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Temporary foreign work permits: Honing the tools to defeat human smuggling☆

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ABSTRACT

We study how temporary visa schemes can be designed to drive smugglers out of business while meeting labor market needs in host countries. After discussing their compatibility with a large range of policy objectives, we show how combining internal and external controls with a regulated market for temporary visas alleviates the policy trade-off between migration control and ending human smuggling. We use information on irregular migration from Senegal to Spain and the Democratic Republic of Congo to South Africa to calibrate the "eviction" prices of visas for these two routes, which are set to throttle smuggling activities. Our results highlight important constraints for governments seeking to prevent temporary workers from overstaying, especially on south–north routes such as Senegal to Spain. They suggest combining a regulated market for visas with tighter sanctions against employers of undocumented workers as a way forward.

1. Introduction

Concerns about immigration have reinforced populism in most OECD countries and are threatening some core institutions of the European Union.[1] However, when regular and irregular migrants are considered separately, public opinion is much more concerned about irregular migration than about regular migration.[2] One of the reasons is the increasing awareness, especially in

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[1] The perceived lack of immigration control has been one of the main drivers for Brexit, with a majority of citizens in the UK endorsing reducing immigration at the time of Brexit (Blinder and Richards, 2017). In 2021–2022, it has even been instrumented at the Poland border by the Belarus government as a weapon against the European Union. See: https://www.prio.org/publications/12877

[2] For example, in 2013, 80 (70) percent of respondents in the UK (France) are concerned about illegal immigration, compared to 40 (32) percent about legal migration (see Hatton, 2017). So, reducing irregular migration is clearly a priority for electorates and the governments. The Eurobarometer (May 2015)

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advanced economies with aging populations, that labor market needs are not all met by native workers. In the absence of sufficient legal migration channels, undocumented workers fill in labor market shortages in low-wage occupations such as agriculture, food processing, construction and services[3] and use the services of smugglers to cross borders irregularly. This feeds powerful criminal networks and leads to all kinds of abuses, including forced labor, child trafficking, and sexual coercion. Is there a more proactive way to recruit low-skilled foreign workers? And can this throttle the market for human smuggling?

We propose a theoretical framework to jointly address these questions. We model the market for irregular migration between oligopolistic smugglers and risk-averse migrants of different skill levels. We draw on existing legal frameworks of temporary foreign work permits (TFWPs) in place in many countries to recruit workers in low-skilled jobs and study how they can be adjusted to compete with the services offered by human smugglers. We derive the "eviction" price of work visas, which is set at a low enough level to drive smugglers out of business. By modeling how smugglers interact with migrants and respond to policies, we show that there is not necessarily a trade-off between undermining human smuggling and controlling migration flows. An important finding is that a policy mix combining enforcement of internal and external controls with TFWPs allows to adjust the eviction price and reach predetermined migration targets. We further show how governments should enforce sanctions against illegal activities in a cost-effective way, by carefully combining them with the implementation of the legal market for temporary visas. We illustrate the fine-tuning of these eviction schemes using model calibrations on a south–north route (Senegal to Spain) and a south–south route (the Democratic Republic of Congo to South Africa).

A key element in the design of workable temporary work permits requires taking into account migrants' incentives to comply with the visa rules. The empirical applications highlight the challenges of enforcing the permits' limited duration on south–north routes, where economic disparities are typically large, enforcement of deportation is lax and protection of migrants' rights is strong. They explain why it is more feasible to regulate migration flows on south–south routes with TFWPs. To overcome this constraint, governments in advanced economies may adopt different combinations of enforcement measures, such as harsh punishment against employers of undocumented workers, deferred payments of a share of the income earned abroad until migrants return to their origin countries and the awarding of points towards more settled status in the future.

Our theoretical framework allows us to question the rationale of current visa policies for low-skilled workers. We characterize situations in which a government may prefer the *status quo* equilibrium with many irregular migrants (basically when the popular support for anti-immigration political platforms is massive) and other situations in which it may favor regular labor migration (when the negative externalities of irregular migration are significant and labor shortages are acute). In this case, the schemes we propose are more likely to be politically feasible than implementing a market for permanent visas. Their limited duration allows policy makers to resolve more easily the migration legalization/control trade-off and to meet labor market needs in host economies. Furthermore, they will support the recruitment of low-skilled workers in short supply in some sectors of the economy as highlighted during the COVID-19 crisis in many european countries.[4]

Given the very large potential economic gains for migrants to reach high wage countries (Clemens et al., 2019) and the strong political instability in some parts of the world, there has been an increasing recognition that restrictions on international migration generate strong incentives for irregular migration. Rather than leaving the market to exploitative smugglers, market-based mechanisms have been proposed by Fernández-Huertas Moraga and Rapoport (2014, 2015a,b) to allocate refugees across destination countries through an efficient tradable system of quotas. To regulate economic migration, a much-discussed proposal has been to sell visas. Extending Becker's seminal proposal to auction visas,[5] several ways of implementing a market for visas have been debated in the press and blogs (Simon et al., 1999; Freeman, 2006; Saint-Paul and Cahuc, 2009; Orrenius and Zavodny, 2010). Selling visas allows a government to raise revenues that would otherwise be captured by smugglers and employers of irregular migrants (Auriol and Mesnard, 2016). These revenues can be used to compensate native workers who would lose from the competition with migrants (Weinstein, 2002). Lokshin and Ravallion (2022) push this idea one step further by exploring how to complete immigration markets through the implementation of a decentralized market for work permits.[6] This proposal requires close monitoring of informal labor markets, including for low-wage domestic workers, who are most likely to rent their right to work to immigrants. It could be difficult to implement in some countries – such as the United States, France, Spain and Italy – where there are large informal labor markets employing native workers.

Our paper brings three main contributions to the theoretical literature on visa design. First, while current policies are tilted towards the recruitment of high-skilled economic migrants,[7] we present a novel system of temporary foreign work permits (TFWPs)

indicates that, on average, 87% of respondents in Europe support additional measures against illegal immigration, with a minimum support of 72% in Romania and maximum support of 94% in Cyprus.

[3] They make up 1 percent of the European workforce and 5 percent of the U.S. workforce, see: Martin, Philip. 2019. "Irregular migrant workers in the EU and the US". Migration data portal – blog. June 19. https://www.migrationdataportal.org/blog/irregular-migrant-workers-eu-and-us

[4] See Fasani and Mazza (2020); Kleine-Rueschkamp, L, and C Ozguzel. in VoxEU, December 9 2020, "COVID-19 and key workers: The role of migrants across regions and cities" https://cepr.org/voxeu/columns/covid-19-and-key-workers-role-migrants-across-regions-and-cities and the report written for the Economic Advisory Committee (CAE) of the Prime Minister in France on the post-pandemic difficulties to recruit workers https://www.cae-eco.fr/immigration-et-difficultes-de-recrutement

[5] Gary S. Becker, 1992. "An Open Door for Immigrants – the Auction". *Wall Street Journal*, October 14. Becker, Gary S., and Edward P. Lazear. 2013. "A Market Solution to Immigration Reform". Wall Street Journal, March 1.Becker, Gary S. 2010. "The price of entry". *The Economist*, June 24. https://www.economist.com/finance-and-economics/2010/06/24/the-price-of-entry

[6] They propose that citizens in high wage countries can rent out their right to work to foreign workers, and spend their time on other activities (e.g., child care, studying, investment in human capital or in hobbies).

[7] See Fasani F.2020 "Immigrant key workers in Europe: The COVID-19 response that comes from abroad" VoxEU May 5. https://cepr.org/voxeu/columns/immigrant-key-workers-europe-covid-19-response-comes-abroad

for low-paying jobs, and study how they can be adjusted to throttle human smugglers' businesses, an objective which has not been addressed by previous policy proposals, nor by past or current TFWP schemes – which we review in the next section.

Second, there is a widespread recognition that controlling migration flows through effective public policies calls for a better understanding of both the supply side and the demand side of the market (OECD, 2015). Yet the scant literature on the supply side of the smuggling market has so far not modeled smugglers' reaction to the implementation of temporary work visas. It has rather focused on the financial constraints faced by poor migrants and their exploitation by smugglers. Friebel and Guriev (2006) study the interactions between indebted irregular migrants and smugglers, who, in addition to offering a bundle of services to cross borders irregularly, arrange for their financing through bonded labor market contracts. In the same vein, Tamura (2010) models how migrants can be exploited on arrival by unscrupulous traffickers. Our framework builds on the industrial organization model of the market for smuggling services by Auriol and Mesnard (2016), who account for the response of smugglers to the implementation of a market for permanent visas.[8] In contrast to permanent visas schemes, one advantage of designing temporary visas against smuggling is that their price can be set at lower levels (and even subsidized in some cases). This leaves less room for bonded labor market contracts and exploitation – although we do not explicitly model these interactions – while the very low (or zero) returns to skill they offer attract low-skilled migrants.

Finally, in designing TFWPs to attract low-skilled workers, we take into account their risk aversion and allow for distortions in their risk perceptions, which, to our knowledge, is novel in the literature on visa design. Risk is a key element in the decision to migration, particularly when there are few legal options, and a growing empirical literature investigates risk attitudes of migrants (Arcand and Mbaye, 2013; Bah and Batista, 2018; Bah et al., 2022). As the considerable risks taken by irregular migrants are sometimes difficult to explain using standard expected utility theory, we present our results using prospect theory à la (Kahneman and Tversky, 1972). All our results are qualitatively robust to using the expected utility theory framework, as shown in the appendices, and we illustrate the variations in their magnitude by numerical calibrations.

The rest of the paper is organized as follows. In Section 2 we review past and current TFWP systems for managing low-skilled immigration and their main limitations. In Section 3 we model the migration market when there is no legal channel to migrate such that workers turn to the smugglers' services. In Section 4 we study how the migration market responds to the implementation of a legal temporary visa scheme. In Section 5, after introducing the host country government's objectives, we study price setting strategies to throttle smugglers' businesses and show how external and internal controls can be combined cost-effectively with temporary visa schemes to regulate labor migration. In Section 6 we present numerical applications on two smuggling routes to discuss the policy implications of the model, before concluding in Section 7.

2. Migration channels for low-skilled workers

The large majority of countries worldwide (86%) have implemented an official immigration policy, which in most cases is designed to meet their labor market requirements.[9] In contrast, concerning emigration, the majority has either no explicit policy (36%) or seeks to lower current levels (32%). This means that matching demand and supply for immigrants is largely left to individuals' initiative and the unregulated market. Moreover, immigration policies in many high wages countries have increasingly targeted high-skilled migrants with very limited possibilities for low-skilled workers.[10] One unintended consequence is to feed the illegal markets with non-eligible workers.

This section overviews the evolution of the large systems of temporary foreign worker permits (TFWPs) over the last hundred years, which have been put in place in many high wages countries to address labor market needs for low-skilled workers. We highlight some of their pitfalls, including the fact that they have become increasingly restrictive in some parts of the world, leaving room for a lucrative smuggling market.

2.1. Temporary foreign work permits

Past experiences show that designing effective policies to meet labor market needs and control immigration is not trivial. After the two world wars (WW), most European countries used TFWPs to meet labor shortages and to reconstruct their economies. For instance in France firms and their representatives set up the General Society of Immigration (SGI) in 1924 to bring in thousands of immigrants in sectors experiencing labor shortage after WWI. In 1945, the French government decided to set up the National Office of Immigration (ONI) to manage and stimulate immigration to help with the reconstruction of the country after WWII.[11] During WWII the "bracero" program in the US was set up to recruit Mexican workers in the agricultural sector on a temporary basis.

[8] Auriol and Mesnard (2016) model smugglers' response to the implementation of a market for permanent visas, designed to attract high-skilled, risk-neutral, foreign workers. Because of the risk-neutrality assumption and the permanent nature of the visas, the paper focuses on illustrating the trade-offs entailed by legal visa schemes, rather than their feasibility. It simply ignores low-skilled migration.

[9] In particular, 61% of countries seek to maintain current levels of legal immigration, while 12% have policies to increase it. Only 13% have policies to lower it, the rest have no official policy or do not seek to influence it (UNDESA, 2017). Among all regions, Europe has the highest proportion of countries seeking to raise immigration levels (32%), followed by Asia (10%). Among countries that aim to decrease immigration, Asia has the highest share of countries seeking to reduce current levels of immigration (23%), followed by Africa (13%).

[10] For example, presenting to the UK parliament its new points-based system, the Home Office (2020) states: "We will reduce overall levels of migration and give top priority to those with the highest skills and the greatest talents: scientists, engineers, academics and other highly-skilled workers. [...] We will not introduce a general low-skilled or temporary work route".

[11] See online: Office Français de l'Immigration et de l'Intégration, *Notre Histoire*. https://www.ofii.fr/notre-histoire/

Although most of these systems were dismantled in the 70 s, following rising unemployment problems, they have since been replaced by more sector-specific recruitment policies for temporary workers.[12] Some countries rely on issuing large numbers of seasonal and TFWPs. In Canada for example, TFWPs of less than three years duration have in some periods outnumbered other types of work visas, with 338,000 TFWPs granted in 2013 up from 101,000 in 2001 (Gross, 2014). In recent decades in the UK, large numbers of workers have been recruited through temporary visa schemes, such as the now discontinued Seasonal Workers Agricultural Schemes (SAWS) and the Sectors Based Scheme (SBS). The threat posed by post-Brexit restrictions on labor inflows from European countries has revived discussions about how to multiply temporary work permits to recruit foreign workers.[13] However, the recent points-based system proposed by the government does not open a route for low-skilled migrants, apart from a quota of 10,000 seasonal workers in agriculture (Home Office, 2020).

In other countries, the unsatisfied demand for low-wage workers in specific sectors of the economy has led to patchy responses. For example, every year since 2006, France has issued exceptional authorizations of stay (“admission exceptionnelle au séjour”, hereafter AES) so that workers in the underground economy could legalize their situation. In practice the AES are granted to workers in sectors “sous tension”, where there is a mismatch between the demand for labor and the number of legal workers willing to take “hard” jobs in catering, construction or social care. These AES workers are overwhelmingly men in their thirties coming from African countries such as Mali, Morocco and Tunisia, and having overstayed in France for, on average, 8 to 10 years (OECD, 2017).

Further, there has been an unprecedented expansion of TFWPs in other parts of the world, in the states of the Arabian Peninsula following the increase in the price of oil in 1973 and, more recently, with the rapid economic growth in East Asian countries and the increasing political and economic interconnectedness between states in the ASEAN region (Kaur, 2010).

These systems of TFWPs are subject to two types of criticism. The first one relates to the frequent violations of labor and human rights by employers of temporary foreign workers. These have been identified and reported by non governmental organizations,[14] international organizations (technical report of Palumbo and Sciurba, 2018), the press,[15] as well as scholars in political sciences, sociology and law (see for example Clark, 2017; Cohen, 2006; Vanyoro, 2019). Forms of bonded labor are more likely to occur when foreign workers rely on their employers for a large range of services such as transport, health care, subsistence and accommodation, and when they do not have enough legal protection or time to be informed of their rights before being repatriated in case of disagreement.[16] There is hence a tension between the arguments of efficiency put forward by economists in favor of temporary foreign work permits, and the rights-based criticisms of the current systems, which are often abused (Sumption and Fernandez Reino, 2018). To attenuate this issue, work and residence rights could be granted to guest-workers separately from a firm’s rights to employ them (Casella and Cox, 2018).

The second type of criticisms relates to the workability of TFWPs as they often feed labor markets with undocumented workers who overstay the duration of their permits.[17] Overstaying has been exacerbated by increasing migration restrictions, which have the unintended effect of discouraging circular migration and of lengthening the time spent abroad, as documented with the Mexico-to-US migration (Angelucci, 2012).

2.2. Smugglers

To overcome these issues, an alternative policy would be to open the borders. Although scholars predict large overall economic gains (see for example Clemens, 2011), fears of massive inflows of migrants make such a solution politically unfeasible, at least in the current context. In response to these fears, most OECD countries combine tighter border controls with visa quotas, which are rather ineffective in stopping undocumented immigration. For instance, enhanced border controls between Mexico and the US following the Immigration Reform Control Agreement (1986) have had small deterrence effects on irregular migration to the US (Gathmann, 2008) but rather exacerbated the risks taken by migrants and their use of smugglers’ services.

Although figures vary across origin and destination countries (see for example Soto et al., 2021, for Central America), reliance on smugglers to enter high wages countries is stronger when it is difficult to migrate through legal channels (UNODC, 2018) and when border controls are enforced more strictly (Carare et al., 2023). Europol reports that over 90% of irregular migrants traveling to the European Union use the *“facilitation services”* offered by smugglers,[18] while 55% of recent migrants from El Salvador, Guatemala and Honduras used smugglers’ services to reach the US for the large majority (89%) of them (Soto et al., 2021). It is also stronger

[12] For a comparison across European countries, see López Sala et al. (2016).

[13] In 2018, this led to the Immigration White Paper proposals to create a seasonal workers pilot in agriculture, accompanied by a 12-month temporary migration program to bring workers at any skill level, and a Youth Mobility Scheme (YMS) to admit young people from certain non-EEA countries to work for up to 2 years (UK Government, 2018).

[14] See for example FLEX (2019), Human Rights Watch (2011).

[15] Annie Kelly, 2019. “Rape and abuse: the price of a job in Spain’s strawberry industry?” *The Guardian*. April 14. https://www.theguardian.com/global-development/2019/apr/14/rape-abuse-claims-spains-strawberry-industry

[16] The vast majority of migrant workers in the gulf countries, who are numerous (e.g., close to 40% of the population in Saudi Arabia), have a job with a visa for one to three years. The main issue with these visas is the kafala system, in which every migrant worker must have a “sponsor” to obtain a residence visa. It gives full legal responsibility, powers, and rights before the State to the sponsor, who is at liberty to cancel the migrant’s work visa and have them expelled, which leads to many abuses. See: ILO. “Labour Migration in the Arab States”. Retrieved online on April 13, 2023. https://www.ilo.org/beirut/areasofwork/labour-migration/WCMS_514910/lang--en/index.htm.

[17] Noticeable exceptions are the East Asian countries, which adopted very strong enforcement policies against undocumented migrants.

[18] European Commission, Europol. “Facilitation of Illegal Migration”. https://www.europol.europa.eu/crime-areas-and-statistics/crime-areas/facilitation-of-illegal-immigration. Retrieved online on April 19, 2023.

when land borders do not exist between origin and destination countries. For example, around 75% of detected cases of irregular border crossing to the UK involve smugglers (Home Office, London (United Kingdom);, 2001).

Defeating smuggling requires to better understand the operations of smugglers, on whom it is hard to collect direct and systematic information. The (UNODC, 2018) report depicts them as profit maximizing entrepreneurs, who target would-be migrants by advertising their services where migrants can easily be reached (through online social networks, in refugee camps and diaspora communities...). They organize air, sea or ground transportation and offer a large range of services – from money loans to assistance in accommodation and job search at destination – which increase migrants' indebtedness and generates bonded labor (Friebel and Guriev, 2006). Indirect evidence suggests that smugglers are prompt to adapt to geopolitical and policy changes. For example, the opening of the central Mediterranean route, following the 2011 fall of the Gaddafi Regime, substantially increased irregular crossings from Lybia to Europe (Friebel et al., 2018). Moreover, investments in border controls between Mexico and the US following the Immigration Reform Control Agreement (1986) pushed smugglers to reorganize their operations and to increase the prices they charge to cross the border (Roberts et al., 2010).

While information on smuggling fees is scattered across various sources that are not representative, there have been several attempts to draw them together in more global perspectives. In an early study covering 500 sources, Petros (2005) highlights that distance, mode of transport, characteristics of migrants and the package of services by smugglers (food, accommodation, documents..) are key elements explaining the large variation in fees observed across places and over time. More recently, international and national agencies watching or reporting irregular border crossings have accumulated data on prices paid by migrants to smugglers. For example, Frontex (2019) reports that migrants who reach Italy from Turkey spend on average EUR 5,000 per person. Secondary movements often add to these costs: according to the (UNODC, 2018), crossing the border between France and the UK costs between USD 5,000 and 7,500. These high fee levels are corroborated by data from the B-BAMF-SOEP survey on asylum seekers arriving in Germany from Eastern Africa and the Middle East between 2013 and 2016, who paid on average EUR 5,541.[19]

Smuggling costs are also very high for south–south migration: for example, fees to reach Southern Africa from the Horn of Africa are between USD 3,000 and 3,500 (UNODC, 2018), which is half the average price for smuggling services from South to Central America (around USD 7,500), as reported by Soto et al. (2021).[20] Services for longer routes involving air transport fare way higher: for instance smuggling services to travel from India and Nepal to the United States are estimated between USD 27,000 and 47,000 (UNODC, 2018).

These high fees explain that, with more than 2.5 million people smuggled around the world each year, the human smuggling market is booming. It brings billions in revenue to criminal networks – a low estimate of economic returns worldwide is around USD 5.5–7 billion in 2016 (UNODC, 2018) –, which are increasingly organized and, in some countries like Mexico, pose a real threat to the rule of law. Smuggling activities cost the lives of thousands of individuals each year. For example, over a total of more than 2 million people arriving to Europe by sea since 2014, more than 20,000 have died or gone missing.[21] Many more have been abused, exploited and are stuck en route in unwanted destinations and situations.[22] This builds on the fact that coercive contracts are easy to enforce on individuals without legal status. For all of these reasons, ending human smuggling has become an urgent issue. The integration of migrants and migration policies has even found its way in the Agenda for Sustainable Development, with specific reference to ending human trafficking and respecting the labor rights of migrant workers (see UNCTAD, 2018, p. 20).[23] Next sections propose a model of the human smuggling market to address these issues.

3. Modeling irregular migration and the smuggling market

When legal migration is restricted under the *status quo*, we assume that workers from poor countries need to hire smugglers to migrate, at price p^I. In line with the literature on criminality applied to the smuggling market (Aronowitz, 2001; Futo and Jandl, 2007; Guerette and Clarke, 2005; Lundgren, 2008; Auriol and Mesnard, 2016), services are provided by N smugglers, who compete *à la Cournot*.[24] This determines the generalized Cournot price, p^I, as solution to the following equation:

$$\frac{p^I - c}{p^I} = \frac{1}{N}\frac{1}{\varepsilon_{D^I,p^I}} \tag{1}$$

[19] The highest fee reported is EUR 72,072 (Keita et al., 2023).

[20] The cost of organizing a caravan to travel from South to Central America without the assistance of smugglers is around USD 2,900 (Soto et al., 2021).

[21] See UNHCR data https://data2.unhcr.org/en/situations/. Along the Central-Mediterranean route from Libya to Italy, more than 17,000 migrants have died or gone missing since 2014, as estimated by the Office International for Migration (see IOM data 2021 https://missingmigrants.iom.int/downloads).

[22] https://www.amnesty.org/en/latest/news/2016/01/female-refugees-face-physical-assault-exploitation-and-sexual-harassment-on-their-journey-through-europe/

[23] Specifically, target 10.7 of the 2030 Sustainable Development Goals calls on countries to facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well managed migration policies. Other migration-related targets in the 2030 Agenda include retaining health workers in developing countries; providing scholarships for study abroad; ending human trafficking; respecting the labor rights of migrant workers, in particular women migrants; reducing the costs of transferring remittances and providing legal identity for all.

[24] Cournot competition can yield both a monopolistic equilibrium and a more competitive equilibrium depending on the number of smugglers N, which is easily endogenized in an equilibrium with free entry and a fixed cost K. Other models of imperfect competition, such as horizontal differentiation, lead to the same type of results, as the smugglers end up reaching marginal cost pricing in all cases. Bertrand competition, with a fixed entry cost K, always leads to a monopoly.

where c represents their marginal operating costs, ε_{D^I,p^I} is the price elasticity of the demand for smugglers' services and N is an integer greater than 1. The generalized Cournot competition demand, $D^I(p^I)$, is between the two extreme cases: $D^I(p^m) \leq D^I(p^I) \leq D^I(c)$ where p^m is the monopoly price ($N = 1$) and the price under perfect competition is equal to the marginal costs c ($N \to \infty$). Other than this price, the important factors to determine the demand for smugglers' services are the economic gains from migration and the risk of crossing borders irregularly, which are studied below.

3.1. Economic gains from irregular migration

Potential candidates for irregular migration are heterogeneous according to their labor efficiency (or skill), θ, which is drawn from the distribution $F(\theta)$ with support $\mathbb{R}_+$. It is assumed that the distribution $F(\theta)$ is twice differentiable with a density function $f(\theta) > 0$. Returns to skills in the home country are given by $\Delta_h(\theta)$, where $\Delta_h : \mathbb{R}_+ \to [1, +\infty)$ is continuous, increasing and concave, with $\Delta_h(0) = 1$. Earnings of individual of type θ are given by $\Delta_h(\theta)w_h$, where w_h is the expected wage of an unskilled individual in her home country.[25]

When a worker succeeds in crossing borders irregularly, she takes on jobs in the undocumented labor market where she does not benefit from returns to her skills, and receives a discounted wage of the minimum wage in the foreign country, dw_f with $d < 1$,[26] which is higher than what she would earn at home w_h. Assuming no returns to skill in the undocumented sector of the destination country, we characterize the demand for workers in labor intensive sectors of the economy such as construction, domestic care, sweatshops, hospitality, or agriculture. Independently of their skills, undocumented workers are paid at a flat rate, which is lower than minimum wages. As will become clear below, this results in a negative selection of irregular migrants and is in line with recent evidence on irregular flows of workers from non conflict areas in Africa and Middle East to Europe (Aksoy and Poutvaara, 2021).[27]

3.2. Migration decision under high risk of failure

The way we model migration decisions from risk averse individuals is fairly general and encompasses both advances in cumulative prospect theory (CPT) following (Tversky and Kahneman, 1992) and the more standard expected utility theory (EUT). CPT postulates that individuals compare lottery outcomes rather than final wealth and allows for them to be risk-seeking for losses and risk-averse for gains through more flexibility in S-shaped value functions. It also leaves flexible the use of nonlinear weighing functions of risk, which may result in individuals over-estimating the odds of rare salient events – e.g. a successful irregular migration – and under-estimating those of more common events – e.g. a failed migration. This accounts for behavioral traits that are hard to explain using EUT, such as the fact that undocumented migrants take on a high risk of their migration failing, with large sunk costs. This motivated our choice of the CPT framework to present our results, but all results are robust to using either framework, as shown in the appendices.

If irregular migrants are intercepted by border guards, with probability q, we assume that they are sent back to their home country and lose the money paid to smugglers.[28] Earnings in the foreign country are used to pay the smuggler's fee p^I and for consumption $dw_f - p^I$. A worker deciding whether to risk irregular migration faces the following lottery $\mathcal{L}_{illegal} = \left[dw_f - p^I, \Delta_h(\theta)w_h - p^I; 1-q, q\right]$ and compares it with the certain payoff she receives when she does not migrate, $\Delta_h(\theta)w_h$. The migration condition is written as: $\omega^+(1-q)u\left(dw_f - p^I - \Delta_h(\theta)w_h\right) + \omega^-(q)u\left(-p^I\right) > 0$, with the probability weighting functions $\omega^+(.)$ accounting for individuals' distorted perceptions of probabilities.[29]

Studying the threshold such that an individual is just indifferent between an irregular migration or not migrating, the marginal type θ^I is the solution of the following equation:

$$\omega^+(1-q)u\left(dw_f - p^I - \Delta_h(\theta)w_h\right) + \omega^-(q)u\left(-p^I\right) = 0 \tag{2}$$

Since u and Δ_h are monotonous functions, the existence and uniqueness of $\theta^I > 0$ are guaranteed if at least one individual (i.e. the type 0) decides to migrate – which is mathematically written as $\omega^+(1-q)u\left(dw_f - w_h - p^I\right) + \omega^-(q)u\left(-p^I\right) > 0$.[30]

Aggregating over the distribution of skills, we obtain the demand for irregular migration as a function of migration price p^I through θ^I, defined implicitly in (2):

$$D^I(p^I) = \int_0^{\theta^I} f(\theta)\mathrm{d}\theta = F(\theta^I) \tag{3}$$

[25] This is consistent with the large body of empirical research on returns to skills (see Lemieux, 2006), where earnings take the form of a (Mincer, 1970) equation. One would postulate $\Delta_h(\theta) = e^{D_h\theta}$, $D_h > 0$.

[26] For empirical evidence on this discount factor see Kossoudji and Cobb-Clark (2002) for the US and Monràs et al. (2020) for Spain.

[27] The model can be extended to the case of a more positive selection of undocumented migrants, which has been observed in other settings with severe liquidity constraints or large positive returns to skills if there is a possibility of obtaining legal status in the host country (Grogger and Hanson, 2011; Orrenius and Zavodny, 2005). To be attractive to higher skilled individuals, the type of visa must give access to jobs with positive returns to skills in the destination country, for example working as middle men on building sites or as health workers, but the pricing mechanism of visas is similar to what we develop below.

[28] In practice, given the large amounts at stake, the final payment may be partially locked in a bank account or under the control of the migrant's network until there is proof of success (UNODC, 2018), but many migrants lose their down-payments.

[29] These functions are simply increasing mappings $w : [0,1] \mapsto [0,1]$, such that $w(0) = 0$, $w(1) = 1$, and for x in the neighborhood of 0 $w(x) \geq x$ (respectively $w(x) \leq x$ for x close to 1). More detail on CPT and on the functions specified by Tversky and Kahneman (1992) can be found in Appendix A and Appendix H.

[30] This result holds both under CPT and EUT (see Appendix B). Without risk ($q = 0$), this condition becomes $dw_f - w_h > p^I$.

The demand for irregular migration is higher the lower the migration price, p^I, the lower the risk, q, the higher the discounted wages earned abroad as an irregular migrant, dw_f, and the lower the wages in the home country, w_h. This implies that if the risk of failure, q, or the price of irregular migration, p^I, is too high relative to the economic gains, then no worker is willing to migrate irregularly and demand is 0. These results, shown in Appendix B, are intuitive since workers compare the costs and economic benefits from irregular migration.

4. Implementing a market for temporary foreign work permits

In this section we study the equilibrium when a government enters the migration market by selling temporary visas of duration τ, to foreign workers willing to take on low paid jobs. These are designed to attract workers in specific sectors with low returns to skills and labor shortage, such as agriculture in Spain and Canada, or domestic care and hospitality in Cyprus. Foreign workers recruited through these schemes earn w_f for a duration τ and spend the rest of their working life $(1-\tau)$ in their country of origin where they earn $\Delta_h(\theta)w_h$ per unit of time. These low paid jobs do not recognize foreign workers' skills even though workers can work in jobs where their skills are recognized in origin countries. The assumption of zero returns to skill abroad is not crucial but eases the presentation. All results are derived in the appendix in a more general case, with some positive returns to skills in the foreign country, which are lower than in the origin country. In line with cross-country evidence on returns to education and skills (Psacharopoulos and Patrinos, 2018; Hanushek and Zhang, 2009) this assumption implies that regular migration through short-term TFWPs selects individuals negatively (see Appendix D).

A workable temporary visa scheme needs to satisfy three constraints. The *individual rationality constraint* is that some workers prefer to migrate temporarily with a visa rather than stay in their home country. The *incentive compatibility constraint* is that some workers prefer to migrate temporarily under the scheme than enter a country without a visa. The *enforceability constraint* is that temporary workers do not overstay their visa duration. Moreover, to set the price and duration of temporary visas, the government, a Stackelberg leader,[31] takes into account that the smugglers will adjust their price in response to the legal offer.

4.1. Demand for temporary visas

The *individual rationality constraint* determines the skill threshold θ^L under which a worker prefers to migrate under the temporary visa scheme $(p^L,\ \tau)$ than stay at home, which is the unique solution to:

$$w_f - \Delta_h(\theta)w_h = \frac{p^L}{\tau}. \tag{4}$$

Individuals under this skill threshold have migration gains, equal to $\tau(w_f - \Delta_h(\theta)w_h)$, larger than the costs they pay to migrate legally, p^L. For legal migration to occur, this threshold, θ^L must be higher than 0, which is satisfied if and only if $w_f - w_h > \frac{p^L}{\tau}$. This condition guarantees that at least the lowest skilled individual is willing to migrate under the temporary visa scheme (see all proofs in Appendix C).

The *incentive compatible constraint* determines the skill threshold, θ^{LI}, such that any individual above this threshold prefers to migrate temporarily with work permits rather than irregularly. Appendix D shows that θ^{LI} is the unique solution to the following equation:

$$\begin{aligned}&\omega^+(1-q)u\left[(d-\tau)\,w_f-(1-\tau)\Delta_h(\theta)w_h-p^I+p^L\right]\\&\quad+\ \omega^-(q)u\left[\tau\left(\Delta_h(\theta)w_h-w_f\right)-p^I+p^L\right]=0\end{aligned} \tag{5}$$

Note that this threshold may be below the minimum skill level of workers ($\theta^{LI} < 0$), in which case no worker will migrate irregularly using a smuggling' service following the implementation of the scheme.

The demand for regular temporary migration comes from workers who satisfy the *individual rationality constraint* and the *incentive compatible constraint*, as follows:

$$D^L\left(p^L,\tau,p^I\right)=\int_{\theta^{LI}}^{\theta^L} f(\theta)\mathrm{d}\theta \tag{6}$$

Comparative statics in Appendix C intuitively shows that more individuals are willing to migrate regularly with a temporary visa than to stay at home as the migration duration increases, the price of visa decreases and the wage differential between host and origin country increases. Moreover, as shown in Appendix D, when irregular migration persists, fewer individuals prefer to migrate irregularly than regularly as the benefit of irregular migration decreases.[32]

[31] Once the government announces its policy, it must stick to it to be credible.

[32] That is, as the income differential between the legal and illegal sectors increases, as the price of smugglers increases, as the risk associated with migrating irregularly increases and, under the condition that the probability of failure is relatively high, as the wage differential between host and origin country increases.

4.2. Enforceable temporary visas

Opponents of guest-worker programs typically question whether temporary visas are enforceable, as workers could be tempted to overstay in the host country and work illegally. To address this, the government could offer incentive compatible guest-worker programs by withholding a share, s, of the income earned abroad and returning it to workers upon completion of the visa after they return to the home country. Enforcement can be strengthened by deporting workers who overstay and take on undocumented work. We note δ the probability of being deported if a worker overstays.

4.2.1. Overstaying constraint

Migrants facing the decision to overstay to work illegally compare the payoff they derive from the lottery $\mathcal{L}_{overstay} = [\tau(1-s)w_f + (1-\tau)dw_f, \tau(1-s)w_f + (1-\tau)\Delta_h(\theta)w_h; 1-\delta, \delta]$, with their payoff if they comply with the rules of the guest worker program, $\tau w_f + (1-\tau)\Delta_h(\theta)w_h$. They decide to return to work in their origin country upon visa completion if and only if:

$$\omega^+(1-\delta)u\left[(1-\tau)\left(dw_f - \Delta_h(\theta)w_h\right) - s\tau w_f\right] + \omega^-(\delta)u\left[-s\tau w_f\right] \leq 0 \tag{7}$$

Since the left hand side of the *enforceability constraint* (7) decreases with θ, skilled workers have more incentive to comply with the visa rules than low-skilled workers. This is because skilled individuals have higher returns to their skills in their origin country. In other words, giving more incentives for workers to return upon completion of their visas helps to avoid a negative selection of overstayers.[33] The following proposition establishes that it is always possible, by combining different policy instruments, to set up a program of TFWPs satisfying the "self-enforceability" constraint (i.e. so that workers do not overstay).

Proposition 1. *For any $\tau, s, d \in (0,1)$, there exists a minimum deportation rate $\underline{\delta}(\tau, s, d) < 1$, decreasing with the share of wages retained s and the duration of visa τ, and increasing with the benefit of undocumented sector employment d, such that temporary migration visas are self-enforceable.*

Proof. See Appendix E. ■

The enforceability constraint (7) is easier to satisfy as the relative benefits of overstaying to work in the undocumented sector decrease and as the enforcement instruments are strengthened.[34] The latter can be implemented through workplace inspections (a lower d), through increasing the costs of overstaying, entailed by a larger share s of wages retained abroad or by a longer visa duration τ, and through enforcement of deportation (a larger δ). For example, after replacing $\delta = 1$ in (7)), it is easy to check that the enforceability constraint is always satisfied. Symmetrically, when $\delta = 0$, the condition (7) becomes:

$$(1-\tau)(dw_f - \Delta_h(\theta)w_h) \leq s\tau w_f \tag{8}$$

so that unless the retention rate s and visa duration τ are very large, the guest worker program will not be self-enforceable when deportation measures are never enforced.

4.2.2. Enforceable short-term visas in practice

Proposition 1 shows the complementarities between the policy instruments and the importance of carefully combining them with the implementation of a market of temporary visas. In practice, most countries already rely on some of these measures to manage labor migration. They combine sticks and carrots to ensure timely return of guest workers.

Large retention fees (large s) and enforced deportation (large δ): In East Asian countries, low rates of guest workers overstaying are enforced through harsh deportation measures and large retention fees (sticks). Employers can withhold substantial parts of the wages and/or can require a large contract-completion deposit, sometimes up to USD10,000 as in Japan, which is paid back to workers upon timely return (Bélanger et al., 2011; Djajić, 2013). There are other ways to enforce compliance with visa rules, such as fines, sometimes even jail sentences, and an exit tax to migrants who would like to leave the host country after the date of compliance (Djajić and Vinogradova, 2015).

Harsh punishment against undocumented work (low d): Alternatively, strict controls of employers and harsh punishment against firms that would employ undocumented migrants (stick) decrease d and, therefore, ease the enforceability of temporary migration visas. Condition (7) is indeed always true when $d = 0$. In countries with very limited economic prospects in informal labor market, such as Luxembourg, Iceland, Norway or Sweden,[35] it is more feasible to design self-enforceable temporary migration visas.

Eligibility for future temporary visas (larger τ): In addition, host countries may put in place a system of credits to gain eligibility for future visa applications if a migrant returns home before the work visa expires (carrot). This instrument has been implemented in Canada and in France.

Limits to TFWP self-enforceability: As a corollary, it is not always possible to enforce the temporary stay of workers by retaining a share of earnings abroad. With low deportation rates (low δ) and thriving informal labor markets for undocumented workers

[33] An overstaying worker stays in the foreign country for the rest of her working life. After the visa expires, if she does not make a timely return to her home country, she loses the retained income. Hence overstaying the visa but returning before the end of her working life is even more costly.

[34] We assume for simplicity that the discount rate equals the interest rate such that withdrawing a share of wages and giving back later is neutral. If the interest rate is higher than the discount rate one could compensate guest-workers by paying interest on the withheld share.

[35] See Bonnet et al. (2019).

(large d), visas need to be unrealistically long and retention shares arbitrarily large to incite workers to return to their home country upon completion of the visa. Indeed visa duration and retention share interact to increase financial losses in case of default.[36] As a consequence, with lax enforcement of deportation and the existence of large informal labor markets for undocumented workers, as in southern Europe and the USA, substantial numbers of migrants may overstay to work irregularly.[37] To illustrate these policy constraints, Section 6 studies the required levels of enforcement instruments needed for workable temporary visas on two (i.e., south–north and south–south) routes.

For the remainder of this section and Section 5, we consider a set of contracts for which the self-enforceability constraint is not binding, such that the exact design of the incentives to prevent overstaying does not affect the results.

4.3. Smugglers' reaction to the sale of temporary visas

When visas can be bought legally, the individual of type θ compares the lottery $\mathcal{L}_{irregular} = \left[dw_f - p^I, \Delta_h(\theta)w_h - p^I; 1-q, q\right]$ with the payoff she retrieves from migrating regularly, $\tau w_f - p^L + (1-\tau)\Delta_h(\theta)w_h$. A constraint for the smugglers is to fix their price low enough relative to the price of a legal permit, to attract the workers of type between 0 and θ^{LI}. This requires that $\theta^{LI} > 0$. Since the value of irregular migration compared to regular migration, $\omega^-(q)u\left[\tau\Delta_h(\theta)w_h - \tau w_f - p^I + p^L\right] + \omega^+(1-q)u\left[dw_f - \tau w_f - (1-\tau)\Delta_h(\theta)w_h - p^I + p^L\right]$, is decreasing in θ, a necessary condition is that the comparison of the lottery must be positive for the lowest skilled worker:

$$\begin{aligned}&\omega^+(1-q)u\left[(d-\tau)w_f - (1-\tau)w_h - p^I + p^L\right]\\&\quad + \omega^-(q)u\left[p^L - p^I - \tau\left(w_f - w_h\right)\right] > 0\end{aligned} \tag{9}$$

This condition is more likely to be satisfied with a higher visa price, a lower smugglers' fee and a shorter visa duration, which all make regular migration less attractive relative to irregular migration.

Under condition (9), the demand faced by the smugglers is:

$$D^I(p^I, p^L) = \int_0^{\theta^{LI}} f(\theta)d\theta = F(\theta^{LI}) \tag{10}$$

Let $p^N(p^L)$ be the solution of (1) computed with the direct price elasticity of demand (10), $\varepsilon_{D^I,p^I} = -\frac{\partial D^I(p^I,p^L)}{\partial p^I}\frac{p^I}{D^I(p^I,p^L)}$, which depends on p^L. The price reaction function of the smugglers is the solution of the following equation:

$$p^I(p^L) = \begin{cases} p^N(p^L) & \text{if } c \le p^N(p^L) \\ \varnothing & \text{otherwise} \end{cases} \tag{11}$$

This shows that the reaction price of the smugglers is increasing in their marginal operating costs, c and in the price of a visa, p^L, and decreasing in the number of smugglers, N.

5. Regulating labor migration with temporary visa schemes

In this section, we discuss the optimality of temporary visa policies from the viewpoint of the host country government. They consist in a visa scheme $\left(\tau, p^L\right)$ and a vector of additional enforcement measures to fight irregular immigration $E = (E_c, E_q, E_d)$, which raise the smugglers' marginal cost, the probability of a failed migration, and decrease the earnings of undocumented workers. In the baseline model, there is no additional investment in repression, $E = (0,0,0)$, such that the levels by default of these key variables are c, q, and d.

5.1. Objectives of the host country government

In choosing its migration policy, the government focuses on a *national/ domestic* objective, as is typical for a government under a constraint of re-election. In other words, the government does not internalize the welfare of foreign consumers/citizens who do not elect it.

We assume that there is a shortage of low-paid workers in the host country of the equivalence of T permanent workers that a government wants to fill, reflecting shortage occupation lists established in many OECD countries.[38] For example, the draft of the proposed Law on Immigration and Asylum presented to the French Assemblée Nationale in February 2023 proposes that regularization be granted to undocumented workers willing to accept jobs in shortage occupations (''métiers en tension'') and having been employed in France for several years. Similarly, in the UK, the Migration Advisory Committee is due to review the shortage occupation list to help the government fine-tune its visa policy.

[36] Eq. (8) presents this constraint in the extreme case in which the deportation is not enforced.

[37] To encourage irregular migrants to return to their origin country, some governments have, instead, given administrative and financial help. See for example the ''Aides au Retour Volontaire'' in France (Dorothéee Pierry. ''Aide au retour volontaire de l'Ofii : à qui s'adresse-t-elle et comment en bénéficier?''. Aide-sociale.fr, July 8, 2022. https://www.aide-sociale.fr/retour-volontaire/) and the EU-IOM joint initiative for migrant protection and reintegration at the EU level (International Organization for Migration. *EU-IOM Joint Initiative*. 2022. https://www.migrationjointinitiative.org/)

[38] For France see https://dares.travail-emploi.gouv.fr/publications/les-tensions-sur-le-marche-du-travail-en-2019 or Le Monde, 27 January 2023, https://www.lemonde.fr/societe/article/2023/01/27/immigration-le-patronat-divise-au-sujet-du-titre-de-sejour-metiers-en-tension_6159547_3224.html.

Taking into account this target of T permanent equivalent workers, we model the government's objective function as a linear combination of different domestic objectives weighting the consumer surplus, the taxpayer surplus and the political externalities entailed by migration in line with a utilitarian welfare criterion.

The consumer surplus related to immigration is the economic surplus generated by foreign workers, $S^g(l^L + l^I)$, net of the total wage bill, $w_f(d(E_d)l^I + l^L)$ under the constraint that $l^L + l^I = T$. That is, the consumer surplus is $S^c\left(l^L, l^I, E\right) = S^g(T) - w_f(d(E_d)l^I + l^L)$ where $l^L = \tau D^L(p^L, \tau, p^I|E)$ and $l^I = (1 - q(E_q))D^I(p^L, \tau, p^I|E)$, are the equilibrium levels of labor available in the economy from regular and irregular migration respectively.

The taxpayer surplus related to immigration is $p^L\frac{l^L}{\tau} - C(E)$, the difference between the revenue from the sale of visas, $p^L\frac{l^L}{\tau}$, and the total investment in control enforcement, $C(E) = E_c + E_d + E_q$.

The negative externalities generated by irregular and regular migration, $\xi_I l^I + \xi_L l^L$, represent the cost of irregular l^I and legal l^L labor migration in terms of government popularity, as well as, for irregular migration, the cost associated to crime generated by smuggling activities. The weight associated to regular migration, $\xi_L \geq 0$, and the weight associated to irregular migration, $\xi_I \geq 0$, are generally not equal.

The government chooses the price p^L and duration τ of the legal visa, as well as the vector of enforcement measures to fight irregular immigration $E = (E_c, E_d, E_q)$ to maximize its objective:

$$\max_{p^L,\tau,E} W^G\left(p^L, \tau, E\right) = S^c\left(l^L, l^I, E\right) + p^L\frac{l^L}{\tau} - C(E) - \left(\xi_I l^I + \xi_L l^L\right) \tag{12}$$

under the constraint that $l^L + l^I = T$. Note that the objective welfare function (12) could easily be embedded in a probabilistic function of voting, where the government seeks reelection – which occurs if the value of $W^G\left(p^L, \tau, E\right)$ is larger than a random shock. In both interpretations, deterministic or probabilistic, the government aims to maximize the objective welfare function (12).

5.2. Maintaining the status quo

Ignoring for a moment the government strategy that determines the attributes of legal visas, we optimize in the baseline scenario (i.e. $E = (0, 0, 0)$) the function (12) with respect to the volume of regular and irregular immigration under the constraint that labor needs are met. This allows us to establish that sometimes the government will choose to maintain the *status quo*. The government solves: $\max_{l^I,l^L} W^G\left(l^L, l^I, 0\right) = S^g(l^L + l^I) - w_f(dl^I + l^L) + p^L\frac{l^L}{\tau} - \xi_I l^I - \xi_L l^L$. The first order conditions are:

$$\begin{cases} \dfrac{\partial W^G\left(l^L, l^I\right)}{\partial l^I} = S^{g\prime}(l^L + l^I) - dw_f - \xi_I \leq 0 \\ \dfrac{\partial W^G\left(l^L, l^I\right)}{\partial l^L} = S^{g\prime}(l^L + l^I) - w_f + \dfrac{p^L}{\tau} - \xi_L \leq 0 \end{cases}$$

The solution to this system of equations is a corner solution. Indeed setting both first order conditions to 0 yields: $\xi_I + dw_f = w_f - \frac{p^L}{\tau} + \xi_L$. Thus, unless $\xi_I + dw_f = w_f - \frac{p^L}{\tau} + \xi_L$, in which case the government is indifferent between legal and irregular immigration, it will prefer one to the other. To be more specific, the government will prefer legal to irregular migration if and only if[39]

$$-w_f(1 - d) + \frac{p^L}{\tau} + \xi_I - \xi_L > 0. \tag{13}$$

This condition is not easily met when $\xi_I \leq \xi_L$. This is typically the case for a government supported by or facing a strong opposition by an anti-immigration party (e.g. Eric Zemmour and Marine Le Pen in France advocating a zero immigration policy and accumulating more than 30% of the votes in the French 2022 presidential election). Indeed condition (13) is equivalent to $d \geq 1 - \frac{p^L}{\tau w_f} + \frac{\xi_L - \xi_I}{w_f}$.

Note that the ratio $\frac{p^L}{\tau w_f}$ is strictly smaller than 1 since the visa cost, p^L, cannot be higher than the expected return from migration, τw_f. To incite individuals to migrate under the legal temporary visa scheme rather than irregularly, the price of a short term visa should be kept at relatively low levels, as demonstrated in Section 4.1. A distinct possibility is that this price is a subsidy (i.e., $p^L < 0$) in which case $1 - \frac{p^L}{\tau w_f} > 1$ and the condition (13) never holds when $\xi_I \leq \xi_L$. The larger the difference between ξ_L and ξ_I, the less likely the condition (13) holds since d is smaller than 1. In other words, there is a whole range of parameters for which the optimum is achieved for $l^I = T$ and $l^L = 0$. In such cases, the government will favor the *status quo* with an inflow of undocumented workers to fill in vacant positions, which corresponds to the equilibrium studied in Section 3.

[39] This result holds when the externalities $\xi_I(l^I)$ and $\xi_L(l^L)$ are linear in the volume of immigration or concave. On the other hand, if the externalities were increasing convex functions, we would, in some cases, obtain interior solutions involving the coexistence of regular and irregular migration such that $\xi_I'(l^I) + dw_f = w_f - \frac{p^L}{\tau} + \xi_L'(l^L)$. Since, officially, rich countries governments seek to fight irregular migration, and in other cases, to minimize total migration, we consider a structure of externalities associated to migration that can capture these objectives.

Now when ξ_I is large enough, condition (13) holds. As explained in the introduction, voters are much more concerned by irregular immigration than by regular immigration. One of the reasons are the large negative externalities for the society entailed by criminal activities associated to the smuggling market. Accordingly, it seems reasonable to assume that $\xi_I \gg \xi_L$, unless the government has been elected on an anti-immigration program. When the political cost of a transparent system of short term visas is not too high compared to the total cost entailed by irregular migration, the government should favor the former over the later. The government offers a legal alternative to meet the labor market needs, fight irregular migration and minimize the negative externalities generated by smugglers.

We study this polar case – of policies leading to zero smuggling – in the next sections. Taking into account how the smugglers respond to the implementation of a visa scheme (τ, p^L), we study the visa price that drives them out of business thereafter called "eviction" price. We then discuss how the chosen visa scheme affects the skill composition of migrants. Finally, we study the cost-effective combination of internal and external control enforcement investments E, which allow a government to reach its target for foreign guest-workers.

5.3. Eliminating smugglers through a sale of visas

Starting from any *status quo* level of policy enforcement (d, c, q), we design schemes to eliminate the incentive to smuggle by selling visas at a low enough price. We establish the following result.

Proposition 2. *The eviction price $\underline{p}^L$ of temporary visas of duration τ below which smugglers exit the market is implicitly defined by*

$$\begin{aligned}&\omega^+(1-q)u\left[(d-\tau)w_f-(1-\tau)w_h-c+\underline{p}^L\right]\\&\quad+\omega^-(q)u\left[\underline{p}^L-c-\tau\left(w_f-w_h\right)\right]=0\end{aligned}\tag{14}$$

The eviction price increases with τ, c, q and decreases with d.

Proof. See Appendix F. ■

Appendix F shows that to throttle the smugglers' businesses, it is necessary that their reaction price be pushed below their marginal cost, i.e. $p^I(p^L) \leq c$, which leaves them zero profit. This determines the eviction price of visas as the implicit solution to: $\theta^{LI} = 0$ for $p^I = c$. Note that this result applies to any initial structure of the market for smugglers: monopolist, oligopolist or competitive. Irrespective of the initial market conditions, to eradicate smugglers by selling visas of duration τ, a government has to apply a price below the price $\underline{p}^L(\tau)$, solution to (14). In this case, the smugglers end up reaching marginal cost pricing and their mark-up vanishes.[40]

Intuitively, the eviction price is increasing in the duration of visa τ: as temporary visas become more valuable, it is easier to throttle the smugglers by introducing legal options to migrate. It is also increasing in the marginal operating costs for smugglers c and in the risk associated with irregular migration q, which both make smugglers' services less attractive. Similarly, if pay-offs to work in the illegal sector decrease relative to the legal sector, pushing down d, the eviction price can be set higher.

Furthermore, there is a minimum duration of temporary visas, $\underline{\tau}$, above which the eviction price is positive. The complementarity of policy instruments to fine-tune the eviction price, highlighted above, allows us to establish the following corollary.

Corollary. *The minimum duration of temporary visa, $\underline{\tau}$, required to set a positive eviction price decreases with q and c, and increases with d.*

Proof. See Appendix F. ■

If the duration of the temporary visa τ is lower than $\underline{\tau}$, then $\underline{p}^L$ is negative (it is a subsidy). Workers will need to be paid to migrate legally under this scheme as the illegal option, enabling a longer stay in the high wage country, becomes more attractive. Occasionally migrants have been subsidized to travel and take up jobs in advanced economies, such as in Europe during the post-WWII reconstruction period (see Wickramasekara, 2015, for a review). Moroccan workers still come to Corsica every year to harvest clementines.[41] The subsidy generally takes the form of a placement office in the country of origin, free transportation to the host country, lodging and training for the migrants. However, with higher risks of failing irregular migration, the eviction price can be set higher as temporary permits become more attractive to migrants. It can also be set higher when smugglers have high marginal costs to operate (increasing their fees) and the economic prospects of working illegally are lower. In countries that have large temporary work permits programs, such as the Gulf countries, Jordan or East-Asian countries, the price is generally strictly positive and the programs are accompanied by strict enforcement policies.

[40] The same reasoning also holds irrespective of the way the competition between the smugglers is modeled in quantity, as modeled in the present paper, or in price.

[41] Mohamed Jaouad El Kanabi, 2020. "Les saisonniers marocains pour sauver la clémentine corse arrivent dans l' île". *HE Press*. October 20. https://fr.hespress.com/169914-les-saisonniers-marocains-pour-sauver-la-clementine-corse-arrivent-dans-lile.html

5.4. Skill diversity of foreign workers

An important aspect of the visa policy aimed at eradicating smugglers is its impact on the skill composition of the migrant population. Voters may, for example, oppose the legalization scheme if it brings workers with a less diverse pool of skills. The next proposition characterizes the visa duration $\tilde{\tau}$ and the associated eviction price $\underline{p}^L(\tilde{\tau})$ such that the pool of migrants' skills remains the same after the sale of visas, compared to the *status quo* with irregular migration.

Proposition 3. *The visa scheme sold at eviction price $\underline{p}^L(\tau)$ increases the skill diversity of migrants if the visa duration τ does not exceed $\tilde{\tau}(q,c,d) \in [0,1]$ solution to*

$$\frac{\underline{p}^L(\tau)}{\tau} = w_f - \Delta_h(\theta^I) w_h \tag{15}$$

where θ^I is defined by Eq. (2) and $\underline{p}^L(\tau)$ by Eq. (14). The threshold $\tilde{\tau}(q,c,d)$ decreases with q and c and increases with d.

Proof. See Appendix G. ■

When introducing a new scheme to meet labor market needs, the government faces a trade-off between the duration of the temporary visas, τ, and the average skill level of migrants recruited: a longer duration implies a pool of temporary migrants with lower skills on average.[42] This result, which as far as we know, is new to the literature, is important for policy purposes. It implies that when a country seeks to recruit migrants to fill positions in low pay jobs (e.g., in agriculture, construction, social care), the longer the work permit, the less qualified the candidates for these jobs will be. For instance a student might wish to travel to a rich country for a few months to pick fruits and vegetables as a way to finance their studies or to accumulate capital to start a business at home. But they might not want to commit to a stay of several years as their human capital would be wasted on such low pay occupation. A relatively short term visa scheme, with low prices, makes it possible to recruit a wider range of workers, enlarging the skill pool of foreign workers.

This establishes that temporary foreign workers on short term visas may come with a larger pool of skills, compared to a pool of undocumented migrants under the *status quo*. However, since they only stay for a limited period, τ, the number of foreign workers living abroad at a given time (i.e. the stock) may decrease following this scheme, provided that the workers do not overstay.[43]

5.5. Cost-effective policies to regulate labor migration

As internal and external controls are costly to enforce, we now turn to studying the optimal combination of internal and external controls for a cost-effective regulation of labor migration. We depart from the *status quo* situation where marginal costs to smuggle is c, the risk of failing irregular migration is q and the wage discount factor for undocumented workers is d, and we determine the government's allocation of additional resources to enforce external and internal controls, $E = (E_c, E_q, E_d)$. We assume that:

(i) $c'(E_c) > 0$ and $c''(E_c) < 0$.
(ii) $q'(E_q) > 0$ and $q''(E_q) < 0$.
(iii) $d'(E_d) < 0$ and $d''(E_d) > 0$.

These assumptions imply that (i) the smugglers' marginal cost and (ii) the probability that a migrant fails the crossing are increasing and concave in repression. They also imply that (iii) the wage discount factor resulting from the enforcement measures is decreasing[44] and convex. The concave shapes of the functions $c(E_c)$ and $q(E_q)$ indicate decreasing returns to scale of external controls, while the convex shape of the function $d(E_d)$ indicates decreasing returns to scale of internal controls. These assumptions are intuitive in the sense that repression works as expected with decreasing return.

Note that we do not embed in the policy instruments the visa duration τ. The work permit duration is more realistically determined by the type of occupation targeted (i.e. seasonal in agriculture, hospitality, or longer term for personal care jobs) or by other priorities such as the targeted skill diversity of workers – in line with Proposition 3 – or the legal framework in destination country.[45]

Replacing c by $c(E_c)$, d by $d(E_d)$ and q by $q(E_q)$ in (14), we can determine the eviction price of temporary visas of duration τ, $\underline{p}^L$, which throttles smuggler businesses given their inflated marginal costs, the reduced payoff to undocumented employment and the increased risk of border crossings. Computing the demand for visa under this new eviction price, $D^L\left(p^L, \tau, p^I | E\right) = F\left(\theta^L(\underline{p}^L)\right)$, the government chooses the optimal investments E_c, E_d, and E_q that minimize their overall costs, net of resources they bring for

[42] A shorter visa duration attracts a smaller pool of migrants, the price remaining constant. However, in an eviction framework, it entails a lower eviction price, which increases the demand for legal visas as $\frac{\partial \theta^L}{\partial p} < 0$. This price effect overrides the effect driven by the change in the visa duration.

[43] The total effect of the policy on the stock of foreign workers depends on how $F(\theta^I)$ under the *status quo* compares to $\tau F(\theta^L)$ under the new scheme. Computing the variation in the number of migrants following the introduction of the visa scheme, $\Delta N = \frac{\tau F(\theta^L) - F(\theta^I)}{F(\theta^I)}$, ΔN is negative if and only if: $\frac{F(\theta^L)}{F(\theta^I)} < \frac{1}{\tau}$.

[44] See Woodland and Yoshida (2006) for a theoretical foundation of this assumption and Cobb-Clark et al. (1995) for empirical evidence.

[45] If we consider visa duration to be flexible, it is easy to determine its optimal level simultaneously with the other instruments by adding one first order condition in Proposition 4: $\tau f(\theta^L)\frac{\partial \theta^L}{\partial \tau} + F(\theta^L) = 0$

the tax payers, while reaching the target of recruiting T equivalent permanent foreign workers (i.e. T/τ temporary workers), as follows:

$$\min E_c + E_d + E_q - \underline{p}^L D^L\left(p^L, \tau, p^I|E\right) \quad \text{s.t.} \quad \tau D^L\left(p^L, \tau, p^I|E\right) = T \tag{16}$$

Focusing on interior solutions, the optimal allocation of resources is summarized in the next proposition.[46]

Proposition 4. *Let $\underline{p}^L(c,d,q)$ be defined in (14) with $c = c(E_c)$, $q = q(E_q)$ and $d = d(E_d)$. To dismantle smugglers through a cost-effective sale of temporary visas of duration τ and meet the labor market needs for T permanent equivalent workers, a government should invest the amounts $\left\{E_c^*, E_d^*, E_q^*\right\}$ in internal and external controls such that*

$$\underline{p}^L(c,d,q) = \tau\left(w_f - \Delta_h(\theta^L)w_h\right) \qquad \text{where } \theta^L = F^{-1}\left(\frac{T}{\tau}\right) \tag{17}$$

$$c'(E_c)\frac{\partial \underline{p}^L}{\partial E_c} = d'(E_d)\frac{\partial \underline{p}^L}{\partial E_d} = q'(E_q)\frac{\partial \underline{p}^L}{\partial E_q} \tag{18}$$

The optimal allocation of resources into internal and external controls is such that at the cost-effective eviction price, the migration demand reaches the target, as shown by (17): at this price, the individual rationality constraint is satisfied for foreign workers of skill levels lower than θ^L, who meet the labor market needs by migrating legally.[47]

More interestingly, independently of the target $T > 0$, the optimal allocation of resources into internal and external controls is such that the marginal rate of transformation between two repressive instruments (i.e., the ratio of their marginal costs) is equalized to the marginal rate of technical substitution between these instruments along the isoquant of the eviction price.[48] This is consistent with an efficient use of scarce and costly resources. Any other allocation is a waste of resources: if these equations do not hold, it is possible, by reallocating public resources, to either achieve the same level of eviction price with a lower total cost of enforcement or to increase the eviction price while spending the same amount on enforcement. Note that this result still holds if a government chooses to combine regular immigration, to meet the labor market needs of T guest workers, and irregular immigration (e.g., because the externalities associated with immigration, whether legal or irregular, are convexly increasing or because enforcing the "eviction" policy is too costly). The only difference is that, instead of equalizing the marginal rate of technical substitution between instruments along the isoquant of the eviction price, it considers the isoquant of the visa price that leads to the targeted level of T guest workers in the economy.

In light of the result in (18), it is highly unlikely that enforcement measures are optimized in practice. A tool clearly underused by policy makers are work-site controls and enforcement of penalties against employers of undocumented migrants (i.e., E_d is minimal). It is striking that, despite the evolution of bio-metric documentation and e-government, efforts to verify the legal status of workers in European or American companies are so sparse. In France, for example, the number of random checks in companies is extremely low and they represent less than 10 percent of checks in the fight against irregular work (most checks are triggered by a denunciation). In 2017, when the accommodation and catering sectors, traditionally two large employers of undocumented workers, were targeted, only 6,330 employees out of the 700,000 in the sector were checked (i.e., 0.9 percent of the workforce).[49] Similarly, in the United States, there is very little enforcement against illegal employment in the workplace (Hanson, 2007). Few American employers who hire irregular immigrants are ever detected or prosecuted. Yet considerable investments have been increasingly allocated to reinforcing U.S. border controls and deportation measures of irregular migrants (i.e., E_c and E_q are large). For instance, since 1993, the annual budget of the U.S. Border Patrol has increased more than ten-fold, from $363 million to nearly $4.9 billion in 2021.[50] Consistently with Proposition 4 and given the discrepancies between external (E_q) and internal (E_d) controls and the availability of new technologies that reduce the marginal cost of control, generalizing systematic workplace checks of the legal status of the workers and punishing severely firms that would employ undocumented workers, may be a more effective way of stemming irregular migration than reinforcing border controls and multiplying deportations. Workplace checks, which diminish the pull factor of irregular migration by lowering its expected return (i.e., $d(E_d)$ is decreasing in E_d), act as a preventive measure. Increasing deportations is a curative measure that has no direct impact on the willingness of firms to employ undocumented workers and is very costly to enforce.

[46] Depending on the functions $c(.)$, $d(.)$, and $q(.)$, it may be the case that the optimal solution involves increasing c only (i.e. $E_d = 0$ and $E_q = 0$), increasing q only (i.e. $E_c = 0$ and $E_d = 0$), decreasing d only (i.e. $E_c = 0$ and $E_q = 0$) or any combination of the three instruments. However, in other cases there will be an interior solution defined in Proposition 4.

[47] The additional investment in enforcement required to achieve an eviction price that leads to exactly $\frac{T}{\tau}$ volume of immigration could be very costly for the government, depending on the exact shape of the enforcement cost functions. If it is too expensive to fine-tune the eviction price at $\underline{p}^L$, the price implicitly determined by (17), the government might instead choose to offer $\frac{T}{\tau}$ short-term visas at a higher price p^L ($p^L > \underline{p}^L$). In this case, the legal recruitment of guest-workers through temporary work permits leaves room for undocumented foreign workers being smuggled, characterizing a situation of coexistence of undocumented and documented foreign workers in the economy.

[48] Eq. (18) is equivalent to $\frac{c'(E_c)}{d'(E_d)} = \left(\frac{\partial \underline{p}^L}{\partial E_d} / \frac{\partial \underline{p}^L}{\partial E_c}\right)$, and $\frac{c'(E_c)}{q'(E_q)} = \left(\frac{\partial \underline{p}^L}{\partial E_q} / \frac{\partial \underline{p}^L}{\partial E_c}\right)$, and $\frac{d'(E_d)}{q'(E_q)} = \left(\frac{\partial \underline{p}^L}{\partial E_q} / \frac{\partial \underline{p}^L}{\partial E_d}\right)$.

[49] France Stratégie, *Évaluation du travail dissimulé et de ses impacts pour les finances publiques (à fin juin 2019)*. July 19, 2019. https://www.strategie.gouv.fr/sites/strategie.gouv.fr/files/atoms/files/hcfips-note2019_evaluation_du_travail_dissimule_20190716.pdf

[50] American Immigration Council, *The Cost of Immigration Enforcement and Border Security*. January 2021. https://www.americanimmigrationcouncil.org/sites/default/files/research/the_cost_of_immigration_enforcement_and_border_security.pdf

Table 1
Benchmark parameter values.

Parameter	Value		Year	Source
Wages (monthly)				
DRC	36 PPP	32,806 FC	2020	20th percentile of computed distribution
Senegal	88 PPP	21,666 Fcfa	2007	20th percentile of computed distribution
South Africa	155 PPP	1,074 R	2020	20th percentile of computed distribution
Spain	857 PPP	694 €	2007	International Labour Organization (2008)
d	0.8			Monràs et al. (2020), Rivera-Batiz (1999); Kossoudji and Cobb-Clark (2002)
Marginal costs				
Senegal to Spain	1,150 PPP	266,666 Fcfa	2007	Mbow and Tamba (2007)
DRC to South Africa	830 PPP	408 USD	2020	inferred from Tshimpaka and Inaka (2020)
Smuggling prices				
Senegal to Spain	1,690 PPP	391,981 Fcfa	2007	Mbaye (2014)
DRC to South Africa	1,220 PPP	600 USD	2020	Tshimpaka and Inaka (2020)

Conversion rates between PPP and LCU, for private consumption, were retrieved from World Bank (2020).

Our results highlight the very strong complementarities between (external and internal) controls and workable temporary visa schemes against smuggling. As the legal migration demand decreases with the visa price (see Eq. (4)) it follows that, at the eviction price $\underline{p}^L$, the legal migration demand, $D^L\left(\underline{p}^L, \tau, p^I|E\right) = F\left(\theta^L(\underline{p}^L)\right)$, decreases with enforcement measures.[51] In other words, fighting irregular migration by increasing the risk of failure, q, through reinforced border controls, increasing the marginal operating costs for smugglers, c, through repression against smugglers or decreasing the discounted value of working illegally, d, through enforcement of fines against employment of undocumented workers, are all policy instruments that can be used to adjust the eviction price. These measures, efficiently combined to minimize the enforcement costs (see Proposition 4), enable a government to control migration flows and reach its target number of foreign workers recruited through the scheme. In stark contrast to the situation in the *status quo*, the regulation of migration flows is done without relying on the abusive power of smugglers, who are driven out of business.

6. Policy implications

Our numerical applications focus on two routes: a south–north route from Senegal to Spain and a south–south route from the Democratic Republic of the Congo (DRC) to South Africa. The results are not fully fledged policy simulations, since we abstract from other changes that may occur in the rest of the economy.[52] However they do illustrate the complementarities between selling temporary visas and other policy instruments in the fight against irregular migration and the constraints of the policy mix.

Estimates of the fees paid by irregular migrants, the marginal costs for smugglers to operate, the risk of failure of irregular migrants and the discounted wage to work as an undocumented worker are retrieved from different surveys and testimonies (see in Table 1). The minimum wage in Spain is from ILO statistics, while we use GDP and Gini coefficients of the World Development Indicators to calibrate low-skill wages in the DRC, Senegal and South Africa (see detail in Appendix H.1).

6.1. Visa prices

To predict migrants' decisions under high risk of failure, we use the CPT functional forms by Tversky and Kahneman (1992) presented in Appendix A, which are consistent with agents' behavior while considering risky gambles (for a literature review see Rabin, 1998; Barberis and Thaler, 2003).[53] For comparison, Appendix H.2 replicates this exercise under EUT and discusses the implications of individuals' risk behavior modeling for our results.

Using Eq. (14), the eviction price $\underline{p}^L(\tau)$ takes the following closed-form expression:

$$\underline{p}^L(\tau) = c + \tau(w_f - w_h) + \left(1 + \left(\lambda \frac{\omega^-(q)}{\omega^+(1-q)}\right)^{\frac{1}{\alpha}}\right)^{-1} (w_h - d w_f) \tag{19}$$

Eviction prices on the two routes are represented in Fig. 1 by different colors as functions of the visa duration in years (on vertical axis),[54] and risk of failure, q (on horizontal axis). The dashed lines represent isoquants of level 0, i.e. combinations of risk of failure

[51] Since the demand for visas is a normal good and since $c'(E_c) > 0$, $d'(E_d) < 0$ and $q'(E_q) > 0$ we can check that $\frac{\mathrm{d}D^L(p^I, p^L|E)}{\mathrm{d}E_k} < 0$, for $k = c, d, q$.

[52] In particular, labor markets may adjust following larger inflows of documented workers, which may dampen the initial incentives to migrate and, in turn, lead to smaller changes in migration flows than the ones we calibrate. However, (Clemens et al., 2018) show very limited effects of the withdrawal of the BRACERO program on the US labor market.

[53] Tversky and Kahneman (1992) generalize the seminal paper by Kahneman and Tversky (1972), which was one of the first to show that individuals have a poor ability to assess probabilities. In particular, this theory provides realistic predictions for individual behavior when confronted with risky choices, both inside (Glöckner and Betsch, 2008) and outside (Barberis et al., 2016) the lab.

[54] Using the model's notations, visa duration in years is equal to $40 \times \tau$.

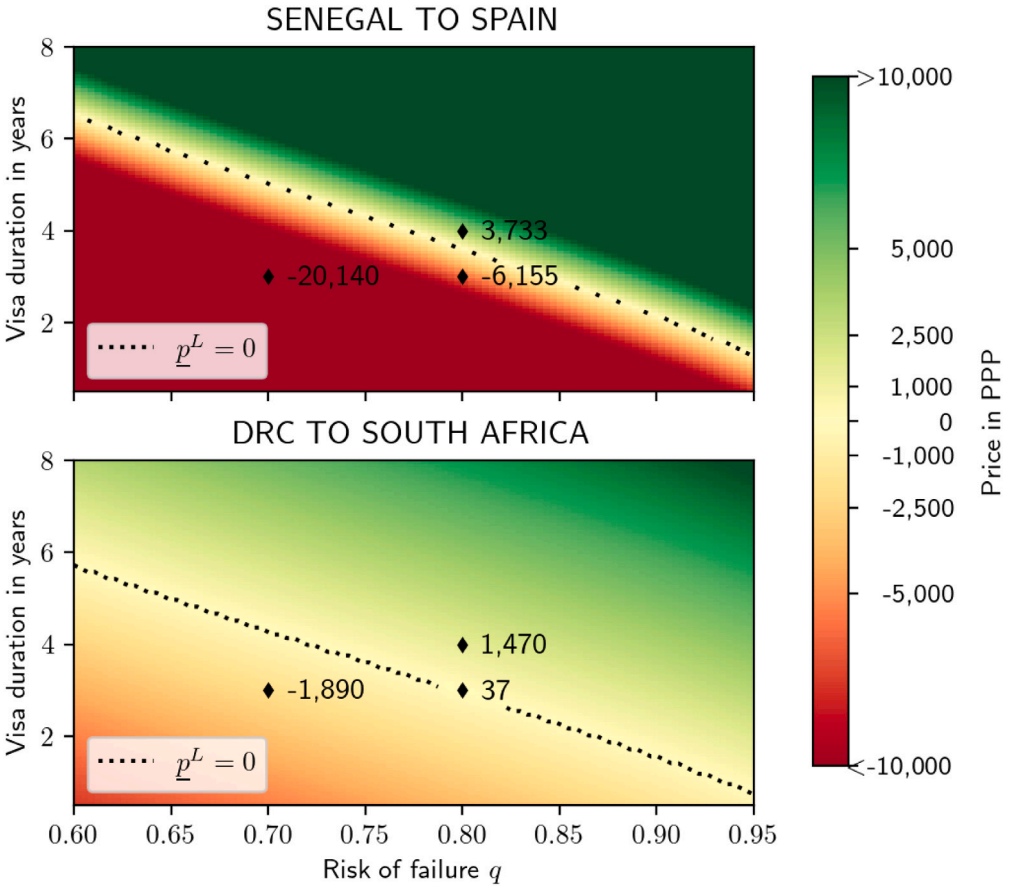

Fig. 1. Eviction prices on a south–north route and a south–south route. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

q and visa duration such that eviction prices are zero. Points in green, North-East of the 0-isoquant, are positive eviction prices. The darker the color, the higher the price. In the opposite direction, points in red represent negative eviction prices (i.e., subsidies).

As highlighted by the color contrast between the two figures, eviction prices on the Senegal–Spain route are much more dispersed than on the DRC–South Africa route. The area in dark red color for the Senegal to Spain route indicates that, for a large range of parameter values (q, τ), large subsidies above 10,000 PPP should be given to migrants in order to erode smugglers' profits on this route, an unrealistic scenario. This is because wages in low-paid jobs (in PPP) in Spain are still approximately 10 times the wages in Senegal. This ratio is twice as large on this route compared to the DRC to South Africa route. Due to this difference, individual prospects are more sensitive to the risk of failing irregular migration and to the visa duration on the south–north route. This observation holds under EUT (see Appendix H.2).

As demonstrated theoretically, eviction prices are increasing in the visa duration τ and the risk of illegal migration failing. Starting from a realistic risk of failure around 80%[55] and a short term visa of 4 years, the eviction price is around 3,733 PPP on the Senegal–Spain route, as compared to 1,470 PPP on the route from the DRC to South Africa. Reducing the visa duration decreases eviction prices substantially: for the same risk, a 3-year visa should be subsidized at −6,155 PPP on the Senegal–Spain route (priced at +37 PPP on the DRC–South Africa route). Similarly, a decrease in the risk of failure decreases sharply the eviction price. With a risk around 70%, a 3-year visa from Senegal to Spain should be subsidized as much as −20,140 PPP (−1,890 PPP for a 3-year visa from the DRC to South Africa).

Since little information is available on irregular migration and since risks of crossing illegally vary a lot over time (see discussion in Appendix H.1), the exacerbated sensitivity makes price-setting strategies particularly challenging on south–north routes. This challenge is reinforced by the fact that there are noticeably more negative eviction prices on the route between Senegal and Spain than on the route between the DRC and South Africa. Since wage differential is larger on this route, so are the incentives to migrate more permanently – although irregularly – when the risk of failing migration is relatively low and visa duration short.

[55] See discussion in refappendix: simulations-benchmark-values and Bah et al. (2022).

6.2. Self-enforceability

A strong constraint on the success of temporary work permit schemes is the compliance of workers with their rules. Since the left hand side of the self-enforceability constraint (7) decreases with θ, low-skilled workers have more incentives to overstay their visa duration than higher skilled workers. This implies that if (7) is satisfied for $\theta = 0$, then it is also satisfied for any worker of skill level $\theta > 0$. As the left hand side of (7) also decreases in s, we define the threshold share of income retention $\bar{s}$ above which workers of all skill levels will not have economic incentives to overstay, as the solution of the following equation:

$$\omega^{+}(1-\delta)u\left[(1-\tau)(dw_f - w_h) - s\tau w_f\right] + \omega^{-}(\delta)u\left[-s\tau w_f\right] = 0 \tag{20}$$

For deportation rates ranging between 25% and 90%, we compute the minimum share of income retention required to incentivize workers' compliance. Results for each route are presented in Fig. 2. Dark colored areas represent combinations of visa duration, τ, and level of deportation, d, which require a high level of income retention to be enforceable. Lighter colored areas show that the minimum share of income retention is a decreasing function of the deportation rate and of the visa duration. This illustrates the complementarity of policy instruments (see Proposition 1).

White areas are sets of visa duration and deportation rate such that visas are not enforceable ($s > 100\%$). The top panels show that such schemes may simply not work when the parameter d takes the benchmark value 0.8, especially where the wages differential is too large (top left figure) and deportations are not enforced. This observation holds under EUT and the enforceability constraint is even tighter in this framework (see Appendix H.3).

In most OECD destination countries deportation rates – although difficult to estimate – are relatively low. The European Commission estimates the fraction of "returnees" among the undocumented migrants ordered to leave Europe in 2019 to be around 29% on average.[56] This suggests that enforcing the policy to reach the required deportation rate will be difficult to implement in most EU countries and very costly.[57]

Even when theoretically feasible (colored areas), incentivizing short-term visa compliance would require retaining more than 50% of the income earned abroad (as highlighted in blue–green shaded areas) for a large range of deportation values. This may constrain migrants to over-accumulate savings abroad. Although the empirical evidence points to very uneven shares of annual income remitted to families of origin across routes, it rarely reaches 50% of the annual earnings.[58] Accordingly, retention shares that are too high are likely to reduce the welfare of migrants and their families, in particular if these funds are otherwise used to consume while abroad or/and insure each other against negative income shocks. On the other hand, forced and deferred remittances may have positive long term effects on development of origin areas. For example, the government of Malawi imposed deferred payments of two-thirds of wages earned abroad to nationals posted to work in South African mines through guest-worker contracts. This increased significantly human capital accumulation in areas affected by the scheme (Dinkelman and Mariotti, 2016). More generally, locking some earnings on a foreign bank account can be beneficial to migrants if the main motive for remittances is future consumption and investment after return. This may give them more control over savings accumulated abroad, and a way to overcome liquidity constraints for lump-sum investments with high returns in their origin countries. As a development policy, positive effects could even be enhanced by generous interest rates for targeted investments, once savings are transferred back to workers upon timely return.

Another way forward suggested by the results is to increase drastically the costs of employing undocumented migrants. This would lead to an equilibrium on the labor market with lower relative earnings for undocumented workers (lower d). As shown in the center and bottom heat maps in Fig. 2, for which d is set to 0.6 and 0.4 respectively, the self-enforceability constraint is largely relaxed: the minimum shares of income retention decline significantly at any given set of policy parameters (deportation-visa duration) such that the colored areas indicating feasible policies are extended. Interestingly, the relative earnings of working as undocumented worker, reflected by d, are likely to decrease in the post-legalization equilibrium: as more foreign workers enter the labor market using TFWPs, labor market shortages decrease, which decreases the relative value of employing undocumented workers. This creates a virtuous circle in favor of the legalization policy.

6.3. Who will bear the costs of visas?

The liquidity constraints of migrants may be regarded, at first glance, as an important limiting factor to the schemes we propose. Indeed one difficulty is that smugglers may provide poor migrants with the means of financing their services through bonded labor contracts (Friebel and Guriev, 2006) and hence may remain competitive for liquidity constrained workers even following the introduction of the visa schemes described above. However, we argue that microfinance schemes for migrants could also offer better financial terms to poor migrants than those offered by smugglers and be competitive. F or example, through retaining a share of earnings abroad, the scheme could also be adapted to finance the visa price to would-be migrants. Moreover, employers of foreign

[56] This statistic is an overestimate of the deportation rate for the overall population of undocumented migrants, since many of them are not caught and ordered to leave, and it varies a lot across countries. See: European Commission, *Statistics on migration to Europe*. 2021. Available online at https://ec.europa.eu/info/strategy/priorities-2019-2024/promoting-our-european-way-life/statistics-migration-europe_en#illegalbordercrossings.

[57] Estimates of overall costs of deporting one person are around USD12,500 in the US in 2011, £ 11,000 in the UK (BBC 2009) and NOK 50,000 (USD 9000) in Norway in 2013 (Djajić and Vinogradova, 2015).

[58] For example, workers from Senegal (respectively Morocco) remit from Spain 49.9% (resp.30.8%) of their earnings (Groenewold and Bilsborrow, 2004), while workers from Senegal (resp. Morocco) remit from France 11.2% (resp. 10.4%) of their earnings (Miotti et al., 2009). See also Yang (2011).

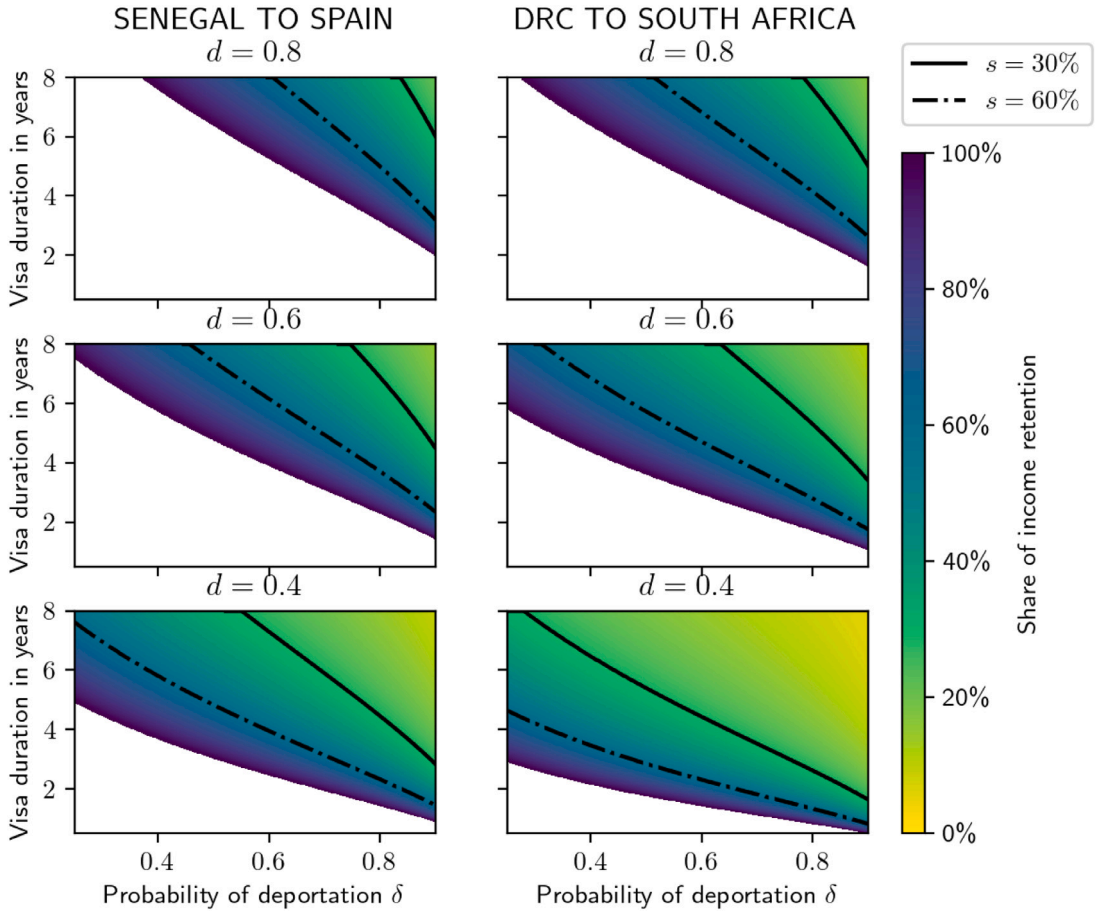

Fig. 2. Self-enforceability constraints on a south–north route and a south–south route. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

workers in destination countries could also bear some or all the costs of the temporary visas. This is in place in some countries with large guest-worker programs such as Cyprus, where employers are responsible for the guest-workers they employ, and pay for transport, visa, and fees of recruitment agencies.[59] This has important historical resonance: during the post World-War I and II economic boom, European countries such as France were organizing campaigns of recruitment of foreign workers from Northern-African countries to work in industrial sector by using the service of local recruitment agencies.[60] Even though such systematic hiring in the hand of employers and their agencies may also be the door to workers' abuses through bonded labor, we argue that migrants may more easily claim for legal protection against unscrupulous legal employers and agencies than against traffickers. Moreover, states with prevailing rule of the law can minimize such issues through enforcing their legal systems or set up mechanisms to grant workers residence and work permits untied to their employers (Casella and Cox, 2018). This opens the door to obvious political economy issues, which we leave for future research.

7. Conclusion

This paper tackles two important concerns for the public, which are often considered as policy trade-offs. The first is how to control migration flows of low-skilled migrants: by this we mean how to control the number of migrants crossing borders to reach a higher wage destination country, as well as their legal status. The second is how to hinder the activities of human smugglers.

[59] Costs paid by employers may also reinforce the political feasibility of the schemes to the extent that this attenuates the perception of unfair competition exerted by cheap foreign labor force on the local labor market.

[60] After the bloodshed of WWI the French government passed laws and administrative regulations on the entry and stay of foreigners signing bilateral agreements with their countries of origin and left to the employers in France the responsibility to deal with the practical aspects of recruitment. "Société Générale d'Immigration" (SGI), incorporated as a limited company, was founded in 1924 by employers' unions to manage labor shortages in the agricultural, sugar and mining sectors.

Building upon the legal frameworks of TFWPs in place in many countries to recruit low-skilled workers, we design visa schemes under which TFWPs are sold at an eviction price – to drive smugglers out of business. We show how the price can be adjusted to reach migration targets if the visas are combined with appropriate enforcement of external and internal controls. Strong measures to fight against smugglers and employers of undocumented workers are hence complementary to the schemes we introduce. The way forward we suggest to discourage overstay involves targeting the illegal employment of undocumented workers, and not necessarily the whole informal labor market.

Politically appealing for governments in destination countries, these visa schemes are designed to meet labor market needs, to dry-up the smuggling markets, and to decrease the number of foreign workers staying irregularly in high wage countries, where they are negatively perceived by citizens, or used as a target by populists to build political support. Compared to more permanent visas, an advantage of selling TFWPs is that they are more affordable to poor workers from low income countries. Yet, their limited duration and their positive price limit their attractiveness, which regulates the flows of guest-workers. However a system of visas against smuggling will need to address the two main weaknesses of past TFWPs: overstay violations and abuses of migrants' rights.

Regarding the first problem, our analysis shows that the larger the wage differential between the origin and the destination country, the harder it is to incentivize guest workers to return home when their visa expires. For this reason, regulating south–south migration flows with the help of TFWP may be feasible, as illustrated by our numerical applications to the DRC–South Africa route. In contrast, self-enforceable TFWPs for migrants on south–north routes with large wage differentials would require large investments in policy enforcement and high retention shares on wages earned abroad. Our simulations for Senegalese workers migrating to Spain illustrate that the level of incentives needed to prevent overstay violations may be too constraining. Where there are large economic disparities combined with lax enforcement of deportation and strong protection of migrants' rights, guest workers are likely to feed the undocumented labor market in host countries.

These results illustrate the practical challenge of discouraging over-stayers. They also help to explain why large TFWP programs flourish in the Gulf and Asian countries. First, the wage gap between origin and destination countries is smaller than in Europe or the US, which cushions the incentives to overstay. Second, enforcement of visa schemes through repressive measures is more effective in those parts of the world where states have strong authoritarian traditions and offer flimsy legal protection to foreign workers, who can be easily deported and sanctioned if caught working without a permit. This often leads to abuses of migrants' rights and the second criticism commonly addressed to TFWPs.

In response to these legitimate concerns we argue that socially just TFWPs built around migrant agency (Consterdine and Samuk, 2018) have the potential to promote rights-based policies, offering migrants safe passage and access to legal labor markets in high wage countries, with better legal protection than if they are left at the mercy of smugglers and illegal employers. To ensure timely return of the temporary guest workers, governments in advanced economies should combine measures increasing sanctions against employers of irregular migrants with strengthening economic incentives embedded in the visa schemes, such as deferred payment of a share of the income earned abroad until migrants return to their origin countries, awarding points towards more settled status in the future and preserving future visa eligibility for compliers, as practiced in Canada.[61] Further, other important factors influence temporary workers' return to their home country: migrants may have preferences to consume in their home country, higher purchasing power, and better investment opportunities, which help insure the circularity of labor migration (Djajić, 2013; Djajić and Vinogradova, 2015; Mesnard, 2004). Embedding these additional factors in our framework of analysis would improve economic prospects in the origin country and relax the self-enforceability constraint.

Even though TFWPs have been implemented with varying levels of success in the past, they have not yet been designed to erode smugglers' profits, nor to promote migrants' rights. Given that migrant workers under this scheme would be employed legally as opposed to illegally under current policies, their living conditions and rights can be more easily protected. Carefully designed active labor recruitment policies from low income countries to high income countries have multiple economic and social benefits for migrants themselves, and for destination, transit and origin countries. This should be considered in the design of future migration policies.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Some detail on cumulative prospect theory

Tversky and Kahneman (1992) build a model featuring loss aversion, as well as both diminishing sensitivity for gains and losses, and diminishing sensitivity regarding probabilities. Agents' appreciation for gains and losses is represented by a value function $u(x)$, which is S-shaped with an inflection point in zero. This reflects individuals being empirically risk-averse for gains and risk-seeking for losses; which (Kahneman and Tversky, 1972) denote as the *reflection effect*.

More specifically, the authors calibrate the following functional form for the value function:

$$u(x) = \begin{cases} x^{\alpha} \text{ , if } x > 0 \\ -\lambda(-x)^{\beta} \text{ , if } x \leq 0 \end{cases} \tag{A.1}$$

[61] Our framework provides an intuition for the effect of eligibility points awarded upon timely return. In our simple static model, this is captured by increasing the visa duration τ, which relaxes the enforceability constraint.

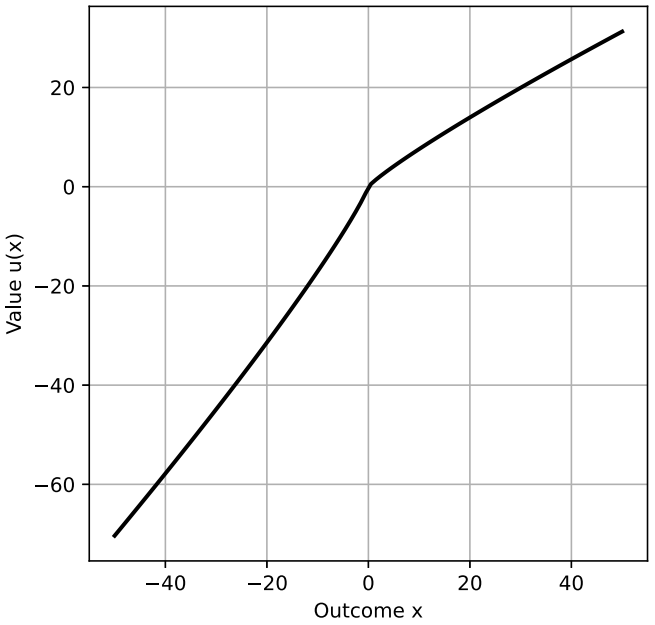

Fig. A.1. Value function as calibrated by Tversky and Kahneman (1992).

where $\alpha, \beta \in (0,1)$ reflect the curvature and indicate the degree of risk preference; i.e. the degree of risk-aversion for gains and the degree of risk-seeking in the domain of losses. $\lambda \geq 1$ is the *coefficient of loss aversion*, which reflects that the decrease in utility from a loss is greater than the increase in utility from a gain of the same amount. In line with Tversky and Kahneman (1992) estimates, we assume in Section 6 that $\alpha = \beta$.

Probability weighting under CPT is cumulative. Consider the lottery $\mathcal{L} = [x_{-m}, \dots, x_0, ..., x_n; p_{-m}, \dots, p_0, \dots, p_n]$, where $x_0 = 0$, $x_i < x_j$ for $i < j$, and $\sum_{i=-m}^{n} p_i = 1$. The value attributed to the lottery $\mathcal{L}$, when it is compared to the certain outcome x_c, is given by

$$\sum_{i=-m}^{n} \pi_i u(x_i - x_c)$$

where

$$\pi_i = \begin{cases} \omega^+(p_n) & \text{, for } i = n \\ \omega^-(p_{-m}) & \text{, for } i = -m \\ \omega^+(p_i + \dots + p_n) - \omega^+(p_{i+1} + \dots + p_n) & \text{, for } 0 \leq i \leq n-1 \\ \omega^-(p_{-m} + \dots + p_i) - \omega^-(p_{-m} + \dots + p_{i-1}) & \text{, for } 1-m \leq i < 0 \end{cases}$$

These weighting functions w^+, for gains, w^-, for losses are concave near 0 and convex near 1 to capture diminishing sensitivity for probabilities. For example Tversky and Kahneman (1992) specify the weighting functions as follows:

$$\omega(q) = \frac{q^\gamma}{(q^\gamma + (1-q)^\gamma)^{\frac{1}{\gamma}}} \tag{A.2}$$

where the parameter $\gamma \in (0,1]$ may slightly differ for the two weighting functions. The form of these weighting functions is represented on Fig. A.2. For $\gamma = 1$, $w^x : q \mapsto \frac{q^\gamma}{(q^\gamma+(1-q)^\gamma)^{\frac{1}{\gamma}}}$ is the identity. The closer γ is to 0, the more distorted the probability weights. When $\gamma \to 0$, the function w^x has an L-shape.

Our model offers only two possible outcomes (success/failure) for an individual choosing to migrate irregularly. Therefore, without any loss of generality, we directly apply the probability weights $\omega^+(1-q)$ and $\omega^-(q)$ to these two outcomes.

In line with Tversky and Kahneman (1992) the weighting function $w^+(1-q)$ (respectively $w^-(q)$) applied to probabilities associated with positive (respectively negative) outcomes is:

$$w^t(q) = \frac{q^{\gamma^t}}{\left(q^{\gamma^t} + (1-q)^{\gamma^t}\right)^{\frac{1}{\gamma^t}}} \qquad \text{with } t = +, -. \tag{A.3}$$

and the value function is:

$$u(x) = \begin{cases} x^\alpha \text{ , if } x > 0 \\ -\lambda(-x)^\alpha \text{ , if } x \leq 0 \end{cases} \quad \text{with } \alpha \in (0,1) \text{ and } \lambda \geq 1. \tag{A.4}$$

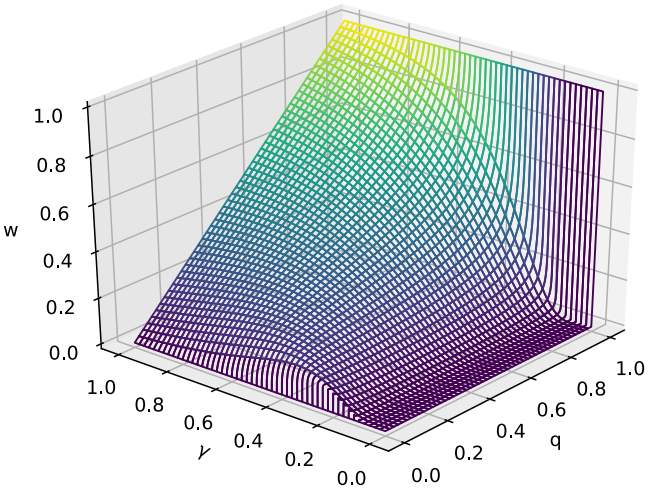

Fig. A.2. Probability weighting functions for $\gamma \in (0, 1]$.

As benchmark values, we choose the parameters calibrated by Tversky and Kahneman (1992): $\lambda = 2.25$, $\alpha = 0.88$, $\gamma^+ = 0.61$ and $\gamma^- = 0.69$. Using these functional forms and Eq. (14), the eviction price $\underline{p}^L(\tau)$ takes the closed-form expression (19).

Appendix B. Characterizing the marginal type of migrant indifferent between migrating irregularly and not migrating

Under CPT

The marginal type θ^I is the solution of the following equation:

$$V_1(\theta) := \omega^+(1-q)u\left(dw_f - p^I - \Delta_h(\theta)w_h\right) + \omega^-(q)u\left(-p^I\right) = 0$$

The function V_1 is clearly decreasing. Besides, for any irregular migration to occur, the condition $V_1(0) > 0$ must be satisfied and $\lim_{\theta\to\infty} V_1(\theta) = -\infty$; which guarantees the existence and uniqueness of the threshold θ^I. Since V_1 increases with d and w_f and decreases in p^I and w_h, so does θ^I. Besides, the marginal value with respect to q is given by $V_{1q}(\theta) = -\omega'^+(1-q)u\left(dw_f - p^I - \Delta_h(\theta)w_h\right) + \omega'^-(q)u\left(-p^I\right) < 0$: θ^I decreases with q.

Under EUT

An individual deciding between irregular migration or staying in origin country compares the expected utility from the lottery $\mathcal{L}_{irregular}$, $(1-q)u\left(dw_f - p^I\right) + qu\left(\Delta_h(\theta)w_h - p^I\right)$, to the utility derived from staying in origin country, $u\left(\Delta_h(\theta)w_h\right)$, where the utility function u is increasing and concave.

Therefore, the type θ^I of the individual indifferent between these two options is solution of the following equation.

$$(1-q)u\left(dw_f - p^I\right) + qu\left(\Delta_h(\theta)w_h - p^I\right) = u\left(\Delta_h(\theta)w_h\right) \tag{B.5}$$

Let us define $V_0(\theta) := (1-q)u\left(dw_f - p^I\right) + qu\left(\Delta_h(\theta)w_h - p^I\right) - u\left(\Delta_h(\theta)w_h\right)$. Since $V_0'(\theta) = w_h\Delta_h'(\theta)\left(qu'\left(\Delta_h(\theta)w_h - p^I\right) - u'\left(\Delta_h(\theta)w_h\right)\right)$, for $q < \frac{u'\left(\Delta_h(\theta)w_h\right)}{u'\left(\Delta_h(\theta)w_h - p^I\right)} \equiv \tilde{q}$, V is decreasing. This condition is satisfied if the probability of failure is not too high relatively to the price of irregular migration. The necessary condition for some migration to occur is $\theta^I > 0$, which implies $V_0(0) > 0$. As we have $\lim_{\theta\to\infty} V(\theta) = -\infty$, Eq. (B.5) admits a unique solution.

Taking the total differential of Eq. (B.5) yields

$$\alpha_\theta \mathrm{d}\theta + \alpha_q \mathrm{d}q + \alpha_d \mathrm{d}d + \alpha_{w_f}\mathrm{d}w_f + \alpha_{p^I}\mathrm{d}p^I + \alpha_{w_h}\mathrm{d}w_h = 0$$

where, for $q < \tilde{q}$,

$$\begin{aligned}
\alpha_\theta &= \Delta_h'(\theta)w_h\left[qu'\left(\Delta_h(\theta)w_h - p^I\right) - u'\left(\Delta_h(\theta)w_h\right)\right] &< 0\\
\alpha_q &= -u\left(dw_f - p^I\right) + u\left(\Delta_h(\theta)w_h - p^I\right) &< 0\\
\alpha_d &= (1-q)w_f u'\left(dw_f - p^I\right) &> 0\\
\alpha_{w_f} &= (1-q)du'\left(dw_f - p^I\right) &> 0\\
\alpha_{p^I} &= -(1-q)u'\left(dw_f - p^I\right) - qu'\left(\Delta_h(\theta)w_h - p^I\right) &< 0\\
\alpha_{w_h} &= \Delta_h(\theta)\left[qu'\left(\Delta_h(\theta)w_h - p^I\right) - u'\left(\Delta_h(\theta)w_h\right)\right] &< 0
\end{aligned}$$

This implies that the threshold θ^I increases in d and w_f and decreases in q, p^I and w_h.

Appendix C. Characterizing the marginal type of migrant indifferent between migrating regularly and not migrating

We model the positive returns to skills in the regular sector of the foreign country with the function $\Delta_f : \mathbb{R}_+ \to [1, +\infty)$, which is continuous, non-decreasing and non-convex, with $\Delta_f(0) = 1$. Earnings are higher in foreign country than in origin country, $\Delta_f(\theta)w_f > \Delta_h(\theta)w_h$. To capture that returns to skills in the destination country are lower than in the origin country with a lower level of economic development, in line with cross-country evidence on returns to education and skills (Psacharopoulos and Patrinos, 2018; Hanushek and Zhang, 2009)) we assume that $\Delta_f(\theta) < \Delta_h(\theta)$ for all $\theta > 0$ and postulate that the income differential between the home and host country decreases with worker's skill level:

$$\Delta'_f(\theta)w_f < \Delta'_h(\theta)w_h \tag{C.6}$$

This characterizes low-paid jobs in host economies, which are the focus of this paper.

The results presented in the main text, with zero returns to skills in foreign country, are simply obtained by setting $\Delta_f(\theta) = 1, \forall\theta \in \mathbb{R}_+$.

Regular migration and staying in origin country are not subject to risk. An individual choosing between these options compares their payoffs and migrates regularly if and only if

$$\tau\Delta_f(\theta)w_f + (1-\tau)\Delta_h(\theta)w_h - p^L > \Delta_h(\theta)w_h \Leftrightarrow \Delta_f(\theta)w_f - \Delta_h(\theta)w_h > \frac{p^L}{\tau}$$

The monotony assumption (C.6) guarantees the uniqueness of the threshold θ_L, which, if it exists, is implicitly determined by the following equation:

$$\Delta_f(\theta)w_f - \Delta_h(\theta)w_h = \frac{p^L}{\tau} \tag{C.7}$$

It also implies that legal migration selects individuals negatively – i.e. by individuals of type $\theta < \theta^L$ – if θ^L exists.

Regular migration occurs if and only if the threshold θ^L is higher than 0, that is $\Delta_f(0)w_f - \Delta_h(0)w_h > w_f\Delta_f(\theta^L)w_f - \Delta_h(\theta^L)w_h$; or, equivalently,

$$w_f - w_h > \frac{p^L}{\tau} \tag{C.8}$$

This condition insures that, for the visa scheme (τ, p^L), θ^L exists.

We show that the threshold θ^L increases with w_f and τ and decreases with w_h and p^L by differentiating equation (C.7):

$$\left(\Delta'_f(\theta)w_f - \Delta'_h(\theta)w_h\right)\mathrm{d}\theta + \Delta_f(\theta)\mathrm{d}w_f - \Delta_h(\theta)\mathrm{d}w_h - \frac{1}{\tau}\mathrm{d}p^L + \frac{p^L}{\tau^2}\mathrm{d}\tau = 0.$$

Appendix D. Characterizing the marginal type of migrant indifferent between migrating regularly and irregularly

In this appendix the returns to skills in the foreign country are given by $\Delta_f(\theta)$ defined in Appendix C. Note that in the case presented in the main text, with zero returns to skills in the foreign country, we replace $\Delta_f(\theta) = 1, \forall\theta \in \mathbb{R}_+$.

When visas can be bought legally, the individual of type θ compares the lottery $\mathcal{L}_{irregular}$ with the payoff she retrieves from migrating regularly, $\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h$.

Under CPT

In the CPT framework, the marginal type of migrant θ^{LI} indifferent between migrating regularly and irregularly is characterized by the following equation.

$$\begin{aligned}&\omega^+(1-q)u\left[dw_f - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right]\\ &+ \omega^-(q)u\left[\Delta_h(\theta)w_h - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right] = 0\end{aligned} \tag{5}$$

Let us define $W_1(\theta) = \omega^+(1-q)u\left[dw_f - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right] + \omega^-(q)u\left[\Delta_h(\theta)w_h - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right]$.

The value of irregular migration with respect to legal migration, $W_1(\theta)$, is decreasing as long as

$$\begin{aligned}&\left(\tau\Delta'_f(\theta)w_f + (1-\tau)\Delta'_h(\theta)w_h\right)\\ &\omega^+(1-q)u'\left[dw_f - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right]\\ &> \tau\left(\Delta'_h(\theta)w_h - \Delta'_f(\theta)w_f\right)\\ &\omega^-(q)u'\left[\Delta_h(\theta)w_h - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right]\end{aligned}$$

This inequality is verified under the following sufficient condition

$$\tau < \frac{\omega^+(1-q)u'\left[(d-\tau)w_f - (1-\tau)w_h + p^L - p^I\right]}{\omega^+(1-q)u'\left[dw_f - \Delta_h(\theta^L)w_h - p^I\right] + \omega^-(q)u'\left[p^L - p^I - \tau\left(w_f - w_h\right)\right]} < 1 \tag{D.9}$$

This involves that, if irregular migration does not always select individuals negatively, at least there exists a threshold value for τ under which it does.

Assume the function W_1 is decreasing.

A necessary condition for some irregular migration to occur is that $W_1(0) > 0$. Besides, since $\theta^L > \theta^I$, $W_1(\theta^L) = \omega^+(1-q)u\left[dw_f - p^I - \Delta_h(\theta^L)w_h\right] + \omega^-(q)u\left[-p^I\right] < 0$. This implies that, when an illegal market exists, Eq. (5) determines implicitly the threshold type, θ^{LI}, such that any individual above this threshold prefers to migrate legally rather than irregularly.

Taking the total differential of Eq. (5) yields

$$\alpha_\theta d\theta + \alpha_q dq + \alpha_d dd + \alpha_{w_f} dw_f + \alpha_{p^I} dp^I + \alpha_{w_h} dw_h + \alpha_\tau d\tau + \alpha_{p^L} dp^L = 0$$

where we already saw that $\alpha_\theta = W_1'(\theta) < 0$ and it is quite straightforward that,

$$\begin{aligned}
\alpha_q =& -\omega'^+(1-q)u\left[dw_f - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right] \\
&+ \omega'^-(q)u\left[\Delta_h(\theta)w_h - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right] < 0 \\
\alpha_d =& w_f\omega^+(1-q)u'\left[dw_f - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right] > 0 \\
\alpha_{p^I} =& -\omega^+(1-q)u'\left[dw_f - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right] \\
&- \omega^-(q)u'\left[\Delta_h(\theta)w_h - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right] < 0 \\
\alpha_\tau =& \left(\Delta_h(\theta)w_h - \Delta_f(\theta)w_f\right) \\
&\times\{\omega^+(1-q)u'\left[dw_f - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right] \\
&+ \omega^-(q)u'\left[\Delta_h(\theta)w_h - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right]\} < 0 \\
\alpha_{p^L} =& -\alpha_{p^I} > 0
\end{aligned}$$

This yields $\partial\theta^{LI}/\partial q < 0$, $\partial\theta^{LI}/\partial d > 0$, $\partial\theta^{LI}/\partial p^I < 0$, $\partial\theta^{LI}/\partial\tau < 0$ and $\partial\theta^{LI}/\partial p^L > 0$.

We show below that θ^{LI} decreases as the wage differential between the home and the foreign countries increases, as long as the probability of failure q is high enough. Consider the following quantities:

$$\begin{aligned}
\alpha_{w_f} =& \left(d - \tau\Delta_f(\theta)\right)\omega^+(1-q)u'\left[dw_f - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right] \\
&- \tau\Delta_f(\theta)\omega^-(q)u'\left[\Delta_h(\theta) - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right] \\
\alpha_{w_h} =& -(1-\tau)\Delta_h(\theta)\omega^+(1-q)u'\left[dw_f - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right] \\
&+ \tau\Delta_h(\theta)\omega^-(q)u'\left[\Delta_h(\theta)w_h - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right]
\end{aligned}$$

The quantity α_{w_f} decreases and α_{w_h} increases in the probability of failure q. Consider the threshold $\underline{q}$, defined implicitly as the solution of the following equation

$$\begin{aligned}
\frac{\omega^+(q)}{\omega^-(1-q)} =& \min\left(\frac{\tau}{1-\tau}; \frac{\tau\Delta_f(\theta)}{d - \tau\Delta_f(\theta)}\right) \\
&\times \frac{u'\left[\Delta_h(\theta)w_h - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right]}{u'\left[dw_f - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right]}
\end{aligned}$$

As long as $q > \underline{q}$, α_{w_f} is negative and α_{w_h} positive. This implies that when the probability of failure is above the threshold $\underline{q}$, θ^{LI} decreases as the wage differential increases .

Under EUT

In the EUT framework, the marginal type of migrant θ^{LI} indifferent between migrating through legal channels and irregularly is characterized by the following equation.

$$(1-q)u\left(dw_f - p^I\right) + qu\left(\Delta_h(\theta)w_h - p^I\right) = u\left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right) \tag{D.10}$$

Let us define $W_0(\theta) = (1-q)u\left(dw_f - p^I\right) + qu\left(\Delta_h(\theta)w_h - p^I\right) - u\left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)$.

Since u is S-shaped, for $\tau < \frac{\Delta_h'(\theta)w_h}{\Delta_f'(\theta)w_f - \Delta_h'(\theta)w_h}\frac{qu'\left(\Delta_h(\theta)w_h - p^I\right) - u'\left(dw_f - p^I\right)}{u'\left(dw_f - p^I\right)} \equiv \hat{\tau}$, we have

$$\begin{aligned}
W_0'(\theta) =& \Delta_h'(\theta)w_h qu'\left(\Delta_h(\theta)w_h - p^I\right) \\
&- \left[\tau\Delta_f'(\theta)w_f + (1-\tau)\Delta_h'(\theta)w_h\right]u'\left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right) \\
&< 0
\end{aligned}$$

For some irregular migration to occur, we necessarily have $W_0(0) > 0$. Besides, since $\Delta_f(\theta)w_f > \Delta_h(\theta)w_h$ and $\lim_{\theta\to\infty}\Delta_f(\theta) = \lim_{\theta\to\infty}\Delta_h(\theta) = +\infty$, $\lim_{\theta\to\infty}W_1(\theta) = -\infty$

Therefore, when the probability of deportation is low enough – leaving room for irregular migration – Eq. (D.10) determines implicitly the threshold type, θ^{LI}, such that any individual above this threshold prefers to migrate regularly than undocumented.

Taking the total differential of Eq. (D.10) yields

$$\alpha_\theta \mathrm{d}\theta + \alpha_q \mathrm{d}q + \alpha_d \mathrm{d}d + \alpha_{w_f} \mathrm{d}w_f + \alpha_{p^I} \mathrm{d}p^I + \alpha_{w_h} \mathrm{d}w_h + \alpha_\tau \mathrm{d}\tau + \alpha_{p^L} \mathrm{d}p^L = 0$$

where, in the neighborhood of θ^{LI}, for $\tau < \hat{\tau}$,

$$\begin{aligned}
\alpha_\theta =& \Delta_h'(\theta) w_h q u'\left(\Delta_h(\theta) w_h - p^I\right) \\
& - \left[\tau \Delta_f'(\theta) w_f + (1-\tau)\Delta_h'(\theta) w_h\right] u'\left(\tau \Delta_f(\theta) w_f - p^L + (1-\tau)\Delta_h(\theta) w_h\right) && < 0 \\
\alpha_q =& -u\left(d w_f - p^I\right) + u\left(\Delta_h(\theta) w_h - p^I\right) && < 0 \\
\alpha_d =& \; w_f (1-q) u'\left(d w_f - p^I\right) && > 0 \\
\alpha_{p^I} =& -(1-q) u'\left(d w_f - p^I\right) - q u'\left(\Delta_h(\theta) w_h - p^I\right) && < 0 \\
\alpha_\tau =& -\left(\tau \Delta_f(\theta) w_f + (1-\tau)\Delta_h(\theta) w_h\right) u'\left(\tau \Delta_f(\theta) w_f - p^L + (1-\tau)\Delta_h(\theta) w_h\right) && < 0 \\
\alpha_{p^L} =& \; u'\left(\tau \Delta_f(\theta) w_f - p^L + (1-\tau)\Delta_h(\theta) w_h\right) && > 0
\end{aligned}$$

This shows that $\partial\theta^{LI}/\partial q < 0$, $\partial\theta^{LI}/\partial d > 0$, $\partial\theta^{LI}/\partial p^I < 0$, $\partial\theta^{LI}/\partial\tau < 0$ and $\partial\theta^{LI}/\partial p^L > 0$.

We show below that θ^{LI} decreases as the wage differential between the home and the foreign countries increases, as long as the probability of failure q is high enough. Consider the following quantities:

$$\begin{aligned}
\alpha_{w_f} &= d(1-q) u'\left(d w_f - p^I\right) - \tau \Delta_f(\theta) u'\left(\tau \Delta_f(\theta) w_f - p^L + (1-\tau)\Delta_h(\theta) w_h\right) \\
\alpha_{w_h} &= \Delta_h(\theta)\left[q u'\left(\Delta_h(\theta) w_h - p^I\right) - (1-\tau) u'\left(\tau \Delta_f(\theta) w_f - p^L + (1-\tau)\Delta_h(\theta) w_h\right)\right]
\end{aligned}$$

The quantity α_{w_f} decreases with the probability of failure q and is, furthermore, negative as long as $q > \tau \frac{\Delta_f(\theta)}{d} \frac{u'\left(\tau \Delta_f(\theta) w_f - p^L + (1-\tau)\Delta_h(\theta) w_h\right)}{u'\left(d w_f - p^I\right)} \equiv \hat{q}$. Besides, α_{w_h} increases with the probability q and is positive as long as $q > (1-\tau) \frac{u'\left(\tau \Delta_f(\theta) w_f - p^L + (1-\tau)\Delta_h(\theta) w_h\right)}{u'\left(d w_f - p^I\right)} \equiv \tilde{q}$. This implies that there exists a threshold value of the probability of failure q, which is the minimum of $\hat{q}$ and $\tilde{q}$, above which θ^{LI} decreases as the wage differential increases.

Appendix E. Self-enforceability of return migration

In this appendix the returns to skills in the foreign country are given by $\Delta_f(\theta)$ defined in Appendix C. Note that in the case presented in the main text, with zero returns to skills in the foreign country, we replace $\Delta_f(\theta) = 1, \forall \theta \in \mathbb{R}_+$.

Migrants facing the decision to overstay to work undocumented compare the payoff they derive from the lottery $\mathcal{L}_{overstay} = [\tau(1-s)\Delta_f(\theta) w_f + (1-\tau) d w_f, \tau(1-s)\Delta_f(\theta) w_f + (1-\tau)\Delta_h(\theta) w_h; 1-\delta, \delta]$, with their payoff if they comply with the rules of the guest worker program, $\tau \Delta_f(\theta) w_f + (1-\tau)\Delta_h(\theta) w_h$.

We show, in both CPT and EUT frameworks, that for any migration contract of duration τ and positive share of wages retention, s, there exists a minimum probability of deportation such that temporary migration visas are self enforceable.

Under CPT

The level of deportation $\underline{\delta}$ such that the individual of type θ is indifferent between overstaying or complying with the visa rules is the solution of the following equation

$$\begin{aligned}
&\omega^+(1-\delta) u\left[\tau(1-s)\Delta_f(\theta) w_f + (1-\tau) d w_f - \left(\tau \Delta_f(\theta) w_f + (1-\tau)\Delta_h(\theta) w_h\right)\right] \\
&\quad + \omega^-(\delta) u\left[\tau(1-s)\Delta_f(\theta) w_f + (1-\tau)\Delta_h(\theta) w_h - \left(\tau \Delta_f(\theta) w_f + (1-\tau)\Delta_h(\theta) w_h\right)\right] = 0
\end{aligned} \tag{E.11}$$

which can be rewritten as follows

$$\omega^+(1-\delta) u\left[-\tau s \Delta_f(\theta) w_f + (1-\tau)\left(d w_f - \Delta_h(\theta) w_h\right)\right] + \omega^-(\delta) u\left[-\tau s \Delta_f(\theta) w_f\right] = 0$$

The function $\phi(\delta) := \omega^+(1-\delta) u\left[-\tau s \Delta_f(\theta) w_f + (1-\tau)\left(d w_f - \Delta_h(\theta) w_h\right)\right] + \omega^-(\delta) u\left[-\tau s \Delta_f(\theta) w_f\right]$ is decreasing in δ.[62]

Since $\phi(0) > 0$ and $\phi(1) < 0$, Eq. (E.11) admits a unique solution, which is the threshold deportation probability $\underline{\delta}$, above which the temporary visas are self-enforceable.

With a similar reasoning we can show that it is not always possible to enforce a temporary stay of workers by retaining a share of earnings abroad. Let us define the function $\psi(s) := \omega^+(1-\delta) u\left[-\tau s \Delta_f(\theta) w_f + (1-\tau)\left(d w_f - \Delta_h(\theta) w_h\right)\right] + \omega^-(\delta) u\left[-\tau s \Delta_f(\theta) w_f\right]$.

It is straightforward to show that this continuous function is decreasing in s and that $\psi(0) > 0$. Two cases arise:

- if the income in the home country is too low, relative to the income obtained as undocumented worker in the foreign country, and $\psi(1) > 0$, then for the level of deportation δ enforced, temporary visas are not self-enforceable;
- otherwise, if $\psi(1) < 0$, there exists a threshold share of earnings retained $\underline{s}$ under which temporary visas are not self-enforceable.

[62] As $\phi'(\delta) = -\omega'^+(1-\delta) u\left[-\tau s \Delta_f(\theta) w_f + (1-\tau)\left(d w_f - \Delta_h(\theta) w_h\right)\right] + \omega'^-(\delta) u\left[-\tau s \Delta_f(\theta) w_f\right] < 0$.

Under EUT

Let us define the function $\phi(\delta)$ as:

$$\begin{aligned}\phi(\delta) = &(1-\delta)u\left[\tau(1-s)\Delta_f(\theta)w_f + (1-\tau)dw_f\right]\\ &+ \delta u\left[\tau(1-s)\Delta_f(\theta)w_f + (1-\tau)\Delta_h(\theta)w_h\right]\\ &- u\left[\tau\Delta_f(\theta)w_f + (1-\tau)\Delta_h(\theta)w_h\right]\end{aligned}$$

The derivative of ϕ is simply given as

$$\begin{aligned}\phi'(\delta) = &u\left[\tau(1-s)\Delta_f(\theta)w_f + (1-\tau)\Delta_h(\theta)w_h\right]\\ &- u\left[\tau(1-s)\Delta_f(\theta)w_f + (1-\tau)dw_f\right]\end{aligned}$$

Since $dw_f > \Delta_h(\theta)w_h$, it is quite straightforward that $\phi'(\delta) < 0$.
Besides, if $s > 0$, $\phi(1) < 0$.
Two cases arise:

- if $\phi(0) < 0$ then, by continuity, the enforceability constraint is always satisfied;
- if $\phi(0) > 0$, there exists a unique threshold deportation probability $0 < \underline{\delta} < 1$, above which the temporary visas are self-enforceable.

This threshold is the implicit solution of $\phi(\underline{\delta}) = 0$.

Appendix F. Characterizing the eviction price

The threshold price, denoted $\underline{p}^L$, below which smugglers are driven out of business is such that $\theta^{IL} = 0$ for $p^I = c$.

Under CPT

The eviction price is defined implicitly as follows

$$\begin{aligned}&\omega^+(1-q)u\left[dw_f - c - \left(\tau w_f - \underline{p}^L + (1-\tau)w_h\right)\right]\\ &+ \omega^-(q)u\left[w_h - c - \left(\tau w_f - \underline{p}^L + (1-\tau)w_h\right)\right] = 0,\end{aligned} \tag{14}$$

which simplifies to:

$$\begin{aligned}&\omega^+(1-q)u\left[(d-\tau)w_f - (1-\tau)w_h - c + \underline{p}^L\right]\\ &+ \omega^-(q)u\left[\underline{p}^L - c - \tau\left(w_f - w_h\right)\right] = 0\end{aligned} \tag{F.12}$$

Taking the total differential of the above equation yields

$$\alpha_{\underline{p}^L}\mathrm{d}\underline{p}^L + \alpha_q\mathrm{d}q + \alpha_d\mathrm{d}d + \alpha_{w_f}\mathrm{d}w_f + \alpha_{p^I}\mathrm{d}p^I + \alpha_{w_h}\mathrm{d}w_h + \alpha_\tau\mathrm{d}\tau = 0$$

We can sign straightforwardly:

$$\begin{aligned}\alpha_{\underline{p}^L} = &\omega^+(1-q)u'\left[(d-\tau)w_f - (1-\tau)w_h + \underline{p}^L - c\right]\\ &+ \omega^-(q)u'\left[\tau(w_h - w_f) + \underline{p}^L - c\right] &> 0\\ \alpha_d = &w_f\omega^+(1-q)u'\left[(d-\tau)w_f - (1-\tau)w_h + \underline{p}^L - c\right] &> 0\\ \alpha_c = &-\omega^+(1-q)u'\left[(d-\tau)w_f - (1-\tau)w_h + \underline{p}^L - c\right]\\ &- \omega^-(q)u'\left[\tau(w_h - w_f) + \underline{p}^L - c\right] &< 0\\ \alpha_\tau = &\left(w_h - w_f\right)\{\omega^+(1-q)u'\left[(d-\tau)w_f - (1-\tau)w_h + \underline{p}^L - c\right]\\ &+ \omega^-(q)u'\left[\tau(w_h - w_f) + \underline{p}^L - c\right]\} &< 0\end{aligned}$$

If legal migration occurs, the rationality constraint is satisfied such that: $\underline{p}^L < \tau(w_f - w_h)$. Besides, if irregular migration persists for a legal price higher than the eviction price, necessarily the payoffs in case of success of irregular migration must be positive for the lowest skilled worker such that: $(d-\tau)w_f - (1-\tau)w_h + \underline{p}^L - c > 0$. This implies that:

$$\begin{aligned}\alpha_q = &-\omega'^+(1-q)u\left[(d-\tau)w_f - (1-\tau)w_h + \underline{p}^L - c\right]\\ &+ \omega'^-(q)u\left[\tau w_h - \tau w_f + \underline{p}^L - c\right] &< 0\end{aligned}$$

This shows that the eviction price is increasing in the probability of failing irregular migration q, the duration of the migration visa τ, and the marginal cost for smugglers to operate c. It is decreasing in the discount factor d.

In particular,

$$\frac{\partial \underline{p}^L}{\partial \tau} = -\frac{\alpha_\tau}{\alpha_{\underline{p}^L}} = w_f - w_h \tag{F.13}$$

which we use later in Appendix G.

Note that $\tau > \frac{dw_f - w_h}{w_f - w_h} - \frac{c}{w_f - w_h}$ is a sufficient condition for the eviction price to be positive.

Indeed, by definition of $\underline{p}^L$,

$$\begin{aligned} &\omega^+(1-q)u\left[dw_f - c - \left(\tau w_f - \underline{p}^L + (1-\tau)w_h\right)\right] \\ &\quad + \omega^-(q)u\left[w_h - c - \left(\tau w_f - \underline{p}^L + (1-\tau)w_h\right)\right] = 0 \end{aligned} \tag{14}$$

Moreover we can show easily that: $\tau > \frac{dw_f - w_h}{w_f - w_h} - \frac{c}{w_f - w_h}$ assures that

$$\omega^+(1-q)u\left[dw_f - w_h - c - \tau(w_f - w_h)\right] + \omega^-(q)u\left[-c - \tau\left(w_f - w_h\right)\right] < 0$$

This yields

$$\begin{aligned} &\omega^+(1-q)u\left[dw_f - c - \left(\tau w_f - \underline{p}^L + (1-\tau)w_h\right)\right] \\ &\quad + \omega^-(q)u\left[w_h - c - \left(\tau w_f - \underline{p}^L + (1-\tau)\, w_h\right)\right] \\ &> \omega^+(1-q)u\left[dw_f - c - \left(\tau w_f + (1-\tau)w_h\right)\right] \\ &\quad + \omega^-(q)u\left[w_h - c - \left(\tau w_f + (1-\tau)w_h\right)\right] \end{aligned}$$

Yet, since $\omega^+(1-q)u\left[dw_f - c - \left(\tau w_f - \underline{p}^L + (1-\tau)w_h\right)\right] + \omega^-(q)u\left[w_h - c - \left(\tau w_f \ -\underline{p}^L + (1-\tau)w_h\right)\right]$ increases with $\underline{p}^L$, the above inequality is equivalent to $\underline{p}^L > 0$.

Hence, there exists a threshold $\underline{\tau} \leq \frac{dw_f - w_h}{w_f - w_h} - \frac{c}{w_f - w_h}$, such that for any $\tau > \underline{\tau}$, $\underline{p}^L > 0$.

This threshold is implicitly defined by Eq. (14) for $\underline{p}^L = 0$ as:

$$\omega^+(1-q)u\left[dw_f - w_h - c - \underline{\tau}(w_f - w_h)\right] + \omega^-(q)u\left[-c - \underline{\tau}\left(w_f - w_h\right)\right] = 0 \tag{F.14}$$

Yet the expression $\omega^+(1-q)u\left[dw_f - w_h - c - \underline{\tau}(w_f - w_h)\right] + \omega^-(q)u\left[-c - \underline{\tau}\left(w_f - w_h\right)\right]$ decreases with q, c, and $\underline{\tau}$ and increases with d. Therefore, differentiating Eq. (F.14) yields that the threshold $\underline{\tau}$ decreases with q and c and increases with d.

Under EUT

Using (D.10), the threshold price is defined implicitly as follows:

$$(1-q)u\left(dw_f - c\right) + qu\left(w_h - c\right) = u\left(\tau w_f - \underline{p}^L + (1-\tau)w_h\right)$$

which is equivalent to

$$\underline{p}^L = \tau w_f + (1-\tau)w_h - u^{-1}\left[(1-q)u\left(dw_f - c\right) + qu\left(w_h - c\right)\right] \tag{F.15}$$

Since u is increasing and $dw_f > w_h$, the eviction price is increasing in the probability of arrest q, the duration of the migration visa τ, and the marginal cost for smugglers to operate c. It is decreasing in the discount factor d.

Moreover, $\underline{p}^L > 0$ if and only if $\tau > \underline{\tau} \equiv \frac{u^{-1}\left[(1-q)u\left(dw_f - c\right) + qu\left(w_h - c\right)\right] - w_h}{w_f - w_h}$. Note that, since $dw_f - c > w_h - c$ and u^{-1} is increasing, the threshold $\underline{\tau}$ decreases in q. It is also straightforward to establish that it decreases in c and increases in d.

Appendix G. Proof of Proposition 3

In this appendix the returns to skills in the foreign country are given by $\Delta_f(\theta)$ defined in Appendix C. The case presented in the main text, with zero returns to skills in the foreign country, is simply obtained by replacing $\Delta_f(\theta) = 1$.

Let us show that the function $z(\tau) = \frac{\underline{p}^L(\tau)}{\Delta_f\left(\theta^I_{p^I}\right)w_f - \Delta_h\left(\theta^I_{p^I}\right)w_h}$ has a unique fixed point on the interval $(0,1)$, which decreases with q. Since $\Delta_f\left(\theta^I_{p^I}\right)w_f - \Delta_h\left(\theta^I_{p^I}\right)w_h$ does not depend on τ, this is equivalent to showing that $\underline{p}^L(\tau)$ has a unique fixed point (decreasing in q) on the interval $\left(0, \Delta_f\left(\theta^I_{p^I}\right)w_f - \Delta_h\left(\theta^I_{p^I}\right)w_h\right)$.

Under EUT

One can show directly $\underline{p}^L$ admits a unique fixed point decreasing in q, since u is increasing and $dw_f > w_h$.

$$\tilde{\tau}w_f + (1-\tilde{\tau})w_h - u^{-1}\left[(1-q)u\left(dw_f - c\right) + qu\left(w_h - c\right)\right] - \tau = 0$$
$$\Leftrightarrow \tilde{\tau} = \frac{u^{-1}\left[(1-q)u\left(dw_f - c\right) + qu\left(w_h - c\right)\right] - w_h}{w_f - w_h - 1}$$

This shows that $\tilde{\tau}$ is decreasing in q and in c and increasing in d.
Since $z(\tau) > 0$, $\tilde{\tau} > 0$; which also involves $\Delta_f\left(\theta^I_{p^I}\right)w_f - \Delta_h\left(\theta^I_{p^I}\right)w_h > w_f - w_h > 1$.
Besides,

$$\tilde{\tau}w_f + (1-\tilde{\tau})w_h - u^{-1}\left[(1-q)u\left(dw_f - c\right) + qu\left(w_h - c\right)\right]$$
$$= \left[u^{-1}\left[(1-q)u\left(dw_f - c\right) + qu\left(w_h - c\right)\right] - w_h\right]\frac{1}{w_f - w_h - 1}$$
$$< \frac{dw_f - w_h - c}{w_f - w_h - 1}$$

Yet, as long as $1 - c < (1-d)w_f$, $\frac{dw_f - w_h - c}{w_f - w_h - 1} < 1$.

Under CPT

Recall that $\underline{p}^L$ is implicitly defined by Eq. (14):

$$\omega^+(1-q)u\left[dw_f - c - \left(\tau w_f - \underline{p}^L + (1-\tau)w_h\right)\right]$$
$$+\ \omega^-(q)u\left[w_h - c - \left(\tau w_f - \underline{p}^L + (1-\tau)w_h\right)\right] = 0$$

We showed in Appendix F that $\underline{p}^L$ is increasing in τ ($\frac{\partial \underline{p}^L}{\partial \tau} = w_f - w_h > 0$) and positive for $\tau > \frac{dw_f - w_h}{w_f - w_h} - \frac{c}{w_f - w_h}$.
Besides, for $\tau = 1$, Eq. (14) becomes

$$\omega^+(1-q)u\left[dw_f - c - \left(w_f - \underline{p}^L\right)\right] + \omega^-(q)u\left[w_h - c - \left(w_f - \underline{p}^L\right)\right] = 0$$

and in this case $\underline{p}^L_{\tau=1} < w_f - w_h < \Delta_f\left(\theta^I_{p^I}\right)w_f - \Delta_h\left(\theta^I_{p^I}\right)w_h$.[63]
The function $\underline{p}^L(\tau)$ admits a unique fixed point $\tilde{\tau}$ on $\left(0, \Delta_f\left(\theta^I_{p^I}\right)w_f - \Delta_h\left(\theta^I_{p^I}\right)w_h\right)$.
Since $\underline{p}^L$ increases with q and c and decreases with d (see Appendix F), $\tilde{\tau}$ decreases with q and c and increases with d.

Appendix H. Detail on numerical applications

H.1. Benchmark values

Smuggling fees According to the survey that Mbaye (2014) did among migrants in Dakar before they undertook their dangerous trip to Europe or the United States, the price charged to reach Spain by sea was around 391,981 Fcfa on average in 2007, which corresponds to 1,690 PPP. Congolese (undocumented) migrants living in South Africa, surveyed by Tshimpaka and Inaka (2020), mention smuggling prices of 600 USD, i.e. approximately 1,220 PPP in 2020 DRC, for an overland journey.

Marginal costs to operate Human smuggling is a highly differentiated illegal activity, which makes its profitability challenging to assess (Sanchez, 2017). In particular, data on operating costs is scarce. As a benchmark for the marginal costs of smugglers' operations, c, we rely on the costs for a captain to reach Spain from Senegal with a typical dingy carrying 30 people, which were estimated in 2007 to be around 8,000,000 Fcfa, i.e. around 267,000 Fcfa per person (Mbow and Tamba, 2007), or 1,150 PPP in international dollars. This corresponds to a profit margin of 32%. Assuming smugglers on the Congo–South Africa route have a similar profit margin, the marginal cost on this route would be around 830 PPP.

Failure rate of illegal migration The failure rate of illegal migration is difficult to estimate and highly volatile: according to the Washington Post, while the success rate of the central Mediterranean route was around 95% between 2015 and 2017, it fell to 45% in 2018.[64] T his increase in the risk of failure is also documented by Bah et al. (2022) who report the high risks of failure, including death, expected by undocumented migrants from Gambia traveling to Europe. The risk of failure has increased further due to COVID-19 border closures and severe mobility restrictions in most countries. Accordingly, our numerical applications allow for a large range of parameters q.

[63] Indeed $\omega^+(1-q)u\left[dw_f - c - \left(w_f - \underline{p}^L\right)\right] + \omega^-(q)u\left[w_h - c - \left(w_f - \underline{p}^L\right)\right]$ is decreasing in $\underline{p}^L$ and $\omega^+(1-q)u\left[dw_f - w_h - c\right] + \omega^-(q)u\left[-c\right] < \omega^+(1-q)u\left(dw_f - c - e^{\Delta_h\theta^I_c}w_h\right) + \omega^-(q)u(-c) = 0$.

[64] Chico Harlan, 2018. "Fewer migrants are making it to Europe. Here's why". TheWashingtonPost, July23.

Relative earnings of informal labor Monràs et al. (2020) estimate the wage ratio between undocumented and legal workers in similar types of jobs in Spain, d, to be around 0.8, which we use in our simulations.[65] This is also in line with evidence from the US labor market (Rivera-Batiz, 1999; Kossoudji and Cobb-Clark, 2002).

Minimum wages Finally, in line with the large body of empirical research on returns to skills (see Lemieux, 2006, for a detailed literature review), we specify the income X_{ij} of an individual i working legally in country $j = h, f$ using a (Mincer, 1970) equation:

$$\ln X_{ij} = \ln w_j + \tilde{\Delta}_j \theta_i \tag{H.16}$$

where $\tilde{\Delta}_j \geq 0$ denotes the returns to skills θ in country j.

To calibrate the income distributions in origin and destination countries we assume that X_{ij} follows a log-normal distribution $\ln X_{ij} \sim \mathcal{N}\left(\mu_j, \sigma_j^2\right)$. We use GDP data and Gini coefficients from the World Development Indicators (WDI) database to estimate the parameters μ_j and σ_j^2.[66]

Many countries either do not enforce minimum wage regulations or they have a large informal sector. In Senegal for example, 9 workers out of 10 and 97% of companies belong to the informal sector (International Labour Organization, 2020). Since the minimum wage set by law is not likely to reflect the wage of low-skilled workers, we follow citegrogger2011income to calibrate the low-skill wage, which is set to the 20th percentile of the income distribution. We follow the same approach regarding the DRC, where the informal sector accounts for 80% of the economy and where the minimum wage, the *salaire minimum interprofessionnel garanti*, was drastically re-evaluated in 2018.[67]

H.2. Eviction prices under expected utility theory

Consider for simplicity an isoelastic utility function[68]

$$u(x) = \begin{cases} \dfrac{1}{1-a} x^{1-a} & \text{, if } a \neq 1 \\ \ln x & \text{, if } a = 1 \end{cases} \quad \text{with } a > 0. \tag{H.17}$$

Applying these functional forms to (F.15), the eviction price $\underline{p}^L(\tau)$ becomes:

$$\underline{p}^L = \begin{cases} \tau w_f + (1-\tau) w_h - \left((1-q)(d w_f - c)^{1-a} + q(w_h - c)^{1-a}\right)^{\frac{1}{1-a}} & \text{, if } a \neq 1 \\ \tau w_f + (1-\tau) w_h - \exp\left((1-q)\ln(d w_f - c) + q \ln(w_h - c)\right) & \text{, if } a = 1 \end{cases} \tag{H.18}$$

There is no clear consensus in the literature on the values for the coefficient of relative risk aversion a. Yet, its most commonly accepted values are between 0.5 and 1.5 (see for example Hansen and Singleton, 1983; Szpiro, 1986; Keane and Wolpin, 2001; Chetty, 2006; Kirdar, 2012). Regarding labor supply behavior, Chetty (2006) estimates the coefficient of relative risk aversion to be around 1. Meanwhile, Djajić (2014) argues that the saving behavior of migrants is more consistent with parameters between 0.9 and 1. Consistently, we derive the eviction prices for $a = 0.95$. Other benchmark values for the marginal costs to operate, failure rate of illegal migration, relative earning of informal labor and minimum wages described in Appendix H.1. The results are presented in Fig. A.3.

This figure is constructed in the same way as Fig. 1 presenting eviction prices as a function of visa duration (vertical axis) and risk of failure (horizontal axis) under prospect theory at the top and under expected utility theory at the bottom. The dashed lines represent isoquants of level 0, which are the combinations of risk of failure and visa duration such that eviction prices are zero.

The darker the color, the higher the eviction price (in green) or subsidy (in red). Using both CPT or EUT frameworks, we find that the eviction prices are more dispersed for the south–north route (graphs to the left) than they are for the south–south route (graphs to the right): the former involves higher stakes, which amplifies potential migrants' sensitivity to their earning prospects determined by risk and visa duration.

The eviction prices for the south–south route are quite similar under both frameworks as shown by the graphs in the right panel. But for the south–north route (to the left), eviction prices are higher under EUT than under CPT. This shows that, with higher stakes on the south–north route, EUT tends to predict individuals to value more highly the legal migration option: there are fewer cases for which the government would have to subsidize temporary foreign workers in order to throttle smugglers' businesses. This implies that on this route, visas at low price (such as for example at administrative fee level) are more likely to attract would-be migrants under EUT than under CPT.

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[65] Using wages data from the *Encuesta Nacional de Immigrantes*, they find a remarkably robust ratio, irrespective of the subgroups of workers considered.

[66] The standard deviation can be written as $\sigma_j = \sqrt{2}\Phi^{-1}\left(\frac{\Gamma_j+1}{2}\right)$ where Φ^{-1} is the reciprocal of the standard normal cumulative density function and Γ_j is the Gini coefficient of income inequality in country j. The expected value of income, $E(X_j)$, is given by $E(X_j) = \exp\left(\mu_j + \frac{\sigma_j^2}{2}\right)$.

[67] Article 91 of the DRC Labor Code, decree # 18/017 of 22 May 2018 stipulates that the *salaire minimum interprofessionnel garanti* should adjust to 7,075 FC daily from 1 July 2019 – instead of 1,680 FC prior 2018. On a basis of 25 workdays, this yields a 176,875 FC monthly wage.

[68] For similar assumptions on risk aversion see for example Vinogradova (2016), Djajić (2013, 2014), Kirdar (2012)

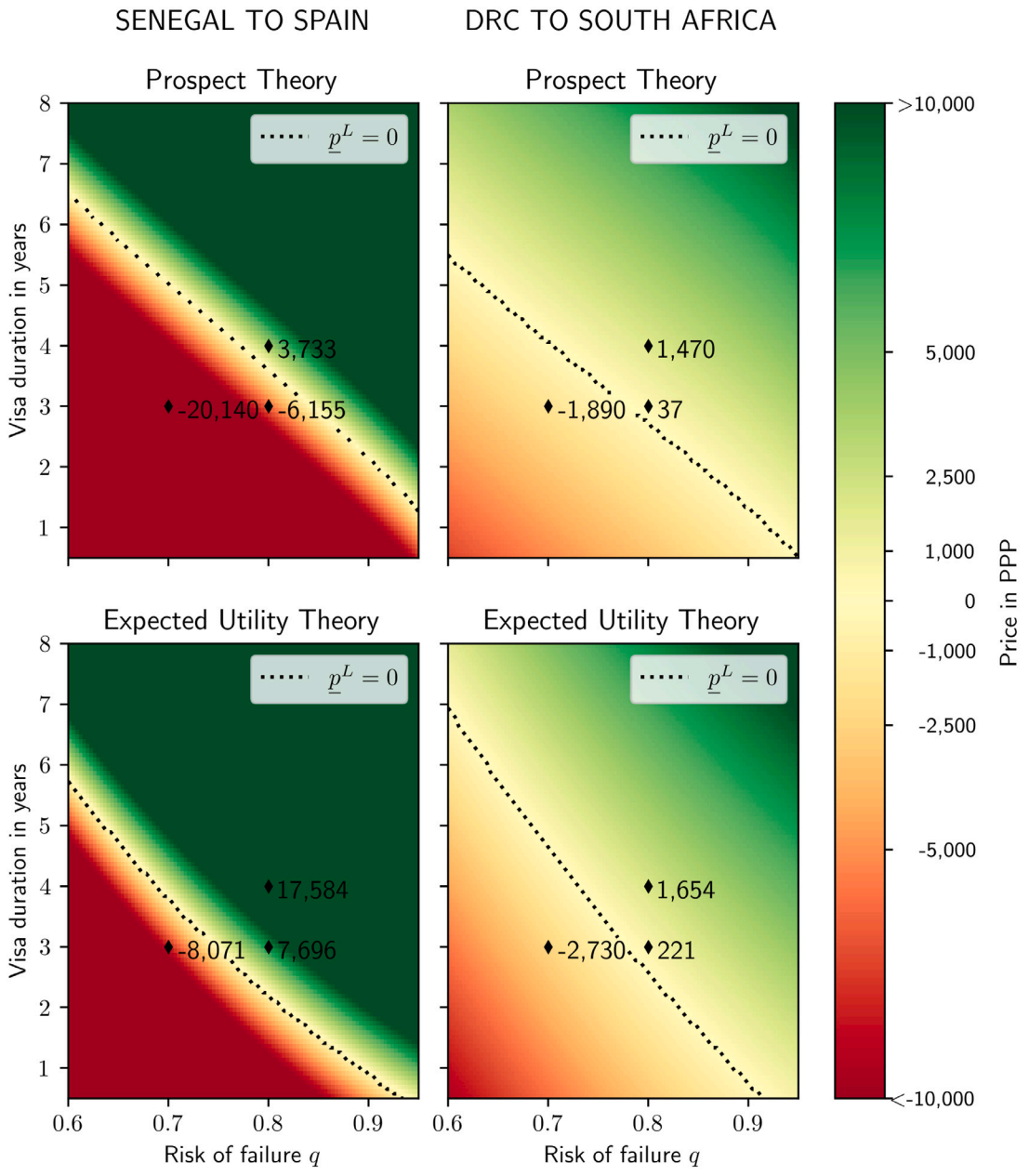

Fig. A.3. Eviction prices on a south–north route and on a south–south route (results under EUT and CPT).

This has to do with the different ways outcomes are compared under CPT and EUT and the different shapes of value (resp. utility) functions. Under CPT, agents assess their expected marginal gains should they work irregularly in the foreign country instead of undertaking legal temporary migration, the *safe outcome*, and they decide to opt for irregular migration if their prospects are increased.

Formally, they compare to 0 the following expression:

$$\omega^+(1-q)\left[dw_f - p^I - \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right]^\alpha$$
$$-\omega^-(q)\lambda\left[-\Delta_h(\theta)w_h + p^I + \left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)\right]^\alpha.$$

Under EUT, agents compare the expected utility associated to the two decisions, i.e.

$$(1-q)\frac{1}{1-a}\left(dw_f - p^I\right)^{1-a} + q\frac{1}{1-a}\left(\Delta_h(\theta)w_h - p^I\right)^{1-a}$$

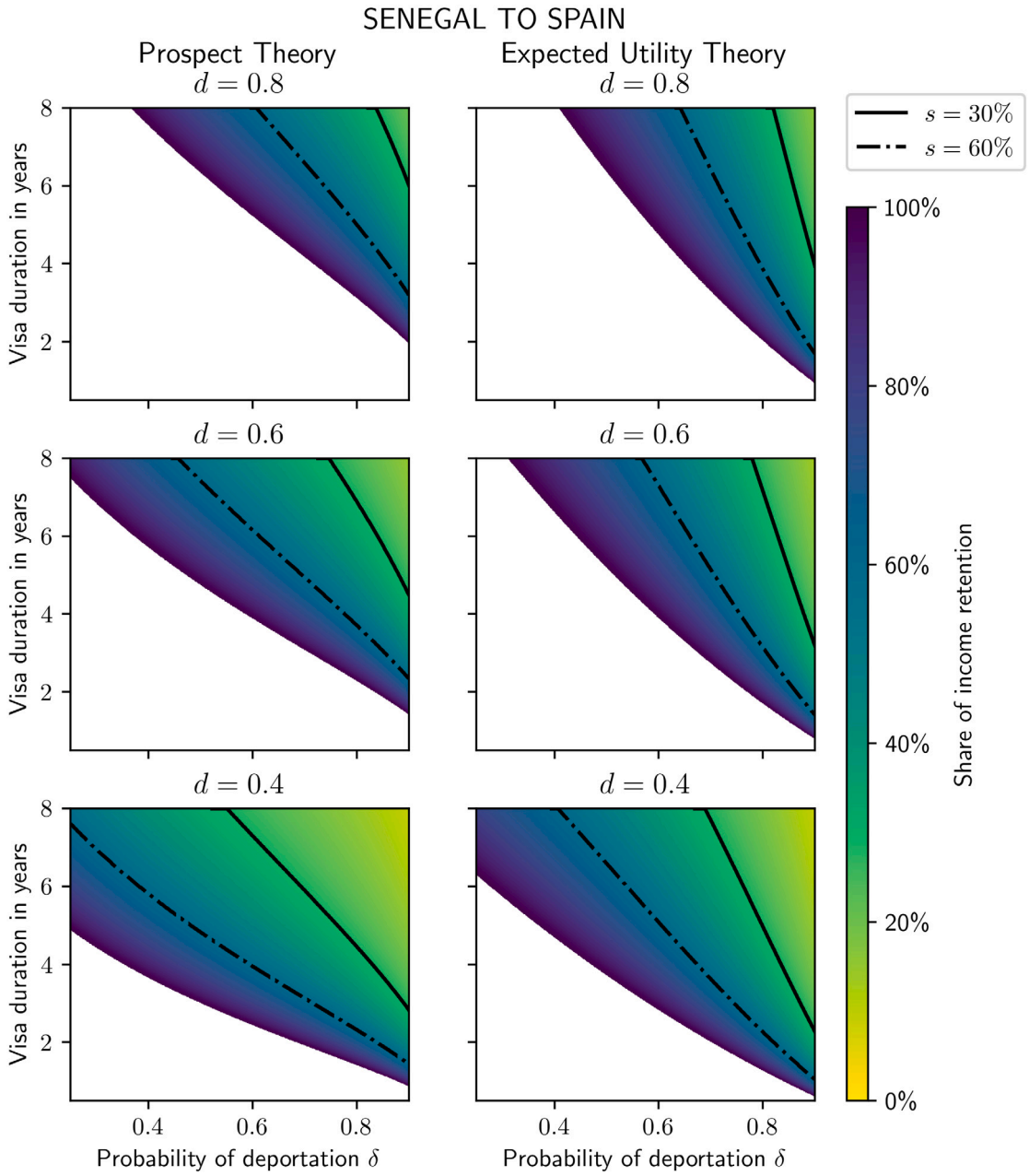

Fig. H.4. Self-enforceability constraints on a south–north route (results under EUT and CPT). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

and

$$\frac{1}{1-a}\left(\tau\Delta_f(\theta)w_f - p^L + (1-\tau)\Delta_h(\theta)w_h\right)^{1-a}.$$

Because of the relatively low curvature $\alpha = 0.88$ of the value function used under CPT (see Fig. A.1) and the normalization to the *safe outcome*, the marginal gains in value/utility derived from irregular work in the foreign country are higher under CPT than under EUT. This is why eviction prices under EUT are noticeably higher than under CPT and this is more pronounced for the south–north route as compared to the south–south route, since the payoffs derived from working legally abroad are significantly larger. The distortions induced by the probability weights under CPT exacerbate this result, as individuals behaving according to CPT overestimate the probability of successful illegal migration.

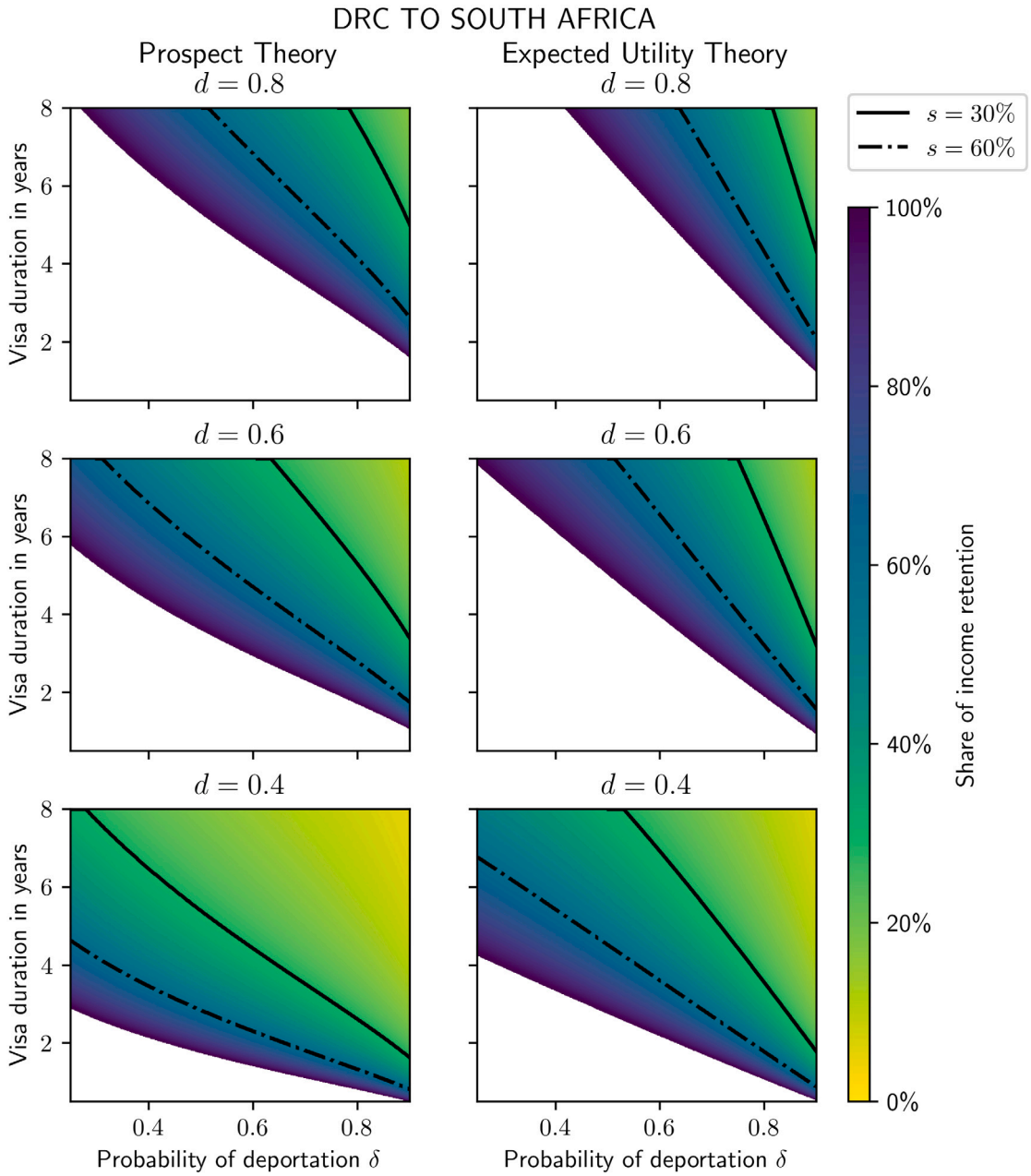

Fig. H.5. Self-enforceability constraints on a south–south route (results under EUT and CPT). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

H.3. Self-enforceability under expected utility theory

Under EUT, the counterpart of Eq. (20), which determines the minimum retention share $\underline{s}$ such that no migrant overstays, is:

$$\begin{aligned}&(1-\delta)u\left(\tau(1-s)w_f+(1-\tau)dw_f\right)+\delta u\left(\tau(1-s)w_f+(1-\tau)w_h\right)\\&=u\left(\tau w_f+(1-\tau)w_h\right)\end{aligned} \tag{H.19}$$

We solve this equation numerically using the isoelastic utility function and the parameter values specified earlier in Appendix H.1 and Appendix H.2.

We present the results using both theoretical frameworks in Figs. H.4 for the route from Senegal to Spain and H.5 for the route from the Democratic Republic of Congo to South Africa. These figures are constructed in the same way as Fig. 2. A color map

indicates for each combination of deportation rate δ and visa duration τ the level of minimum income retention such that the visa scheme is self-enforceable. Darker (lighter) colors correspond to high (low) levels of income retention. White areas indicate combinations (δ, τ) for which visas are not enforceable ($s > 100\%$).

Whether derived under EUT or CPT, the self-enforceability constraint is more difficult to satisfy when the parameter d is at the benchmark level equal to 0.8 (in the top graphs). This result is re-enforced when wage differentials are large such as on the Senegal to Spain route, in Fig. H.4) and deportation is weakly enforced (low δ). Under both frameworks, policy enforcement involving lower values for d, by discouraging irregular work, makes visa schemes more workable.

Comparing the size of the white areas or the isoquants of the share of income retention in the left and right graphs, we find that self-enforceability is more likely under CPT than under EUT.[69] Comparing equation (H.19) under EUT with Eq. (20) under CPT shows that the option to overstay is less valuable under CPT than under EUT. Due to the different shapes of the utility and value functions, the normalization and the *loss aversion* under CPT, the risky losses when caught to be working irregularly more likely outbalance the gains under CPT than under EUT.

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[69] This difference is less striking when the discounting factor is high ($d = 0.8$) and the wage differential is large on the south–north route.

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