The international platform of Ludwig-Maximilians University's Center for Economic Studies and the Ifo Institute

Working Papers
www.cesifo.org/wp

Tradable Immigration Quotas

Jesús Fernández-Huertas Moraga
Hillel Rapoport

CESIFO WORKING PAPER NO. 4087
CATEGORY 1: PUBLIC FINANCE
JANUARY 2013

CESifo
Center for Economic Studies & Ifo Institute

CESifo *Working Paper No. 4087*

Tradable Immigration Quotas

Abstract

International migration is maybe the single most effective way to alleviate global poverty. When a given host country allows more immigrants in, this creates costs and benefits for that particular country as well as a positive externality for individuals and governments who care about world poverty. This implies that the existing international migration regime is inefficient as it fails to internalize such externality. In addition, host countries quite often restrict immigration due to its apparently unbearable social and political costs, however these costs are never measured and made comparable across countries. In this paper we first discuss theoretically how tradable immigration quotas (TIQs) can reveal countries' comparative advantage in hosting immigrants and, once coupled with a matching mechanism taking migrants' preferences over destinations and countries preferences over migrants' types into account, generate substantial welfare gains. We then discuss two potential applications: a market for the resettlement of international (e.g., climate change) refugees, and the creation of an OECD poverty-reduction visa program adapted from the US green card lottery.

JEL-Code: F220, F500, H870, I300, K330, O190.

Keywords: immigration, immigration policy, tradable quotas, refugees resettlement, climate change, international public goods.

Jesús Fernández-Huertas Moraga
FEDEA & IAE (CSIC)
Jorge Juan, 46
Spain – 28001 Madrid
jfernandezhuertas@fedea.es

Hillel Rapoport
Center for International Development
Kennedy School of Government
Harvard University
79 JFK Street
USA – Cambridge, MA 02138
hillel.rapoport@hks.harvard.edu

January 10, 2013

> I am distressed by the sight of poverty; I am benefited by its alleviation; but I am benefited equally whether I or someone else pays for its alleviation (Milton Friedman, "Capitalism and Freedom", 1962, page 191)[1]

1 Introduction

People care about poverty out of altruism (i.e., genuine concern for others' well-being) and self-interest, because they fear for their security, health, and property. To the same extent that domestic poverty alleviation has the dimension of a domestic public good, international poverty alleviation has the dimension of an international public good. Whenever a given country increases its foreign aid to one of the countries where many of the world's poor live, this generates a positive externality for all those in the world, individuals and governments, who care about international poverty reduction. Whenever a given country chooses to "let their people come" (Pritchett, 2006), increasing the number of immigration visas granted to nationals of one of the countries where many of the world poor live, this generates a positive externality for all those who care about international poverty reduction. In both cases and given the public good nature of poverty alleviation, free riding is likely to prevail and result in global under-provision of foreign aid, debt relief programs, and immigration visas. While the international community has established international organizations and set up institutions to coordinate foreign aid and debt relief efforts, no such institutional setting exists for international migration.

In reality, high-income countries quite often restrict immigration of poor people from

[1]We thank Ran Abramitzky, Simone Bertoli, Omer Biran, George Borjas, Brian Burgoon, Roberto Burguet, María Calle, Alessandra Casella, Kfir Eliaz, Avner Greif, Timothy Hatton, Glenn Loury, Igal Milchtaich, Panu Poutvaara, Lant Pritchett, Dani Rodrik, Robert Stavins, Eiko Thielemann, David Weil, participants at the 4^{th} INSIDE Workshop (Barcelona), the 3^{rd} AFD-World Bank Migration and Development Conference, the 2010 Meeting of the Spanish Economic Association, the 2012 Environment and Development Conference at CERDI, the Third TEMPO Conference on International Migration at the IAB in Nuremberg, the first CEMIR conference at CESifo, Munich, December 2012, and seminar audiences at IAE (CSIC), Lille, Paris School of Economics, Toulouse School of Economics, Harvard Kennedy School, Harvard Center for Population and Development Studies, Science Po, Stanford, Louvain, UCL and Brown, for comments and suggestions. We are particularly indebted to David De la Croix and Frédéric Docquier for stimulating exchanges and to Lídia Brun for helpful research assistance. Jesús Fernández-Huertas Moraga received financial support from the ECO2008-04785 project funded by the Spanish Ministry for Science and Innovation.

poor countries due to its apparently unbearable social and political costs. However, these non-economic costs – potential threats to national identity and social cohesion - are never measured and made comparable across countries.[2] Differences in the perceived costs of immigration may come from different demographic structures (e.g., dependency ratios), histories of previous immigration, or preferences for ethnic, religious and cultural diversity. Whatever the source, these differences imply that some countries have a comparative advantage in hosting immigrants. A system of tradable immigration quotas (TIQs), therefore, creates an opportunity to reveal and exploit such comparative advantages.[3] We first show this theoretically in Section 2 where we adapt a generic model of tradable quotas to migration and supplement it with a matching mechanism taking migrants' and countries' preferences into account. This matching component is essential because, in contrast for example to pollution particles – a well-know application of tradable quotas –, migrants have preferences over their destination and destination countries have preferences over the origin (and, possibly, other characteristics) of immigrants. Taking these preferences into account creates opportunities for strategic behavior that may undermine the efficiency of the proposed system but that can also boost its attractiveness. Finally, the feasibility of a TIQs system is evaluated in Section 3 against the background of two potential applications: a market for the resettlement of international (including climate change) refugees, and an OECD poverty-reduction visa program inspired by the US diversity lottery. The rest of this introduction discusses the poverty-alleviation effects of international migration, the idea that visas can substitute for aid, and the related literature.

1.1 International migration and poverty reduction

Globalization is quite advanced for goods and capital but still very imperfect for low-skill labor mobility. Partly due to this asymmetry in the extents of globalization at different

[2]Clearly, negative attitudes toward immigration constitute a strong political barrier to more labor mobility. See for example O'Rourke and Sinnott (2006), Dustmann and Preston (2007), Hanson, Scheve and Slaughter (2007), Mayda (2008), Facchini and Mayda (2008), or Hainmueller and Hiscox (2010). Using survey data from 21 European countries, Card, Dustmann and Preston (2012) find that "non-economic costs", which they term "compositional concerns,"are two to five times more important in explaining attitudes towards immigration than concerns about wages and net fiscal contributions.

[3]See Reinhart (2000) for evidence on the fact that firms learn their cost functions when incentivized to do so through a system of tradable pollution permits.

margins, the potential gains from even a small liberalization of international migration are orders of magnitude higher than, say, a full liberalization of trade in goods and services, a comprehensive full debt relief program, or a doubling of official development aid (Pritchett, 2006, 2010; Clemens, 2011). In the words of Rodrik (2007, p. 240), therefore, allowing for more international mobility of workers today is really "going for the real gains."The poverty-reduction effect of these gains, obviously, depends on their distributional impact across and within countries. Recent literature suggests that this impact is substantial both directly (that is, through the extraction of migrants out of poverty) and indirectly, through the developmental impact of migration on source countries.

The main difficulty in measuring the income gains accruing to migrants as a result of migration is to produce sensible counterfactuals of domestic earnings for migrants, accounting not just for their observable characteristics but also for unobservable characteristics such as motivation at work, attitudes toward risk, cognitive ability, etc. McKenzie, Gibson and Stillman (2010) use the New Zealand migration lottery program to "clean" income gains estimates from such self-selection effects. Comparing lottery-winning migrants to lottery-losing non-migrants, they find migration increases migrants' earnings by a factor of four. This is consistent with the non-experimental results of Clemens, Montenegro and Pritchett (2008) who compare workers in developing countries to workers from the same countries working in the United States. After controlling for workers' characteristics, migration is found to raise real wages by 200 percent, 250 percent and 680 percent respectively for Guatemalans, Filipinos and Haitians. These income gains would seem to exceed the potential gains of any *in situ* development policy by orders of magnitude. For example, they calculate that the total present value of access to a lifetime of micro-credit is equivalent to the wage difference of just four work weeks of the same worker in the US versus in Bangladesh, or that the present value of a lifetime wage increment of one additional year of schooling (obtained at no cost) is equivalent to 11 weeks work of the same worker in the US versus in Bolivia.

The effects of migration on poverty reduction through the direct extraction of migrants out of poverty can be illustrated by figures put together by Clemens and Pritchett (2008) using three poverty standards at US$1, 2 and 10 per day (in PPP). Respectively 50, 75 and 93 percent of all Haitian "naturals" (people born in Haiti) live below the $1, 2 and 10 poverty lines. Out of the 25 percent of all Haitians between the first two lines, 26 percent are US immigrants. Out of the 18 percent between the last two lines, 82 percent are US immigrants.

By the latter measure, among the 56 percent of all Mexicans between the last two lines, 43 percent are US immigrants. While it would be an abuse of language to interpret these figures as indicative of the share of people escaping poverty thanks to migration, they are clearly suggestive of large direct effects of migration on poverty reduction.[4] In addition, we know that while migrants initially come from the middle of the income and wealth distributions, network and other dynamic effects act to reduce migration costs, making migration affordable to households down the income ladder. This generates poverty and inequality reducing effects both directly, through migrants' self-selection patterns, and indirectly, through general equilibrium effects and distributional effects of remittances gradually reaching poorer households (McKenzie and Rapoport, 2007, 2010; Shen et al., 2010).

1.2 Visas, Not Aid! Alternative strategies for international poverty reduction

The idea that visas can be used as part of an aid relief strategy first materialized when the US Temporary Protected Status (TPS) mechanism, enacted in 1990, was applied to thousands of Hondurans and Nicaraguans in the aftermath of Hurricane Mitch in 1998 (UNHCR, 2009). TPS was also granted to illegal Salvadorian immigrants following the earthquakes that devastated El Salvador in 2001. The decision was made by then President George W. Bush at the request of the Salvadorian President, Francisco Flores, during a White House meeting. The status allowed 150,000 undocumented Salvadorians to legally remain in the United States for eighteen months.[5] More recently, TPS was also granted to tens of thousands of illegal Haitian immigrants following the earthquake in Haiti in 2010, and in 2012 Haiti has been added to the list of countries eligible to participate in the H-2 visa program for temporary and seasonal workers. As Clemens put it, "while there have been cases – including Haiti – where deportation policy was relaxed in response to a disaster (...), ending Haiti's H-2 visa exclusion is the first time in at least half a century that US admission policy

[4]They may even be seen as conservative. In the case of Mexico, they neglect the induced effects of migration on poverty through increased wages for low-skill workers (Mishra, 2007), consumption of remittance income, and the fact that there is evidence of negative selection into migration both on observables and unobservables, meaning that migrants would on average earn less in Mexico if they had not migrated than those who did not migrate (Fernández-Huertas Moraga, 2011).

[5]President Bush was quoted saying: "This will allow them to continue to work here and to remit some of their wages back home to support El Salvador's recovery efforts." The New York Times, March 3, 2001.

was changed in response to increased need in the wake of a disaster."[6]

To the same extent that the international community has repeatedly called for the rich nations to contribute to development aid and assistance on a fair basis, setting quantitative objectives such as "0.7 percent of GDP,"one may ask whether some countries contribute more than others to global poverty reduction through their welcoming more low-skill immigrants from poor countries. As can be seen from Table 1, high-income countries contributed on average 0.2 percent of their GDP to foreign aid in 2000. The only countries that met the 0.7 percent mark were Denmark, Luxembourg, Netherlands, Norway and Sweden. The United States contributed just 0.1 percent, the lowest figure among the group of high-income countries. However, the US were host to 45 percent of all low-skill immigrants originating from Low-Income Countries in 2000 and received more than 50 percent of the flow of such immigrants between 1990 and 2000. Countries such as Australia, Canada or the UK welcomed more than twice as many low-skill immigrants from poor countries as what an allocation based on GDP shares would predict, and conversely for countries such as Germany, Australia or Japan (50 percent or less).

1.3 Related literature

The idea of using market-based systems in the context of immigration is not new. It can be traced back at least to Gary Becker's proposal to auction immigration visas as an effective way of screening workers under a quantity constraint (Becker, 1992). Orrenius and Zavodny (2010) and Peri (2012) have recently integrated variants of such auctioning of visas (to employers of immigrants rather than to the workers themselves) as part of their proposals for large immigration policy reforms. However, these proposals address some of the inefficiencies of the current immigration system (e.g., its illegal and criminal dimensions – see also Auriol and Mesnard, 2012), or the imperfect matching between workers and jobs, but not the type of positive international externalities we address in this paper.[7] On the other hand, the idea that issuing immigration visas can be analogous to contributing to an international public good is not fully new either as it was first discussed in the case of refugees by scholars in

[6]See http://blogs.cgdev.org/globaldevelopment/2012/01/why-im-thrilled-the-united-states-has-stopped-excluding-haitians-from-temporary-work-visas.php.

[7]See also Djajic et al. (2012) for a theoretical framework where home and host countries decide on their education policy and visa policy strategically.

Table 1: **Contributions to ODA and to immigration from LICs.**

Countries	GDP per cap. 2000 US=100	GDP in 2000 (%)	ODA in 2000 (%)	Low-skill Mig. Stock from LICs 2000 (%)	Low-skill Net flow from LICs 90-00 (%)	ODA share/ GDP share	Mig. stock share/ GDP share
Australia	61	1.7	1.9	4.3	5.6	1.1	2.5
Austria	69	0.8	0.8	0.1	0.3	1.0	0.2
Belgium	65	1.0	1.5	1.6	0.2	1.6	1.7
Canada	68	3.0	3.2	6.4	5.7	1.1	2.1
Denmark	87	0.7	3.1	0.7	1.2	4.7	1.0
Finland	68	0.5	0.7	0.2	0.5	1.4	0.4
France	63	5.5	7.5	10.3	5.9	1.4	1.9
Germany	67	7.9	9.4	3.9	3.3	1.2	0.5
Greece	33	0.5	0.4	0.3	0.0	0.8	0.5
Iceland	89	0.0	0.0	0.1	0.1	0.4	2.1
Ireland	73	0.4	0.4	0.1	0.1	1.1	0.1
Italy	56	4.6	2.6	2.6	2.8	0.6	0.6
Japan	106	19.4	25.1	3.1	2.6	1.3	0.2
Luxembourg	134	0.1	0.2	0.0	0.0	2.7	0.3
Netherlands	70	1.6	5.9	1.9	1.7	3.7	1.2
New Zealand	38	0.2	0.2	0.4	0.5	1.0	1.8
Norway	108	0.7	2.3	0.7	0.9	3.4	1.0
Portugal	32	0.5	0.5	0.6	1.0	1.1	1.2
Spain	42	2.4	2.3	1.2	1.7	0.9	0.5
Sweden	80	1.0	3.3	1.2	1.8	3.3	1.2
Switzerland	101	1.0	1.6	0.9	0.7	1.6	0.8
UK	73	6.1	8.5	14.9	12.2	1.4	2.4
US	100	40.5	18.5	44.7	51.2	0.5	1.1
Total		$24 tr.	$54 bi.	2.5 mi.	1 mi.		

Notes: Migration data from Docquier and Marfouk (2006) refer to immigrants aged 25 or more. Low income countries are defined according to the World Bank classification.

the field of international law (Schuck, 1997; Hathaway and Neve, 1997). The central concept in this literature was (and still is, see Hatton, 2012) that of "burden sharing." However, these scholars fell short of proposing a TIQs system as they envisioned the possibility for countries to trade refugees for money on a strictly bilateral basis. More recently, De la Croix and Gosseries (2007) suggested that tradable immigration quotas could be used for temporary unskilled immigrants; however, they did not model this proposal formally and coupled it with a source-country market for emigration rights among skilled migrants (as an alternative to a Bhagwati tax). Similarly, Pritchett (2006) reflects on the immigration experience of Gulf countries to discuss possible variants of guest-worker programs; the main tradeoffs faced are between the lack of prospects for permanent integration (as immigrants are offered only temporary visas and no political rights) and the number of people that can benefit from the program thanks to the implied turnover.

The closest related paper is certainly De la Croix and Docquier (2010), who also stress that a higher level of low-skill immigration than currently observed would contribute to reduce world poverty and propose a tax-subsidy scheme to encourage rich countries to accept more low-skill immigrants than they would unilaterally admit in a way that ensures voluntary participation. The tax would consist of contributions to a global fund that would then be refunded through a subsidy as countries accept more immigrants. Their focus is on participation constraints to ensure the political feasibility of their proposal. However, efficiency as well as feasibility crucially hinge on a correct determination of the appropriate tax and subsidy levels, for which the informational requirements of their model may seen excessive.

The mechanism proposed in this paper is less demanding in terms of informational requirements since the revelation of the opportunity costs of immigration (that is, of countries comparative advantage in hosting immigrants) is precisely one of its main objectives. It may equally apply to temporary, humanitarian or permanent economic migration. Differently from De la Croix and Docquier (2010), we initially leave participation constraints outside of the model. However, our model can satisfy participation constraints through the manipulation of initial quotas (see Appendix A); this requires knowledge about the net cost of migration for all the countries involved, an information which is unknown ex-ante but can be revealed over time through the market. Another advantage of the mechanism we propose is that it takes into account the fact that migrants have preferences over locations and that countries have preferences over the type of migrants they receive, something that has been

ignored by previous literature.

2 Theoretical framework

There is a vast literature on tradable quotas markets, starting with the seminal contribution of Coase (1960). The literature has mainly concerned applications related to cap-and-trade systems to reduce pollution levels[8] and the creation of a market for tradable emission permits is still proposed as one of the most promising instruments to address climate change challenges (Stavins, 2011). Hahn and Stavins (2010a, 2010b) discuss the pros and cons of tradable quotas and try to explain why they are so popular among politicians. The main reason they put forward is the ability of such schemes to achieve efficiency and cost-effectiveness even in the presence of well known problems such as market power and political bargaining. While in practice tradable quotas have not been used except for environmental policy, they have also been proposed as a potential solution to a variety of externality situations such as deficit reduction (Casella, 1999) or fertility controls (Boulding, 1964; De la Croix and Gosseries, 2009).

In this section we extend the idea of tradable quotas to immigration. This extension requires adapting the mechanism to the peculiarities of immigration. We start by introducing tradable immigration quotas under the assumptions that prospective migrants are indifferent between potential destinations and that countries are indifferent with respect to the identity of the migrants and care only about their quantity, what we call the "homogenous" case (section 2.1). We next extend the model first by taking immigrants' preferences into account (section 2.2) and then by introducing destination countries' preferences over the types of migrants they receive (section 2.3).

2.1 TIQs with homogenous agents

Consider that each individual country i faces a decision about the number of immigrants (m_i) to let in and that the net cost of receiving these immigrants is described by the net total cost function $c_i(m_i)$. It is a reduced form taking into account diverse components such as the direct cost of receiving immigrants, administrative costs of processing their visa applications, social costs inherent to diversity, lower trust and social cohesion in heterogeneous populations

[8] Crocker (1966), Dales (1968) and Montgomery (1972) are the earliest contributors.

(Alesina and La Ferrara, 2000, 2002), political costs associated with xenophobic sentiments, as well as all the economic and social cost and benefits that migrants may bring about (e.g., the immigration surplus, immigrants' net fiscal contribution, and the value for country i of its contribution to reducing global poverty by receiving m_i immigrants).[9] It is assumed that $c_i(m_i)$ is a convex differentiable function in the number of migrants with an interior positive minimum. Nothing is said about the sign of the cost function to allow for the possibility that immigrants are considered either a net burden (total positive cost) or are positively valued (total negative cost) by the destination country.

In this section we treat migrants as homogenous in the sense that we assume all potential immigrants to be indifferent between going to any of the N possible destination countries, an assumption that will be relaxed in Section 2.2. Immigrants are also considered homogeneous from the point of view of the receiving countries. Therefore, the marginal cost of an immigrant can be interpreted as the expected net cost of a typical (or average) migrant. For simplicity we assume that destination countries can effectively choose the number of immigrants they want (we can consider enforcement costs as another part of the reduced form cost function $c_i(m_i)$). A destination country i would therefore solve the following maximization problem:

$$\max_{m_i} g_i(M_{-i}) - c_i(m_i) \tag{1}$$

where $g_i(\cdot)$ captures the externality for country i from immigration to other rich countries and $M_{-i} = \sum_{j \neq i} m_j$. Given that the externality is linked to the induced reduction of poverty at the world level, we assume that $g_i'(\cdot) > 0$. The optimal solution is:

$$c_i'\left(m_i^{NC}\right) = 0 \tag{2}$$

where NC stands for the non-cooperative solution. As explained in the previous section, immigration to one country generates a positive externality for the other countries. Hence, the non-cooperative equilibrium does not satisfy a general optimal level M^{GO}. To see why this is the case, consider the global optimal problem:

[9] On the immigration surplus and immigrants' net fiscal contribution, see for example Borjas (1994, 1999). On price and wage effects, see Cortes (2008) and, for a recent reassessment, Ottaviano and Peri (2012).

$$\max_{\{m_i\}_{i=1}^N} \sum_{i=1}^{N} \left[g_i \left(M_{-i} \right) - c_i \left(m_i \right) \right] \tag{3}$$

The first order conditions are:

$$-c_i' \left(m_i^{GO} \right) + \sum_{j \neq i} g_j' \left(M_{-j}^{GO} \right) = 0 \qquad \forall i = 1...N \tag{4}$$

Since $g_i' (\cdot) > 0$, we have $c_i' \left(m_i^{GO} \right) = \sum_{j \neq i} g_j' \left(M_{-j}^{GO} \right) > 0 = c_i' \left(m_i^{NC} \right)$ and thus $m_i^{GO} > m_i^{NC}$. The Nash solution (m_i^{NC}) clearly implies a lower level of migration than it is desirable at the world level:[10]

$$M^{NC} \equiv \sum_{i=1}^{N} m_i^{NC} < \sum_{i=1}^{N} m_i^{GO} \equiv M^{GO} \tag{5}$$

Notwithstanding participation constraints discussed below, assume now that N countries sign a multilateral agreement, or a central authority steps in to coordinate these countries towards a higher level of total international migration M (decided outside of the model) such that:

$$M^{NC} < M \leq M^{GO}$$

That is, the agreement would go part of the way towards achieving an optimal global level of international migration.

The problem that must be solved by this central authority can be written as:

$$\max_{\{m_i\}_{i=1}^N} \sum_{i=1}^{N} \left[g_i \left(M_{-i} \right) - c_i \left(m_i \right) \right] \tag{6}$$

$$s.t. \qquad \sum_{i=1}^{N} m_i \leq M$$

The first order conditions are:

[10] For a more explicit modeling of the externality in the case of refugee protection, see Barbou des Places and Deffains (2004), Hatton (2004, 2011), Hatton and Williamson (2004) or Bubb, Kremer and Levine (2011). In the case of immigration, see De la Croix and Docquier (2010).

$$-c_i'\left(m_i^{cm}\right)+\sum_{j\neq i} g_j'\left(M_{-j}^{cm}\right)+\pi=0 \qquad \forall i=1...N \tag{7}$$

where cm stands for constrained maximization and π is the multiplier associated to the constraint. It must also be true that:

$$\pi\left(M-\sum_{i=1}^{N} m_i^{cm}\right)=0 \tag{8}$$

Since $g_i'(\cdot)>0$ and the multiplier associated to the constraint $\pi\geq 0$, we know as before that $c_i'\left(m_i^{cm}\right)=\sum_{j\neq i} g_j'\left(M_{-j}^{cm}\right)+\pi>0=c_i'\left(m_i^{NC}\right)$ so that $m_i^{cm}>m_i^{NC}$ and $\sum_{i=1}^{N} m_i^{cm}>M^{NC}$.

Since $\sum_{i=1}^{N} m_i^{NC}=M^{NC}<M$, we can then be sure that $\pi>0$, so that:

$$M=\sum_{i=1}^{N} m_i^{cm} \tag{9}$$

The optimal solution to this constrained maximization problem equates the marginal cost of accepting one additional immigrant $(c_i'\left(m_i^{cm}\right))$ for a given number of immigrants M to the shadow price of increasing the size of the program (π) plus the sum of the welfare gains obtained by the other countries when country i decides to accept one additional immigrant $(\sum_{j\neq i} g_j'\left(M_{-j}^{cm}\right))$. If we assume that these welfare gains are common to all participating countries (for example, take $g_i\left(M_{-i}\right)=\beta M_{-i}$), the optimal solution for this constrained maximization problem will completely equalize marginal costs across destination countries. In the linear example, the solution would be: $c_i'\left(m_i^{cm}\right)=(N-1)\beta+\pi\equiv\lambda$.

Let us now assume that the above solution is implemented by creating a market for immigration quotas that would open for a limited time, after which immigrants receive visas to their final destinations. Under this system, each country is assigned an initial quota of immigrants m_{i0} that can then be traded in a market in which the price for accepting one additional immigrant will be represented by p.[11] The initial distribution of quotas must be agreed upon by the countries participating in the multilateral agreement or established by a central authority and be such that:

[11]The notion of paying a price to avoid migration might not appear very attractive politically. This can easily be circumvented by wording the proposal so that countries have two means for contributing to poverty reduction through immigration: bidding visas, or bidding money to fund the settlement of immigrants in third countries.

$$M = \sum_{i=1}^{N} m_{i0} \tag{10}$$

It is assumed that the cost functions are expressed in monetary units and that the market is competitive so that all countries behave as price-takers (we discuss this assumption below).

The problem that each country must solve in this case is:

$$\min_{m_i} c_i\left(m_i\right) - p\left(m_i - m_{i0}\right) \tag{11}$$

If the market is competitive, the first order condition will be:

$$c_i'\left(m_i^M\right) = p \tag{12}$$

The marginal costs of accepting one additional immigrant will then be equalized across destinations through the market. In addition, the market must clear:

$$M = \sum_{i=1}^{N} m_{i0} = \sum_{i=1}^{N} m_i^M \tag{13}$$

Proposition 1 *The market solution to (6) is efficient.*

Proof. The market solution will be efficient ($m_i^M = m_i^{cm}$) as long as it can be proved that $p = \lambda$. To see that this is the case, suppose $p \neq \lambda$. There are two possibilities:

- $p < \lambda$. From the first order conditions in both problems, this implies: $c_i'\left(m_i^M\right) < c_i'\left(m_i^{cm}\right)$ so that $m_i^M < m_i^{cm}$ for all i because of the convexity of $c_i\left(m_i\right)$. But then $M = \sum_{i=1}^{N} m_i^M < \sum_{i=1}^{N} m_i^{cm}$, a contradiction.

- $p > \lambda$. Following the same reasoning, this implies $m_i^M > m_i^{cm}$ for all i so that $M = \sum_{i=1}^{N} m_i^M > \sum_{i=1}^{N} m_i^{cm} = M$, contradicting the solution to the constrained maximization problem.

■

It is clear, therefore, that a TIQs system is able to replicate the constrained maximization solution and that the initial distribution of quotas only has redistributive consequences as long as the market is competitive.

The competitiveness of a market where destination countries operate as buyers or sellers deserves some attention. Casella (1999), when proposing the creation of a market for tradable deficit permits in the European Monetary Union (just 12 countries at the time), advocated establishing a computerized continuous double auction mechanism, with sellers and buyers repeatedly submitting bid and ask prices, a market design employed in many exchanges around the world (e.g., the New York Stock Exchange). Friedman and Ostroy (1995), among others, have shown experimentally that such a mechanism converges to competitive equilibrium outcomes even in the presence of just a few large buyers or sellers. The intuition is that the mechanism promotes a Bertrand-type competition. Coalitions are easily formed in experiments but they quickly unravel towards the competititve equilibrium price. However, authors such as Muller et al. (2002) suggest that the presence of a monopolist or a monopsonist can cause the price to diverge from the competitive equilibrium case. Still, even in these cases, they show that efficiency is not affected significantly, which can be explained by the ability of the monopsonist or monopolist to successfully price discriminate. These results are consistent with the empirical observations of Hahn and Stavins (2010a and 2010b) discussed above.

Another natural question that arises is why the market should be used to solve the externality problem instead of relying on other mechanisms such as taxation. The answer follows the reasoning of Baumol and Oates (1995). The market for tradable quotas and an appropriate Pigouvian tax/subsidy are equivalent in an environment of perfect information. However, if we assume that the cost functions of individual countries are only known to the countries themselves, then a market for tradable quotas is superior to a Pigouvian tax/subsidy since the tax would only ensure a certain level of marginal cost whereas the market makes sure that the final objective (i.e., achieving the agreed upon number of immigrants M) is attained.[12] From a Coasian perspective, we must also assume that transaction costs are low relatively to the gains from the market. This is why implementing a TIQs system is more likely where organizational costs have already been incurred for other purposes, which is the case for example for international refugees (see our first application in Section 3), or where the potential gains at stake are huge, as is the case with reducing global poverty.

[12] According to Weitzman's (1974) terminology, the marginal benefit of the externality is perfectly inelastic so that the quantitative restriction (the market) is preferred over the price restriction (Pigouvian tax). We could add that, in our view, learning one's cost function is a discovery process, which is more likely to occur in a market.

In any event, tradable quotas solutions to externality problems need to address the challenge of participation to the same extent that taxes and subsidies schemes do. De la Croix and Docquier (2010), whose mechanism is Pigouvian, concentrate on a design that satisfies participation constraints by compensating the initial tax payments with subsidies that ensure that no country is worse off. We show in Appendix A that a TIQs system can also be made individually rational for every country through the manipulation of initial quotas. The problem, both for De la Croix and Docquier (2010) and for us if we were to introduce participation constraints, is the unreallistically large informational requirement implied by the determination of the "right" subsidy or initial quota for each country. While one can always set the initial allocation of quotas so that there will only be winners, taking participation constraints into account requires using information that countries have usually no incentive to reveal.

In the absence of such readily available information, we can only note that countries do sign international agreements, even if they lose, on issues such as the environment, refugee protection, or ban of whales hunting, when there is a clear sense that an important international public good is provided (leading to strong international pressure on individual countries to sign) and there is a perception that contributions are shared fairly. We also note that even if just a few countries initially agree to participate, they can generate a Pareto improvement and induce more countries to join in the future (as in Courtois and Haeringuer, 2012, or Petrakis and Xepapadeas, 1996). This process is abundantly documented in the political science and political economy of international organizations literature (e.g., Keohane, 1982; Finnemore and Sikkink, 1998; Dai, 2007; Gilligan, 2009), which describe it as resulting from a combination of "normative entrenchment," "expressive behavior" (Hillman, 2010) and "name it and shame it" schemes. More prosaically, we also suggest that the issue of participation constraints is mitigated when a TIQs system is supplemented by a matching mechanism where countries can express their preferences over the types of migrants they receive, as discussed in Section 2.3 below.

2.2 Taking Migrants' Preferences into Account

So far we have assumed that an international agency (or a multilateral agreement) determines that M immigrants must be distributed among N countries who agreed to host them according to some pre-determined tradable quotas. At this point, we have a sequence $\left\{m_i^M\right\}_{i=1}^N$

of immigrant assignments for each of the potential destination countries. The problem is now to assign indivisible items (rights for a migrant to enter a given destination country, or "visas") to agents (migrants) taking into account the preferences of the latter. In this sense, the problem is exactly analogous to assigning houses to tenants (Abdulkadiroglu and Sonmez, 1999).

The solution proposed by Abdulkadiroglu and Sonmez (1999) is the use of the top trading cycles mechanism, which in our case, where no immigrant has previous rights to enter a particular country, is equivalent to a random serial dictatorship.[13] The application of the top trading cycles mechanism to the problem at hand would work as follows:

1. Each immigrant ranks all potential destination countries, specifying those to which she would not want to go at all.

2. An ordering of immigrants is randomly chosen from a given distribution of orderings.

3. For any given ranking of countries done by the immigrants and ordering of immigrants, assign the first immigrant her first choice, the second immigrant her first choice and so on until an immigrant chooses first a country whose quota is filled. In that case, assign that immigrant her second choice or, if that one is also filled, her third choice and so on. If all the quotas are filled for the countries for which the immigrant would be willing to go, that particular individual is taken out of the mechanism and substituted for another one initially out of the total number M.

The described mechanism is *individually rational* as it ensures every eventual immigrant a visa that is at least as good as the possibility of staying in her original country. It is also *incentive compatible* (no immigrant has an incentive to misrepresent her preferences whatever the strategies others use) and Pareto efficient in the sense that there is no possibility for immigrants to benefit from a mutual exchange of assigned visas, at least ex-ante. In reality, it could well be that two relatives prefer to be together in a less preferred destination than alone in a more preferred one. To this end, more complex matching mechanisms, such as those described by Roth (2002), could be adopted to prevent families from being divided into different destination countries.

[13]See however Appendix B for an application to refugee resettlement where migrants have pre-existing rights.

If such a matching mechanism is introduced, the problem that a central authority would need to solve in order to minimize the total costs of distributing M migrants over N destinations is completely equivalent to the simple maximization model of the previous section. The solution would just equalize the marginal costs of accepting an additional immigrant across countries.

A potential difficulty arises if one of the N participating destination countries is such an undesirable destination that only a fraction (or none) of the potential immigrants willing to apply for a visa would consider going there. In such a case, equation (13) might no longer be verified. Notwithstanding this difficulty (that will be addressed below), the planner's problem once the above-described matching mechanism is introduced becomes:

$$\min_{\{m_i\}_{i=1}^N} \sum_{i=1}^{N} c_i\left(m_i^{MM}\right) \tag{14}$$

$$\begin{aligned} s.t. \qquad \sum_{i=1}^{N} m_i^{MM} &\geq M \\ m_i^{MM} &= F_i\left(m_1, m_2, ..., m_N\right) \qquad \forall i = 1...N \end{aligned}$$

The last set of constraints embeds the matching mechanism. The sequence $\{F_i\}_{i=1}^N$ of functions $F_i : [0, M]^N \to [0, M]$ transforms an allocation of visas $\{m_i\}_{i=1}^N$ decided by the central planner as if countries were homogenous from the migrants' perspective into another allocation $\left\{m_i^{MM}\right\}_{i=1}^N$ that does take into account migrants' preferences through the matching mechanism (denoted MM). Notice that it will always be the case that $m_i^{MM} \leq m_i$, as discussed above.

The functions in the sequence $\{F_i\}_{i=1}^N$ can be approximated by differentiable functions, for example by interpolating a polynomial that will take exactly the same values where the matching function is defined. In such a case, the solution to the total minimum cost problem above can be obtained from the following first order conditions:

$$\sum_{j=1}^{N} \frac{\partial F_j}{\partial m_i}\left(c_j'\left(m_j^{MM}\right) - \lambda\right) = 0 \qquad \forall i = 1...N \tag{15}$$

where λ is the multiplier associated with the first constraint. In this case, the equalization of marginal costs across countries is just one possible solution. For example, consider the case in which the matching mechanism does not alter the planner's allocation. This implies:

$$\frac{\partial F_j}{\partial m_i} = 0 \qquad \forall i \neq j \tag{16}$$

$$\frac{\partial F_i}{\partial m_i} = 1 \tag{17}$$

We now ask whether the introduction of a matching mechanism taking migrants' preferences into account affects the ability of a TIQs system to replicate the solution to the total minimum cost problem. This will depend on the design of the market. If countries are compensated depending on the number of migrants for whom they bid in the market (m_i), a TIQs system will be unable to replicate the total minimum cost solution. However, this is not the case if they are compensated by the number of migrants they actually receive: m_i^{MM}. The difference between these two compensation schemes is what we term the implicit penalty. This penalty prevents countries from having an interest in becoming undesirable locations.

Consider what happens if there are countries to which just a few or no migrants want to go. Suppose that the matching mechanism establishes an implicit penalty for those countries that are not attractive to migrants. The key is that countries would pay depending on the final outcome of the matching mechanism m_i^{MM} rather than on the buying and selling decisions adopted in the market m_i. In other words, their objective function is $c_i\left(m_i^{MM}\right) - p\left(m_i^{MM} - m_{i0}\right)$ rather than $c_i\left(m_i^{MM}\right) - p\left(m_i - m_{i0}\right)$. This generates a penalty for countries that turn out to be undesirable destinations.[14]

To see this more clearly, specify the functions $F_i\left(m_1, m_2, ..., m_N\right)$ as:

$$\begin{aligned} m_j^{MM} &= F_j\left(m_1, m_2, ..., m_N\right) = m_j \qquad \forall j \neq i \\ m_i^{MM} &= F_i\left(m_1, m_2, ..., m_N\right) = m_i \qquad \text{if } m_i \leq \bar{m}_i \\ &= \bar{m}_i \qquad \text{otherwise} \end{aligned} \tag{18}$$

The interpretation is that only $\bar{m}_i$ individuals in the world are willing to go to country i even as a last resort.

[14] As a practical matter, this penalty could be collected by the international organization or body in charge of setting up the market. Similarly to the Clarke's tax literature, the only formal requirement is that the tax cannot be redistributed among the participating countries.

First, suppose country i cannot affect $\bar{m}_i$, the solution (denoted by a star) would then be characterized by the following first order conditions:

$$\begin{aligned} c_i'(m_i^*) &= p \qquad \text{if } m_i^* \leq \bar{m}_i \\ m_i^* &= \bar{m}_i \qquad \text{otherwise} \end{aligned} \tag{19}$$

Of course, the second solution is the interesting one in the sense that the first solution simply replicates the results in section 2.1. It must be noted that, with $m_i^* = \bar{m}_i$, we will have $c_i'(\bar{m}_i) < p$.

If country i were able to manipulate $\bar{m}_i$, it would try to increase it up to the point where the marginal cost equates the price. It would have no incentive to decrease its attractiveness as a destination for migrants since it would then have to pay – or stop earning if $\bar{m}_i > m_{i0}$ – the market price p instead of incurring a – by definition lower – marginal cost for all inframarginal migrants. If anything, a country that is not attractive to migrants would have incentives to become more attractive. Indeed, suppose that a country receives an initial quota m_{i0} such that $c_i'(m_{i0}) = p$. For that country, it makes no sense to buy or sell in the market. But now suppose that $m_{i0} > \bar{m}_i$. If countries were compensated according to market outcomes, country i's cost would be $c_i(\bar{m}_i) - p(m_{i0} - m_{i0}) = c_i(\bar{m}_i)$. Because of the penalty, country i's cost is $c_i(\bar{m}_i) - p(\bar{m}_i - m_{i0}) > c_i(\bar{m}_i)$. The amount $p(m_{i0} - \bar{m}_i)$ would be the penalty for not complying with the number of migrants that the country was supposed to take. It is easy to see that this result extends to any case in which the result from the market is greater than the number of migrants who would actually be willing to go to country i: $m_i > \bar{m}_i$. It is also clear that the penalty remains implicit as long as countries have perfect knowledge about $\bar{m}_i$ (see the solution to the problem below). As it will be seen in the applications, this is not an extreme assumption since we can consider that the preferences of refugees or migrants are collected before the market opens. As a way to prevent price manipulations (e.g., one country offering to host all the migrants at price 0 knowing that it would only receive $\bar{m}_i$), we can even restrict participating countries to bid up to $\bar{m}_i$. Formally, we can include this constraint in the functions $F_i(m_1, m_2, ..., m_N)$.

In general terms, we can write the problem that a representative country i would face as:

$$\min_{m_i} c_i\left(m_i^{MM}\right) - p(m_i - m_{i0}) + p\left(m_i - m_i^{MM}\right) \tag{20}$$

$$s.t. \qquad m_i^{MM} = F_i\left(m_1, m_2, ..., m_N\right)$$

where $p\left(m_i - m_i^{MM}\right)$ represents the penalty. Notice that the objective function simplifies to $c_i\left(m_i^{MM}\right) - p\left(m_i^{MM} - m_{i0}\right)$. The first order condition associated with this problem is:

$$\frac{\partial F_i}{\partial m_i}\left(c_i'\left(m_i^{MM}\right) - p\right) = 0 \tag{21}$$

Once the problem is correctly written, the following proposition holds:

Proposition 2 *Let (20) represent the structure of the problem solved by country i participating in a market for tradable immigration quotas. In particular, the setup of the market is such that country i pays (is compensated) for the actual number of migrants received m_i^{MM} rather than by the number of migrants bid in the market m_i, so that $p\left(m_i - m_i^{MM}\right)$ can be considered as a penalty associated to the outcome of the matching mechanism, denoted by $m_i^{MM} = F_i\left(m_1, m_2, ..., m_N\right)$.*

Under this definition of a market for tradable immigration quotas, at least one of the market solutions to (14) is efficient, specifically marginal cost equalization across countries.

Proof. One solution to (21) is $c_i'\left(m_i^{MM}\right) = p$. Substituting p with λ, it is easy to see that this solution would also solve equation (15). ■

2.3 Taking Countries' Preferences into Account

Countries may also have preferences over the types of migrants they receive. Indeed, our current formulation of the marginal cost function $c_i'\left(m_i\right)$ can be interpreted as the marginal cost over ex-ante identical immigrants. In principle, however, we could allow countries to choose immigrants in the same way in which we allowed immigrants to choose destination countries. Before we deal with this issue formally, one may want to ask whether it is an important one in practice. It is certainly the case that countries have preferences over the ethnic, religious or national origin of immigrants due to common linguistic or cultural characteristics and to shared histories (leading, for example, to the constitution of migration and diaspora networks). To a large extent, this tends to coincide with the migrants' preferences and to be reflected in their ranking of preferred destinations. Still, the correspondence may be far from perfect, and receiving countries do have preferences over certain types of migrants

such as skilled individuals, or individuals with specific skills. For labor/economic migration in general, and even for relatively unskilled immigration, it is therefore likely that countries will have strong preferences over the types of migrants they receive. This is less likely to be the case for the types of immigration we focus on in section 3.1, that is, humanitarian and refugee migration, as it can more easily be argued that refugees and asylum seekers are ex-ante identical from the viewpoint of the receiving countries. But again, this does not imply that some countries will not favor certain types of refugees.

In any event, there are two ways of allowing for heterogeneity of countries with respect to migrants' characteristics/types. The simplest and less interesting one is to create a different market for each type of migrants that countries can consider. Then, the results presented so far automatically go through with as many markets as immigrant types we want to consider. A second possibility is to group different types of migrants into the same market even if they are heterogeneous. To this end, we first need to define types, which we index by k. Then we can redefine the total cost function as $c_i(\boldsymbol{m}_i)$ where $\boldsymbol{m}_i$ is a vector of K elements (types of migrants) denoted m_i^k. Assuming that the cost function is convex in each of the elements of the vector $\boldsymbol{m}_i$,[15] we can recover the results proven above. Indeed, consider the total minimum cost problem:

$$\min_{\left\{\left\{m_i^k\right\}_{k=1}^K\right\}_{i=1}^N} \sum_{i=1}^N c_i\left(\mathbf{m}_i^{MM}\right) \tag{22}$$

$$\begin{aligned} s.t. \qquad \sum_{i=1}^N \sum_{k=1}^K m_i^{k,MM} &\geq M \\ m_i^{k,MM} &= F_i^k\left(\mathbf{m}_1, \mathbf{m}_2, ..., \mathbf{m}_N\right) \qquad \forall i = 1...N; \forall k = 1...K \end{aligned}$$

For the solution, we would have $N \times K$ first order conditions:

$$\sum_{j=1}^N \sum_{l=1}^K \frac{\partial F_j^l}{\partial m_i^k}\left(\frac{\partial c_j}{\partial m_j^l} - \lambda\right) = 0 \qquad \forall i = 1...N; \forall k = 1...K \tag{23}$$

We would also have a condition associated to the constraint:

[15] The cost functions must be such that the global optimal solution implies higher levels of migration than the non-cooperative solution so that we can use total cost minimization as an alternative to utility maximization. For example, this is true if we assume the cost functions are separable in the elements of the vector $\boldsymbol{m}_i$.

$$\lambda \left(M - \sum_{i=1}^{N} \sum_{k=1}^{K} m_i^{k,MM} \right) = 0 \tag{24}$$

The matching mechanism creates a dependence between the migrants of each type accepted by each country and those of the same or other types accepted by other countries. Still, marginal cost equalization across migrant types and across countries remains a solution to the problem. In cases where the matching mechanism does not affect the market outcome (that is: $\frac{\partial F_i^k}{\partial m_i^k} = 1$ and $\frac{\partial F_j^l}{\partial m_i^k} = 0, \forall i \neq j, l \neq k$), the first order conditions would simplify to:

$$\frac{\partial c_i}{\partial m_i^k} \left(m_i^{k,M} \right) = \lambda \qquad \forall i = 1...N; \forall k = 1...K \tag{25}$$

In terms of the market for TIQs with heterogeneous country preferences, the formulation of the problem that each individual country would face is the following:

$$\min_{\{m_i^k\}_{k=1}^K} c_i \left(\mathbf{m}_i^{MM} \right) - p \left(\sum_{k=1}^{K} m_i^k - m_{i0} \right) + \sum_{k=1}^{K} p \left(m_i^k - m_i^{k,MM} \right) \tag{26}$$

$$s.t. \qquad m_i^{k,MM} = F_i^k \left(\mathbf{m}_1, \mathbf{m}_2, ..., \mathbf{m}_N \right) \qquad \forall k = 1...K$$

The first order conditions associated with this problem are:

$$\sum_{l=1}^{K} \frac{\partial F_i^l}{\partial m_i^k} \left(\frac{\partial c_i}{\partial m_i^l} - p \right) = 0 \qquad \forall k = 1...K \tag{27}$$

Proposition 3 *Let (26) represent the structure of the problem solved by country i participating in a market for tradable immigration quotas. In particular, the setup of the market is such that country i pays (is compensated) for the actual number of migrants received* $m_i^{k,MM}$ *rather than by the number of migrants bid in the market* m_i^k*, so that* $\sum_{k=1}^{K} p \left(m_i^k - m_i^{k,MM} \right)$ *can be considered as a penalty associated to the outcomes of the matching mechanism, denoted by* $m_i^{k,MM} = F_i^k \left(\mathbf{m}_1, \mathbf{m}_2, ..., \mathbf{m}_N \right)$.

Under this definition of a market for tradable immigration quotas, at least one of the market solutions to (22) is efficient, specifically marginal cost equalization across countries.

Proof. One solution to (27) is $\frac{\partial c_i}{\partial m_i^l} = p$. Substituting p with λ, it is easy to see that this solution would also solve equation (23). ■

In particular, when the matching mechanism does not affect the outcome of the market ($\frac{\partial F_i^k}{\partial m_i^k} = 1$ and $\frac{\partial F_j^l}{\partial m_i^k} = 0, \forall l \neq k$),[16] it would be the only solution:

$$\frac{\partial c_i}{\partial m_i^k}\left(m_i^{k,M}\right) = p \qquad \forall k = 1...K \tag{28}$$

Summing up, the heterogeneity of migrants reflected in countries' preferences does not alter the efficiency properties of the market. This result does not extend to the matching mechanism. If we allow countries to choose their preferred types of migrants, the appropriate matching mechanism is no longer equivalent to assigning houses to tenants without existing rights. The closest analogy, instead, is the college admissions problem, that is, the allocation of students to colleges (Gale and Shapley, 1962; Roth 1985). Our context has specific features, however, that make it different; notably, countries are assigned a quota (which they can trade) and pay a penalty for the unfilled slots. Still, there is a lot to learn from the college admissions literature for our purpose. In particular, the matching literature[17] presents a very negative result concerning the allocation of students (migrants) to colleges (countries): the impossibility of having a stable Pareto-efficient matching mechanism in which countries (colleges) reveal their preferences truthfully over the type of migrants (students) they want. As demonstrated by Roth (1985), "*there exists no stable mechanism that makes it a dominant strategy for each school to state its preferences over the students truthfully.*"Despite the differences, this impossibility theorem remains true in our specific context.[18]

Beyond this negative result, here are two main solution concepts that have been proposed for the college admission problem: the school-proposing (country-proposing) and the student-proposing (migrant-proposing) deferred acceptance algorithm. They consist of one side of the matching (countries or migrants) submitting their preferences and the other side accepting or rejecting them in as many steps as necessary until there are no migrants or countries left to assign. Both algorithms converge to the most desirable outcome for countries and migrants respectively. In a recent paper, Azevedo and Leshno (2012) show that, using a continuum to approximate the number of migrants with a finite number of countries, both algorithms converge to the same unique stable solution.

In the context of the market for TIQs and independently of whether a country-proposing or a migrant-proposing deferred acceptance algorithm is introduced, the market will equally

[16] In addition, this implicitly assumes no limits on the number of potential migrants of each type.

[17] See the review by Sonmez and Unver (2011).

[18] The existence of the market does not invalidate the counter-example in Roth (1985).

tend to marginal cost equalization across migrant types and quantities. Thus, the externality that justifies the creation of the market in the first place is correctly addressed. What changes are the desirable properties of the final outcome for both migrants and countries and these desirable properties will be associated to the choice of the matching mechanism. For example, Sonmez and Unver (2011) report how a design based on the student-proposing deferred acceptance algorithm was introduced in the hospital-intern entry labor market in the US on the basis of the fact that this algorithm ensures truth-telling by the interns whereas the college-proposing algorithm does not ensure truth-telling even by the hospitals. On the contrary, a recent contribution by Pathak and Sonmez (2011) defines a new concept of manipulability and supports a college-proposing deferred acceptance mechanism on the grounds that it is less manipulable than the student-proposing one.[19]

As this issue is still unsettled in the matching literature, we just point out to the fact that any mechanism is compatible with our market for TIQs. We find the manipulability concept in Pathak and Sonmez (2011) convincing and would suggest the use of a country-proposing deferred acceptance mechanism. Still, allowing for taking into account countries preferences over migrants types could introduce a trade-off. On the one hand, as we show below, cost-efficiency is increased in the sense that countries might be willing both to take more immigrants in, and to participate more in the market if they can pick their preferred immigrants (and even more so if the matching mechanism employs an algorithm that favors them). On the other hand, the matching mechanism could create additional uncertainty if we assume that the uncertainty associated to not knowing ex ante which types of migrants will be received and doing nothing about it (as in subsections 2.1 and 2.2) is smaller than the uncertainty associated with doing something about it by trying to select preferred migrants through the matching mechanism. In principle, one could argue that uncertainty could also be reduced by the possibility of choice but this is ultimately an empirical question. Theoretically, however, it is relevant to consider this issue because high uncertainty is known to affect transaction costs and decrease the desirability of tradable quotas (Hahn and Stavins, 2010a).[20]

[19]Under some conditions, Azevedo and Budish (2012) argue that deferred acceptance algorithms are strategy-proof *in the large*, meaning that the incentives to manipulate them disappear as the size of the matching market grows.

[20]We do not attempt to model this problem in a dynamic setting, which would allow for updating of beliefs over the immigrants' mix to be received.

The efficiency gains from letting countries choose their preferred migrants are easier to understand by abstracting for a moment from migrants' preferences (so that $\mathbf{m}_i = \mathbf{m}_i^{MM}$) and rewriting individual country problems in the following way:

$$\min_{m_i, \{\alpha_i^k\}_{k=1}^K} TC^C = c_i(\mathbf{m}_i) - p(m_i - m_{i0}) \tag{29}$$

$$\begin{aligned} s.t. \qquad \sum_{k=1}^{K} m_i^k &= m_i \\ m_i^k &= \alpha_i^k m_i \qquad \forall k = 1...K \\ \alpha_i^k &\geq 0 \qquad \forall k = 1...K \end{aligned}$$

where α_i^k represents the share of migrants of a particular type k chosen by country i through the matching mechanism out of a total quota of migrants m_i obtained through the market. The matching mechanism allows countries to choose their respective optimal shares of migrants so as to minimize TC^C (where the superscript C stands for countries "choice of migrants").

Consider the alternative problem:

$$\min_{m_i} TC^{NC} = c_i(\mathbf{m}_i) - p(m_i - m_{i0}) \tag{30}$$

$$\begin{aligned} s.t. \qquad \sum_{k=1}^{K} m_i^k &= m_i \\ m_i^k &= \alpha_i^k m_i \qquad \forall k = 1...K \\ \alpha_i^k &\geq 0 \qquad \forall k = 1...K \end{aligned}$$

The only difference between problem (29) and problem (30) is that the latter does not allow countries to choose their preferred migrants in order to minimize their total cost (TC^{NC} refers to the case where countries cannot choose migrants). In this case, the shares denoted by α_i^k are no longer a choice variable but are exogenously given.

Proposition 4 *The solution to (30), where countries cannot choose their preferred mix of migrant types, implies for each country a total cost that is at least as large as the total cost*

implied by the solution to (29), where countries can choose their preferred mix of migrant types:

$$TC^{NC}(m_i^{NC}) \geq TC^C\left(m_i^C, \left\{\alpha_i^{k,C}\right\}_{k=1}^K\right)$$

Proof. Problem (30) is a constrained version of (29). Thus, a solution to (30) cannot lead to a minimum cost that is lower than that coming from a solution to (29), whose domain is larger. ■

Proposition 4 shows that the market for TIQs can be made more efficient by letting countries choose their preferred types of migrants. There are two obvious non-exclusive ways to exploit these efficiency gains. First, they can be used to increase the number of migrants allocated through the mechanism while keeping the total cost constant. Second, they can be used to relax participation constraints so that more countries have more incentives to enter the market.

We illustrate Proposition 4 with a simple example below, showing the possible gains that arise from allowing countries to choose their preferred mix of migrants.

Example 1 *Suppose there are only two countries A and B and two types of migrants H and L. The cost functions for both countries are:*

$$\begin{aligned} c_A\left(m_A^H, m_A^L\right) &= \frac{1}{2}\left(a^H\left(m_A^H\right)^2 + a^L\left(m_A^L\right)^2\right) \\ c_B\left(m_B^H, m_B^L\right) &= \frac{1}{2}\left(b^H\left(m_B^H\right)^2 + b^L\left(m_B^L\right)^2\right) \end{aligned}$$

Suppose we need to allocate M migrants. If country preferences are taken into account and assuming both countries behave as price-takers, the solution will be determined by M and by the equilibrium price p^{het} through these equations:

$$\begin{aligned} a^H m_A^H = a^L m_A^L = b^H m_B^H = b^L m_B^L &= p^{het} \\ m_A^H + m_A^L + m_B^H + m_B^L &= M \end{aligned}$$

We can solve for the equilibrium price:

$$p^{het} = \frac{M}{\frac{1}{a^H} + \frac{1}{a^L} + \frac{1}{b^H} + \frac{1}{b^L}}$$

The total cost associated to this outcome (summing over the total costs for both countries) would be:

$$TC^{het} = \frac{M^2}{2}\frac{1}{\frac{1}{a^H}+\frac{1}{a^L}+\frac{1}{b^H}+\frac{1}{b^L}}$$

Consider now the case in which countries cannot choose the type of migrants. They can bid in the market for an overall number of migrants but the types are obtained through the matching mechanism. Assume country A expects to receive α migrants of type H for a given total obtained in the market m_A. Similarly, country B expects to receive β migrants of type H. This is a simplification for a realistic situation in which countries can have an expected probability distribution of migrants' preferences. The cost functions will be:

$$\begin{aligned} c_A\left(m_A^H, m_A^L\right) &= \frac{1}{2}\left(a^H\left(\alpha m_A\right)^2 + a^L\left(\left(1-\alpha\right)m_A\right)^2\right) = \\ &= \frac{1}{2}m_A^2\left(a^H\alpha^2 + a^L\left(1-\alpha\right)^2\right) = \frac{1}{2}m_A^2\Omega \\ c_B\left(m_B^H, m_B^L\right) &= \frac{1}{2}\left(b^H\left(\beta m_B\right)^2 + b^L\left(\left(1-\beta\right)m_B\right)^2\right) = \frac{1}{2}m_B^2\Phi \end{aligned}$$

Under these two cost functions, the resulting equilibrium price is:

$$p^{\alpha\beta} = \frac{M}{\frac{1}{\Omega}+\frac{1}{\Phi}}$$

The total cost will depend on the parameters α and β:

$$TC^{\alpha\beta} = \frac{M^2}{2}\frac{\Omega\Phi}{\Omega+\Phi}$$

It is easy to show that $TC^{het} \leq TC^{\alpha\beta}$. Also, we can find the values of α and β that minimize $TC^{\alpha\beta}$:

$$\hat{\alpha} = \frac{a^L}{a^H+a^L}; \hat{\beta} = \frac{b^L}{b^H+b^L}$$

Plugging these into $TC^{\alpha\beta}$, we get $TC^{\hat{\alpha}\hat{\beta}}$, which, not surprisingly, coincides with TC^{het}:

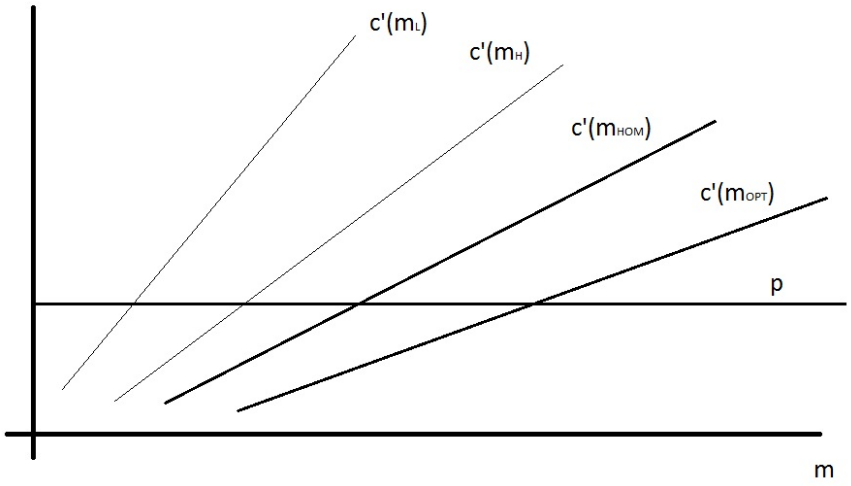
$$TC^{het} = \frac{M^2}{2}\frac{1}{\frac{1}{a^H}+\frac{1}{a^L}+\frac{1}{b^H}+\frac{1}{b^L}} = TC^{\hat{\alpha}\hat{\beta}}$$

In addition, we have that $p^{het} = p^{\hat{\alpha}\hat{\beta}} \leq p^{\alpha\beta}$.

The minimum price and the maximum efficiency (through minimum total cost) is achieved when both countries are able to obtain their preferred (cost-minimizing) mix of migrants through the matching mechanism. Any other mix results in a higher cost (individual and total) and a higher price.

Graphically, figures 1 and 2 show how the market achieves efficiency. Figure 1 represents the marginal cost functions for each type for an individual country depending on the number of migrants received (horizontal axis). The optimal (cost-minimizing) mix of migrants is the one that equates the marginal cost of each type, $c'(m_H)$ *and* $c'(m_L)$*, to the price* p*. The horizontal sum of the marginal cost functions for both types at the optimal mix is represented by the overall marginal cost function* $c'(m_{OPT})$*. This horizontal sum with the optimal weights (*$\hat{\alpha}$ *or* $\hat{\beta}$ *in the example above) will always be below any alternative way of horizontally summing* $c'(m_H)$ *and* $c'(m_L)$*, for example the marginal cost* $c'(m_{HOM})$ *depicted in figure 1, which would result in a lower number of migrants being chosen by this particular country.*

Figure 1: Country Marginal Cost Functions for Types and their Sums



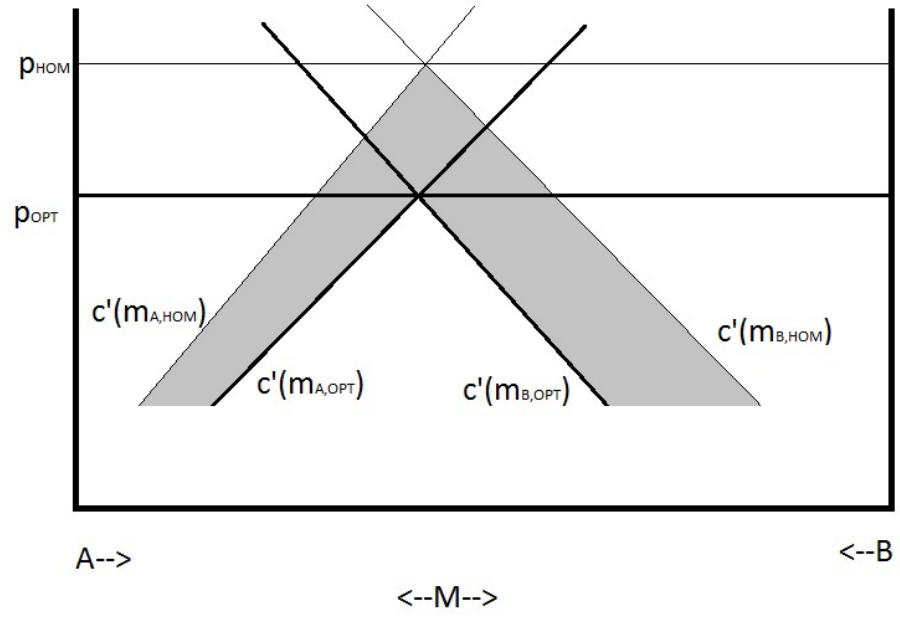
Note: m is the number of migrants; p is the price; $c'(m_H)$ and $c'(m_L)$ are the marginal cost functions for migrants of type H and L, respectively; $c'(m_{HOM})$ is an arbitrary horizontal sum of $c'(m_H)$ and $c'(m_L)$; $c'(m_{OPT}$ is the optimal (cost-minimizing) horizontal sum of $c'(m_H)$ and $c'(m_L)$.

Figure 2 combines the representation in figure 1 to create a market with only two countries that behave as price-takers. For country A, the origin is in the left vertical axis whereas for country B the origin for the number of migrants variable is in the right vertical axis. The total length of the horizontal axis measures the size of the market M: the total number of migrants to be allocated. In this case, only two sums of marginal cost functions are represented for each country, one where they cannot choose the optimal mix, termed $c'(m_{A,HOM})$ *and* $c'(m_{B,HOM})$*, and one where they do, termed* $c'(m_{A,OPT})$ *and* $c'(m_{B,OPT})$*. This figure allows to see clearly how countries can attain a lower overall price* p_{OPT} *by choosing their preferred mix of migrants. Whenever they cannot choose their preferred mix, this results in a higher equilibrium price, such as* p_{HOM}*, and a general efficiency loss. The total cost for each country can be calculated as the integral limited by the marginal cost function and the total number of migrants. Figure 2 depicts in grey the total cost increase (efficiency loss) due to the fact that countries are not able to choose their preferred migrant mix.*

A numerical example is useful to build further intuition of the results. Consider $a^H = 1; a^L = 2; b^H = 3; b^L = 4$*. The total number of migrants to allocate is 100. Suppose countries cannot express their preferences and receive one half of migrants of each type, that is* $\alpha = \beta = \frac{1}{2}$*. In this case, the price that will clear the market is* $p^{\frac{1}{2},\frac{1}{2}} = 52.5$*. Country A will get 70 migrants, 35 of type H and 35 of type L while country B will get 30 migrants, 15 of type H and 15 of type L, according to the equal probability assumption made above. The total cost of the mechanism would be* $TC^{\frac{1}{2},\frac{1}{2}} = 2,625$*.*

Now suppose that countries can get their preferred mix through the matching mechanism. With the above numbers, we would have $\alpha = \frac{2}{3}$ *and* $\beta = \frac{4}{7}$*. Then, the market clearing price is lower:* $p^{\hat{\alpha}\hat{\beta}} = 48$*. Country A will get 72 migrants, 48 of type H and 24 of type L while country B will get 28 migrants, 16 of type H and 12 of type L. The total cost of the mechanism would be* $TC^{\hat{\alpha}\hat{\beta}} = 2,400$*.*

Figure 2: A TIQs Market with Two Countries



Note: M is the total number of migrants to be allocated by the market; p_{HOM} is the price in a market in which countries cannot choose their preferred migrant mix; p_{OPT} is the price in a market in which countries can choose their preferred migrant mix; marginal costs as in figure 1 for countries A and B with B migrants being counted from right to left; the shaded area represent the difference in total costs between the market with country preferences taken into account and a market where country preferences are not satisfied.

3 Applications

3.1 Climate Change, Refugee Protection and Resettlement

As explained in the introduction, the idea that visas can be exchanged for monetary contributions was first advanced in the context of refugee protection and resettlement. This is not surprising as refugee protection is a classical example of an international public good. In this section we first briefly describe the current refugee protection system and discuss why and how a system of tradable refugees' resettlement quotas could represent a substantial improvement over the current situation. We also discuss the case of climate change refugees, for which a TIQs system along the lines discussed in section 2 would seem particularly relevant.

3.1.1 Background

The Geneva Refugee Convention, adopted on July 28, 1951, defines a refugee as "a person who is outside his/her country of nationality or habitual residence; has a well founded fear of persecution because of his/her race, religion, nationality, membership in a particular social group or political opinion; and is unable or unwilling to avail himself/herself of the protection of that country, or to return there for fear of persecution."The 148 countries that signed the Geneva Convention and/or its extension in the 1967 Protocol are committed to admit any person satisfying the above criteria and asking for asylum and to grant that person protection and basic human rights. The number of international refugees as just defined has been relatively stable during the last decade at about 10 million. This is in contrast to the number of Internally Displaced Persons (IDPs), who now represent the bulk of the total "population of concern" to the United Nations High Commissioner for Refugees.

In its preamble, the Geneva Convention recognizes that "the grant of asylum may place unduly heavy burdens on certain countries" and that "a satisfactory solution of a problem of which the United Nations has recognized the international scope and nature cannot be achieved without international cooperation." Indeed, the "refugee burden" tends to fall disproportionately on countries with low capacity to assume it, usually on countries which are contiguous to the refugees' origin countries and serve as countries of first asylum. This is generally addressed through relief and emergency aid financed by the international community. However, as time passes, many refugees often find themselves unable to return to their home country due to persistent political, economic or environmental crisis. At the end of

2003, the UNHCR calculated that at least 6.2 million refugees could be considered in "protracted refugee status" (UNHCR, 2004a).[21] For this type of refugees, resettlement appears as the main durable solution.

The current system of refugee protection is widely viewed as inefficient and leading to under-provision of refugee protection and asylum at the international level.[22] One of the reasons for this unsatisfactory outcome is that it has long been plagued by a "screening" problem, that is, the difficulty for countries to distinguish between refugees genuinely seeking asylum and regular economic migrants. The inability to differentiate between these two types has repeatedly been put forward as a justification for tightening refugee protection policies, resulting in a race to the bottom in refugees' acceptance standards (Barbou des Places and Deffains, 2004; Hatton, 2004; Neumayer, 2004; Bubb, Kremer and Levine, 2011). This prompted proposals to reform the 1951 Convention, notably during the 1990s when Schuck (1997) and Hathaway and Neve (1997) made parallel proposals to use tradable quotas in the context of refugee resettlement. In the words of Schuck (1997, p. 248), "the proposal consists of two main elements. First, a group of states would (...) arrange for an existing or newly-established international agency to assign to each participating state a refugee protection quota. (...) Second, the participating states would then be permitted to trade their quotas by paying others to fulfill their obligations." through bilateral exchange (Schuck, 1997, pp. 283-284). In what follows we generalize these ideas to fully-fledged tradable quotas system.

3.1.2 A market for tradable refugee quotas

Refugees' resettlement is probably where a TIQs system is both most needed and feasible. Indeed, as noted by the UNHCR, "resettlement is an area of activity where multilateral agreements between States have the potential to achieve a significant impact on solving protracted refugee situations and thereby facilitate solutions for a greater number of refugees" (UNHCR, 2004b). We propose to consider refugees in "protracted refugee status" as candidates to international resettlement to at least partially solve the screening problem discussed above: receiving such status takes a long time and would therefore be a very costly detour

[21] This measure only counted refugees in developing countries who had been in exile for five or more years in refugee camps larger than 25,000. It is thus likely to be an under-estimation.

[22] See for example Hatton (2011). Hatton (2012) argues that refugees and asylum systems constitute the most likely area of agreement for the coordination of migration policies among countries, particularly at the European Union level.

for obtaining refugee status unduly. The potential for implementation also comes from the very low number of yearly international resettlements and the tremendous differences in the contributions of the main stakeholders in this process (see Table 2). Last but not least, the institutional framework for the mechanism to be implemented already exists, meaning that to a large extent the associated transaction costs have already been borne. Indeed, each year around June, global resettlement policies and quotas are discussed at the Geneva Annual Tripartite Consultations, a series of meetings involving government representatives from most OECD countries, the UNHCR, the European Commission, non-governmental organizations involved in resettlement activities, and the International Organization for Migration. Resettlement countries already agree on resettlement quotas for the year ahead. The only required innovation would be to allow for the possibility of opening a market to trade these quotas at a future date.

As demonstrated in Section 2, the possibility of trading quotas would induce a reduction in the cost of resettlements or allow for increasing initial resettlement for a given total cost. Based on these understandings, suppose an international agency (say, the UNHCR) determines that M refugees must be resettled and N countries agree to become resettlement countries and are assigned a quota of refugees based on some agreed-upon rule.[23] Once the total number M and the initial distribution of quotas $\{m_{i0}\}_{i=1}^{N}$ are agreed upon among the N participating resettlement countries,[24] the subset of refugees that will actually be resettled has to be decided. This is critical since the number of refugees that countries are likely to agree upon for resettlement is much lower than the total number of refugees. The UNHCR should be the appropriate agent to select the group of refugees to be resettled, possibly with the help of NGOs. Finally, to make sure that the market is competitive, we follow Casella (1999) in proposing a computerized continuous double auction to organize trades. This departs notably from the original idea of Schuck (1997) and Hathaway and Neve (1997)

[23]Assume also that all refugees are already outside of their home country (e.g., in refugee camps) and a market as described above operates among the N possible destination countries. Then the problem is exactly analogous to assigning houses to tenants with existing rights (Abdulkadiroglu and Sonmez, 1999). Since the refugees must always be given the possibility of staying in their country of first asylum (i.e., no individual can be forced into an undesired destination), the right of the refugees to stay in their original location can be considered as their current "house" (see appendix B).

[24]In the case of the European Union, Hatton and Williamson (2004) propose a double contribution: financial contributions to a European Refugee Fund, which should be proportional to the countries' GDP, and contributions through resettlement quotas, which should be proportional to the countries population.

Table 2: **Resettlement Arrivals of Refugees (2011)**

Country of arrival	**Numbers**
Argentina	28
Australia	9,226
Belgium	29
Brazil	23
Canada	12,929
Chile	23
Denmark	516
Finland	584
Germany	63
Ireland	45
Japan	18
Netherlands	538
New Zealand	497
Norway	1,273
Paraguay	22
Philippines	13
Portugal	30
Sweden	1,895
United Kingdom	454
United States	51,458
Uruguay	4
TOTAL	**79,784**

Source: www.uhcr.org

who proposed bilateral negotiation processes in which the relative strength of the parties was likely to play a more decisive role.

3.1.3 Climate Change Refugees

A system of tradable refugee resettlement quotas would seem even more relevant in the case of climate change refugees for at least three reasons. First, in the case of displacement due to climate change, the need for refugee protection is unlikely to be temporary and requires long-term solutions. Second, it is relatively easy in this case to determine who is entitled to refugee protection. And third, the need for international resettlement is obvious in certain circumstances such as the disappearance of some states, which is likely to happen to a number of small island-states in the Pacific and the Caribbean (Kelman, 2008).

Note however that the term "climate change refugee" is controversial (see Dun and Gemenne, 2008; Stavropoulou, 2008; Barnett and Webber, 2010). For example, the UNHCR limits the use of the term "climate change refugees" to population movements provoked by armed conflicts that may have a climate root (e.g., Darfur).[25] However, in practice, the UNHCR has often played a major role in the aftermath of natural disasters independently of whether they entailed civil conflict. This has been the case for the 2004 tsunami in Indonesia and Sri Lanka, the 2005 earthquake and the 2007 floods in Pakistan, the 2006 floods in Somalia or the 2008 cyclone in Myanmar.

Partly due to disputes on terminology and, for the most part, to disagreement on the expected magnitude of climate change, the range of the estimates in terms of numbers of displaced individuals due to climate change is quite large. Elverland (2009) calculated that 20 million people have been displaced because of climate-related events in 2008 alone. His count included 6.5 million from floods in India, 2 million from a storm in the Philippines and 2 million from a storm in the US. Clearly, these are not the types of displacements (mostly internal and temporary in nature) for which a market for tradable refugee quotas would be an adequate tool. Long-run climate change refugees estimates vary wildly, from twenty million to one billion by 2050. The most widely cited number is Myers' (2005) estimate of 200 million, out of which one million would come from disappearing island states. At

[25]Contrary to the UNHCR, individual countries already recognize extreme events by which they host individuals that do not satisfy the conditions of refugee status. See our discussion of the US temporary protected status in Section 1.2 above.

least for these one million people, the mechanism proposed here would seem to be entirely appropriate.

3.2 Extending the US Diversity Lottery Visa

In this section we draw on the experience of an existing immigration program, namely, the US diversity lottery visa (or green card lottery) to illustrate the possible workings of a TIQs system that could be adopted by the OECD member countries as a policy tool to fight global poverty.

3.2.1 Background: the US Green Card Lottery

Each year, 50,000 immigration visas are made available through a lottery to people who come from countries with low levels of immigration (less than 50,000 immigrants in the previous five years) to the US.[26] These visas are termed Diversity Visas and the lottery is known as the Green Card Lottery Program. Individuals from non-excluded countries are eligible if they have at least "a high school education or its equivalent or have, within the past five years, two years of work experience in an occupation requiring at least two years' training or experience." Someone receiving a visa through the Diversity Visa Lottery Program will be authorized to live and work permanently in the United States and will also be allowed to bring the dependents listed on his/her application.

For example, the application process for the 2010 Diversity Lottery program took place between October and November 2008. The only excluded countries were: Brazil, Canada, China, Colombia, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, India, Jamaica, Mexico, Pakistan, Peru, the Philippines, Poland, South Korea, the United Kingdom (except Northern Ireland) and its dependent territories, and Vietnam. There were a total of 13,6 million applications that entered the lottery, out of which the Department of State randomly selected 102,800: a 0.76 percent average probability of winning the lottery, although the actual probabilities differ by country, favoring natives of small-size countries. Nigeria was the country with the highest number of registered applicants (lottery winners) with 6,006, closely followed by Bangladesh (6,001) and Ethiopia (5,200). The final 50,000 visas

[26]The Nicaraguan and Central American Relief Act (NACARA) passed by Congress in November 1997 stipulated that up to 5,000 of the 55,000 annually-allocated diversity visas should be made available for use under the NACARA program. The reduction of the limit of available visas to 50,000 began in 2000.

will come out of these since many applicants will not complete the visa process. Applicants are not provided any type of assistance such as airfare, housing assistance, or subsidies. If selected, they are required to provide evidence that they will not become a public charge in the United States before being issued a visa.

3.2.2 An OECD Poverty Reduction Visa?

It is conceivable to extend the US Diversity Visa Program to other high-income receiving countries and to target potential migrants (be them permanent or temporary, that is, of the guest-worker type) according to the expected contribution of their immigration to global poverty reduction. Under such an extension, each destination country would be assigned a number of visas (initial quotas) and be allowed to trade them in a centralized market. Eligible migration candidates (e.g., residents of poor countries at environmental, political or economic risk) would be asked about their preferences over potential destinations, and destination countries would be asked about their preferences over migrants' types. Implementing such a program would require addressing a number of issues with regards to screening,[27] market regulation,[28] definition of a fair distribution of initial quotas, and participation of enough destination countries, along the general lines discussed in Section 2.

3.2.3 Simulations

We present a simple numerical simulation of the way an OECD Poverty Reduction Visa could be implemented. To determine initial quotas, we assume participation of all the high-income countries, set the total number of visas that the US would award at the current size of the US Diversity Program (50,000) and assign quotas to the other countries so that they are proportional to GDP. Since the US GDP represents 36 percent of the high-income OECD countries in 2008, this implies setting the total number of visas to 140,140 (see Table 3 for the distribution).

One of the advantages of the proposed mechanism is to allow countries to discover the real shape of their country-specific cost functions ($c_i(m_i)$ in our model), for which we have

[27] In the case of the US Diversity Visa, the US Department of State screens applicants both for economic and security reasons; in an OECD-extended framework, either a common screening procedure or a procedure where each country has veto right could be agreed upon.

[28] Here we again follow Casella (1999) in proposing a computerized continuous double auction to organize trades.

to choose a specification to perform the simulation. De la Croix and Docquier (2010), for example, choose the function $\frac{\gamma_i}{2}\left(\frac{m_i}{n_i}\right)^2$, where n_i is the number of natives in country i and γ_i is a country-specific parameter that can be interpreted as the degree of aversion to immigration.[29] They calibrate it to match the observed distribution of migration stocks across rich countries. In our simulation, we arbitrarily choose the following specification:[30]

$$c_i(m_i) = \frac{\gamma_i}{2}\frac{m_i^2}{pop_i}$$

Defining pop_i as the total population of country i, this allows us to write marginal costs as a linear function of the new migration share:

$$c_i'(m_i) = \gamma_i \frac{m_i}{pop_i}$$

This simple marginal cost function implies that countries do not want to receive any more migrants than they currently have. In other words, we here interpret m_i as denoting the new immigrants only while previously accepted immigrants are considered part of the population.

We present two different simulations. In the first one, we assign to γ_i the following values from the 2003 ISSP National Identity Module (Facchini and Mayda, 2008): "share of respondents who believe immigration should be reduced a lot." We interpret this as a proxy for anti-immigration attitudes. Since the numbers we present are just illustrative, we are

[29] In De la Croix and Docquier (2010), countries maximize the following national utility function:

$$U_i = u(C_i) + \beta u(C_o) - \frac{\gamma_i}{2}\left(\frac{m_i}{n_i}\right)^2$$

where C_i is the consumption level of country i inhabitants, C_o is the consumption level of poor country individuals (positively affected by migration and β is a parameter that denotes altruism towards poor country individuals when positive. Positive values of β are one possible way of formalizing the externality.

[30] In fact, the exact translation between De la Croix and Docquier's (2010) model and ours would mean that:

$$g_i(M_{-i}) - c_i(m_i) = u(C_i(m_i)) + \beta u(C_o(M_{-i})) - \frac{\gamma_i}{2}\left(\frac{m_i}{n_i}\right)^2$$

Both functional forms are equally arbitrary but they serve the purpose of illustrating the mechanism.

Note that we do not "believe" in a particular specification, the very purpose of the proposed mechanism being precisely to reveal the "true" immigration cost function, and choose the above cost functions for illustrative purposes only.

agnostic as to what measure of anti-immigration sentiment should be used. We only have the formal requirement that the measure we pick is characterized by sufficient variability to generate enough gains from trade.

The results can be seen in Table 3, columns 3 to 5. The countries with relatively low GDP and low anti-immigration sentiment would become quota buyers and receive a monetary compensation in return: Spain, Canada, Japan, Portugal and Australia would all host substantially more immigrants than their assigned quota. On the other side of the market, Germany, the UK, France, the US, the Netherlands and Norway would all receive significantly less immigrants than their assigned quotas. All in all, 16 percent of the total number of quotas would be traded, generating an efficiency gain of 17 percent of the total cost compared to the initial quota allocation.

In our second parameterization, we identify γ_i with the inverse of the 1990-2000 net migration flows of non-tertiary educated individuals from low-income countries received by country i (taken from Docquier and Marfouk (2006) – see Table 1) to population in country i. The intuition behind this measure is that the acceptance of immigrants during the 1990-2000 is a measure of the degree of revealed tolerance for immigration. The results of a market for TIQs with our second measure can be seen from Table 3, columns 6 to 8. This time, the main quota buyers would be the US, the UK, Australia and Canada with more than one thousand extra immigrants received in exchange for widely varying cost reductions with respect to their original quotas (between 141 percent for Australia and 19 percent for the US). The main sellers, those who pay for accepting less immigrants than they are initially assigned, would be Japan, Germany, Italy and Spain in this order, all with more than three thousand quotas sold. In summary, the cost reduction would be 57 percent and the traded quotas would amount to 13 percent of the total.

Obviously, the two simulations yield very different results; this is not surprising given our view that immigration cost functions can hardly be calibrated using real world data and can only be exposed through a revelation mechanism such as a TIQs system.

4 Conclusion

Providing visas to low-skill workers from poor countries contributes to global poverty alleviation, an international public good. The current system where each country sets its

Table 3: **Simulations of an OECD Poverty Reduction Visa with a market for TIQs**

Countries	Initial quotas	Aversion 1: ISSP 2003	Market Quota 1	Cost Reduc. 1 v. initial quota	Aversion 2: inv. flows 90-00 over total pop.	Market Quota 2	Cost Reduc. 2 v. initial quota
Australia	3,602	16.8	4,681	9%	393	7,882	141%
Austria	1,467	32.7	934	13%	3318	363	57%
Belgium	1,789	26.0	1,510	2%	4714	328	67%
Canada	5,326	10.2	11,965	155%	600	8,024	26%
Denmark	1,211	25.9	779	13%	477	1,667	14%
Finland	967	15.8	1,231	7%	1198	641	11%
France	10,134	35.4	6,457	13%	1096	8,217	4%
Germany	12,948	44.3	6,799	23%	2598	4,569	42%
Greece	1,263	26.0	1,585	7%	84620	19	97%
Iceland	59	26.0	45	6%	420	109	72%
Ireland	949	27.7	587	15%	3221	199	63%
Italy	8,171	26.0	8,439	0%	2180	3,969	26%
Japan	17,423	20.2	23,242	11%	4983	3,705	62%
Luxembourg	191	26.0	69	41%	1861	38	64%
Netherlands	3,090	37.8	1,594	23%	1010	2,354	6%
N. Zealand	461	26.8	584	7%	955	646	16%
Norway	1,603	36.4	481	49%	522	1,321	3%
Portugal	864	19.1	2,041	186%	1077	1,425	42%
Spain	5,691	13.2	12,657	150%	2762	2,384	34%
Sweden	1,699	25.6	1,323	5%	540	2,466	20%
Switzerland	1,745	16.9	1,659	0%	1143	967	20%
UK	9,487	50.9	4,427	28%	519	17,119	65%
US	50,000	23.7	47,050	0%	613	71,725	19%
Total	140,140	26.6	140,140	17%	2280.0	140,140	57%
Quotas traded			16%			13%	

immigration policy non-cooperatively fails to internalize the externality arising from the international public good nature of global poverty alleviation and results in a global under-provision of visas. This paper shows that a market for tradable immigration quotas (TIQs) supplemented by a matching mechanism between migrants and destinations can go part of the way towards addressing such inefficiencies. Indeed, a key advantage of a TIQs system is its ability to reveal information on the country-specific costs of hosting additional migrants and to provide a framework to realize the welfare gains arising from the fact that certain countries have a comparative advantage in hospitality. In addition, the type of matching mechanism we propose as well as the small scale of the applications envisionned should assure participation of a sufficient number of host countries for the proposed system to be viable.[31] Specifically, we considered two situations in which a TIQs system would seem a natural extension of existing policies: a market for the resettlement of international refugees, and the creation of an OECD poverty reduction visa program.

We conclude with a brief discussion of three possible directions for future research. First, a natural question to ask about the immigration cost functions, which are so central to the analysis, is: whose cost function? We are of course not certain that the implicit cost function that drives supply and demand in a market for immigration quotas is the one that maximizes the welfare of the average or the median voter and does not reflect the interests of pressure groups. Immigration policy is a rich ground for political economy and TIQs would make no exception. Second, the proposed mechanism is in theory flexible enough to address at least partly the issue of illegal migration. In the presence of undesired illegal migrants and to the extent that these are included in the group of migrants targeted by a TIQs system, a country is offered the option to go down its cost curve by trading migrants already on its soil (and who could therefore be seen as having pre-existing rights, see Appendix B) or be compensated for their presence. How would this affect the incentives on both sides to migrate, legalize or deport is another potential extension of this work. Finally, we note that the main contributor to global inequality is not race, gender, education or social class, but birthplace. A third direction for future research, therefore, is to envision immigration policy from the perspective of global justice (Findlay, 1982, Pritchett, 2010). From this perspective, allowing for more international migration through a TIQs system can be seen as a practical and cost-efficient way to supply a (very partial) social insurance against the risk of being

[31] Moral objections to a TIQs system are discussed in Kuosmanen (2012).

born in a failed country.

References

[1] Abdulkadiroglu, A. and T. Sonmez (1999): House Allocation with Existing Tenants, Journal of Economic Theory, 88: 233-260

[2] Alesina, A. and E. La Ferrara (2000): Participation in Heterogeneous Communities, Quarterly Journal of Economics, 115(3): 847-904.

[3] Alesina, A. and E. La Ferrara (2002): Who trusts others?, Journal of Public Economics, 85(2): 207-234.

[4] Auriol, E. and A. Mesnard (2012): Sale of Visas: A Smuggler's Final Song?, CEPR Discussion Paper No 8965.

[5] Azevedo, E.M. and E. Budish (2012): Strategyproofness in the Large as a Desideratum for Market Design, mimeo.

[6] Azevedo, E.M. and J.D. Leshno (2012): A Supply and Demand Framework for Two-Sided Matching Markets, mimeo.

[7] Barbou Des Places, S. and B. Deffains (2004): Cooperation in the shadow of regulatory competition: the case of asylum legislation in Europe, International Review of Law and Economics 23: 345-364

[8] Barnett, J. and Webber, M. (2010): Accommodating Migration to Promote Adaptation to Climate Change, World Bank Policy Research Working Paper 5270. Background Paper to the 2010 World Development Report.

[9] Baumol, W. J. and W. E. Oates (1995): The theory of environmental policy. Second Edition. Cambridge University Press.

[10] Becker, G.S. (1992): An Open Door for Immigrants – the Auction, The Wall Street Journal, October 14.

[11] Bubb, R., M. Kremer and D. I. Levine (2011): The Economics of International Refugee Law, Journal of Legal Studies, forthcoming.

[12] Card, D., C. Dustmann and I. Preston (2012): Immigration, wages and compositional amenities, Journal of the European Economic Association, 10 (1): 78-119.

[13] Casella, A. (1999): Tradable Deficit Permits. Efficient Implementation of the Stability Pact, Economic Policy 29: 323-347.

[14] Chen, Y. and T. Sonmez (2002): Improving Efficiency of On-Campus Housing: An Experimental Study, American Economic Review, 92 (5): 1669-1686.

[15] Clemens, M. (2011): Economics and Emigration: Trillion-Dollar Bills on the Sidewalk?, Journal of Economic Perspectives, 25, 3: 83-106.

[16] Clemens, M. and L. Pritchett (2008): Income per natural, Population and Development Review, 34 (3): 395-434

[17] Clemens, M., C. Montenegro and L. Pritchett (2008): The place premium: wage differences for identical workers across the US border, CGD Working Paper No 148, Washington DC: Center for Global Development.

[18] Coase, R. (1960): The Problem of Social Cost, Journal of Law and Economics, 3: 1-44.

[19] Cortes, P. (2008): The effect of low-skill immigration on US prices: evidence from CPI data, Journal of Political Economy, 116, 3: 381-422.

[20] Courtois, P and G. Haeringuer (2012): Environmental Cooperation: Ratifying Second-Best Agreements, Public Choice 151: 565-584.

[21] Crocker, T.D. (1966): The Structuring of Atmospheric Pollution Control Systems. In The Economics of Air Pollution, ed. Harold Wolozin, 61-86. New York.

[22] Dai, X. (2007): International Institutions and National Policies, Cambridge, Ma: Cambridge University Press.

[23] Dales, J.H. (1968): Land, Water and Ownership, Canadian Journal of Economics 1 (4): 791-804.

[24] De la Croix, D. and F. Docquier (2010): An Incentive Mechanism to Break the Low-skill Immigration Deadlock, CREAM Discussion Paper No 08/10, May.

[25] De la Croix, D. and A. Gosseries (2007): Procreation, Migration, and Tradable Quotas, in Population Aging, Intergenerational Transfers and the Macroeconomy, edited by R. Clark, A.Mason and N. Ogawa. Edward Elgar Publishing: 227-249.

[26] Djajic, S., M.S. Michael and A. Vinogradova (2012): Migration of skilled workers: policy interaction between host and source countries, Journal of Public Economics, 96, 11-12: 1015-24.

[27] Docquier, F. and A. Marfouk (2006): International migration by educational attainment (1990-2000), in International Migration, Remittances and Development, edited by C. Ozden and M. Schiff. Palgrave Macmillan: New York.

[28] Dun, O. and Gemenne, F. (2008): Defining 'environmental migration', Forced Migration Review, 31, 10-11.

[29] Dustmann, C. and I. Preston (2007): Racial and economic factors in attitudes to immigration, B.E. Journal of Economic Analysis and Policy, 7 (1) (Advances): Article 62.

[30] Elverland, S. (2009): 20 million Climate Displaced in 2008, Norwegian Refugee Council, available at: http://www.nrc.no/?did=9407544

[31] Facchini, G. and A. M. Mayda (2008): From individual attitudes towards migrants to migration policy outcomes: Theory and evidence, Economic Policy 23: 651-713

[32] Fernández-Huertas Moraga, J. (2011): New evidence on emigrant selection, The Review of Economics and Statistics 93 (1): 72-96.

[33] Findlay, R. (1982): International distributive justice, Journal of International Economics, 13: 1-14.

[34] Finnemore, M. and K. Sikkink (1998): International norm dynamics and political change, International Organization, 52, 4: 887-917.

[35] Friedman, D. and J. Ostroy (1995): Competitivity in Auction Markets: An Experimental and Theoretical Investigation, The Economic Journal 105 (428): 22-53.

[36] Gale, D. and L. Shapley (1962): College Admissions and the Stability of Marriage, American Mathematical Monthly 69, 9-15.

[37] Gilligan, M.J. (2009): The transactions costs approach to international institutions; in Helen Milner and Andrew Moravcsik, eds.: Power, Interdependence, and Nonstate Actors in World Politics, Princeton: Princeton University Press.

[38] Hahn, R.W. and R.N. Stavins (2010a): The Effect of Allowance Allocations on Cap-and-Trade System Performance, The Journal of Law and Economics, forthcoming.

[39] Hahn, R.W. and R.N. Stavins (2010b): Why cap-and-trade should (and does) have appeal to politicians, voxeu.org (13 April 2010).

[40] Hainmueller, J. and M.J. Hiscox (2010): Attitudes towards highly skilled and low-skilled immigration: evidence from a survey experiment, American Political Science Review, 104, 1: 61-84.

[41] Hanson, G.H. (2009): The economic consequences of the international migration of labor, Annual Review of Economics, 1: 179-208.

[42] Hanson, G. H., K. Scheve and M. J. Slaughter (2007): Public Finance And Individual Preferences Over Globalization Strategies, Economics and Politics 19 (1): 1-33

[43] Hathaway, J. C. and R. A. Neve (1997): Making International Refugee Law Relevant Again: A Proposal for Collectivized and Solution-Oriented Protection, Harvard Human Rights Journal, 10: 115-211

[44] Hatton, T. J. (2004): Seeking asylum in Europe, Economic Policy, 19 (38): 5-62

[45] Hatton, T. J. (2011): Seeking Asylum. Trends and Policies in the OECD. CEPR. London, UK.

[46] Hatton, T.J. (2012): Asylum Policy in the EU: the case for deeper integration, Norface Migration Discussion Paper No 2012-16.

[47] Hatton, T. J. and J. G. Williamson (2004): Refugees, Asylum Seekers and Policy in Europe, NBER Working Paper 10680.

[48] Hillman, A. (2010): Expressive behavior in economics and politics, European Journal of Political Economy, 26: 403-18.

[49] Kelman, I. (2008): Island evacuation, Forced Migration Review, 31, 20-21.

[50] Kuosmanen, J. (2012): What (If Anything) Is Wrong with Trading Refugee Quotas?, Res Publica (September), 1-17.

[51] Mayda, A. M. (2008): Why are people more pro-trade than pro-migration?, Economics Letters, 101 (3): 160-163

[52] McKenzie, D., J. Gibson and S. Stillman (2010): How important is selection? Experimental vs. Non-Experimental Measures of the Income Gains from Migration, Journal of the European Economic Association, 8, 4: 913-945

[53] McKenzie, D. and H. Rapoport (2007): Network effects and the dynamics of migration and inequality: theory and evidence from Mexico, Journal of Development Economics, 84, 1: 1-24

[54] McKenzie, D. and H. Rapoport (2010): Self-selection patterns in US-Mexico migration: the role of migration networks, The Review of Economics and Statistics 92 (4): 811-821.

[55] Mishra, P. (2007): Emigration and wages in source countries: evidence from Mexico, Journal of Development Economics, 82, 1: 180-99

[56] Montgomery, D.W. (1972): Markets in Licenses and Efficient Pollution Control Programs, Journal of Economic Theory 5 (3): 395-418.

[57] Muller, R.A., S. Mestelman, J. Spraggon and R. Godby (2002): Can Double Auctions Control Monopoly and Monopsony Power in Emissions Trading Markets?, Journal of Environmental Economics and Management 44: 70-92.

[58] Myers, N. (2005): Environmental Refugees: An emergent security issue, 13th Economic Forum, Prague

[59] Neumayer, E. (2004): Asylum Destination Choice: What Makes some European Countries more Attractive than Others?, European Union Politics, 5 (2): 155-180

[60] Orrenius, P.M. and M. Zavodny (2010): Beside the Golden Door: U.S. Immigration Reform in a New Era of Globalization, Washington, D.C.: AEI Press.

[61] O'Rourke, K. H. and Sinnott, R. (2006): The determinants of individual attitudes towards immigration, European Journal of Political Economy 22 (4): 838-861.

[62] Ottaviano, G.I.P. and G. Peri (2012): Rethinking the effect of immigration on wages, Journal of the European Economic Association, 10, 1: 152-97.

[63] Pathak, P. and T. Sonmez (2011): School Admissions Reform in Chicago and England: Comparing Mechanisms by Their Vulnerability to Manipulation, American Economic Review, forthcoming.

[64] Peri, G. (2012): Rationalizing US Immigration Policy: Reforms for Simplicity, Fairness and Economic Growth, Policy Brief, The Hamilton Project, May.

[65] Petrakis, E. and A. Xepapadeas (1996): Environmental consciousness and moral hazard in international agreements to protect the environment, Journal of Public Economics, 60: 95-110.

[66] Pritchett, L. (2006): Let their people come. Breaking the gridlock on global labor mobility, Washington, DC: Center for Global Development.

[67] Pritchett, L. (2010): The cliff at the border; in Ravi Kanbur and Michael Spence, eds.: Equity and Growth in a Globalizing World, Washington DC, World Bank, Commission on Growth and Development, forthcoming.

[68] Reinhart, F.L. (2000): Down to Earth: Applying Business Principles to Environmental Management, Boston, MA: Harvard Business School Press.

[69] Rodrik, D. (2007): One economics, many recipes: globalization, institutions and economic growth, Princeton: Princeton University Press.

[70] Roth, A. E. (1985): The College Admissions Problem is not Equivalent to the Marriage Problem, Journal of Economic Theory 36, 277-288

[71] Roth, A. E. (2002): The Economist as an Engineer: Game Theory, Experimental Economics and Computation as Tools of Design Economics, Econometrica, 70 (4): 1341-1378.

[72] Schuck, P. H. (1997): Refugee Burden-Sharing: A Modest Proposal, Yale Journal of International Law, 22: 243-297

[73] Shen, I.-L., F. Docquier and H. Rapoport (2010): Remittances and inequality: a dynamic migration model, Journal of Economic Inequality, 8, 2: 197-220

[74] Sonmez, T. and M. U. Unver (2011): Matching, Allocation and Exchange of Discrete Resources, in J. Benhabib, A. Bisin and M. Jackson, eds.: Handbook of Social Economics, Amsterdam: North Holland.

[75] Stavins, R.N. (2011): The Problem of the Commons: Still Unsettled after 100 Years, American Economic Review 101: 81-108.

[76] Stavropoulou, M. (2008): Drowning in definitions?, Forced Migration Review, 31, 11-12.

[77] UNHCR (2004a): Protracted Refugee Situations. Executive Committee of the High Commissioner's Programme. Standing Committee 30th Meeting. 10 June.

[78] UNHCR (2004b): Progress Report on Resettlement. Executive Committee of the High Commissioner's Programme. Standing Committee 30th Meeting. 7 June.

[79] UNHCR (2009): Forced Displacement in the Context of Climate Change: Challenges for States Under International Law, Paper submitted by the Office of the United Nations High Commissioner for Refugees in cooperation with the Norwegian Refugee Council, the Representative of the Secretary General on the Human Rights of Internally Displaced Persons and the United Nations University to the 6th session of the Ad Hoc Working Group on Long-Term Cooperative Action under the Convention (AWG-LCA 6) from 1 until 12 June in Bonn.

[80] Walmsley, T.L., A.L. Winters and S.A. Ahmed (2009): The Impact of the Movement of Labour: Results from a Model of Bilateral Migration Flows, Mimeo., University of Sussex.

[81] Weitzman, M. L. (1974): Prices vs. Quantities, The Review of Economic Studies, 41 (4): 477-4

5 Supplementary Appendix

5.1 Appendix A: Taking participation constraints into account.

The general formulation of the problem in which the countries participation constraints are satisfied is:

$$\max_{\{m_{i0}\}_{i=1}^{N}} \sum_{i=1}^{N} \left[g_i\left(M_{-i}^{M}\right) - c_i\left(m_i^{M}\right) \right]$$

$$\begin{aligned} s.t. \qquad \sum_{i=1}^{N} m_{i0} &= M \\ g_i\left(M_{-i}^{M}\right) - c_i\left(m_i^{M}\right) + p\left(m_i^{M} - m_{i0}\right) &\geq g_i\left(M_{-i}^{NC}\right) - c_i\left(m_i^{NC}\right) \qquad \forall i = 1...N \\ m_i^{M} &= \arg\min\left\{ c_i\left(m_i\right) - p\left(m_i - m_{i0}\right) \right\} \qquad \forall i = 1...N \end{aligned}$$

The first order conditions are:

$$\begin{aligned} \mu - p\pi_i &= 0 \qquad \forall i = 1...N \\ \sum_{i=1}^{N} m_{i0} - M &= 0 \\ \pi_i \left[g_i\left(M_{-i}^{M}\right) - c_i\left(m_i^{M}\right) + p\left(m_i^{M} - m_{i0}\right) - g_i\left(M_{-i}^{NC}\right) + c_i\left(m_i^{NC}\right) \right] &= 0 \qquad \forall i = 1...N \\ \pi_i &\geq 0 \end{aligned}$$

where μ is associated to $\sum_{i=1}^{N} m_{i0} = M$ and π_i is associated to $g_i\left(M_{-i}^{M}\right) - c_i\left(m_i^{M}\right) + p\left(m_i^{M} - m_{i0}\right) \geq g_i\left(M_{-i}^{NC}\right) - c_i\left(m_i^{NC}\right)$. We are using the fact that $\frac{\partial m_j^{M}}{\partial m_{i0}} = 0 = \frac{\partial p}{\partial m_{i0}}$ $\forall i, j$ since the solution to the market problem does not depend on the initial allocation of quotas.

From the first set of conditions, we have:

$$\pi_i = \frac{\mu}{p} > 0 \qquad \forall i = 1...N$$

This leaves us with a rule to allocate initial quotas satisfying:

$$g_i\left(M_{-i}^{M}\right) - c_i\left(m_i^{M}\right) + p\left(m_i^{M} - m_{i0}\right) - g_i\left(M_{-i}^{NC}\right) + c_i\left(m_i^{NC}\right) = 0 \qquad \forall i = 1...N$$

which implies:

$$m_{i0} = m_i^M + \frac{g_i\left(M_{-i}^M\right) - g_i\left(M_{-i}^{NC}\right)}{p} - \frac{c_i\left(m_i^M\right) - c_i\left(m_i^{NC}\right)}{p} \qquad \forall i = 1...N$$

The countries benefitting the most from the externality (higher $g_i\left(M_{-i}^M\right) - g_i\left(M_{-i}^{NC}\right)$) should get higher initial quotas whereas those who deviate most from their individually optimal migration level because of the market (higher $c_i\left(m_i^M\right) - c_i\left(m_i^{NC}\right)$) should get lower initial quotas.

It must be the case that:

$$\sum_{i=1}^{N}\left[g_i\left(M_{-i}^M\right) - g_i\left(M_{-i}^{NC}\right)\right] = \sum_{i=1}^{N}\left[c_i\left(m_i^M\right) - c_i\left(m_i^{NC}\right)\right]$$

The overall gain from the market must equate the overall cost of the market for a maximum utility level to be obtained.

5.2 Appendix B: Application of the top trading cycles mechanism to the resettlement of refugees

The application of the top trading cycles mechanism to the refugee resettlement problem would work as follows:

1. Each refugee ranks all potential destination countries, specifying those to which she would not want to be resettled at all.

2. An ordering of refugees is randomly chosen from a given distribution of orderings.

3. For any given ranking of countries done by the refugees and ordering of refugees, the outcome is obtained using the following algorithm:

   (a) Assign the first refugee (from the ordering obtained in step 2) her top choice, the second refugee her top choice among the remaining visas, and so on, until someone requests a visa for which the quota (resulting from the market) is filled.

It is as if the first refugee with a visa in that quota is requested to exchange her visa.[32][33]

(b) If at that point, the refugee whose visa is requested has already chosen before, then go to the second refugee in that quota. If this one has also chosen, go to the third and so on. If the quota is filled with refugees who have already chosen before, then do not disturb the procedure (there is no room for Pareto improvement). Otherwise, modify the remainder of the ordering by inserting the refugee who did not choose yet to the top of the line and go on with the procedure.[34]

(c) Similarly, insert any refugee who is not already served at the top of the line once her visa (to stay in her first asylum country) is requested.

(d) If at any point a loop forms, it is formed exclusively by refugees with a visa each of them requesting the visa of the refugee who is next in the loop (a loop is an ordered list of refugees $(j_1, j_2, ..., j_k)$ where refugee j_1 requests the visa of refugee j_2, refugee j_2 requests the visa of refugee j_3..., refugee j_k requests the visa of refugee j_1). In such cases, remove all refugees in the loop by assigning them the visas they request and continue the procedure.

A key ingredient of this mechanism is that a refugee whose visa is requested is upgraded to the first place at the remaining of the line before her visa is allocated. As a result, the top trading cycles mechanism is individually rational, as it assures every refugee a visa that is at least as good as the possibility of staying in her first-asylum country. It is also

[32]How can this situation take place? For example, suppose that there are 10 refugees to be resettled. 5 of them stay in a refugee camp in country A and 5 in another refugee camp in country B. Suppose the market assigns 3 refugees to A, 5 to B and 2 to a third country C. This information is summarized in:

Countries	A	B	C
Initial situation	5	5	0
Market	3	5	2

Suppose the first refugee to choose is staying in country A and decides to request a visa for country B. It is as if she has requested one of the visas that one of the refugees (the second in the ordering in step 2) is already holding.

[33]Notice that when the country of first asylum is unique, the top trading cycles mechanism is equivalent to the random serial dictatorship.

[34]Following the previous example, the first refugee in country B is now at the top of the list and can choose before the previous one does so that there is a possibility that her position is freed if she chooses country A or C.

incentive compatible (no refugee has an incentive to misrepresent her preferences whatever the strategies others use) and Pareto efficient.

This is a direct application of Abdulkadiroglu and Sonmez (1999) following directly the exposition in Chen and Sonmez (2002) and substituting word by word house for visa and refugee for tenant. The relevant point for the case of refugees studied here is the possibility that the final allocation determined by the market might not be achieved. This can be seen in the following example:

Example 2 *Suppose the international community decides* 3 *refugees must be resettled. There are three countries willing to host them: A, B and C. The country of first asylum is country A for the first two refugees and country C for the last one. Suppose that the original distribution of quotas is the following:*

$$m_A^0 = 1; \qquad m_B^0 = 1; \qquad m_C^0 = 1$$

Now, the market opens, trade takes place and the following distribution of quotas is attained:

$$m_A^M = 0; \qquad m_B^M = 2; \qquad m_C^M = 1$$

There are 216 different refugee preference profiles that will generate different outcomes once the matching mechanism is applied. As an illustration, six of these preference profiles will be considered by fixing the preferences of the third refugee and assuming that the first two refugees have identical preferences:

1	*Preferences*	*First Asylum*	*Final Resettlement*		
					$m_A^* = 2 > m_A^M$
Refugee 1	$A \succ B \succ C$	A	A	$\Longrightarrow$	$m_B^* = 1 < m_B^M$
Refugee 2	$A \succ B \succ C$	A	A		$m_C^* = 0 < m_C^M$
Refugee 3	$A \succ B \succ C$	C	B		

The ordering of the refugees is taken randomly, as suggested in the step 1 of the top trading cycles mechanism. In this first example, refugees 1 and 2 prefer to stay in their first asylum country A whereas 3 chooses to move to country B, where there are two visas available.

2	*Preferences*	*First Asylum*	*Final Resettlement*		
					$m_A^* = 2 > m_A^M$
Refugee 1	$A \succ C \succ B$	A	A	$\Longrightarrow$	$m_B^* = 1 < m_B^M$
Refugee 2	$A \succ C \succ B$	A	A		$m_C^* = 0 < m_C^M$
Refugee 3	$A \succ B \succ C$	C	B		

This second case works the same way as the first one.

3	*Preferences*	*First Asylum*	*Final Resettlement*		
					$m_A^* = 0 = m_A^M$
Refugee 1	$B \succ A \succ C$	A	B	$\Longrightarrow$	$m_B^* = 2 = m_B^M$
Refugee 2	$B \succ A \succ C$	A	B		$m_C^* = 1 = m_C^M$
Refugee 3	$A \succ B \succ C$	C	C		

In this third preference profile, refugees 1 and 2 take the two visas that country B offers so that refugee 3 has to stay in country C. The market allocation is maintained under the matching mechanism in this case.

4	*Preferences*	*First Asylum*	*Final Resettlement*		
					$m_A^* = 0 = m_A^M$
Refugee 1	$B \succ C \succ A$	A	B	$\Longrightarrow$	$m_B^* = 2 = m_B^M$
Refugee 2	$B \succ C \succ A$	A	B		$m_C^* = 1 = m_C^M$
Refugee 3	$A \succ B \succ C$	C	C		

The fourth preference profile is also compatible with the market allocation.

5	*Preferences*	*First Asylum*	*Final Resettlement*		
					$m_A^* = 1 > m_A^M$
Refugee 1	$C \succ A \succ B$	A	C	$\Longrightarrow$	$m_B^* = 1 < m_B^M$
Refugee 2	$C \succ A \succ B$	A	A		$m_C^* = 1 = m_C^M$
Refugee 3	$A \succ B \succ C$	C	B		

In this case, refugee 1 demands the only visa available for country C. Since this visa belongs to refugee 3, refugee 3 gets to choose first. Refugee 3 chooses one of the two visas available for country B since there is no visa available for country A, her most preferred one. Then, refugee 1 can choose and take the visa for country C that has become available. Finally, refugee 2 can choose to go to country B, where there is still one visa available, or to remain in country A, which is her selected option.

6	*Preferences*	*First Asylum*	*Final Resettlement*		
					$m_A^* = 1 > m_A^M$
Refugee 1	$C \succ B \succ A$	A	C	$\Longrightarrow$	$m_B^* = 1 < m_B^M$
Refugee 2	$C \succ B \succ A$	A	A		$m_C^* = 1 = m_C^M$
Refugee 3	$A \succ B \succ C$	C	B		

The reasoning in this case is the same as in the previous one so that the market allocation is not reached.

A more extreme example can be considered in which the matching mechanism distorts the allocation initially established by the market. Suppose that the preferences of refugees are such that, even though they would be willing to go to other countries (suppose $m_i^a = M$ for all $i = 1...N$), they prefer the neighboring country of first asylum (country n). As long as $M > m_n^M$, it is clear that the cost minimizing allocation suggested by the market won't be realized. As a result, we have to differentiate the market allocation $\left\{m_i^M\right\}_{i=1}^N$ from the realized allocation once the matching mechanism comes into place: $\left\{m_i^{MM}\right\}_{i=1}^N$. Both allocations will be different whenever $m_n^{MM} > m_n^M$, which implies that $m_h^{MM} < m_h^M$ for some $h \neq n$. Notice that it cannot be the case that the realized allocation implies taking more refugees than those allocated for the market for any country who is not the first asylum country, that is $\nexists i \neq n \; s.t. \; m_i^{MM} > m_i^M$. This is the main difference with the general immigration case presented in the main text. Since the original refugee camps are included as potential destinations, we allow for the possibility that the allocation of the matching mechanism ends up assigning a larger number of refugees to a particular country (where a refugee camp is located) than that resulting from the market.

In such cases, it is clear that costs are not minimized for countries n and h. However, the relevant comparison is not with the market unfeasible (in that case) solution but with an alternative system or lack of system like the one that is prevalent nowadays by which most of the refugees stay in the first-asylum country in very poor conditions without this country being compensated (at least it would be compensated under the market system by the refugees in excess of its market quota times the market price). Also, it can be said that country h is punished with a higher cost for not being a desirable enough destination for refugees. In this sense, the initial distribution of quotas ($\{m_{i0}\}_{i=1}^N$) is crucial to avoid that low capacity countries are forced to pay an excessive price for participating in the system.