Sale of Visas: A Smuggler's Final Song ?

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Abstract

We study how smugglers respond to different types of migration policies -legalisation, through the sale of migration visas, or more traditional repressive policies through borders' enforcement or employers' sanctions- by changing the price they propose to illegal migrants. In this context a government that aims at dismantling smugglers and controlling migration flows faces a trade-off. Dismantling smugglers by the sale of visas increases the flows of migrants and may worsen their skill composition. In contrast, repressive policies decrease the flows of illegal migrants and may improve their skill composition but reinforce the smugglers' abusive power as they apply higher prices. We then study the conditions under which a budget-neutral combination of both types of measures may be effective at dismantling smugglers' businesses and controlling migration flows. Simulations allow us to quantify the partial equilibrium effects of the different policies under study.

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Key words : migration, migration policies, market structure.

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1 Introduction

Human smuggling entails huge costs for societies. First, it is a dangerous operation, which frequently results in the death of those involved.[1] Even when migrants are successful at reaching destination areas, they are most often exploited in transit and destination countries and deprived of all kinds of rights due to their illegal status (see, for example Poulin, 2005 on prostitution and human trafficking or Human Rights Watch, 2000, on bonded labour in sweatshops). Second, crossing borders illegally entails very high financial costs. For border crossings such as from Mexico into the United States, human smugglers can charge up to $4,000, while trans-pacific crossings of Chinese immigrants into the United States cost above $35,000 in the mid 90s and have since increased sharply.[2] This makes people smuggling a booming business. As of 2003, it brought over $5 billion profits a year in the US and around €4 billion in the EU (Padgett, 2003).[3] Over the years, human smuggling has evolved from small scale to large scale operations integrated with other types of illegal and lucrative transnational activities such as drug shipping and prostitution. These activities led by international criminal organizations are posing a threat to the rule of law in countries of origin, transit, and destination.

Although it is important for policy makers to understand why such illegal activities and their associated criminalities are so prevalent, there are surprisingly very few studies on the supply side of illegal migration (noticeable exceptions are Guriev and Friebel, 2006 and Tamura, 2010). The paper contributes to this new literature by, first, studying the industrial organization of human smuggling, notably smugglers pricing and offer strategies, and second, exploring what type of economic policies can be implemented to fight against them.

[1] The Economist, August 06, 2005 reports that each year, an estimated 2000 people get drown in the Mediterranean on their journey from Africa into Europe

[2] On smugglers' fees paid by Chinese migrants in the 1990s see Guriev and Friebel, 2006. On fees paid in 2010 see the website: http://www.havocscope.com/black-market-prices/human-smuggling-fees/ which also gives references to its sources of information.

[3] The annual associated flows of smuggled immigrants are estimated to be at around 350.000 in the US and 800.000 in the EU (The Economist 6 August 2005). These rough estimates should be dealt with caution as reliable data on such illegal activity are difficult to obtain.

Current migration policies, which combine quotas on visas with repression of illegal migration are very imperfect instruments to fight against the illegal migration business.[4] In fact, strong restrictions on labour mobility imply that many candidates are obliged to arrange long distance migration with the help of intermediaries, who organise air, sea or ground transportation, provide them with forged documents, clothes, food and accommodation during the trip (de Haas, 2006). Empirically, the question as to whether repressive measures are effective at decreasing the number of illegal migrants is still very much debated. It is indeed difficult to obtain good data on illegal migration and to identify the causal impact of the policies. In spite of these difficulties a few empirical papers investigate the determinants of illegal migration and attempt to assess its responsiveness to border enforcement measures (Donato et al., 1992, Massey and Espinosa, 1997, Hanson and Spilimbergo, 1999, Hanson et al., 2002, Angelucci 2004). To our knowledge, all existing evidence on illegal migration focuses on cross border migration between the US and Mexico and points to small or unsignificant effect of stricter deportation rules and stricter border controls after the Immigration Reform and Control Act (for a review see Hanson, 2006). For example, using detailed data on cross-border trips of illegal workers from the Mexican Migration Project, Gathman (2008) shows that the price elasticity of demand for illegal migration is relatively small: when the price to cross the borders with the help of coyotes increases, migrants may choose to migrate by their own means and forego the services of smugglers by taking additional risks to cross the border in more remote areas.

However, we expect long distance migration to respond more strongly to smugglers' prices as it is not feasible without their services. Although there is no evidence on the price elasticity of long haul illegal migration, we know from

[4] Illegal migration represents a sizeable proportion of the foreign population living in high wages countries. In Europe for example, the Clandestino Research Project estimates that 1.8 to 3.3 million irregular foreign residents live in the old Member States of the EU15 in 2008 (See at: http://clandestino.eliamep.gr/). This represents 0.46% to 0.83% of their population and 7% to 12% of their foreign population. Worldwide, the International Labour Organisation estimates that 10 to15 per cent of migration today involves migration under irregular situations i.e. entering or working in countries without authorization (http://www.ilo.org/public/libdoc/ilo/2006/106B09_492_engl.pdf).

the history that long distance *legal* migration responded strongly to changes in the market structure of shipping cartels at the beginning of the 20th century. This has been tested empirically by Deltas et al (2008), who show that the existence of relatively tight, well-organized cartels restricted the flow of transatlantic migrants below what would have occurred in a more competitive environment. Today, illegal migration still entails sizeable costs, which may continue to be prohibitively expensive for poor workers and may depend strongly on the industrial organisation of smugglers.

Since repressive policies are ineffective at eliminating smugglers, the paper focuses on what would happen if a government uses basic economic tools, such as price schemes, to fight them by offering candidates the option to pay a fee to cross the border legally. The idea of selling migration visas to regulate migration flows is not new and policy proposals have already fed many debates in general press, blogs and policy reports (see Becker, 2002, the Becker-Posner blog of 31rst July 2005, Freeman, 2006, Orrenius and Zavodny 2010, Saint Paul, 2009 and early discussions by Simon, 1989), being strongly criticised by other economists such as A.Banerjee or S.Mullainathan (The Economist, 26 June 2010). The proponents of legalisation argue that, instead of fuelling the mafia by restricting migration, governments should collect money by selling visas (for instance through auctions). Indeed a business can only be controlled and taxed if it is legal. The government hence realizes a double benefit: first it collects new taxes, and second it spends less on repression because mafia are weakened by the legalisation of their business.

Despite these appealing features, legalisation has not yet been seriously analysed as a tool to eradicate the smuggling industry and its implications in terms of migration equilibrium have not been fully studied by scholars or policy makers. Our goal is thus to develop a model of legalisation to assess its policy relevance. Our analysis shows that the sale of visas at smuggler monopoly price, or higher, will not be sufficient to eliminate smugglers, nor to improve the skill composition of migrants. Indeed prohibition creates a barrier to the entry of the market where it applies. Mafia rely on this legal barrier, and on violence, to

cartelize the industry. They are hence able to charge high prices. We may thus expect the operation of smugglers' cartels not to affect all immigrants equally but to act as a positive selection on immigrants, with higher prices disproportionately reducing the flow of lower income immigrants, as was reported by multiple contemporary accounts on shipping cartels at the turn from the 19th to the 20th century. In this context the big markups imply that they may respond to legalisation measures by lowering the price they propose to would-be migrants and still make a profit. Legalisation will hence increase the flows of migrants and decrease their skill composition.

To be more specific we model the migration market as follows. The demand comes from workers, who choose to work in the foreign country or in the origin country, weighing the benefits of higher wages in foreign countries against migration costs. Migration price is determined by smugglers who maximise their profits. Policies shape the market structure. They may reinforce the monopolistic position of the smugglers by increasing their fixed costs or their marginal costs to operate and hence their prices, or force them to propose lower prices to compete with the migration visas on sale. We will see that neither traditional repressive measures nor more "innovative" pricing tools through the sale of migration visas are satisfactory policies. The formers help controlling migration flows but, far from suppressing smugglers, they may even increase their abusive power when they increase the price paid by the migrants for their service. The latter help eradicating smugglers' activities at the costs of increasing substantially migration flows. The paper then explores how a combination of these measures may be effective at eradicating the smugglers and controlling migration flows, without necessarily increasing the budget deficit. Finally, using our model and estimates from previous studies on Chinese migration to the US, we estimate at around USD 15000 the price of visas, which would drive oligopolistic smugglers out of business. In order to implement such policies without increasing migration flows, the government should increase by more than ten times the marginal costs for smugglers to operate or should reduce the expected earnings of illegal migrants to be 33% those of workers of same skills employed in the

legal sector of the economy, for instance by increasing controls in firms. The reasons why such pricing/repression schemes are not implemented are then discussed with the policy implications of the paper. The status quo with illegal migration may reflect political-economy issues as some people benefit more from lax enforcement measures, as argued for example by Facchini and Testa (2010).

Relation to the literature

There is an expanding theoretical literature on illegal immigration control, following Ethier (1986). Epstein et al.(1999) take into account its dynamic aspects, as migrants who enter legally may subsequently move into the illegal sector in order to avoid deportation and Djajic (1999) investigates its counterproductive effects as migrants may move into new sectors and new areas, where new migration networks may form. In practice countries such as Israel, Cyprus and Lebanon have tried to regulate long distance migration through local agencies located in South East Asian countries such as Philippines and Sri Lanka. These legal intermediaries organise the shipment of cheap labour force to full-fill shortages on labour markets. As migrants under these schemes are obliged to return to their home country at the term of their contract, this is the source of another type of illegal migration from those overstaying illegally in the destination country (Djajic, 2010, Schiff, 2011).

Another type of legalisation measures proceeds through "exceptional" amnisties, which have been repeatedly granted in the recent past to illegal migrants living in European countries, such as Spain, Greece, or in the US. As they pose an obvious problem on time consistency and credibility of the state, a few theoretical papers have studied their rationale and optimal design (Chau, 2001, or Epstein and Weiss, 2001, Karlson et al., 2003, Solano, 2009). The question as to whether such legalisation measures have been effective at decreasing the number of illegal migrants remains largely open (Maas, 2009). Direct evidence is often missing or suffers from obvious difficulties in establishing a causal impact of policy measures, which are themselves responding to complex historical and socio-economic factors.

However, none of the papers on illegal migration mentioned above takes into account the organisation of the supply side of the market by smugglers' cartels, which is the main focus of our paper and is an important determinant of long haul migration flows, as suggested by the historical evidence on shipment cartels. Similarly none of the papers on legalisation studies the possibility of using standard economic tools such as visa sale to control the migration flows and the impact of such legalisation on migration equilibrium. While focusing on this particular channel of illegal entry (i.e., through the services of smugglers) makes the originality of the paper, this also limits the interpretation of the policy implications. We may expect spill-over effects on other channels, if would-be migrants choose between different methods of entry, which are beyond the scope of this paper.

By studying the response by smugglers to policy measures, our paper is close in spirit to Guriev and Friebel (2006), who model how smugglers establish labour/debt contracts with poor migrants, which force them to repay their fee. In this context, they show that deportation and border control policies do not have the same effects on illegal migration: stricter deportation policies may increase the flow of illegal immigrants and worsen the skill composition of immigrants while stricter border controls decrease overall immigration and may result in an increase in debt-financed migration. A key assumption of their model is that migrants are liquidity constrained and cannot pay upfront the fee, which gives rise to these contracts. In a different context where contracts are not legally enforceable between traffickers and smuggled migrants, which leads to migrants' exploitation, Tamura (2010) shows that destination countries with limited resources may prefer to improve the apprehension of smugglers and their clients at the border rather than inland.

In contrast to these papers we do not focus specifically on liquidity constrained or on exploited smuggled migrants but on all workers who use the services of smugglers to migrate illegally and we study the effects a larger set of policy measures - sale of migration visas versus more traditional repressive policies through borders' enforcement or employers' sanctions - on the equilibrium

of the market for smuggled migrants.[5] Our results show that only a combination of them may be effective at both dismantling smugglers' businesses and controlling migration flows, while limiting increases in budget deficit entailed by stricter controls.

The rest of the paper is organised as follows. Section 2 presents the set-up of the model and describes the different possible structures of the illegal migration market in absence of legalisation measures. Section 3 studies the effects of introducing pricing tools and repressive measures to regulate migration flows. Section 4 extends our model by taking into account the strong uncertainty that represents illegal migration for risk averse individuals. Section 5 uses calibrations to illustrate the policy implications of the model and Section 6 concludes.

2 Migration equilibrium

This section studies the migration market equilibrium, when workers pay a migration price to the smugglers, p, to migrate illegally to a high wages destination country. We thereby assume that individuals need to hire a smuggler if they wish to migrate.[6] For simplicity of exposition the analysis is derived under the assumption that illegal migration entails no risk or equivalently that individuals are risk neutral. This allows us to focus on problems linked to industrial organisation of supply side. Section 4 shows that our results are robust to the introduction of risk aversion.

At the beginning of his working life of total duration 1, a worker maximises her lifetime utility. With perfect foresight she chooses her location either abroad or in home country and consumes all her income.[7]

[5] Note that financial constraints are likely to be less binding with the introduction of visas as migrants can more easily get a regular loan. And legalisation diminishes the scope for human trafficking as laws can be more easily enforced against exploitative smugglers.

[6] Although figures vary a lot across destination countries, we expect this to be the case where it is difficult to migrate illegally through different channels, in particular when migration policies are very restrictive and when geographical borders do not exist between origin and destination countries. In the UK for example smugglers are involved in around 75% of detected cases of illegal border crossing (IND, 2001).

[7] As there is no sequential decision the model is essentially static.

Workers are heterogeneous according to their labour efficiency (or skill), θ, which are distributed identically and independently according to the density function $f(\theta)$ and distribution $F(\theta)$ over $\left[\underline{\theta}, \overline{\theta}\right]$ with $\underline{\theta} \geq 0$.[8]

If there is no migration visa for sale, we assume that workers can only work in the illegal sector of the economy such that expected earnings abroad are $d\theta w_{\mathsf{f}}$, with θw_{f} being the wages in the legal sector and $d < 1$. The discount factor d simply captures the fact that workers would have more opportunities if they worked legally rather than illegally.[9] Note that the way we model the returns to skills leads to a positive selection of illegal migrants. Indeed long distant illegal migration flows, which are very difficult to undertake without the help of smugglers, are very costly for workers from low wages countries and this is likely to lead to a more positive selection of workers than what has been largely documented for the Mexican migration.[10] This also turned out to be the case in the High-Costs migration period after 1993 for the Mexican workers, who have been more severely liquidity constrained (Borger, 2011).[11]

The worker knows the discounted income she will earn in the foreign country on the illegal market, $d\theta w_{\mathsf{f}}$, which is assumed higher than the discounted income in home country θw_{h}:

$$dw_{\mathsf{f}} > w_{\mathsf{h}}$$

Note also that labour market is considered exogenous, which is justified by the fact that the number of workers on the labour market is very large as compared

[8] Instead of considering skill heterogeneity, we could easily embed into the model other dimensions of heterogeneity, which may affect the returns to migration (such as physical abilities or degrees of risk aversion in the extended model with risk outlined below) without changing its main results.

[9] It is for example the case if they cannot easily change employer in the illegal sector or if they are caught in a debt-labour contract upon arrival (see Friebel and Guriev, 2006).

[10] As Hatton and Williamson put it (2008) "Greater distances, [...] and (for the poorest regions) the poverty constraint all imply that US and EU migrants coming from farther away should be more positively selected". However, most of the empirical evidence we have on selection is either on legal migration (see Beine et al, 2007 or Docquier and Rapoport, 2007) or on cross-border illegal migration between Mexico and the US such that it is difficult to validate this assumption empirically.

[11] Although we present the model in the case of positive selection, it can easily be extended to the case of negative selection or intermediate selection as shown in the Appendix (8.1). In these cases, the key insights of the model would be very similar provided that the sale of visas is carefully designed and targeted to low-skilled workers in order to be effective at eradicating the smuggling industry.

to the flows of migrants. If she lives abroad earnings are used to consume and to pay for migration price p, such that she consumes $\theta dw_{\mathsf{f}} - p$ whereas, if she stays in origin country, she consumes θw_{h}.[12] Therefore the worker decides to migrate if her life time utility, equal to $u(\theta dw_{\mathsf{f}} - p)$ in case she migrates, is higher than her utility in case she does not migrate, equal to $u(\theta w_{\mathsf{h}})$. With increasing utility functions, the migration condition can be rewritten as $\theta w_{\mathsf{h}} < \theta dw_{\mathsf{f}} - p$. This shows that individuals are more likely to migrate the higher the wage differential between foreign and home countries, the higher their skill level (what we called "positive selection") and the lower the migration costs.

Solving for the skill level such that an individual is just indifferent between migrating illegally or not, we obtain the illegal migration threshold θ^{I} written as:

$$\theta^{\mathsf{I}} = \frac{p}{dw_{\mathsf{f}} - w_{\mathsf{h}}} \tag{1}$$

And aggregating over the distribution of skills, we obtain the demand for illegal migration as a function of migration price p:

$$D^{\mathsf{I}}(p) = \int_{I}^{\bar{}} f(\theta)d\theta = 1 - F(\theta^{\mathsf{I}}) \tag{2}$$

As θ^{I} is increasing in p and decreasing in d, it is easy to show that the demand for migration is higher the lower the migration price, p, and the higher the wages differential $dw_{\mathsf{f}} - w_{\mathsf{h}}$ between the two countries.

2.1 The smugglers

Because legal restrictions constitute barriers to market entry, the smuggling business is concentrated. A few criminal networks actually provide the service. We model the oligopolistic market for illegal migration as a generalized Cournot competition. We focus on symmetric equilibrium (i.e., each smuggler has the same market share). Let $P^{\mathsf{I}}(q) = (dw_{\mathsf{f}} - w_{\mathsf{h}})F^{-1}(1-q)$ denote the inverse

[12] She perfectly knows the wages per unit of time that she will get at home and abroad and the discount rate. She computes the net present value of her future flow of income. Since wages and discount rate are exogenous we avoid introducing separate notation and directly focus on net present values.

demand function for illegal migration. Smuggler $j = 1, .., N$ maximises with respect to q^{j} the profit function:

$$\pi^{\mathsf{j}}(q^{\mathsf{j}}, Q^{-\mathsf{j}}) = \left[P^{\mathsf{I}}(q^{\mathsf{j}} + Q^{-\mathsf{j}}) - c\right] q^{\mathsf{j}}$$

where c represents the marginal costs for the smuggler and $Q^{-\mathsf{j}} = \sum_{\mathsf{k} \neq \mathsf{j}} q^{\mathsf{k}}$ is the offer made by the competitors of $j = 1, ..., N$. The first order condition is sufficient under the assumption that the demand function is not too convex. In a symmetric equilibrium $q^{\mathsf{j}} = \frac{\mathsf{Q}}{\mathsf{N}}$ and the generalized Cournot price with N smugglers, p^{N}, is such that:

$$\frac{p^{\mathsf{N}} - c}{p^{\mathsf{N}}} = \frac{1}{N} \frac{1}{\varepsilon_{\mathsf{D}^{I};\mathsf{p}}} \tag{3}$$

It is easy to check that when there is only one smuggler, $N = 1$, we are back to the standard monopoly case $p^1 = p^{\mathsf{m}}$: the Lerner index is equated to the inverse of the price elasticity of demand. When on the contrary $N \to \infty$ we obtain the competitive case so that $p^{\infty} = c$. Since $c < p^{\mathsf{m}}$ the demand for illegal migration is larger under perfect competition than with a monopoly. The generalized Cournot competition demand is between these two extreme cases: $D^{\mathsf{I}}(p^{\mathsf{m}}) < D^{\mathsf{I}}(p^{\mathsf{N}}) < D^{\mathsf{I}}(c)$ for all $N > 1$.

It is worth noting that the smugglers might face different populations of migrants. For instance illiterate candidate from rural areas are different from educated workers from urban centers. If the oligopolistic smugglers can identify them, they will apply different prices to these different populations (i.e., third degree price discrimination). Let assume for instance that they are K different pools of migrant identified by $k = 1, ..., K$. The skill parameter of workers in group k are distributed identically and independently according to the density function $f_{\mathsf{k}}(\theta)$ and distribution $F_{\mathsf{k}}(\theta)$ over $\left[\underline{\theta}_{\mathsf{k}}, \overline{\theta}_{\mathsf{k}}\right]$. The wages of these workers might also be type dependent: $\{w_{\mathsf{f}\,\mathsf{k}}, w_{\mathsf{h}\mathsf{k}}\}$. The demand for migration faced by the smuggler in group k is $D^{\mathsf{I}}_{\mathsf{k}}(p) = \int_{\underline{I}_{k}(\mathsf{p})}^{\overline{k}} f_{\mathsf{k}}(\theta) d\theta = 1 - F_{\mathsf{k}}(\theta^{\mathsf{I}}_{\mathsf{k}}(p))$, where $\theta^{\mathsf{I}}_{\mathsf{k}}(p) = \frac{\mathsf{p}}{\mathsf{d}\mathsf{w}_{fk} - \mathsf{w}_{hk}}$. The optimal smuggler prices determined by (3) vary from one group to the other according to the price elasticity of its demand $\varepsilon_{\mathsf{D}^{I}_{k};\mathsf{p}} = -\frac{\mathsf{p}\mathsf{D}^{I'}_{k}(\mathsf{p})}{\mathsf{D}^{I}_{k}(\mathsf{p})}$. As it is standard in the price discrimination literature, the groups

with the largest price elasticity gets the smallest price. Groups endowed with low price elasticity (i.e., captive migrants) face higher prices.

2.2 A simple example

This subsection illustrates the market equilibrium with the example of a uniform distribution of skills over $[0, 1]$, which gives easily tractable closed form solutions.

From (1) and (2) we can write explicitly the demand for illegal migration as:

$$D^{\mathsf{I}}(p) = 1 - \frac{p}{dw_{\mathsf{f}} - w_{\mathsf{h}}} \tag{4}$$

In the case of a generalized Cournot competition, we can use (3) to establish that the price is $p^{\mathsf{N}} = \frac{\mathsf{d}\mathsf{w}_f - \mathsf{w}_h + \mathsf{N}\,\mathsf{c}}{\mathsf{N}+1}$ such that $p^{\mathsf{m}}(= p^1) = \frac{\mathsf{d}\mathsf{w}_f - \mathsf{w}_h}{2} + \frac{\mathsf{c}}{2}$ and $p^{\mathsf{pc}}(= \lim_{\mathsf{N}\to+\infty} p^{\mathsf{N}}) = c$.

We deduce that the generalized Cournot demand is

$$D^{\mathsf{I}}(p^{\mathsf{N}}) = \frac{N}{N+1}\left(1 - \frac{c}{dw_{\mathsf{f}} - w_{\mathsf{h}}}\right) \tag{5}$$

Depending on the degree of competitiveness of the market, measured by N, the demand is between the demand on monopolistic market $D^{\mathsf{I}}(p^{\mathsf{m}}) = \frac{1}{2} - \frac{\mathsf{c}}{2(\mathsf{d}\mathsf{w}_f - \mathsf{w}_h)}$, and the demand in perfect competition $D^{\mathsf{I}}(c) = 2D^{\mathsf{I}}(p^{\mathsf{m}})$.

3 Sale of visas

This section studies the effects of selling migration visas when the smuggler has already paid for the fixed costs of smuggling and has a monopolistic position on the market. This represents the easiest case for a government to fight against smugglers given high price they impose to the migrants. More importantly, this is also without loss of generality as will become clearer in section 3.2.

In order to eradicate smugglers the government can try to legalize the market for migration. To do so, he can create a permit to migrate that people can buy. A simple idea would be to create a permit that will cost the same price, p^{L}, as the price imposed by the smuggler to illegal migrants, noted $p^{\mathsf{I}} : p^{\mathsf{L}} = p^{\mathsf{I}}$. However, this policy will increase migration flows. Comparing the legal

migration threshold, written as $\theta^{L} = \frac{p}{w_f - w_h}$, with (1), it is easy to see that, for given migration price p, the legal migration threshold is always lower than the illegal one: $\theta^{L}(p) \leq \theta^{I}(p)\ \forall p > 0$. This is because migration pay-offs are higher under legal than illegal migration as wages differential between foreign and home countries are higher. More importantly such pricing policy of legal migration will not eradicate smuggling.

To determine the pricing scheme for legal migrants a government needs to take into account that the smugglers will react to its policy. The government is a Stackelberg leader and the smuggler is a follower, who adapts his response to the legal policy.[13] The model is solved by backwards induction. We first study the smuggler's reaction to legalization. Then we study the optimal pricing policy of a government, taking into account the smuggler's reaction.

3.1 Smuggler's reaction to legalization

By comparing the payoffs if an individual of type θ migrates legally, $\theta w_f - p^{L}$, with the payoffs if she migrates illegally, $d\theta w_f - p^{I}$, we can write the condition such that an individual of type θ prefers to migrate legally than illegally as :

$$p^{L} < p^{I} + (1-d)\theta w_f \tag{6}$$

The premium $(1-d)\theta w_f$ that workers are willing to pay in order to migrate legally is increasing in the labour efficiency (skill) of workers.

This relationship determines the threshold type, θ^{L}, defined as :

$$\theta^{L} = \frac{p^{L} - p^{I}}{(1-d)w_f} \tag{7}$$

such that any individual above this threshold prefers to migrate legally than illegally. We can easily check that $\partial\theta^{L}/\partial d < 0$. This simply says that the larger the income differential between the legal and illegal sectors, the more individuals prefer to migrate legally than illegally.

Using (1), we can write the threshold type $\theta^{I} = \frac{p^{I}}{dw_f - w_h}$ above which an individual prefers to migrate illegally through the smuggler than to stay in her

[13] This is a reasonable assumption as a government cannot react as quickly as smugglers. Moreover, once it announces its policy, the government must stick to it to be credible.

origin country. If $\theta^{L} < \theta^{I}$ nobody chooses to migrate illegally. A constraint for the smuggler is to fix its price low enough as compared to the price of a legal permit in order to attract the workers of type between θ^{I} and θ^{L}.

This constraint can be written as : $\frac{p^{I}}{dw_f - w_h} < \frac{p^{L} - p^{I}}{(1-d)w_f}$ or, equivalently, as:

$$p^{I} < \frac{dw_f - w_h}{w_f - w_h} p^{L} \tag{8}$$

This shows that the lower the relative payoffs of illegal migration as compared to legal migration, captured by the ratio $\frac{dw_f - w_h}{w_f - w_h}$, and the lower is the legal price of migration, p^{L}, the more difficult it is for the smuggler to meet this constraint.

The smuggler chooses the optimal entry fee for illegal migrant under the constraint (8). It knows that only the low skill workers, of type between θ^{I} and θ^{L}, will migrate illegally and pay p^{I}. Its profits can be written as:

$$\begin{aligned} \Pi(p^{I}, p^{L}) &= (p^{I} - c) D^{I}(p^{I}, p^{L}) \\ \text{with } D^{I}(p^{I}, p^{L}) &= \int_{\frac{p^{I}}{dw_f - w_h}}^{\frac{p^{L} - p^{I}}{(1-d)w_f}} f(\theta) d\theta \end{aligned} \tag{9}$$

After maximisation of the profit, the reaction function of the smuggler, $p^{I}(p^{L})$, is implicitly defined as follows:

$$D^{I}(p^{I}, p^{L}) + (p^{I} - c) \frac{\partial D^{I}(p^{I}, p^{L})}{\partial p^{I}} = 0 \tag{10}$$

under the condition that:

$$2 \frac{\partial D^{I}(p^{I}, p^{L})}{\partial p^{I}} + (p^{I} - c) \frac{\partial^{2} D^{I}(p^{I}, p^{L})}{\partial p^{I\,2}} \leq 0$$

In the uniform example, we obtain a closed form solution for the smuggler reaction price function, $p^{I}(p^{L})$, which is linear in migration visa price p^{L} (all mathematical proofs are derived in the Appendix):

$$p^{I}(p^{L}) = p^{L} \frac{dw_f - w_h}{2(w_f - w_h)} + \frac{c}{2} \tag{11}$$

The smuggler is active and applies this price if condition (8) holds, which is equivalent to:

$$c < \frac{dw_f - w_h}{w_f - w_h} p^{L}$$

3.2 Government policies

Since illegal activities linked to human smuggling entail large negative externalities for societies there is a strong popular demand in many countries to suppress them. In Mexico for example, human smuggling is integrated with drug business and other criminal activities, which lead to high insecurity and became recently one of the main electoral concerns.[14] This is also true for OECD countries, where most governments want to eradicate this industry. For instance Sweden has recently adopted a strict policy against such type of criminal networks. This Section studies how economic tools can be used to reach this objective and their effects on the migration market.

3.2.1 Eliminating smugglers

We first consider a policy, which aims at breaking all incentives to smuggle. It consists in applying a small enough price for legal migration such that the smuggler will have negative profits. This requires that the marginal costs to smuggle is higher than the reaction price, i.e. $p^{\mathsf{I}}(p^{\mathsf{L}}) \leq c$.

More precisely the threshold price noted $\underline{p}^{\mathsf{L}}$, below which the smuggler exits the market solves the equation: $p^{\mathsf{I}}(\underline{p}^{\mathsf{L}}) = c$ where $p^{\mathsf{I}}(p^{\mathsf{L}})$ is defined by equation (10). We deduce that $\underline{p}^{\mathsf{L}}$ is such that $\theta^{\mathsf{L}} = \theta^{\mathsf{I}}$ defined respectively in equations (7) and (1) for $p^{\mathsf{I}} = c$. That is, $\underline{p}^{\mathsf{L}}$ is such that: $\frac{\underline{p}^{L} - \mathsf{c}}{(1-\mathsf{d})\mathsf{w}_f} = \frac{\mathsf{c}}{\mathsf{d}\mathsf{w}_f - \mathsf{w}_h}$. This yields:

$$\underline{p}^{\mathsf{L}} = \frac{w_{\mathsf{f}} - w_{\mathsf{h}}}{dw_{\mathsf{f}} - w_{\mathsf{h}}} c \tag{12}$$

In other words, the government that wants to push smugglers' reaction price down until their mark-up has vanished has to apply the price $\underline{p}^{\mathsf{L}}$ so that the smugglers reaction function is $p^{\mathsf{I}}(\underline{p}^{\mathsf{L}}) = c$. Note that this result applies to any initial structure of the market for smugglers: monopolist, oligopolistic or competitive : irrespective of the initial market conditions, if the government wants to eradicate smugglers through legalisation, the smugglers end up reaching their marginal costs pricing.

[14] The Economist, June 30th 2011.

Comparing $\underline{p}^{\mathsf{L}} = \frac{\mathsf{w}_f - \mathsf{w}_h}{\mathsf{d}\mathsf{w}_f - \mathsf{w}_h} c$ and $p^{\mathsf{pc}} = c$ we can establish, since $d < 1$, that the price imposed by the government to dismantle the smugglers is higher than the price imposed by smugglers under perfect competition. Nevertheless, the migration demand, which is now legal, can be written as:

$$D^{\mathsf{L}}(\underline{p}^{\mathsf{L}}) = \int_{\frac{c(\frac{w_f - w_h}{dw_f - w_h})}{w_f - w_h}}^{\bar{}} f(\theta) d\theta$$

$$D^{\mathsf{L}}(\underline{p}^{\mathsf{L}}) = 1 - F\left(\frac{c}{d w_{\mathsf{f}} - w_{\mathsf{h}}}\right) \tag{13}$$

The legal migration demand $D^{\mathsf{L}}(\underline{p}^{\mathsf{L}})$ in (13) is exactly the same as the demand for illegal migration under perfect competition of smugglers: $D^{\mathsf{L}}(\underline{p}^{\mathsf{L}}) = D^{\mathsf{I}}(c)$. This is because, for a given migration price, more workers are willing to migrate legally than if the migration were solely organized by competitive smugglers. The next proposition summarises this result.

Proposition 1 *A policy that reduces the number of illegal migrants to zero through the sale of visas yields the same level of migration as under perfect competition among smugglers.*

Dismantling the smugglers by lowering the price reduces the number of illegal migrants to zero by destroying smuggler profits, which is its primary objective, but it also increases substantially migration flows and lowers skills on average. For example, when skills are uniformly distributed, the demand under legalization is twice the demand under the unconstrained monopoly ($D^{\mathsf{L}}(\underline{p}^{\mathsf{L}}) = 2D^{\mathsf{I}}(p^{\mathsf{m}})$). There is no available data to assess the relevance of Proposition 1 on migration flows because no country has so far used such pricing scheme. However the theoretical framework, which is quite general, applies to other markets with positive demand and legal prohibition. The theory predicts that destroying a mafia by legalizing its activity will inevitably increase the demand of the formerly prohibited product or service. It is thus useful to look at other products and services, such as alcohol, drugs or sexual services, that are, or have been, successively prohibited and legalised to assess the relevance of Proposition 1.

The main problem to test the impact of repression measures on consumption is the lack of data on trade volume during prohibition time. However, using mortality, mental health and crime statistics, Miron and Zwiebel (1991) estimate the consumption of alcohol during Prohibition in the US (1920-1933). They find that alcohol consumption fell sharply at the beginning of Prohibition, to approximately 30% of its pre-Prohibition level. During the next several years alcohol consumption increased, but remained below its pre-Prohibition level, at about 60-70%. Consumption increased to approximately its pre-Prohibition level only during the decade after Prohibition was abolished.

Another piece of evidence concerns prices. The theory predicts a sharp decrease in prices if one aims at eliminating mafia through legalisation. Consistently with this prediction, Miron (2003) shows that cocaine and heroin are substantially more expensive than they would be in a legalized market: "*the data imply that cocaine is four times as expensive as it would be in a legal market, and heroin perhaps nineteen times.*"

Finally, regarding the sex market, Poulin (2005) claims that the legalization of prostitution in countries such as the Netherland, Germany or Australia, has generated an expansion of this industry: "*An "abolitionist" country like France, with a population estimated at 61 million, has half as many prostituted people on its territory as does a small country like the Netherlands (16 million) and 20 times fewer than a country like Germany, with a population of around 82.4 million.*"

It is clear that more empirical studies are called to understand the consequences of legalisation. Yet, based on the theory and on the available empirical evidence, we predict a sharp increase in migration flows if visas were sold at the price that would drive the smugglers out of business.

3.2.2 The policy trade-o¤

Such increases may not be acceptable in most OECD countries, where there is a strong popular demand for controlling migration flows. We now characterize the optimal policy for a government that aims at minimizing migration flows.

A natural way for economists to handle this problem is to consider market solutions. We thus study what happens if the government uses the sale of migration visas to control migration flows. A constraint for the government is that the price of these visas, p^{L}, has to be lower than $\overline{p}_{\mathsf{L}}$, the threshold price above which no worker will migrate legally. This threshold is the minimum value of two constraints:

- The (IR) constraint: $p^{\mathsf{L}} \leq \overline{\theta}(w_{\mathsf{f}} - w_{\mathsf{h}})$, which implies that someone at least prefers to migrate legally than stay at home, and
- The (IC) constraint: $p^{\mathsf{L}} \leq \overline{\theta}(1-d)w_{\mathsf{f}} + p^{\mathsf{I}}$, which implies that someone at least prefers to migrate legally than illegally.

The legal migration is positive if and only if $p^{\mathsf{L}} \leq \min\left\{\overline{\theta}(w_{\mathsf{f}} - w_{\mathsf{h}}), \overline{\theta}(1-d)w_{\mathsf{f}} + p^{\mathsf{I}}\right\}$. Since we have assumed assumption 1 that $dw_{\mathsf{f}} > w_{\mathsf{h}}$ it is easy to check that the (IC) constraint is binding whenever the smuggler is active. Indeed $\overline{\theta}(w_{\mathsf{f}} - w_{\mathsf{h}}) > \overline{\theta}(1-d)w_{\mathsf{f}} + p^{\mathsf{I}}$ is equivalent to $p^{\mathsf{I}} < \overline{\theta}(dw_{\mathsf{f}} - w_{\mathsf{h}})$, which, by virtue of (1), necessarily holds when the smuggler is active. We deduce that $\overline{p}^{L} = \overline{\theta}(1-d)w_{\mathsf{f}} + p^{\mathsf{I}}$. Since by virtue of equation (10), $p^{\mathsf{I}}(p^{\mathsf{L}})$ is endogenously determined, the threshold $\overline{p}^{\mathsf{L}}$ is a fixed point such that:

$$\overline{p}^{\mathsf{L}} = \overline{\theta}(1-d)w_{\mathsf{f}} + p^{\mathsf{I}}(\overline{p}^{\mathsf{L}}) \tag{14}$$

Under the assumption that $\frac{\partial^2 \mathsf{D}^I(\mathsf{p}^I;\mathsf{p}^L)}{\partial \mathsf{p}^I \partial \mathsf{p}^L} \geq 0$, one can check after totally differentiating equation (10), that $\frac{\mathsf{dp}^I(\mathsf{p}^L)}{\mathsf{dp}^L} > 0$. This implies that $\overline{p}^{\mathsf{L}}$ exists and is unique. Indeed if $p^{\mathsf{L}} = 0$ then $\overline{\theta}(1-d)w_{\mathsf{f}} + p^{\mathsf{I}}(0) > 0$, while $\overline{\theta}(1-d)w_{\mathsf{f}} + p^{\mathsf{I}}(+\infty) = \overline{\theta}(1-d)w_{\mathsf{f}} + p^{\mathsf{m}} < +\infty$. We deduce that p^{L} and $\overline{\theta}(1-d)w_{\mathsf{f}} + p^{\mathsf{I}}(p_{\mathsf{L}})$ cross once and only once at $\overline{p}^{\mathsf{L}} > 0$.

The government internalizes the reaction function of the monopolist smuggler $p^{\mathsf{I}}(p^{\mathsf{L}})$ in (11). By using (1), we can write the objective function of the government, as follows:

$$\min_{\mathsf{p}^L \leq \overline{\mathsf{p}}^L} \int_{\frac{p^I(p^L)}{dw_f - w_h}}^{-} f(\theta)d\theta = \min_{\mathsf{p}^L \leq \overline{\mathsf{p}}^L} \left[1 - F\left(\frac{p^{\mathsf{I}}(p^{\mathsf{L}})}{dw_{\mathsf{f}} - w_{\mathsf{h}}}\right)\right] \tag{15}$$

Differentiating (15) with respect to p^L yields $-\frac{1}{w_f - w_h} f\left(\frac{p^I(p^L)}{w_f - w_h}\right) \frac{dp^I(p^L)}{dp^L} \leq 0$ since $\frac{dp^I(p^L)}{dp^L} > 0$. A government, which aims at minimizing migration flows, will fix the highest possible price for its visas $p^{L*} = \overline{p}^L$. The migration demand under such policy is higher than in the case of an unconstrained monopoly. Indeed when $\overline{p}^L \leq p^L \leq \overline{\theta}(w_f - w_h)$, the smuggler is a monopoly as nobody wants to migrate legally if the monopoly applies its optimal reaction price $p^I(p^L)$. However it cannot apply the unconstrained monopoly price $p^m = p^1$ (see 3) as some migrants would then choose legal migration, lowering the smuggler profit. This entails larger migration flows even though no visa is sold in such case.[15]

Figure 1 illustrates this result. It shows the smuggler monopoly reaction function as a function of p^L in the uniform example, as defined by (11). With the uniform distribution example, replacing (11) into (14) the visa price satisfies: $p^{L*} = [c + 2(1-d)w_f] \frac{w_f - w_h}{(2-d)w_f - w_h}$. We can easily show that the reaction smuggler price $p^I(p^{L*})$ is lower than the price p^m imposed by the smuggler under unconstrained monopoly (see the Appendix). The next proposition summarizes the result.

Proposition 2 *Regulating migration flows through the sale of migration visas necessarily increases the total number of migrants and lowers their average skill level.*

Proposition 2 implies that a government, which aims at minimizing the demand for migration, cannot do better than an unconstrained monopoly smuggler. So, if the objective is to decrease the total number of migrants, there are more effective policy instruments than selling migration permits. Using our results above it is straightforward to check that a repressive policy against smugglers increasing their costs to operate, c, or decreasing the benefits of illegal migration, d, would do better at decreasing the migration demand. Such measures would also imply that the pool of illegal migrants will be more skilled on average. So far we have considered two types of policies to control illegal immigration: one policy relies on pricing schemes and economic tools to suppress

[15] The monopoly is unconstrained to apply its monopolistic price only when $p^L > \overline{\theta}(w_f \quad w_h)$.

smuggling, while the other policy is essentially repressive and aims at minimizing illegal migration flows. Both solutions are politically unsatisfactory. The former leads to a substantial increase in migration flows, while the latter does not eradicate smugglers and makes them more abusive (i.e., they apply higher prices). In what follows we explore how a combination of both types of approaches might help to simultaneously fight the smugglers and control migration flows, without increasing the burden of public deficit.

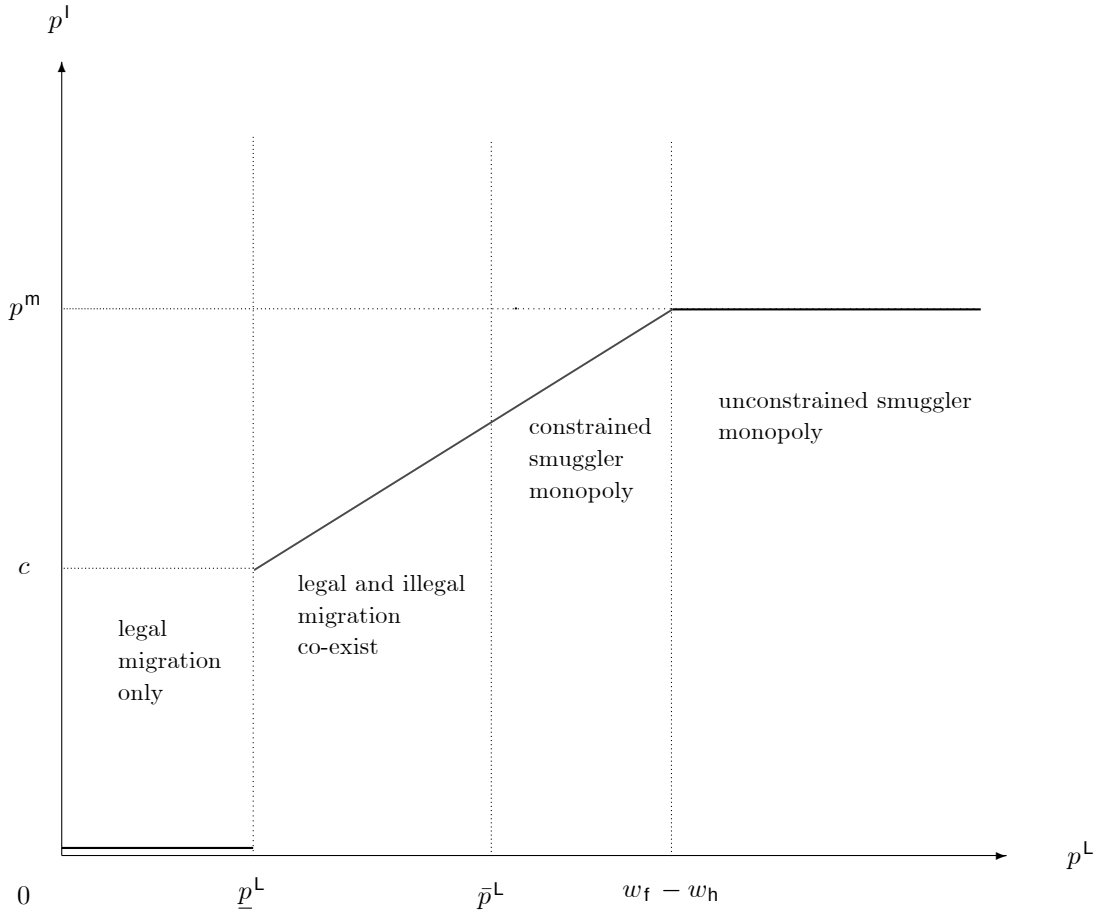

Figure 1: Pricing scheme of the smuggler $p^{\mathsf{l}}(p^{\mathsf{L}})$ in the uniform example

3.2.3 A¤ordable migration control through legalisation

In this section we consider a policy where the funds raised from the sale of the legal permits are used to fight illegal migration and increase c or, alternatively, decrease d in such a way that increases in migration flows following the legalisation are limited as much as is affordable.

We start from the statu quo situation where the marginal cost to smuggle is c. The government can use the new funds raised through the sale of migration permits to increase these costs by reinforcing "external" (or borders') controls. We denote $c(R)$ the marginal costs that the smugglers face when the government invests $R \geq 0$ in additional repression. We assume that, in the absence of additional investment, the marginal costs of the smuggler are the statu quo level: $c(0) = c$. Moreover we assume that $c'(R) > 0$ and $c''(R) < 0$ and that $\lim_{R \to +\infty} c(R) = \overline{c} < \overline{\theta}\,(dw_{\mathsf{f}} - w_{\mathsf{h}})$. The concave shape indicates decreasing returns to scale in the fight against smugglers. Moreover, there is an upper bound to the costs that the government can impose on smugglers such that it is not possible to totally eradicate migration through repression. This captures the documented fact that smugglers never die even though people who operate for them at different levels of the business may die or be caught by borders' guards (see Jones and Pardthaisong, 1999 on Thai smugglers, Yun and Poisson 2005 on Chinese smugglers, or Mahmoud and Trebesch, 2010). Finally, if the government does not want to increase its public deficit the maximum amount of money it can invest in repression is such that:

$$R \leq D(p^{\mathsf{L}})p^{\mathsf{L}} \tag{16}$$

Replacing c by $c(R)$ in (12), we can erd[(b)27(y)]TJ(rd[(b)2i-69.779-326.00(amd[(in)-2633Td[(is)-322(n)-1(ot

We can then show in the Appendix that the optimal amount of additional investments in repression, R^*, which exists and is unique, is a fixed point which equalises the budget constraint (16) and satisfies the relationships for the visa price (17) and demand (18). That is, it is such that:

$$R^* = p^{\mathsf{L}}(R^*)D^{\mathsf{L}}(R^*) \tag{19}$$

Symmetrically, the second way an affordable migration control through legalisation policy can be implemented is through increasing internal controls at worksites and enforcing the sanctions paid by the employers of illegal migrants, which incurs additional costs, noted F^*, for the government. The Appendix shows that to finance this policy the government may use all the funds raised from the sale of visas as shown by the budget constraint:

$$F^* = p^{\mathsf{L}}\left(F^*\right) D^{\mathsf{L}}\left(F^*\right) \tag{20}$$

where $p^{\mathsf{L}}(F^*) = \frac{\mathsf{w}_f - \mathsf{w}_h}{\mathsf{d}(\mathsf{F}^*)\mathsf{w}_f - \mathsf{w}_h} c$ and the corresponding demand for legal migration is $D^{\mathsf{L}}(F^*) = D^{\mathsf{L}}\left(p^{\mathsf{L}}(F^*)\right)$.

These two different ways of implementing such an affordable policy are summarised in the next proposition.

Proposition 3 *A government that aims at dismantling smugglers while limiting migration flows without increasing its budget deficit invests the maximum possible amount in re-enforcing (either external (19) or internal (20)) controls, which is affordable through the sale of visas.*

Since the demand for visas is a normal good and since $c'(R) > 0$ (alternatively $d'(F) < 0$) it is straightforward to check that $\frac{\mathsf{dD}^{L}(\mathsf{R})}{\mathsf{dR}} < 0$ ($\frac{\mathsf{dD}^{L}(\mathsf{F})}{\mathsf{dF}} < 0$). When repression increases against smugglers, the marginal costs of their activity, c, increase, which is transmitted to the smugglers' price. Alternatively, when sanctions are enforced against employers of illegal migrants, this is transmitted to the pay-offs of migrants, which are decreased. As a result the government can raise the price of legal visas without fueling smugglers' demand. This policy allows to control migration flows without relying on the help of smugglers.

Indeed, by construction, such policy pushes smugglers out of the market by eroding their profits.

The next question is which of the two types of instruments (external/internal controls) is the most effective at eradicating the smuggling industry for a given budget *and* at limiting the increase of migration. We understand quite intuitively that the answer depends crucially on the relative elasticities of the two functions $d(F)$ and $c(R)$. The mathematical condition, which captures the relative effectiveness of the two instruments considered, is derived at the end of Appendix (8.3).

3.2.4 Discussion

The main issue raised by the affordable policy described in Proposition 3 is its effectiveness at limiting migration flows. This ultimately depends on the elasticities of the functions $c(R)$ and $d(F)$, which are likely to vary from one country to the other. For example, when there is a physical border between the two countries it is difficult to raise smugglers' costs by increasing repression, as the evidence on illegal migration between Mexico and the US mentioned in the introduction shows. The equilibrium price of migration visas will then be quite low. Such policy of legalisation will be ineffective at limiting migration flows, and will be hard to sustain politically. By contrast, in the case of long-haul migration, it might be easier to increase smugglers' costs by reinforcing external controls. In practice the way the repressive policy is set up is very important. The goal is to raise c to increase concentration, not necessarily to dismantle existing cartels. Breaking established smugglers networks might give rise, through the emergence of several smaller smuggler networks, to more competition in the illegal migration business and, hence, to lower prices and higher demand.[16]

[16] The failure of the "war on drugs" launched in the United States in the 1980s has been partly explained by such effects. The US authorities decided to infiltrate the drug mafia to dismantle it. The infiltration operation, which was very costly, was successful. The dismantling of the well organized cartels which followed gave rise to the emergence of many smaller drug networks fighting fiercely in price to gain market share. As a result, the consumption of cocaine increased in the US (see Poret 2002).

The effects of stricter internal repression measures, which would increase penalties paid by employers of undocumented immigrants, are even less known and studied than the effects of stricter external controls. Yet such policy has proved to be effective, at least in other industry. Focusing on the sex business, Poulin (2005) shows that repressive policy can successfully decrease the demand, when, as in Sweden, legislation is passed to prosecute the customers, who are the final users of the business. As technologies develop to detect forged documents, for example using biometric identity cards, prosecuting firms that employ illegal workers (i.e., decreasing d) could be a more cost effective way to reduce illegal migration than borders' enforcement measures (i.e., increasing c).

Strikingly, in 2008 in France there were only 1706 labor inspectors for more than 3.8 millions of firms. Among those firms, only 1.6 millions, the largest ones, were eligible for a control. With only 22590 controls to check for illegal workers, an eligible firm is inspected on average once every 70 years, or alternatively faces a 1.42% probability of being inspected each year. And smaller firms face a 0 probability of inspection although many illegal migrants work in small construction firms and in restaurants. At the same time France has spent more than 232 millions of euros in repression measures such as dismantelling illegal immigrants' camps, police enforcement at the borders and deportation measures. Similarly in the US, there is very little enforcement against illegal immigration at worksites (Hanson, 2007). Between 1999 and 2003, the number of man hours US immigration agents devoted to worksite inspections declined from 480.000 (or 9 percent of total agent hours) to 180.000 hours (or 4 percent of total man hours). Few US employers who hire illegal immigrants are detected or prosecuted. The number of US employers paying fines of at least $5.000 for hiring unauthorized workers was only fifteen in 1990, which fell to twelve in 1994 and to zero in 2004.[17] And strikingly, at the same time, considerable amounts have been increasingly invested in the controls of the US borders. The number of man hours spent policing the US-Mexico border increased by 2.9 times between

[17] "Immigration Enforcement : Preliminary Observations on Employment Verification and Worksite Enforcement" GAO-05-822T June 21, 2005, cited by Hanson 2007, p19.

1990 and 2005 and the Border Patrol, which was increased from 9,000 agents in 2001 to 20,000 in 2009, costs an estimated $4 billion annually. As of today, more than 670 miles of border fences, walls, bollards and spikes that Congress decreed in 2006 at an estimated cost of $4 billion (plus future maintenance) are almost completed.[18]

Finally note that enforcing the fines paid by employers using undocumented workers may also contribute to raising additional funds for the government. This could easily be taken into account in the budget constraint (20) by adding a term (increasing in F) on the right hand side,which would not change the main insights of the model and only reinforces the likelihood of this instrument being more cost-effective than increasing external controls. Although sanctioning employers of illegal migrants may be a more effective way to legalise migration while limiting migration flows than re-inforcing borders' controls, such affordable policy will typically encounter strong resistance from powerful lobbies as observed for example in the US with agricultural lobbies. This may explain why, under current policies, large number of illegal migrants still bear the costs of being exploited in destination areas and face the constant risk of being deported.

4 Risk aversion

So far we considered either situations entailing no risk or risk neutral individuals. It is probably more realistic to consider that individuals are risk averse. As migrating illegally entails important risks, this may be of significance to determine the number and type of migrants. This section shows the robustness of our results to the introduction of risk aversion. It reports only the main results. For the detailed computations we refer to Appendix 8.4.

We extend the model by introducing standard CARA utility function $u(x) = 1-exp(-ax)$, where a is the absolute risk aversion parameter.[19] We also assume

[18] The Washington Post, Sunday, July 18, 2010. http://www.washingtonpost.com/wp-dyn/content/article/2010/07/16/AR2010071602720.html

[19] However the results are robust to other utility functions characterising risk averse individuals. We have for instance checked their robustness using logarithmic utility function $u(x) = \log x$ (computations available on request).

that illegal migration entails a risk: migrants reach the destination country and stay abroad with probability q, and otherwise are deported and loose the sunk costs paid to the smuggler. In order to compare the results in the cases with and without risk aversion, we assume that if they manage to avoid deportation while in migration, they earn a wage δw_f with $\delta \leq 1$ so that the expected revenue from illegal migration is the same in the two cases, which can be written as:

$$q\delta w_f + (1-q)w_h = dw_f \tag{21}$$

Any distortion can hence be ascribed to the introduction of the risk aversion.

One can check in the appendix 8.4 that the illegal migration threshold θ^I_{ra} is now a solution of the following equation:

$$\frac{1-e^{-ap^I}}{1-e^{-a\,(\,w_f - w_h)}} = q \tag{22}$$

The risk neutrality (and/or absence of risk) benchmark case of equation (1), $\theta^I = \frac{p^I}{dw_f - w_h}$, is simply obtained in equation (22) by setting $q = 1$, which also implies $\delta = d$. Since θ^I_{ra} is decreasing with q and since $\theta^I_{ra} = \theta^I$ when $q = 1$ we deduce that $\theta^I_{ra} > \theta^I$ for all $q < 1$.

We have just shown that one implication of introducing risk into the model is that, as we may expect, the risk of being deported will discourage risk averse individuals to migrate illegally. Therefore a consequence of not introducing legal visas is to reduce further the migration demand as illegal migrants face a risk of deportation. The logic of the pricing scheme of smugglers described in section 2 remains the same as before but it takes into account the new (lower) demand from risk averse individuals. Risk aversion implies that the price imposed by smugglers is then lower than the price they would impose to risk neutral individuals with the same expected revenue from migration, an intuitive result formally shown in the Appendix 8.4.

We have hence established the following lemma:

Lemma 1 *Risk aversion limits the number of illegal migrants and reduces the price imposed by smugglers.*

We now turn to the government policy of visas sale and the reaction of smugglers. If individuals can buy a legal permit to migrate at price p^{L}, smugglers need to price their services low enough so that at least one individual wishes to migrate illegally. The skill level $\theta^{\mathsf{L}}_{\mathsf{ra}}$ of the marginal illegal migrant who is just indifferent between migrating illegally and legally satisfies the following equation:

$$\frac{1-e^{-\mathsf{a}(\ (\mathsf{w}_f-\mathsf{w}_h)+\mathsf{p}^I-\mathsf{p}^L)}}{1-e^{-\mathsf{a}\ (\ \mathsf{w}_f-\mathsf{w}_h)}}=q \tag{23}$$

Solving for the threshold $\theta^{\mathsf{L}}_{\mathsf{ra}}$ and comparing it to (7) we show in Appendix 8.4 that risk aversion increases the demand for legal visas: $\theta^{\mathsf{L}}_{\mathsf{ra}}<\theta^{\mathsf{L}}$ as established by Lemma 2.

Lemma 2 *Risk aversion increases the demand for legal visas.*

When legal visas are put on sale, risk averse individuals are willing to pay a higher price to get valid documentation. Since we also showed that $\theta^{\mathsf{I}}_{\mathsf{ra}}>\theta^{\mathsf{I}}$, risk aversion reduces the illegal migration demand, $D^{\mathsf{I}}_{\mathsf{ra}}(p^{\mathsf{I}},p^{\mathsf{L}})=\int_{\substack{I\\ra}}^{\substack{L\\ra}} f(\theta)d\theta=F(\theta^{\mathsf{L}}_{\mathsf{ra}})-F(\theta^{\mathsf{I}}_{\mathsf{ra}})$, by the two ends. On the one hand, the illegal migration flows in the absence of legal pricing schemes are lower than with risk neutral individuals. On the other hand, as individuals are less willing to bear the risk of deportation, legal visas sale decreases illegal migration flows even further.

For the sake of realism we focus on situations where smugglers are initially active in equilibrium. Their reaction function, $p^{\mathsf{I}}_{\mathsf{ra}}(p^{\mathsf{L}})$, is solution of the same equation as in (10) using the demand $D^{\mathsf{I}}_{\mathsf{ra}}(p^{\mathsf{I}},p^{\mathsf{L}})$. If the government wants to eliminate them by its pricing policy, it still needs to push their reaction price to the limit value c so that $\theta^{\mathsf{L}}_{\mathsf{ra}}(c,\underline{p}^{\mathsf{L}}_{\mathsf{ra}})=\theta^{\mathsf{I}}_{\mathsf{ra}}(c)$. It follows that Proposition 1 holds true under risk aversion. If the government wants to eradicate smugglers through legalisation it will face the same demand as under perfect competition among smugglers: $D^{\mathsf{L}}(\underline{p}^{\mathsf{L}}_{\mathsf{ra}})=D^{\mathsf{I}}_{\mathsf{ra}}(c)$. The main difference is that the demand is lower than in the risk neutral case, $D^{\mathsf{I}}_{\mathsf{ra}}(c)<D^{\mathsf{I}}(c)$.

We show in Appendix 8.4 that $\underline{p}^{\mathsf{L}}_{\mathsf{ra}}$ is decreasing in q. Moreover as for $q=1$ $\underline{p}^{\mathsf{L}}_{\mathsf{ra}}=\underline{p}^{\mathsf{L}}$ this implies that the visa price, which drives smugglers out of business,

is higher with risk (when $q < 1$) than without: $\underline{p}^{L}_{ra} > \underline{p}^{L}$ as established by Lemma 3.

Lemma 3 *Risk aversion increases the visa price, which drives the smugglers out of business:* $\underline{p}^{L}_{ra} > \underline{p}^{L}$.

Finally the results of section 3.2.2 remains valid under risk aversion. If the smuggler is active the binding constraint is the IC and $\overline{p}^{L}_{ra}$ is solution of the following equation derived in Appendix:

$$e^{-a(\bar{w}_f - p^L)} = qe^{-a(\bar{w}_f - p^I_{ra}(p^L))} + (1-q)e^{-a(\bar{w}_h - p^I_{ra}(p^L))} \tag{24}$$

The rest of the reasoning then holds true. Proposition 2 and 3 are robust to the introduction of risk aversion but the price and demand functions in Proposition 3 are changed as explained above due to the risk aversion.

This section has shown that the results of the paper are robust to the introduction of risk aversion. The main impact of risk aversion is to limit the demand for illegal migration and to push the price of legal visas up.

5 Implications

As it is impossible to run regressions to test our model, this section uses calibrations to interpret its results and quantify the policy effects outlined above. While interpreting our results we have to keep in mind that they are not full-fledged policy simulations. The model focuses on the migration market only and abstracts from any other changes that may occur in the rest of the economy as a consequence of large increases in migration flows. In particular, adjustments on the labour market may dampen the initial incentives to migrate, leading to smaller increases in migration flows following sale of visas than the ones we calibrate. Also, this may generate complex politico-economic problems, as not everybody in the host country will have the same welfare gains or losses following these changes. These are not captured by our model and the implications we draw below are purely used to illustrate the partial equilibrium effects on the migration market outlined by our model.

We borrow most of the estimates used in our calibrations from Friebel and Guriev, 2006, and from the scarce information we have on the smuggling industry from case-studies on Chinese smugglers (Yun and Poisson, 2005).

5.1 Rationality of migration decisions

We first check that the incentive rationality constraint of our model is satisfied for the wages differential between the US and China observed in 2005 and for a larger range of wage differentials between advanced and developing countries.

We depart from the estimated prices paid by Chinese illegal migrants to go to the US, which have been documented in Friebel and Guriev, 2006 and previous work to be above USD 35.000 in mid 1990s and then continued to rise.

To calibrate d, we use Cobb-Clark and Kossoudji's (2002) estimates of 14 to 24% legalization premia which, we round at 20%. Assuming $d = 0.8$ is also in line with the findings of Rivera-Batiz (1999) on the gap in wages differential between legal and undocumented immigrants on the US market, which remains unexplained by differences in measured characteristics of these two groups.[20]

To calculate the net present value of working illegally in the US we take the average minimum wages in the US, \$6.15 per hour, and assume that a migrant works 45 hours for 52 weeks per year over a period of 40 years. Accordingly, assuming the discount and growth rates of future wages equal to zero, NPV of earnings in the US is around \$575640 ($= 52 * 45 * \$6.15 * 40$) Moreover, estimates of the GDP per capita in China in terms of purchasing power parity are in the range of \$4000 such that, over 40 years, the NPV of earnings in China are estimated around \$160000 ($=\$4000 * 40$).[21] We can check that the IR constraint, $p^{\mathsf{I}} \leq (dw_{\mathsf{f}} - w_{\mathsf{h}})$, is largely satisfied (as $p^{\mathsf{I}} < 575640 * 0.8 - 160000$).[22]

[20] Although these estimates are based on Mexican immigrants and may be different for long-distance illegal migrants, who may come from very different areas such as South East Asia, Russia or Africa and may have different skill distributions, these are, to our knowledge, the best available proxies.

[21] This estimate of GDP per capita reported by the CIA World Factbook 2005 corresponds to a wage equal to 1.7 dollar per hour in China, which, given the adjustment by the differential in purchasing power between China and the US, does not seem unreasonable. See https://www.cia.gov/library/publications/the-world-factbook/

[22] More generally, we check that the constraint $p^I \quad w_h(d\frac{w_f}{w_h} \quad 1)$ is easily satisfied for a large

5.2 Risk aversion and probability of deportation

From the Cournot Price (3) and replacing the price elasticity of the demand for migration $\varepsilon_{D_{ra},p}$ using our calculations in Appendix (38) we can write the marginal costs for smugglers to operate, c_{ra}, as follows:

$$c_{\mathsf{ra}} = p^{\mathsf{I}} - \frac{1}{N}\frac{(\delta w_{\mathsf{f}} - w_{\mathsf{h}}) - \frac{\log q - \log\left(q-(1-e^{-ap^I})\right)}{a}}{\frac{e^{-ap^I}}{q-1+e^{-ap^I}}} \tag{25}$$

which in the case with risk neutrality (and/or absence of risk) simplifies to $c = p^{\mathsf{I}}(1 - \frac{1}{N}\frac{1}{\varepsilon_{D^I,p}})$ with $\frac{1}{\varepsilon_{D^I,p}} = \frac{(w_f - w_h) - p^I}{p^I}$.

Using the lower bound of the price paid by Chinese to migrate illegally to the US, $p^{\mathsf{I}} = \$35000$, and the results of our model, we could calibrate a lower bound of the marginal costs for smugglers to operate. However this would require some estimate of the degree of risk aversion of would-be migrants, a, and on the deportation probabilities q , which are typically difficult to observe.

Instead, we have some direct evidence from Chinese smugglers on their marginal costs to operate, which are reported to be around 8000 euros to cross the borders to France and higher to the US (Yun and Poisson, 2005), which we estimate to be around \$10000 for our simulations. Using our model and this information we can infer a range of risk parameters a compatible with a large range of deportation probabilities, q.

Replacing in (25) with $p^{\mathsf{I}} = 35000$, $\delta = 0.8$, $w_{\mathsf{f}} = 575640$, $w_{\mathsf{h}} = 160000$, $N = 2$, and $c_{\mathsf{ra}} = 10000$ Figure 2 plots the absolute risk aversion parameters a, as a function of q represented on the horizontal axis.

5.3 Price of visas and migration demand

The next step is to estimate the demand for illegal migration given the marginal costs to operate observed for the Chinese smugglers and compare it to the

range of ratios $\frac{w_f}{w_h}$ (=2, 3, 4, 5, 7, 10, 15, and 25) based on wage differentials between advanced and developing countries reported by Freeman et al. (2000) or on purchasing power adjusted wages ratios computed by Clements et al. (2009) for workers who are otherwise observably identical. However, since we do not have good estimates for the prices to cross illegally from one origin to another destination country, we prefer to focus on the illegal Chinese migration to the US for the remainder of our simulations.

demand for migration after a government dismantles the smuggler's business by selling visas.

We can first simulate the visa price that would eradicate the smugglers and, from there, simulate the increase in migration demand that would follow.

We use the analytical solution for p^{L}_{ra} derived in equation (42) of the Appendix as follows:

$$p^{L}_{ra} = \frac{w_f - w_h}{a(\delta w_f - w_h)}(\log q - \log(q - 1 + e^{-c_{ra}a}))$$

Figure 3 shows the range of visa prices corresponding to the above simulations of $a(q)$ for a large range of q satisfying $c_{ra} = \$10000$.

In the case with risk neutrality (and/or absence of risk) we replace with $q = 1$ and find reassuringly $\underline{p}^{L} = \frac{w_f - w_h}{dw_f - w_h}c$ in line with our former results (12). Hence, based on our crude estimates of the model the visa price imposed by the government to eradicate the smugglers should be around \$13831($= \frac{575640-160000}{0:8*575640-160000}10000$).

The final step is to estimate the magnitude of the increase in demand resulting from the sale of visas, $\frac{D^{L}(p^{L}_{ra}) - D^{I}_{ra}(p^{I})}{D^{I}_{ra}(p^{I})}$, which will of course depend on the distribution of migrants' skills. Assuming a uniform distribution over $[0, 1]$ the demand for illegal migration in the absence of legalisation is: $D^{I}_{ra}(p^{I}) = 1 - \theta^{I}_{ra}$, with θ^{I}_{ra} solution of the equation (22). Therefore the demand for illegal migration is

$$D^{I}_{ra}(p^{I}) = 1 - \frac{log(q) - log\left(q - (1 - e^{-ap^{I}})\right)}{a(\delta w_f - w_h)}$$

whereas, after legalisation, the demand becomes

$$D^{L}_{ra}(p^{L}_{ra}) = 1 - \frac{log(q) - log\left(q - (1 - e^{-c_{ra}a})\right)}{a(\delta w_f - w_h)}$$

For the different values of a and $q(a)$ plotted above and p^{I}=\$35000 we can simulate the increase in migration demand following the policy as follows:

$$\frac{D^{L}_{ra}(p^{L}_{ra}) - D^{I}_{ra}(p^{I})}{D^{I}_{ra}(p^{I})} = \frac{log\left(q - (1 - e^{-c_{ra}a})\right) - log\left(q - (1 - e^{-ap^{I}})\right)}{a(\delta w_f - w_h) - log(q) + log\left(q - (1 - e^{-ap^{I}})\right)}$$

Figure 4 simulates the increases in migration demand following a legalisation scheme that would use only one instrument, the sale of visa, and would keep

constant the marginal costs for smugglers to operate, for the range of values of the parameters a and q we simulated above.

In the case with risk neutrality (and/or absence of risk) we know from (5) that $D^{I}(p^{N}) = \frac{N}{N+1}\left(1 - \frac{c}{dw_f - w_h}\right)$ and that the demand resulting from the sale of visas is $D^{L}(\underline{p}^{L}) = 1 - \frac{c}{dw_f - w_h}$. We deduce that $\frac{D^{L}(\underline{p}^{L}) - D^{I}(p^{N})}{D^{I}(p^{N})} = \frac{1 - \frac{N}{N+1}}{\frac{N}{N+1}} = \frac{1}{N}$. Hence the migration demand increases by $\frac{1}{N}$ following the legalisation policy. The more concentrated the smugglers' oligopolistic market the bigger is the jump. For instance the demand would increase by 50% if there are initially two cartels of smugglers on the market.

5.4 Legalisation with migration control

The calculations above were made assuming that the level of repression is kept unchanged by the government. We now allow the government to make additional investments in repression, R, which increase the marginal costs for smugglers to operate and study the level of marginal costs $c(R^*)$ which would bring the same level of migration after legalisation combined with repression as under the oligopolistic market for smugglers.

We know that $c(R^*)$ is such that $D^{I}_{ra}(p^{I}) = D^{L}\left(p^{L}(R^*)\right)$ with

$$D^{L}\left(p^{L}(R^*)\right) = 1 - \frac{log(q) - log\left(q - (1 - e^{-c(R^*)a})\right)}{a(\delta w_f - w_h)}$$

This entails $c(R^*) = p^{I}$, which is to be compared to c_{ra} as expressed by equation (25). Therefore we find easily that:

$$c(R^*) = c_{ra} + \frac{1}{N}\frac{(\delta w_f - w_h) - \frac{\log q - \log\left(q - (1 - e^{-ap^I})\right)}{a}}{\frac{e^{-ap^I}}{q - 1 + e^{-ap^I}}} \tag{26}$$

As $c(.)$ is increasing in R, this determines a unique level of repression above which the policy of legalisation with repression brings a lower level of migration than under the *statu quo*. We see straightforwardly that this level decreases with the initial number of smugglers on the market, as it is less difficult to fight against the smugglers the lower their margin of profit.

To quantify this additional effort in repression combined with legalisation to mainain the demand we can compute using (25) and (26) the per cent increase in marginal costs such scheme would involve as follows:

$$\frac{1}{N}\frac{(\delta w_f - w_h) - \frac{\log q - \log\left(q-(1-e^{-ap^I})\right)}{a}}{c_{ra}\frac{e^{-ap^I}}{q-1+e^{-ap^I}}}$$

$$\text{or } \frac{\left(qe^{ap^I} - e^{ap^I} + 1\right)(a\delta w_f - aw_h - logq + log\left(q - 1 + e^{-ap^I}\right))}{Nc_{ra}}$$

Figure 5 simulates this increase for the parameter values discussed earlier.

In the case without risk ($q = 1$) we find that the increased marginal costs have to satisfy the following:

$$c(R^*) = \frac{1}{N+1}(dw_f - w_h) + \frac{N}{N+1}c$$

which is estimated around \$106840($= \frac{1}{3}(0.8 * 575640 - 160000) + 2/3 * 10000$).[23]

This result suggests that legalising migration without increasing migration flows would require to multiply more than ten times the current marginal costs of the smugglers through additional investments in repression. As it seems reasonable to assume decreasing returns to scale to borders' enforcement measures this would require to increase by more than ten times the budget devoted to such measures.

5.5 Affordability and comparison of different policy measures

The question is whether such policy is affordable through the sale of visas. As mentioned earlier, this again highly depends on the function $c(R^*)$ as can be seen through the affordability condition $R^* < D^L\left(p^L(R^*)\right)p^L(R^*)$, which can be re-written in general as:

$$R^* < \left[1 - \frac{log(q) - log\left(q - (1 - e^{-c(R^*)a})\right)}{a(\delta w_f - w_h)}\right]\left[\frac{w_f - w_h}{a(\delta w_f - w_h)}(\log q - \log(q - 1 + e^{-c(R^*)a}))\right] \tag{27}$$

[23] We can also check reassuringly that this satisfies $D^I(p^N) = D^L\left(p^L(R^*)\right)$ using (18) and (5).

or in the case without risk ($q = 1$) as:

$$R^* < \left[1 - \frac{c(R^*)}{dw_{\mathsf{f}} - w_{\mathsf{h}}}\right] \frac{w_{\mathsf{f}} - w_{\mathsf{h}}}{dw_{\mathsf{f}} - w_{\mathsf{h}}} c(R^*) \tag{28}$$

Alternatively the government could make additional investmentsin internal repression and increase the probabilities of deportation of illegal migrants (hence decreasing q in our model) to acieve the same goal of legalising without increasing the migration demand. Similarly as above the minimum additional amount of investments R^* should be such that $D^{\mathsf{l}}_{\mathsf{fa}}(p^{\mathsf{l}}) = D^{\mathsf{L}}\left(p^{\mathsf{L}}(R^*)\right)$ or after replacing $q(R^*) = q\frac{(1-\mathsf{e}^{-ca})}{1-\mathsf{e}^{-p^I a}}$. After calculating the percent decrease in q necessary to implement such scheme as $1 - \frac{(1-\mathsf{e}^{-ca})}{1-\mathsf{e}^{-p^I a}}$, Figure 5 simulates it for the same range of degrees of risk aversion as studied above. Again we could rewrite the affordability condition (27) above by endogeneising q as a function of R^* (instead of c kept constant) and see that this highly depends on the elasticity of the function $q(R^*)$.

In the case with no risk of deportation, we could also consider repression measures, which would lower the expected earnings abroad (such as punishing the employers for hiring undocumented employees). With the same reasoning as above we determine the level of discounting on wages in the foreign country, d^*, which yields the same level of migration after legalisation as under the oligopolistic market for smugglers. Assuming a uniform distribution of skills d^* is such that:

$$\frac{N}{N+1}\left(1 - \frac{c}{dw_{\mathsf{f}} - w_{\mathsf{h}}}\right) = 1 - \frac{c}{d^* w_{\mathsf{f}} - w_{\mathsf{h}}} \tag{29}$$

Replacing in (29) with the former results of our calibrations and $N = 2$ yields $d^* \simeq 0.33$ and we could again straightforwardly the studdy the affordability condition (28) where $d(R^*)$ is a funtion of the additional investments R^* (instead of c kept constant) and see that this highly depends on the elasticity of the function $d(R^*)$.

Accordingly, a government who would aim at legalising migration without increasing migration flows, should increase repression measures to reduce the expected earnings of illegal migrants to 33% of the earnings of workers of same skills employed in the legal sector of the economy.

Whether investing additional repression into punishment of employers of illegal workers is more cost-effective than increasing borders' enforcement measures, which increase marginal costs for smugglers to operate, remains largely open. However, with improvements of modern technologies such as biometric identity documents it may be argued that, in some cases as in the US, more effective controls of undocumented workers at the workplace, may become a more effective means of control than borders' enforcement. Moreover, it could be more easily financed by the fines paid by the employers, which can complement the resources raised through the sale of visas.

6 Conclusion

This paper has addressed a simple question: is there a role for the state to regulate migration flows by selling visas to would-be migrants?

The answer is nuanced. When smugglers have already paid fixed costs to settle their businesses, it is difficult for the government to compete. The model shows that dismantling migration flows by proposing a low enough price would be at the cost of increasing substantially migration flows and decreasing the average skill level of migrants. So there is a trade-off between having fewer illegal migrants or more legal migrants in the economy. We also show that selling migration visas a government cannot do better to control migration flows than leaving a monopolistic smuggler to operate unconstrained. On the other hand, repressive measures, which tend to increase the costs of smugglers to operate, may be effective at controlling migration flows. However, such measures are not satisfactory either, as they increase the price paid by illegal migrants to smugglers, hence, increasing the amount of resources feeding the illegal sector of the economy. The paper studies then a combination of policies using repression and pricing tools, which would allow a government to dismantle the smugglers while limiting migration flows without necessarily increasing the budget deficit.

So the question that remains largely open is why such pricing tools combined with other policy instruments are not used to legalise migration. Although an-

swering this question is beyond the scope of the paper, we may consider a few hypotheses that are worth investigating in future work and other fields of social sciences. In some countries like France one immediate answer is that the legal framework is very strong and could not easily be modified to introduce such pricing schemes, which, in the field of migration, would be considered as unethical or violating human rights. However, one may argue that, without complete opening of the borders between countries, rationing of visas generates important monetary "hidden costs", such as briberies, paid by applicants. This also provides rents to those who succeed to migrate legally and the other "unlucky" illegal migrants are often exploited in destination countries, in addition to risking their life and financial resources to migrate. From this viewpoint, it is not clear that transparent pricing tools would be less ethical than the existing situation, which also creates rents to smugglers and feeds all kinds of illegal activities. A second answer highlighted in the paper is that "natives" may prefer to have fewer and lowly paid illegal immigrants rather than a larger number of legal workers, who would enjoy a more complete set of rights, including the access to social benefits, public services and political rights.[24]

A third hypothesis supported by our calibrations is that "affordable" and effective migration policies may involve sanctioning employers of illegal migrants. Although this may be a more effective way to legalise migration while limiting migration flows than re-inforcing borders' controls, such "affordable" policy will typically encounter strong resistance from powerful lobbies as observed for example in the US. All these considerations may explain why, under current policies, large number of illegal migrants still bear the costs of being exploited in destination areas and face the constant risk of being deported.

[24] We can also use the model to calibrate the revealed loss for a society of having additional migrants following the implementation of a legalisation scheme through the sale of visas. Based on the rough estimates used above, our estimates show that the revealed costs for the society per additional migrant are higher than the fees paid by long distance illegal migrants. These results are available upon request.

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8 Appendix

8.1 Negative or intermediate self-selection of illegal workers

A strong assumption of the model is that illegal workers self-select positively through migration according to their skill level. This generates interesting findings as a government will compete with smugglers to attract the highest skill workers of the poor economy by selling migration visas. However, depending on the relative returns to skill in the origin and destination countries the case of negative self-selection of workers (i.e. from the bottom of the skill distribution in the origin economy) may also occur through illegal migration. Moreover the existence of liquidity constraints may also generate an intermediate selection of illegal workers (i.e. from the middle of the skill distribution). These two types of selection characterise the large migration flows of undocumented Mexican

workers to the US in the low costs period pre 1993 and high costs periods post 1993 (Borger 2011).

To capture the case of negative selection, we could adopt the extreme assumption that workers working in the illegal sector of the destination country are paid at a flat rate, dw_{f} which does not depend on their skill.[25] After writing the migration condition as $\theta w_{\mathsf{h}} < dw_{\mathsf{f}} - p$, we can solve for the skill threshold, noted θ^{l}, *below* which an individual prefers to migrate illegally than not migrate:

$$\theta^{\mathsf{l}} = \frac{dw_{\mathsf{f}} - p}{w_{\mathsf{h}}} \tag{30}$$

This shows that workers are more likely to migrate the higher the wage differential between foreign and home countries and the lower their productivity.

After aggregating over the distribution of skills, we obtain the demand for illegal migration as a function of migration price p:

$$D^{\mathsf{l}}(p) = \int_0^{I} f(\theta)d\theta = F(\theta^{\mathsf{l}}) \tag{31}$$

As θ^{l} is decreasing in p and w_{h} and increasing in d and w_{f}, it is easy to show that, once again, the demand for illegal migration is higher the lower the migration price, p, and the higher the wages differential $dw_{\mathsf{f}} - w_{\mathsf{h}}$ between the two countries.

We study what happens if the government enters the migration market and sells visas. If returns to skill are higher in the legal sector of the destination country than in origin country, legal migration will attract the highest skilled workers. (A simple case is assuming wages in the legal sector equal to θw_{f} and there are fixed costs of migration) Therefore, following the legalisation policy, a different pool of workers, who would not have migrated illegally otherwise, will decide to migrate legally. Moreover, there will be a large increase in the average skill level of migrants due to the positive selection of new immigrants through legal migration, which arrive in addition to the pool of illegal migrants. And

[25] Such extreme assumption could be relaxed by considering a flatter rate of return to skill in the illegal sector of the foreign country as compared to the labour market in the origin country, without changing the key insight of this Appendix.

the government using this tool does not compete with established smugglers, unless it proposes a price so low that it attracts all the workers.

So, if the aim of the policy is to eradicate human smuggling by competing with them and attracting the low skilled-workers, a more effective policy in this case would be to sell visas to low skilled-workers only and the same reasoning as in the present paper would hence apply but at the bottom of the skill distribution.

In a more flexible model with intermediate selection of undocumented workers due to liquidity constraints (Borger 2011) and positive selection of legal workers the sale of visas should still be targeted to lower skill workers to be effective at pushing smugglers out of business.

8.2 Example for Proposition 2

This section develops Proposition 2 in the case of a uniform distribution of skills distributed over 0 and 1. From (9), the profits of the smuggler when the government proposes a (legal) migration price, p^{L}, are written successively as:

$$\begin{aligned}\Pi(p^{\mathsf{I}}, p^{\mathsf{L}}) &= (p^{\mathsf{I}} - c) \int_{\frac{p^I}{dw_f - w_h}}^{(\mathsf{p}^L - \mathsf{p}^I)=(1-\mathsf{d})\mathsf{w}_f} d\theta \\ \Pi(p^{\mathsf{I}}, p^{\mathsf{L}}) &= (p^{\mathsf{I}} - c) \left[\frac{(p^{\mathsf{L}} - p^{\mathsf{I}})}{(1-d)w_{\mathsf{f}}} - \frac{p^{\mathsf{I}}}{dw_{\mathsf{f}} - w_{\mathsf{h}}} \right]\end{aligned}$$

which, after maximisation and simplification, gives :

$$p^{\mathsf{I}}(p_{\mathsf{L}}) = p_{\mathsf{L}} \frac{(dw_{\mathsf{f}} - w_{\mathsf{h}})}{2(w_{\mathsf{f}} - w_{\mathsf{h}})} + c/2 \tag{32}$$

We now turn to showing that such reaction smuggler price is smaller than the price imposed by the smuggler under unconstrained monopoly.

Replacing in (32) with the optimal price imposed by the government $p^{\mathsf{L}*} = [c + 2(1-d)w_{\mathsf{f}}]\,(\frac{(\mathsf{w}_f - \mathsf{w}_h)}{(2-\mathsf{d})\mathsf{w}_f - \mathsf{w}_h})$, we find:

$$p^{\mathsf{I}}(p^*_{\mathsf{L}}) = [c + 2(1-d)w_{\mathsf{f}}]\,(\frac{(dw_{\mathsf{f}} - w_{\mathsf{h}})}{2(2-d)w_{\mathsf{f}} - 2w_{\mathsf{h}}}) + c/2$$

and compare it to the price under unconstrained smuggler's monopoly equal to:

$$p^{\mathsf{m}} = (dw_{\mathsf{f}} - w_{\mathsf{h}})/2 + c/2$$

After replacing and simplifying the inequality, we find easily that

$$p^{\mathsf{I}}(p_{\mathsf{L}}^*) < p^{\mathsf{m}} if and only if c < [dw_{\mathsf{f}} - w_{\mathsf{h}}]$$

From (1), we obtain that: $dw_{\mathsf{f}} - w_{\mathsf{h}} > p$ otherwise there is no illegal migrant. Moreover, necessarily $c < p$ otherwise the smuggler does not operate. Therefore, when the smuggler operates, we find necessarily that $c < (dw_{\mathsf{f}} - w_{\mathsf{h}})$, which implies that $p^{\mathsf{I}}(p_{\mathsf{L}}^*) < p^{\mathsf{m}}$.

8.3 Proof of Proposition 3

Let $p^{\mathsf{L}}(R) = \frac{w_f - w_h}{dw_f - w_h} c(R)$ the price which dismantles the traffickers and let $D^{\mathsf{L}}(R) = D^{\mathsf{L}}\left(\frac{w_f - w_h}{dw_f - w_h} c(R)\right)$ the legal demand for visas associated to this price. The budget constraint for the state results in: $R \leq D^{\mathsf{L}}(R) p^{\mathsf{L}}(R)$. The government that aims at minimizing immigration while dismantling smugglers without increasing the budget deficit then solves:

$$\min_{\mathsf{R}} D^{\mathsf{L}}(R)$$

$$R \leq D^{\mathsf{L}}(R) p^{\mathsf{L}}(R)$$

Since by assumption $D^{\mathsf{L}\prime}(p) < 0$ (normal good) and $c'(R) > 0$, the demand verifies $\frac{dD^{L}(R)}{dR} < 0$. It reaches its minimum when R is maximum. We deduce that, at the optimum, the constraint is binding. To complete the proof we need to show that for a broad class of cost functions, $c(R)$, there exists a unique fixed point, $R^* > 0$, so that $R^* = D^{\mathsf{L}}(R^*) p^{\mathsf{L}}(R^*)$.

Let $\gamma(R) = \frac{R}{D^{L}(R)}$. The solution to the government problem verifies $\gamma(R) = p^{\mathsf{L}}(R)$. Under the assumptions that $D^{\mathsf{L}}(p)$ is decreasing and concave, that $c(R)$ is increasing, concave and that $c(0) = c$ and $\lim_{R \to +\infty} c(R) = \overline{c} < \overline{\theta}\,(dw_{\mathsf{f}} - w_{\mathsf{h}})$, we have:

- $D^{\mathsf{L}}(R)$ is decreasing and concave in R so that $\gamma'(R) > 0$ and $\gamma''(R) > 0$.
- $p^{\mathsf{L}}(R)$ is increasing and concave.
- $p^{\mathsf{L}}(0) = \frac{w_f - w_h}{dw_f - w_h} c > 0 = \gamma(0)$.

- $\lim_{R\to+\infty} p^L(R) = \frac{w_f - w_h}{d w_f - w_h}\overline{c} < \lim_{R\to+\infty} \gamma(R) = \frac{\lim_{R\to+\infty} R}{D^L\left(\frac{w_f - w_h}{d w_f - w_h}\overline{c}\right)} \to +\infty$

We deduce that $\gamma(R)$ and $p^L(R)$ cross only once at $R^* > 0$. QED

We now assume that additional investments in sanctions are marginally less effective such that $d(.)$ is decreasing and convex ($d'(F) < 0$ and $d''(F) > 0$) and that $\lim_{F\to+\infty} d(F) = \underline{d}$ such that $(\underline{d} w_f - w_h) > c$. The convex shape indicates decreasing returns to scale in the fight against illegal work. Moreover, there is a lower bound to the discount factor to work in the illegal sector, which may be due to a range or reasons including political-economy issues. We assume that this bound is such that it is not possible to totally eradicate migration through internal controls only.

We can show very similarly that increasing fines to employers using additional internal enforcement measures, F, instead of additional investments in borders' enforcement, R, the budget constraint for the state results in: $F \leq D^L(F)p^L(F)$. The government that aims at minimizing immigration while dismantling smugglers without increasing the budget deficit solves:

$$\min_F D^L(F)$$

$$F \leq D^L(F)p^L(F)$$

Since by assumption $D^{L\prime}(p) < 0$ (normal good),using $p^L(F) = \frac{w_f - w_h}{d(F) w_f - w_h} c$ and $d'(F) < 0$, the demand verifies $\frac{dD^L(F)}{dF} < 0$. It reaches its minimum when F is maximum. We deduce that, at the optimum, the constraint is binding. To complete the proof we need to show that for a broad class of cost functions, $d(F)$, there exists a unique fixed point, $F^* > 0$, so that $F^* = D^L(F^*)p^L(F^*)$.

Let $\mu(F) = \frac{F}{D^L(F)}$. The solution to the government problem verifies $\mu(F) = p^L(F)$. Under the assumptions that $D^L(p)$ is decreasing and concave, that $d(F)$ is decreasing, convex and that $d(0) = d$ and $\lim_{F\to+\infty} d(F) = \underline{d}$ such that $\overline{\theta}\,(\underline{d} w_f - w_h) > c$, we have:

- $D^L(F)$ is decreasing and concave in F so that $\mu'(F) > 0$ and $\mu''(F) > 0$.

- $p^L(F)$ is increasing and concave.
- $p^L(0) = \frac{w_f - w_h}{dw_f - w_h} c > 0 = \gamma(0)$.
- $\lim_{F \to +\infty} p^L(F) = \frac{w_f - w_h}{dw_f - w_h} c < \lim_{F \to +\infty} \mu(F) = \frac{\lim_{F \to +\infty} F}{D^L\left(\frac{w_f - w_h}{dw_f - w_h} c\right)} \to +\infty$

We deduce that $\mu(F)$ and $p^L(F)$ cross only once at $F^* > 0$. QED

In order to compare the cost effectiveness of the two types of instruments, we show that $D^L(F^*) < D^L(R^*)$ is successively equivalent to:

$$\begin{aligned} p^L(F^*) &> p^L(R^*) \\ \frac{w_f - w_h}{dw_f - w_h} c(R^*) &< \frac{w_f - w_h}{d(F^*)w_f - w_h} c \\ \frac{c(R^*)}{c} &< \frac{dw_f - w_h}{d(F^*)w_f - w_h} \end{aligned}$$

The relative cost-effectiveness of the two instruments thus highly depends on the relative elaticity of the two functions $c(.)$ and $d(.)$ to additional investments in external controls (R^*) versus internal ones (F^*).

8.4 Risk aversion

Proof of Lemma 1

Applying the expected utility theorem and comparing the individual's expected utility in case he/she migrates, equal to $qu(\theta\delta w_f - p^I) + (1-q)u\left(\theta w_h - p^I\right)$ with the expected utility in case she does not migrate, equal to $u\left(\theta w_h\right)$, we can write the migration condition as: $u\left(\theta w_h\right) < qu(\theta\delta w_f - p^I) + (1-q)u\left(\theta w_h - p^I\right)$. Studying the threshold such that an individual is just indifferent between migrating illegally or not migrating, the marginal type θ^I_{ra} is the solution of the following equation: $u\left(\theta w_h\right) = qu(\theta\delta w_f - p^I) + (1-q)u\left(\theta w_h - p^I\right)$. Substituting $u(x) = 1 - exp(-ax)$ and rearranging this expression, we obtain the illegal migration threshold θ^I_{ra} as a solution of the equation (22): $\frac{1 - e^{-ap^I}}{1 - e^{-a\theta(\delta w_f - w_h)}} = q$.

Let $\nu(\theta) = \frac{1 - e^{-ap^I}}{1 - e^{-a\theta(\delta w_f - w_h)}}$. Deriving twice the function $\nu(\theta)$ one can easily check that it is decreasing and convex in θ. Moreover $\lim_{\to 0} \nu(\theta) = +\infty$ and

$\lim_{\to\infty} \nu(\theta) = 1 - e^{-\mathsf{ap}^I}$. We deduce, first, that if q is strictly higher than $1 - e^{-\mathsf{ap}^I}$ then $\theta^{\mathsf{l}}_{\mathsf{ra}}$ exists and is unique and, second, that $\theta^{\mathsf{l}}_{\mathsf{ra}}$ is decreasing with q.

We can write the demand for illegal migration as a function of the migration price p^{l} similarly as before, except that θ^{l} is now replaced by $\theta^{\mathsf{l}}_{\mathsf{ra}}$:

$$D^{\mathsf{l}}_{\mathsf{ra}}(p^{\mathsf{l}}) = \int_{\frac{I}{ra}}^{-} f(\theta)d\theta = 1 - F(\theta^{\mathsf{l}}_{\mathsf{ra}}) \tag{33}$$

As $\theta^{\mathsf{l}}_{\mathsf{ra}}$ is increasing in p^{l} and decreasing in δ, the demand for migration remains higher the lower the migration price, p^{l}, and the higher the wages differential $\delta w_{\mathsf{f}} - w_{\mathsf{h}}$ between the two countries. The logic of the pricing scheme of smugglers described in section 2 remains thus the same as before but it takes into account the new (lower) demand from risk averse individuals (33).

We now formally show in the uniform example that risk aversion implies that the price imposed by smugglers is then lower than the price they would impose to risk neutral individuals with the same expected revenue from migration With risk neutrality we have $\theta^{\mathsf{l}}(p) = \frac{\mathsf{p}}{\mathsf{dw}_f - \mathsf{w}_h}$ and

$$D^{\mathsf{l}}(p) = \int_{I}^{1} f(\theta)d\theta = 1 - F(\theta^{\mathsf{l}}) = 1 - \theta^{\mathsf{l}}(p) \tag{34}$$

We deduce that the (absolute value) of the price elasticity of demand is:

$$\varepsilon_{D,p} = \frac{-D^{\mathsf{l}\prime}(p)p}{D^{\mathsf{l}}(p)} = \frac{\theta^{\mathsf{l}}(p)}{1 - \theta^{\mathsf{l}}(p)} = \frac{p}{(dw_{\mathsf{f}} - w_{\mathsf{h}}) - p}$$

With risk aversion, we have $\theta^{\mathsf{l}}_{\mathsf{ra}}$ which is such that:

$$\frac{1 - e^{-\mathsf{ap}}}{1 - e^{-\mathsf{a}\ (\ \mathsf{w}_f - \mathsf{w}_h)}} = q \tag{35}$$

We deduce that :

$$\theta^{\mathsf{l}}_{\mathsf{ra}}(p) = \frac{log(q) - log\left(q - (1 - e^{-\mathsf{ap}})\right)}{a(\delta w_{\mathsf{f}} - w_{\mathsf{h}})} \tag{36}$$

the demand is:

$$D^{\mathsf{l}}_{\mathsf{ra}}(p) = \int_{\frac{I}{ra}}^{1} f(\theta)d\theta = 1 - F(\theta^{\mathsf{l}}_{\mathsf{ra}}) = 1 - \theta^{\mathsf{l}}_{\mathsf{ra}}(p) \tag{37}$$

It is straightforward to check that if $q = 1$ (i.e., there is no risk of deportation in migrating illegally) then $\delta = d$ so that $\theta^{I}_{ra}(p) = \theta^{I}(p)$.

We deduce that the (absolute value) of the price elasticity of demand is:

$$\varepsilon_{D_{ra},p} = \frac{-D^{I\prime}_{ra}(p)p}{D^{I}_{ra}(p)} = \frac{p\frac{e^{-ap}}{q-1+e^{-ap}}}{(\delta w_f - w_h) - \frac{\log(q)-\log(q-(1-e^{-ap}))}{a}} \tag{38}$$

Here again it is easy to check that $\varepsilon_{D_{ra},p} = \varepsilon_{D,p}$ when $q = 1$. After differentiating $\varepsilon_{D_{ra},p}$ with respect to $q \leq 1$ and noting that $a(\delta w_f - w_h) - log(q) + log\left(q - (1 - e^{-ap})\right) > 0$ as $0 < \theta^{I}_{ra}(p) < 1$ one can check that $\varepsilon_{D_{ra},p}$ is decreasing in q:

$$\frac{d\varepsilon_{D_{ra},p}}{dq} \equiv -\Big(a(\delta w_f - w_h) - log(q) + log\left(q - (1 - e^{-ap})\right)\Big) - \frac{1 - e^{-ap}}{q} < 0 \tag{39}$$

So when the risk augments (i.e. q diminishes) the demand price elasticity increases, and thus, everything else being equal, the monopoly price is lower.QED

Proof of Lemma 2

We now turn to the government policy of visas sale and the reaction of smugglers. If individuals can buy a legal permit to migrate at price p^{L}, smugglers need to price their services low enough so that at least one individual wishes to migrate illegally. The skill level θ^{L}_{ra} of the marginal illegal migrant who is just indifferent between migrating illegally and legally satisfies $u\left(\theta w_f - p^{L}\right) = qu(\theta\delta w_f - p^{I}) + (1 - q)u\left(\theta w_h - p^{I}\right)$. Substituting $u(x) = 1 - exp(-ax)$ and rearranging this expression, we obtain the legal migration threshold θ^{L}_{ra} as a solution of the following equation:

$$\frac{1 - e^{-a(\ (w_f - w_h) + p^I - p^L)}}{1 - e^{-a\ (\ w_f - w_h)}} = q \tag{40}$$

Solving for the threshold θ^{L}_{ra} and comparing it to (7) we show in the following that $\theta^{L}_{ra} < \theta^{L}$.

Proof. Let $\rho(\theta) = \frac{1-e^{-a(\theta(w_f - w_h) + p^I - p^L)}}{1-e^{-a\theta(\delta w_f - w_h)}}$. Equation (40)defines θ^{L}_{ra} as a solution of $\rho(\theta) = q$. The benchmark case of risk neutrality is obtained by setting $q = 1$ in this equation. Indeed when $q = 1$ and $\delta = d$ the unique solution to $\rho(\theta) = 1$

is θ^{L} defined equation (7). This also implies that the function $\rho(\theta)$ crosses once and only once the horizontal line 1.

Next, deriving $\rho(\theta)$ with respect to θ yields:

$$\rho'(\theta) = \frac{a(1-e^{-a(\ (w_f-w_h)+p^I-p^L)})}{1-e^{-a\ (\ w_f-w_h)}} \left\{ \frac{(w_f - w_h)e^{-a(\ (w_f-w_h)+p^I-p^L)}}{1-e^{-a(\ (w_f-w_h)+p^I-p^L)}} - \frac{(\delta w_f - w_h)e^{-a\ (\ w_f-w_h)}}{1-e^{-a\ (\ w_f-w_h)}} \right\}$$

To study the sign of $\rho'(\theta)$ we consider 2 cases:

- If $\theta \leq \frac{p^L-p^I}{w_f-w_h}$ then $\theta(w_f-w_h)+p^I-p^L \leq 0$ so that $1-e^{-a(\ (w_f-w_h)+p^I-p^L)} \leq 0$. Since by assumption $w_f - w_h \geq \delta w_f - w_h \geq 0$ all the other elements in the fractions composing $\rho'(\theta)$ are positive. We deduce that both the first term and the term in the brackets are negative such that $\rho'(\theta) > 0$.

- If $\frac{p^L-p^I}{w_f-w_h} < \theta \leq \frac{p^L-p^I}{(1-\ )w_f} = \theta^{L}$ then $0 < \theta(w_f-w_h)+p^I-p^L \leq \theta(\delta w_f-w_h)$ and $1-e^{-a(\ (w_f-w_h)+p^I-p^L)} > 0$. Since $1-e^{-ax}$ is log concave in x, we have that $\frac{e^{-a(\theta(w_f-w_h)+p^I-p^L)}}{1-e^{-a(\theta(w_f-w_h)+p^I-p^L)}} \geq \frac{e^{-a\theta(\delta w_f-w_h)}}{1-e^{-a\theta(\delta w_f-w_h)}}$. Moreover we have $w_f-w_h \geq \delta w_f-w_h \geq 0$ such that the term in the brackets is now positive. Similarly the first term is also now positive such that $\rho'(\theta) > 0$.

We have just shown that the continuous function $\rho(\theta)$ is increasing for $\theta \in [0, \theta^{L}]$. Moreover it crosses once and only once the horizontal line at $q = 1$ for $\theta = \theta^{L}$. We deduce that for $\theta > \theta^{L}$ $\rho(\theta) > 1$ so that equation (40) never holds. The relevant domain for θ^{L}_{ra} in equation (40) when q varies between 0 and 1 is $\theta \in [0, \theta^{L}]$. This implies that if θ^{L}_{ra} exists it is necessarily such that $\theta^{L}_{ra} \leq \theta^{L}$ with a strict inequality for any $q < 1$.

To finish the proof of Lemma 2 we need to show that θ^{L}_{ra} exists and is unique. It is done by noting that $\lim_{\to 0} \rho(\theta) = -\infty$. So the function $\rho(\theta)$ strictly increases between $-\infty$ and 1 when θ varies between 0 and θ^{L}. It necessarily crosses the line $q \in [0, 1]$ once and only once.QED ■

Proof of Lemma 3

In order to eradicate the smugglers we know that

$$\theta^{I}_{ra}(c) = \theta^{L}_{ra}(c, p^{L}_{ra}) \tag{41}$$

with $\theta^{I}_{ra}(c) = \frac{\log(q)-\log\left(q-(1-e^{-ca})\right)}{a(\ w_f-w_h)}$ and $\theta^{L}_{ra}(c, p^{L}_{ra})$ is the implicit solution of $q = \frac{1-e^{-a(\theta(w_f-w_h)+c-p^{L}_{ra})}}{1-e^{-a\theta(\delta w_f-w_h)}}$.

This implies that p^{L}_{ra} is solution solution of

$$\begin{aligned} q(1-e^{-a\ (\ w_f-w_h)}) &= 1-e^{-a(\ (w_f-w_h)+c-p^{L}_{ra})} \\ \text{with } \theta &= \frac{\log(q)-\log\left(q-(1-e^{-ca})\right)}{a(\delta w_f-w_h)} \end{aligned}$$

This yields successively that:

$$\begin{aligned} c &= \theta(w_f-w_h)+c-p^{L}_{ra} \text{ with } \theta = \frac{\log(q)-\log\left(q-(1-e^{-ca})\right)}{a(\delta w_f-w_h)} \\ p^{L}_{ra} &= \frac{\log(q)-\log\left(q-(1-e^{-ca})\right)}{a(\delta w_f-w_h)}(w_f-w_h) \\ p^{L}_{ra} &= \frac{w_f-w_h}{a(\delta w_f-w_h)}(\log q-\log(q-1+e^{-ca})) \end{aligned} \tag{42}$$

and we can check easily that $dp^{L}_{ra}/dq < 0$.QED

The reasoning of section 3.2.2 remains valid under risk aversion. The IR constraint, which can be written $1-e^{-a(\bar{}w_f-p^{L})} \geq 1-e^{-a\bar{}w_h}$, is unchanged. The IC constraint becomes $1-e^{-a(\bar{}w_f-p^{L})} \geq q(1-e^{-a(\bar{}\ w_f-p^{I})})+(1-q)(1-e^{-a(\bar{}w_h-p^{I})})$. The IC constraint is binding if $q(1-e^{-a(\bar{}\ w_f-p^{I})})+(1-q)(1-e^{-a(\bar{}w_h-p^{I})}) \geq 1-e^{-a\bar{}w_h}$, which is a necessary condition for the smuggler to be active. So if the smuggler is active the binding constraint is the IC and $\overline{p}^{L}_{ra}$ is solution of the following equation:

$$e^{-a(\bar{}w_f-p^{L})} = qe^{-a(\bar{}\ w_f-p^{I}_{ra}(p^{L}))}+(1-q)e^{-a(\bar{}w_h-p^{I}_{ra}(p^{L}))}$$