.30$	$\eta = 0.40$	$\eta = 0.45$	
Tightness θ^*	0.571	0.4	0.236	0.082	0.01	
Smuggling fee w^*	9.91	14.65	18.5	21.61	22.8	
Smuggler contact rate $h(\theta^*)$	1.52	1.98	2.96	6.5	24.9	
Migrants welfare $V_s^{M^*}$	148.8	141.6	134.8	128.4	125.6	
Incoming irregular migrants M_t^*	1044	1037	1028	1008	968	
Expected fatalities δM_t^*	26.1	25.9	25.7	25.2	24.2	
Smugglers S_s^*	772	638	460	221	57	

Note: Column (3) reports benchmark results, with parameters values summarized in Table 2.

Finally, it must be acknowledged that the analysis in this section revealed the effect of changes in parameters, one by one, on the equilibrium variables. In reality, none of these policies is implemented in isolation. To the contrary, the European Commission and its border control arm, Frontex, carry on multiple actions to deter irregular migration.

6 Conclusion

Irregular migration and migrant smuggling are two facets of the same phenomenon, and control of the former has important consequences on the latter. In this paper, we introduce a search and matching model to analyze the complex interaction between forced migrants and smugglers, and determine the effect of various policies on the flows of irregular migrants to Europe.

Sensitivity and impact analysis revealed that the equilibrium numbers of smugglers and irregular migrants reaching destination decrease with the costs associated to the smuggling activity. In particular, our simulations have shown that increasing the controls leading to a higher likelihood to catch the smuggler and the migrants during the journey or increasing the cost of being arrested for the smuggler should contribute to reducing the number of incoming irregular migrants. These findings are in line with the results of existing studies. [Sanchez \(2020\)](#) criticized the mainstream approach of the EU member country governments to migration policy for emphasizing the consequences of migration on the destination countries, while neglecting the migrants' interests. This criticism is most relevant in the case of forced migration. Our analysis provides an answer to this criticism as it allowed us to study the effect of these policies on the smuggling

fee and the migrant welfare, and warns policymakers on the dramatic consequences of a raising burden on migrants that are already in an extremely fragile situation.

Similar to [Auriol and Mesnard \(2016\)](#), in our model simulations, a more generous legal visa policy would allow to reduce in a significant way the flow of irregular migrants and push smugglers out of the market; furthermore, in our model this favourable outcome is achieved without deteriorating migrants' welfare, nor increasing the total flows of migrants, and leads to less fatalities.

Because many of the pushed-back migrants return, a "moderate" asylum policy (not too tough, not too loose) might actually maximize the number of irregular migrants arriving every period, and lead to higher numbers of irregular migrants than a very lenient asylum policy.

Our analysis was built on some simplifying assumptions; relaxing them might open interesting paths for future research. First, our model was built on the traditional "small-firm" version of the matching model, which suits well to a large segment of the smuggling market to the EU. However, some of the smuggling is carried out by structured criminal organizations, that have many characteristics of a "large firm". An alternative model could then be developed along the standard "large-firm" matching model (also presented in [Pissarides, 2000](#)), with a main difference from our results, the persistence of positive rents for these organisations.

Second, to keep the analysis as simple as possible, we assumed that the rate to which the smuggler can be intercepted and arrested is equal to the rate to which the migrants are intercepted and sent back to their country of origin. In a more general setting, the two rates could be different (but correlated), as smugglers might avoid detection by abandoning the migrants. Besides, the probability of authorities intercepting the migrants during the journey has been kept exogenous for the sake of simplicity. A more realistic model might also make this probability endogenous, for instance by linking it to the size of the group of migrants guided by smugglers, as in [Brausmann and Djajić \(2022\)](#) or [Pham and Komiyama \(2022\)](#).

Finally, the asset value of the migrants was inferred from standard valuations models that assume risk neutrality in an expected utility framework. A more realistic analysis could acknowledge that on average migrants are relatively willing to take risks ([Jaeger et al., 2010](#); [Gibson and McKenzie, 2011](#)). The decision model might also include probability weighting to downplay losses associated to extreme events such as in the study by [Auriol et al. \(2021\)](#). Redeveloping our analysis using a more sophisticated risk-decision model of migration could be an interesting path for further research.

Despite these limitations, a matching model *à la* [Pissarides \(2000\)](#) provides a relevant framework to analyze such a large-flow market with substantial trade frictions originating in the illegal nature of the migrant smuggling activity.

Acknowledgement and data availability

Authors thank participants at the LEM economic seminar in Lille in 2019, at the GLO Virtual Seminar in 2022, at the CES IELM seminar in Paris in 2022 and at the Borders workshop in Ghent in 2022 for their suggestions and constructive remarks.

The authors confirm that all data generated or analysed during this study are included in this document. Furthermore, primary and secondary sources and data supporting the findings of this study were all publicly available at the time of submission.

Authors declare no conflict of interest related to this work.

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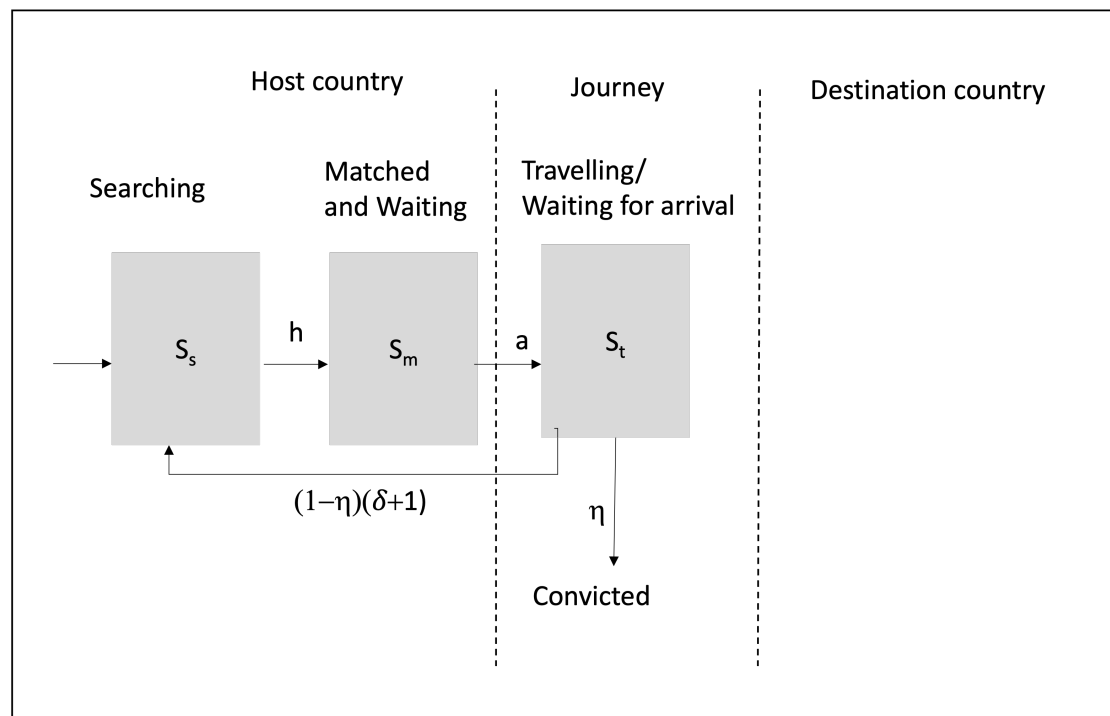
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A Appendix

A.1 Flow diagram for the smugglers

Figure A.1: Flow diagram for the smugglers



Note: S_s , S_m and S_t denote the numbers of smugglers respectively searching for a candidate to migration, matched with a candidate and waiting for an opportunity to start the journey, and on the road or waiting for the smuggled migrant to arrive at destination.

A.2 The smuggling fee under directed search

As an alternative mechanism to the Nash bargaining used in the main text, in this Appendix we assume that search is directed (Moen, 1997): smugglers post and advertise fees, while migrants queue to reach them (see Wright et al., 2021, for a survey of this literature).

In this alternative framework, migrants still retain some influence on the search process as they can choose for which smuggler they queue. They can trade-off a higher fee against less queuing time (and vice-versa). In equilibrium, identical smugglers post the same fee and the number of migrants per smuggler is the same.

The smugglers' decision problem is to post a fee maximising the value V_s^S taking into account the relationship between the fee and the arrival of migrants. Using equations (12) and (15), this can be written:

$$\begin{aligned} \max_{\theta, w} (rV_s^S) &= -c + h(\theta) (V_m^S - V_s^S) \\ \text{s.t. } rV_s^M &= g(\theta) (V_m^M - V_s^M) + \sigma (Y - V_s^M). \end{aligned} \quad (\text{A.1})$$

The Lagrangian of this problem is:

$$L(\theta, w, \phi) = -c + h(\theta) (V_m^S - V_s^S) + \phi [rV_s^M - g(\theta) (V_m^M - V_s^M) - \sigma (Y - V_s^M)], \quad (\text{A.2})$$

with ϕ the Lagrange multiplier.

The related FOCs are:

$$h'(\theta) (V_m^S - V_s^S) - \phi g'(\theta) (V_m^M - V_s^M) = 0 \quad (\text{A.3})$$

$$h(\theta) \frac{\partial (V_m^S - V_s^S)}{\partial w} - \phi g(\theta) \frac{\partial (V_m^M - V_s^M)}{\partial w} = 0. \quad (\text{A.4})$$

Dividing (A.3) by (A.4) and rearranging, we obtain:

$$\frac{h'(\theta)}{h(\theta)} \frac{\partial (V_m^S - V_s^S) / \partial w}{V_m^S - V_s^S} = \frac{g'(\theta)}{g(\theta)} \frac{\partial (V_m^M - V_s^M) / \partial w}{V_m^M - V_s^M}. \quad (\text{A.5})$$

Denoting $\alpha(\theta) = -\theta \frac{h'(\theta)}{h(\theta)} \in (0, 1)$ the elasticity of the matching function, we obtain:

$$\alpha(\theta) \frac{\partial (V_m^M - V_s^M) / \partial w}{V_m^M - V_s^M} = -[1 - \alpha(\theta)] \frac{\partial (V_m^S - V_s^S) / \partial w}{(V_m^S - V_s^S)}. \quad (\text{A.6})$$

Under directed search, the key parameter determining the respective surplus shares is the matching elasticity α . In the Cobb-Douglas specification for the matching function, the elasticity α is constant.

From equations (12) to (17) we can infer that:

$$\frac{\partial (V_m^M - V_s^M)}{\partial w} = -\frac{\partial (V_m^S - V_s^S)}{\partial w}. \quad (\text{A.7})$$

The surplus sharing rule under directed search then is:

$$(1 - \alpha) (V_m^S - V_s^S) = \alpha (V_m^M - V_s^M). \quad (\text{A.8})$$

This rule has a similar structure as the rule based on the Nash bargaining used in the main text, with the main difference that the surplus shares depend now on the elasticity α (instead

of the bargaining power β). If the Hosios condition for efficiency of the matching process under Nash bargaining (Hosios, 1990) holds ($\alpha = \beta$), the two rules are identical.

One of the main differences between the two settings is that here, the ratio $1/\theta = M_s/S_s$ can be interpreted as the average number of migrants queuing for a smuggler, and therefore represents the queue length.

A.3 Partial equilibrium properties of the smuggling fee

Equation (22) can be written as:

$$w = (1 - \beta) \left(\frac{\eta K}{r + \delta + \eta + 1} \right) + \beta \left(\frac{\mu Y - \delta D + [\eta + (1 - \mu)] V_s^M}{r + \delta + \eta + 1} - \frac{a + r}{a} V_s^M \right), \quad (\text{A.9})$$

with V_s^M given by equation (24).

To determine the impact of the market tightness on the smuggling fee, notice that:

$$\frac{\partial w}{\partial \theta} = \frac{\partial w}{\partial V_s^M} \frac{\partial V_s^M}{\partial \theta} \leq 0, \quad (\text{A.10})$$

thus w decreases with θ .

We denote $B = \left(\frac{r + \delta + \mu}{r + \delta + \eta + 1} + \frac{r}{a} \right) \geq 0$.

The partial derivatives of the smuggling fee with respect to the parameters are:

$$\frac{\partial w}{\partial c} = - (1 - \beta) \frac{\theta}{r + \sigma} B \leq 0 \quad (\text{A.11})$$

$$\frac{\partial w}{\partial \eta} = (1 - \beta) \frac{(r + \delta + 1) K}{(r + \delta + \eta + 1)^2} - \beta \frac{\mu Y - \delta D - (r + \delta + \mu) V_s^M}{(r + \delta + \eta + 1)^2} \leq 0 \quad (\text{A.12})$$

$$\frac{\partial w}{\partial K} = \frac{(1 - \beta) \eta}{r + \delta + \eta + 1} \geq 0 \quad (\text{A.13})$$

$$\frac{\partial w}{\partial \delta} = - \frac{(1 - \beta) \eta K + \beta [\mu Y + (r + \eta + 1) D + (\eta + 1 - \mu) V_s^M]}{(r + \delta + \eta + 1)^2} \leq 0 \quad (\text{A.14})$$

$$\frac{\partial w}{\partial D} = \frac{-\beta \delta}{r + \delta + \eta + 1} \leq 0 \quad (\text{A.15})$$

$$\frac{\partial w}{\partial \mu} = \beta \left(\frac{Y - V_s^M}{r + \delta + \eta + 1} \right) \geq 0 \quad (\text{A.16})$$

$$\frac{\partial w}{\partial Y} = \beta \left(\frac{\mu}{r + \delta + \eta + 1} - \frac{\sigma}{r + \sigma} B \right) \leq 0 \quad (\text{A.17})$$

$$\frac{\partial w}{\partial a} = \frac{r \beta V_s^M}{a^2} \geq 0 \quad (\text{A.18})$$

$$\frac{\partial w}{\partial \sigma} = \left[\frac{(1 - \beta) c \theta - \beta r Y}{(r + \sigma)^2} \right] B \leq 0 \quad (\text{A.19})$$

$$\frac{\partial w}{\partial p} = 0. \quad (\text{A.20})$$

A rise in Y has an ambiguous impact on the fee: it raises the migrants' final gain from migration and hence the surplus to be shared, but at the same time, it also raises their outside option in the bargain, which has the opposite effect. Interestingly, this total effect becomes unambiguously positive whenever σ tends to zero: the negative effect disappears in this case.

To determine the effect of the (smuggler's) bargaining power β on the fee w , let's re-write the surplus, using equations (13) to (17):

$$\Sigma = \frac{a}{a+r} \left[\left(V_t^M - \frac{a+r}{a} V_s^M \right) - \left(\frac{\eta K}{r+\delta+\eta+1} \right) \right]. \quad (\text{A.21})$$

It must be positive, otherwise the market is not viable, which implies that $V_t^M - \frac{a+r}{a} V_s^M \geq \frac{\eta K}{r+\delta+\eta+1}$. Differentiating the fee equation (21) yields:

$$\frac{\partial w}{\partial \beta} = \left(V_t^M - \frac{a+r}{a} V_s^M \right) - \left(\frac{\eta K}{r+\delta+\eta+1} \right) \geq 0. \quad (\text{A.22})$$

A.4 Explicit expressions and existence condition for the equilibrium

From equations (23) and (25), we obtain the implicit definition of θ^* :

$$\frac{c}{h(\theta^*)} = \beta \Sigma^*. \quad (\text{A.23})$$

with:

$$\Sigma^* = \frac{a}{a+r} \left[\frac{\mu Y - \delta D - \eta K}{r+\delta+\eta+1} - \left(\frac{r+\delta+\mu}{r+\delta+\eta+1} + \frac{r}{a} \right) \left(\frac{\sigma Y}{r+\sigma} + \frac{1-\beta}{\beta} \frac{c \theta^*}{r+\sigma} \right) \right]. \quad (\text{A.24})$$

We further notice that, considering (A.23) and (A.24), an equilibrium exists provided $\lim_{\theta^* \rightarrow 0} \Sigma^* \geq 0$, which yields the following parametric condition:

$$\left(\frac{\mu Y - \delta D - \eta K}{r+\delta+\eta+1} \right) - \left(\frac{r+\delta+\mu}{r+\delta+\eta+1} + \frac{r}{a} \right) \left(\frac{\sigma Y}{r+\sigma} \right) \geq 0. \quad (\text{A.25})$$

A.5 Equilibrium properties of the smuggling market tightness

Let us now study the equilibrium properties of the tightness θ^* , which is the key endogenous variable of this model.

Differentiating eq. (26) with respect to any parameter X different from c, β, p , we obtain:

$$\frac{d\theta^*}{dX} = - \frac{h(\theta^*) d_X \Sigma^*}{h'(\theta^*) \Sigma^* + h(\theta^*) d_\theta \Sigma^*}. \quad (\text{A.26})$$

Yet, equation (A.24) implies that the equilibrium surplus is decreasing with the market tightness:

$$d_\theta \Sigma^* = - \frac{a}{a+r} B \left(\frac{1-\beta}{\beta} \frac{c}{r+\sigma} \right) \leq 0. \quad (\text{A.27})$$

Since $h'(\theta^*) \leq 0$ and $d_\theta \Sigma^* \leq 0$, the sign of $\frac{d\theta^*}{dX}$ is the sign of $d_X \Sigma^*$ for any $X \neq (c, \beta, p)$.

These derivatives are the following:

$$d_\eta \Sigma^* = \frac{a}{a+r} \left(\frac{-(r+\delta+1)K + \delta D - \mu Y + (r+\delta+\mu)V_s^M}{(r+\delta+\eta+1)^2} \right) \leq 0 \quad (\text{A.28})$$

$$d_K \Sigma^* = -\frac{a}{a+r} \frac{\eta}{r+\delta+\eta+1} \leq 0 \quad (\text{A.29})$$

$$d_\delta \Sigma^* = -\frac{a}{a+r} \left(\frac{-\eta K + \mu Y + (r+\eta+1)D + (\eta+1-\mu)V_s^M}{(r+\delta+\eta+1)^2} \right) \leq 0 \quad (\text{A.30})$$

$$d_D \Sigma^* = -\frac{a}{a+r} \frac{\delta}{r+\delta+\eta+1} \leq 0 \quad (\text{A.31})$$

$$d_\mu \Sigma^* = \frac{a}{a+r} \frac{Y - V_s^M}{r+\delta+\eta+1} \geq 0 \quad (\text{A.32})$$

$$d_Y \Sigma^* = \frac{a}{a+r} \left[\frac{\mu}{r+\delta+\eta+1} - \frac{\sigma}{r+\sigma} B \right] \leq 0 \quad (\text{A.33})$$

$$d_a \Sigma^* = \frac{r}{a(a+r)} (\Sigma^* + V_s^M) \geq 0 \quad (\text{A.34})$$

$$d_\sigma \Sigma^* = -\frac{a}{a+r} B \left(\frac{rY}{(r+\sigma)^2} - \frac{1-\beta}{\beta} \frac{c\theta^*}{(r+\sigma)^2} \right) \leq 0. \quad (\text{A.35})$$

For parameters c and β , we have:

$$\frac{d\theta^*}{dc} = -\frac{h(\theta^*) d_c \Sigma^* - \frac{1}{\beta}}{h'(\theta^*) \Sigma^* + h(\theta^*) d_\theta \Sigma^*} \quad (\text{A.36})$$

$$\frac{d\theta^*}{d\beta} = -\frac{\frac{c}{\beta^2} + h(\theta^*) d_\beta \Sigma^*}{h'(\theta^*) \Sigma^* + h(\theta^*) d_\theta \Sigma^*}. \quad (\text{A.37})$$

Thus $\frac{d\theta^*}{dc}$ and $\frac{d\theta^*}{d\beta}$ are respectively of the same sign as $\left(h(\theta^*) d_c \Sigma^* - \frac{1}{\beta} \right)$ and $\left(\frac{c}{\beta^2} + h(\theta^*) d_\beta \Sigma^* \right)$.

The partial derivatives of interest are:

$$d_c \Sigma^* = -\frac{a}{a+r} B \left(\frac{1-\beta}{\beta} \frac{\theta^*}{r+\sigma} \right) \leq 0 \quad (\text{A.38})$$

$$d_\beta \Sigma^* = \frac{a}{a+r} B \left(\frac{1}{\beta^2} \frac{c\theta^*}{r+\sigma} \right) \geq 0. \quad (\text{A.39})$$

This implies that:

$$h(\theta^*) d_c \Sigma^* - \frac{1}{\beta} \leq 0 \quad (\text{A.40})$$

$$\frac{c}{\beta^2} + h(\theta^*) d_\beta \Sigma^* \geq 0. \quad (\text{A.41})$$

Finally, for parameter p , we have:

$$\frac{d\theta^*}{dp} = -\frac{\Sigma^* d_p h(\theta^*)}{d_\theta h(\theta^*) \Sigma^* + h(\theta^*) d_\theta \Sigma^*}. \quad (\text{A.42})$$

Thus $\frac{d\theta^*}{dp}$ is of the same sign as $d_p h(\theta^*)$, which is positive.

A.6 Equilibrium properties of the smuggling fee

Let us now study the equilibrium properties of the equilibrium smuggling fee w^* , which is the other key endogenous variable of this model, given by equation (25).

For any parameter X , we have:

$$\frac{dw^*}{dX} = \frac{\partial w^*}{\partial X} + \underbrace{\frac{\partial w^*}{\partial \theta^*}}_{-} \frac{d\theta^*}{dX}. \quad (\text{A.43})$$

Then, for parameters η , δ , Y and σ , we have:

$$\frac{dw^*}{d\eta} = \underbrace{\frac{\partial w^*}{\partial \eta}}_{+/-} + \underbrace{\frac{\partial w^*}{\partial \theta^*}}_{-} \underbrace{\frac{d\theta^*}{d\eta}}_{+/-} \gtrless 0 \quad (\text{A.44})$$

$$\frac{dw^*}{d\delta} = \underbrace{\frac{\partial w^*}{\partial \delta}}_{-} + \underbrace{\frac{\partial w^*}{\partial \theta^*}}_{-} \underbrace{\frac{d\theta^*}{d\delta}}_{+/-} \gtrless 0 \quad (\text{A.45})$$

$$\frac{dw^*}{dY} = \underbrace{\frac{\partial w^*}{\partial Y}}_{+/-} + \underbrace{\frac{\partial w^*}{\partial \theta^*}}_{-} \underbrace{\frac{d\theta^*}{dY}}_{+/-} \gtrless 0 \quad (\text{A.46})$$

$$\frac{dw^*}{d\sigma} = \underbrace{\frac{\partial w^*}{\partial \sigma}}_{+/-} + \underbrace{\frac{\partial w^*}{\partial \theta^*}}_{-} \underbrace{\frac{d\theta^*}{d\sigma}}_{+/-} \gtrless 0. \quad (\text{A.47})$$

Similarly, for parameters K and p , we simply obtain:

$$\frac{dw^*}{dK} = \underbrace{\frac{\partial w^*}{\partial K}}_{+} + \underbrace{\frac{\partial w^*}{\partial \theta^*}}_{-} \underbrace{\frac{d\theta^*}{dK}}_{-} \geq 0 \quad (\text{A.48})$$

$$\frac{dw^*}{dp} = \underbrace{\frac{\partial w^*}{\partial p}}_{0} + \underbrace{\frac{\partial w^*}{\partial \theta^*}}_{-} \underbrace{\frac{d\theta^*}{dp}}_{+} < 0. \quad (\text{A.49})$$

For parameter $X = c, D, \mu, a, \beta$, we have:

$$\text{sign} \frac{\partial w^*}{\partial X} = -\text{sign} \frac{\partial w^*}{\partial \theta^*} \frac{d\theta^*}{dX}, \quad (\text{A.50})$$

so, to be able to conclude, we must replace $\frac{\partial w^*}{\partial X}$, $\frac{\partial w^*}{\partial \theta^*}$ and $\frac{d\theta^*}{dX}$ with their expressions.

For parameter $X = D, \mu, a$, $\frac{d\theta^*}{dX}$ is derived from equation (26):

$$\frac{d\theta^*}{dX} = \frac{\beta d_X \Sigma^*}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} - \beta d_\theta \Sigma^*} = \frac{\beta d_X \Sigma^*}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + B(1-\beta) \frac{a}{a+r} \frac{c}{r+\sigma}}. \quad (\text{A.51})$$

We then obtain:

$$\frac{dw^*}{dD} = \frac{-\beta\delta}{r + \delta + \eta + 1} \left\{ \frac{-\frac{ch'(\theta^*)}{h^2(\theta^*)}}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + B(1-\beta)\frac{a}{a+r}\frac{c}{r+\sigma}} \right\} \leq 0 \quad (\text{A.52})$$

$$\frac{dw^*}{d\mu} = \beta \left(\frac{Y - V_s^M}{r + \delta + \eta + 1} \right) \left\{ \frac{-\frac{ch'(\theta^*)}{h^2(\theta^*)}}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + (1-\beta)B\frac{a}{a+r}\frac{c}{r+\sigma}} \right\} \geq 0 \quad (\text{A.53})$$

$$\frac{dw^*}{da} = \underbrace{\frac{r\beta V_s^M}{a^2} \left(\frac{-\frac{ch'(\theta^*)}{h^2(\theta^*)}}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + B(1-\beta)\frac{a}{a+r}\frac{c}{r+\sigma}} \right)}_{+} - \underbrace{\frac{B(1-\beta)\frac{c}{r+\sigma}\beta\frac{r}{a(a+r)}\Sigma^*}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + B(1-\beta)\frac{a}{a+r}\frac{c}{r+\sigma}}}_{-} \geq 0. \quad (\text{A.54})$$

For parameter c , we have:

$$\frac{dw^*}{dc} = -B(1-\beta)\frac{\theta^*}{r+\sigma} \left(1 + \frac{c}{\theta^*} \frac{d\theta^*}{dc} \right) \leq 0. \quad (\text{A.55})$$

Thus if $\frac{c}{\theta^*} \frac{d\theta^*}{dc} > -1$, then $\frac{dw^*}{dc} < 0$; conversely, if $\frac{c}{\theta^*} \frac{d\theta^*}{dc} < -1$, then $\frac{dw^*}{dc} > 0$.

For parameter β , we have:

$$\frac{d\theta^*}{d\beta} = \frac{\Sigma^* + \beta d_\beta \Sigma^*}{d_\theta \left(\beta \Sigma^* - \frac{ch(\theta^*)}{h(\theta^*)} \right)} = \frac{\Sigma^* + \frac{1}{\beta} \frac{aB}{a+r} \frac{c\theta^*}{r+\sigma}}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + B(1-\beta)\frac{a}{a+r}\frac{c}{r+\sigma}}. \quad (\text{A.56})$$

Thus:

$$\frac{dw^*}{d\beta} = \frac{B}{\beta} \frac{\sigma Y}{r + \sigma} + \left(\frac{a+r}{a} \Sigma^* + \frac{B}{\beta} \frac{c\theta^*}{r + \sigma} \right) \left[\frac{-\frac{ch'(\theta^*)}{h^2(\theta^*)}}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + B(1-\beta)\frac{a}{a+r}\frac{c}{r+\sigma}} \right] \geq 0. \quad (\text{A.57})$$

A.7 Properties of the smuggler contact rate

For any parameter $X \neq p$, the smuggler contact rate varies in the opposite direction as the tightness θ^* since we have:

$$\frac{dh(\theta^*)}{dX} = \underbrace{h'(\theta^*)}_{-} \frac{d\theta^*}{dX}. \quad (\text{A.58})$$

Its variations with respect to parameter p are ambiguous:

$$\frac{dh(\theta^*)}{dp} = \underbrace{\frac{h(\theta^*)}{p}}_{+} + \underbrace{h'(\theta^*)}_{-} \underbrace{\frac{d\theta^*}{dp}}_{+} \leq 0. \quad (\text{A.59})$$

Introducing the elasticity of the matching function, $\alpha(\theta) = -\theta \frac{h'(\theta)}{h(\theta)}$, we can write:

$$\frac{dh(\theta^*)}{dp} = \frac{\theta^*}{p} h'(\theta^*) \left(\frac{p}{\theta^*} \frac{d\theta^*}{dp} - \frac{1}{\alpha(\theta^*)} \right). \quad (\text{A.60})$$

Thus $h(\theta^*)$ increases with p if and only if $\frac{p}{\theta^*} \frac{d\theta^*}{dp} \geq \frac{1}{\alpha(\theta^*)}$.

A.8 Properties of the migrants welfare

The migrants welfare is given by equation (24):

$$V_s^{M*} = \frac{\sigma Y}{r + \sigma} + \frac{1 - \beta}{\beta} \frac{c \theta^*}{r + \sigma}. \quad (\text{A.61})$$

For any parameter $X \neq Y, \sigma, c, \beta$, we have:

$$\frac{dV_s^M}{dX} = \frac{1 - \beta}{\beta} \frac{c}{r + \sigma} \frac{d\theta^*}{dX}. \quad (\text{A.62})$$

Thus V_s^M varies like θ^* for these parameters.

For parameters Y, σ, c, β , we have:

$$\frac{dV_s^M}{dY} = \frac{\sigma}{r + \sigma} + \frac{1 - \beta}{\beta} \frac{c}{r + \sigma} \underbrace{\frac{d\theta^*}{dY}}_{+/-} \geq 0 \quad (\text{A.63})$$

$$\frac{\partial V_s^M}{\partial \sigma} = \frac{rY}{(r + \sigma)^2} + \frac{1 - \beta}{\beta} \frac{c}{r + \sigma} \left(\underbrace{\frac{d\theta^*}{d\sigma}}_{+/-} - \frac{\theta^*}{r + \sigma} \right) \geq 0 \quad (\text{A.64})$$

$$\frac{dV_s^M}{dc} = \frac{1 - \beta}{\beta} \frac{\theta^*}{r + \sigma} \left(1 + \frac{c}{\theta^*} \underbrace{\frac{\partial \theta^*}{\partial c}}_{-} \right) \quad (\text{A.65})$$

$$= -\frac{1 - \beta}{\beta} \frac{c}{r + \sigma} \frac{1}{h(\theta^*)} \left(\frac{1 - \alpha(\theta^*)}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + B(1 - \beta) \frac{a}{a+r} \frac{c}{r+\sigma}} \right) < 0 \quad (\text{A.66})$$

$$\frac{dV_s^M}{d\beta} = \frac{c}{r + \sigma} \left(\frac{1 - \beta}{\beta} \underbrace{\frac{\partial \theta^*}{\partial \beta}}_{+} - \frac{\theta^*}{\beta^2} \right) \quad (\text{A.67})$$

$$= \frac{c}{r + \sigma} \frac{\Sigma^*}{\beta} \left(\frac{(1 - \beta) - \alpha(\theta^*)}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + B(1 - \beta) \frac{a}{a+r} \frac{c}{r+\sigma}} \right) \geq 0. \quad (\text{A.68})$$

Therefore $\text{sign}\left(\frac{dV_s^M}{d\beta}\right) = \text{sign}(1 - \beta - \alpha(\theta^*))$.

A.9 Properties of the number of incoming migrants

The number of incoming migrants M_t^* is given by equation (9):

$$M_t^* = \frac{N}{\frac{\sigma}{g(\theta^*)} (\delta + \eta + 1) + \delta + \mu}. \quad (\text{A.69})$$

It is increasing with the tightness θ^* :

$$\frac{\partial M_t^*}{\partial \theta^*} = (M_t^*)^2 \frac{\sigma (\delta + \eta + 1)}{N} \frac{g'(\theta^*)}{g^2(\theta^*)} \geq 0. \quad (\text{A.70})$$

For parameter $X = c, K, D, Y, a, \beta$, we have:

$$\frac{dM_t^*}{dX} = \underbrace{\frac{\partial M_t^*}{\partial \theta^*}}_+ \frac{d\theta^*}{dX}. \quad (\text{A.71})$$

Thus M_t^* varies like θ^* for these parameters.

For parameter $X = \eta, \delta, \mu, \sigma, p$, we have:

$$\frac{dM_t^*}{dX} = \frac{\partial M_t^*}{\partial X} + \frac{\partial M_t^*}{\partial \theta^*} \frac{d\theta^*}{dX} \quad (\text{A.72})$$

$$\frac{dM_t^*}{d\eta} = -\frac{(M_t^*)^2}{N} \left[\frac{\sigma}{g(\theta^*)} \left(1 - (\delta + \eta + 1) \frac{g'(\theta^*)}{g(\theta^*)} \underbrace{\frac{d\theta^*}{d\eta}}_{+/-} \right) \right] \leq 0 \quad (\text{A.73})$$

$$\frac{dM_t^*}{d\delta} = -\frac{(M_t^*)^2}{N} \left[1 + \frac{\sigma}{g(\theta^*)} \left(1 - (\delta + \eta + 1) \frac{g'(\theta^*)}{g(\theta^*)} \underbrace{\frac{d\theta^*}{d\delta}}_{+/-} \right) \right] \leq 0 \quad (\text{A.74})$$

$$\frac{dM_t^*}{d\mu} = -\frac{(M_t^*)^2}{N} \left[1 - \sigma (\delta + \eta + 1) \frac{g'(\theta^*)}{g^2(\theta^*)} \underbrace{\frac{d\theta^*}{d\mu}}_+ \right] \leq 0 \quad (\text{A.75})$$

$$\frac{dM_t^*}{d\sigma} = -\frac{(M_t^*)^2}{N} \frac{\delta + \eta + 1}{g(\theta^*)} \left[1 - \frac{\sigma g'(\theta^*)}{g(\theta^*)} \underbrace{\frac{d\theta^*}{d\sigma}}_{+/-} \right] \leq 0 \quad (\text{A.76})$$

$$\frac{dM_t^*}{dp} = \frac{(M_t^*)^2}{N} \frac{\sigma (\delta + \eta + 1)}{g^2(\theta^*)} \left[\underbrace{d_p g(\theta^*)}_+ + g'(\theta^*) \underbrace{\frac{d\theta^*}{dp}}_+ \right] \geq 0. \quad (\text{A.77})$$

A.10 Properties of the number of searching smugglers

The number of searching smugglers S_s^* is given by equation (11):

$$S_s^* = \frac{\delta + \eta + 1}{h(\theta^*)} M_t^*. \quad (\text{A.78})$$

It is increasing with the tightness θ^* :

$$\frac{\partial S_s^*}{\partial \theta^*} = \frac{\delta + \eta + 1}{h^2(\theta^*)} \left[h(\theta^*) \underbrace{\frac{\partial M_t^*}{\partial \theta^*}}_+ - M_t^* \underbrace{h'(\theta^*)}_- \right] \geq 0. \quad (\text{A.79})$$

For any parameter $X \neq \eta, \delta, p$, we have:

$$\frac{dS_s^*}{dX} = \frac{\delta + \eta + 1}{h(\theta^*)} \frac{dM_t^*}{dX}. \quad (\text{A.80})$$

Thus S_s^* varies like M_t^* for these parameters.

For parameter $X = \eta, \delta$, we have:

$$\frac{dS_s^*}{dX} = \frac{M_t^*}{h(\theta^*)} + \frac{\delta + \eta + 1}{h^2(\theta^*)} \left(h(\theta^*) \underbrace{\frac{dM_t^*}{dX}}_{+/-} - M_t^* \frac{dh(\theta^*)}{dX} \right) \leq 0. \quad (\text{A.81})$$

For parameter p , we have:

$$\frac{dS_s^*}{dp} = \frac{\delta + \eta + 1}{h^2(\theta^*)} \left(h(\theta^*) \underbrace{\frac{dM_t^*}{dp}}_{+} - M_t^* \underbrace{\frac{dh(\theta^*)}{dp}}_{+/-} \right) \leq 0. \quad (\text{A.82})$$

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ESSEC | CPE Registration number 200511927D
Period of registration: 30 June 2017 - 29 June 2023
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