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# Migration dynamics

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Most migration flows include observable jumps, a phenomenon that is in line with migration irreversibility. We present a real option model where the migration choice depends on both the wage differential between the host country and the country of origin, and on the probability of full integration into the host country. The optimal migration decision of an individual consists of waiting to migrate in a (coordinated) mass of individuals. The size of the migration flow depends on the behavioural characteristics of the ethnic groups: the more "sociable" they are, the larger the wave and the lower the wage differential required. The second part of the paper is devoted to calibrating the model and simulating migration flows into Italy over the last decade. Our calibration can replicate the migration jumps in the short term. In particular, the calibrated model is able to project the induced labour demand elasticity level of the host country and the behavioural rationale of the migrants.

*Keywords:* migration; real option; labour market; network effect.

*JEL Classifications:* F22; J61; O15; R23.

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## 1. Introduction

Much economic research deals with mass migration inflows, observing that migration dynamics are in general characterised by gradual waves at the beginning of their processes, followed by suddenly increasing migration rates (so-called “migration jumps” or “mass immigration”) and then again by constant entry rates. Thus, Angrist and Kugler (2003), using descriptive statistics from the Eurostat labour force surveys for 18 EU and other EEA countries, observe that the late 1980s and early 1990s witnessed a “marked upturn”. Moretti (1999), studying Italian migration in the United States and Canada, between 1876 and 1913, highlights a sharp increase in the migration flow after 1900. A remarkable surge in immigration was also observable in the United States (Ottaviano and Peri 2005; Peri 2006; Massey 1995), in the UK (Jackman and Savouri 1992), in France (Thierry and Rogers 2004) and in Europe (Maillat 1986).[1] What could be the causes of these particular dynamics? We try to answer this question by searching for an endogenous explanation of migration jumps. We offer a model that merges the real option approach of investment decision applied to migration choice and the works on migration networks into a single framework.

In the economic literature, the main variable that affects the migration decision is the wage differential between the host country and the country of origin (Todaro 1969; Langley 1974; Hart 1975; Borjas 1990, 1994). Nevertheless, even if the wage differential is important, it is not sufficient to totally explain migrant behaviour. Evidence seems to stress the focal role of community networks in the migrant’s choice (Boyd 1989; Bauer and Zimmermann 1997; Winters et al. 2001; Bauer et al. 2002; Coniglio 2003; Munshi 2001, 2003; Heitmueller 2003). Moretti (1999), for example, with an alternative model to Todaro’s, found evidence that both the timing and the destination of migration could be explained by the presence of social networks in the host country.

1 The same evidence is found in Friedberg (2001), Hatton and Williamson (2006), Pedersen et al. (2004), and Hartog and Winkelmann (2003).

Furthermore, the fact that the migration decision is in many cases at least partially irreversible, is a third element that may help to explain the presence of jumps in the migration flows. In this respect, Burda (1995), following a real option approach, implemented Sjaastad's assumption (1962) that describes migration choice in terms of investment. Burda showed that individuals prefer to wait before migrating, even if the present value of the wage differential is positive, because of the uncertainty and the sunk costs associated with migration.[2] Subsequently Khwaja (2002) and Anam et al. (2004) developed Burda's approach by describing the role of uncertainty in the migration decision. Another work that uses real option in migration is Feist (1998), in which the author analyses the option value of the low-skilled workers to escape to the unofficial sector if welfare benefits come too close to the net wage in the official sector.

Assimilating the decision of each individual to migrate to a new country as a decision on an irreversible investment, we investigated the role played by social networks to help immigrants integrate into the host country, where an immigrant is completely integrated when his/her economic and social status is no different from the natives' status in the host country. We did this by considering the opportunity that each immigrant becomes a member of a network (a community) of homogeneous individuals, located in the host country. The community helps the immigrants to obtain a higher wage or improve their working conditions if there are strong ties among the members ("positive network externalities"). The larger the community, the higher the number of ties, the higher the flow of information on job opportunities, and therefore the higher the probability of integrating.

Nevertheless, if the number of immigrants continues to increase, labour competition as well as higher alienation[3] among immigrants inside the community may reduce their net benefits ("negative network externalities").

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2 Investment is defined as the act of incurring an immediate cost in the expectation of future payoff. However, when the immediate cost is sunk (at least partially) and there is uncertainty over future rewards, the timing of the investment decision becomes crucial (Dixit and Pindyck 1994, p. 3).

3 This is the case in which the members of the incumbent population discontinue their attraction of immigrants (see Heitmueller 2003).

The struggle between these two forces is shown by an inverted U-shaped benefit function which follows directly by modelling the probability of each immigrant being totally integrated into the host country *à la* Bass (1969).[4] The Bass model[5] describes the "behavioural rationale" of migration flows well by focusing on the role played by two kinds of immigrants: the innovators or individualists, and the imitators. The innovators are those individuals that decide to migrate independently of the decisions of others. The imitators are those individuals influenced by the number of previous migrants: they share information and tend to establish a network. The weight of each different type of immigrant influences the timing of migration and then the size of the community.[6]

On the one hand, the stronger the ties among individuals, the larger the wave. On the other hand, the presence of congestion in the community and/or strong competition among workers in the host country delays entry.[7]

Finally, we calibrate the model and simulate some migration flows into Italy in the period 1994–2000 by using the official national statistic

4 From a theoretical point of view, an U-shaped benefit function can be derived as combination of a "herd behaviour" and a network effect (see Bauer et al. 2002) or as an application of the theory of clubs (see Vergalli 2008).

5 The Bass model was originally built to study the diffusion of new durable products and largely adopted in the marketing literature.

6 The distinction between innovators and imitators is reminiscent of "the upper class theory of fashion" (Veblen 1924) as modeled by Matsuyama (1992). In his model individuals belong to one of two groups, respectively, with conformist and with anti-conformist preferences, and the equilibrium shows a chase-flight pattern, with anti-conformist playing the role of fashion leaders and conformist playing the role of fashion followers.

7 Similar results are showed by Corneo and Jeanne (1999). They describe a continuous-time economy populated by two types of individuals, "desirable type" (natives) and "undesirable type" (tourists), in which an action is interpreted as a choice of location. Their model describes the dynamics of social location, defining the conditions for the take-off. In particular, they show that if an arbitrarily small number of individuals from a socially desirable group innovate, a large wave of imitators will follow even when the new behaviour is more costly than the old one.

**Table 1.** Average migration growth rates

| Country | Inflow | Growth rate Period 1 | | Growth rate Period 2 | | Growth rate Period 3 | |
|---|---|---|---|---|---|---|---|
| Germany | China | 1.28 | 1995–1999 | 3.21 | 2000–2002 | 2.87 | 2003 |
| | Nigeria | 1.17 | 1995–1999 | 2.09 | 2000–2003 | | |
| | Syria | 1.09 | 1995–1998 | 1.52 | 1999–2003 | | |
| | Thailand | 0.76 | 1995–1999 | 1.11 | 2000–2003 | | |
| Italy | Albania | 0.11 | 1994–1996 | 0.89 | 1997 | 0.12 | 1998–2003 |
| | China | 0.10 | 1994–1996 | 0.63 | 1997 | 0.07 | 1998–2003 |
| | Philippines | 0.06 | 1994–1996 | 0.24 | 1997 | −0.03 | 1998–2003 |
| | Romania | 0.19 | 1994–1996 | 0.32 | 1997–2000 | 0.16 | 2001–2003 |
| Netherlands | Angola | 1.83 | 1996–1999 | 4.48 | 2000–2002 | | |
| | China | 1.33 | 1996–2000 | 3.24 | 2001–2002 | | |
| | Sudan | 1.67 | 1996–1997 | 2.43 | 1998–2001 | 1.86 | 2002 |
| | Suriname | 1.41 | 1996–2000 | 2.70 | 2001–2002 | | |
| Sweden | Chile | 0.88 | 1981–1985 | 2.71 | 1986–1989 | 0.46 | 1990–2001 |
| | Ethiopia | 0.81 | 1981–1985 | 4.01 | 1986–1992 | 0.93 | 1993–2001 |
| | Ireland | 1.83 | 1981–1988 | 5.20 | 1989–1990 | 1.47 | 1991–2001 |
| | Somalia | 0.25 | 1981–1990 | 3.84 | 1991–1994 | 1.43 | 1995–2001 |
| UK | Ghana | 1.04 | 1992–1998 | 1.72 | 1999–2004 | | |
| | Pakistan | 1.12 | 1992–1998 | 2.04 | 1999–2003 | 1.76 | 2004 |
| | Somalia | 2.98 | 1992–1999 | 19.98 | 2000–2002 | 9.71 | 2003–2004 |
| | Turkey | 1.25 | 1992–1995 | 3.57 | 1996–2004 | | |

database (ISTAT)[8]. The results fit the theoretical approach and replicate the observable migration jumps.

### *1.1 Some supporting evidence*

Table 1 shows the average growth rates of certain immigration inflow into five European countries (Germany, Italy, The Netherlands, Sweden and the UK) for different periods. The data for Germany were taken from the Statistisches Bundesamt (Federal Statistical Office); for the Netherlands

8 ISTAT (Istituto Nazionale di Statistica) is the Official National Statistical Institute and its database is based on data from the Ministry of the Interior, www.istat.it.

from the Statistics Netherlands (Centraal Bureau voor de Statistiek); for Sweden from the Statistics Sweden (Statistiska Centralbyrån) and for the UK from the Home Office, the British government. For Italy, the data were taken from the ISTAT database for the years between 1994 and 2000 and from the Caritas report[9] for the period between 2001 and 2003. Both the ISTAT dataset and the Caritas data were supplied by the Ministry of Internal Affairs, and were up-dated and revised by the official statistical institute until 2000[10] (therefore, the two datasets overlap in the period between 1994 and 2000).

We can see that the migration process does not proceed smoothly, but it has sudden increases in the inflow growth rates. In some periods the inflow growth rate doubles (like in Germany and Netherlands), sometimes triples (like in Netherlands and UK) and sometimes increases even more (Italy and Sweden or for some ethnic groups in the other countries).

Looking at the immigration reforms[11] (see Boeri and Bucker 2005) in the countries and in the periods considered, we can see that they are not homogeneous with respect to the generosity of the welfare system for the immigrants. In two cases (UK and Netherlands) the reforms tightened the condition for immigration, in one case (Sweden) the policy did not substantially change over the years and in the last two cases (Germany and Italy), favoured immigration. Furthermore in Germany, the reform did not directly affect immigration. Because of the heterogeneity of reforms as a homogeneous phenomenon it seems that, at first glance, the

9 Caritas Internationalis, however, " is a confederation of 162 Catholic relief, development and social service organisations working in over 200 countries and territories" (Caritas 2003). The edition of the Caritas Statistic Immigration Report is part of the project "The image of Migrants in Italy, Through Media, Civil Society and the Labour Market", developed in the framework of the EU/EQUAL Initiative, managed by the Italian Ministry of Welfare. The project has been promoted by the International Organisation for Migration, Caritas of Rome and the Archive of Immigration and involves other 19 partners, including both Italian and immigrant associations. The first Caritas Report ("Dossier Statistico Immigrazione") was produced by the Caritas Organisation since 1991 and it has now become an annual report on immigration.

10 For the lack of official revised data after year 2000 at the moment of our submission, we have used Caritas dataset for the years between 2001 and 2003.

11 See Fondazione Rodolfo Benedetti Documentation Centre, http://www.frdb.org.

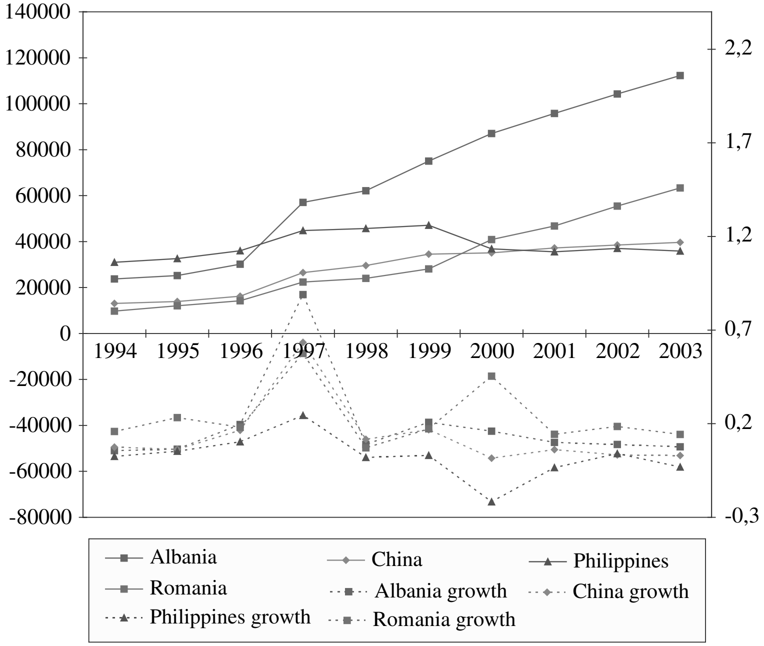


**Fig. 1.** Migration jumps

immigration reforms were not the only variable affecting migration choice. For this we looked for an additional endogenous explanation that could explain migration jumps.

Finally, since we focus our analysis on Italy, in Fig. 1 we have shown the four main foreign flows and their growth rates in Italy between 1994 and 2003: Albanians, Chinese, Filipinos and Romanians.[12] The migration flows have been depleted from the two important regularisations for

12 Description of the data:

– According to ISTAT (Istituto Nazionale di Statistica), "foreigners" in Italy are persons with foreign citizenship. A child born to parents who are both foreign citizens is considered to be a foreigner as well. A child born to an Italian and a foreign parent is considered to be an Italian citizen. Once a foreigner acquires Italian citizenship, they are not reported in official statistics as foreigners any more.
– Data are based on the number of valid residence permits issued to foreigners as of December 31 of each year. Children under 18 years old who are registered on their parents' permits are not counted.

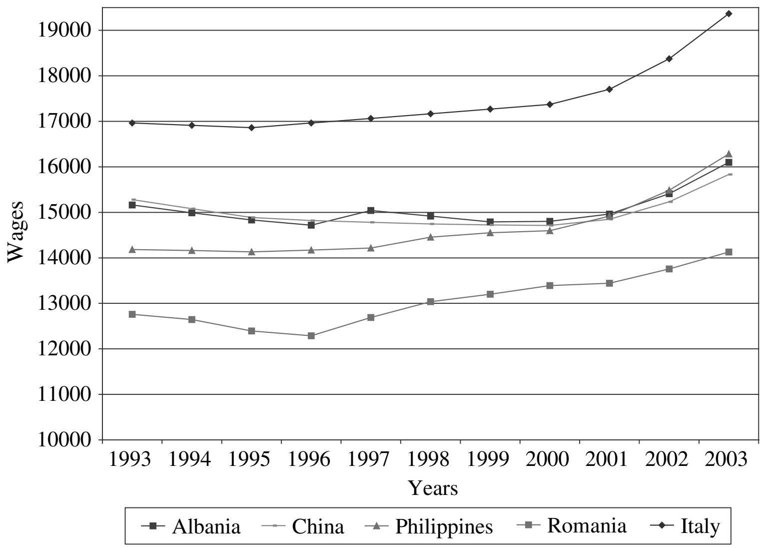


**Fig. 2.** Wage levels

illegal immigrants introduced in Italy in 1996 and 1998, and registrated by the ISTAT database in subsequently years.[13] For the sake of completeness, Fig. 2 also shows the wage differentials in the same period. These were obtained from the World Bank International Comparison Programme database and were deflated using the Bank of Italy[14] deflator.

Figure 1 shows that, for all nationalities, the migration process was not smooth. We observed "some substantial high increases in the inflow growth rates" that we defined as "migration jumps". In particular, we can see an important jump in 1997 after a certain number of years characterised by low waves, as if a mass of individuals was waiting for something to happen before deciding to migrate. Moreover, all nationalities showed heterogeneities in their behaviour after 1997: the Chineses

13 The expectation of regularisation programs foreseen by potential immigrants, can be interpreted as an endogenous cause for migration. Nevertheless the political programs are not common knowledge. In fact in the period after 1991 in Italy a quota system was imposed on the immigration flows and, therefore was both extraordinary and had unpredictable results.

14 http://www.bancaditalia.it.

and the Filipinos had declining flows, whereas the Romanians had a second jump in 2000.[15]

Another important aspect was that the wage differential did not seem to be the main variable driving migration flows. In all cases (except, partially, for Romania and Albania), the jumps did not occur together with a steady rise in relative wage levels, as stressed by Moretti (1999). Then, if policy choices do not completely explain migration dynamics, why do potential migrants wait before taking their decision to migrate? What are they waiting for? And why do they move on mass? We try to answer all these questions by examining whether the migration investment characteristics and the role of ethnic groups, can explain the migration jumps observed in Fig. 1. Although the phenomenon may be consistent with various explanations, simple arguments have to do with logistics: it takes time to decide and coordinate migration. This is consistent with the progressive acceleration in migration flows: migration delays arise because it is worth waiting to decide when certain fundamental uncertainties are resolved over time and the decision is mostly irreversible. A logistic curve also shows the fact that learning about the host country's labour market takes place sequentially and strongly depends on the role of an ethnic network in the host country.

This paper is organised as follows. Section 3 presents the model and the basic assumptions. Section 4 develops the theoretical framework that combines real option theory and the network effects, namely the optimal migration strategy in the presence of positive and negative externalities. Section 5 calibrates the model and Sect. 6 makes some simulations which confirm the theoretical results. Finally, Sect. 7 summarises the conclusions.

## 2. The model

We assume that an individual that move to another country is completely integrated when his economic and social status is no different from the native one. Nevertheless, the timing of the migrant's integration suffers from a phenomenon of attrition because of the lack of information about

15 The same phenomenon is also showed for five European countries in the updated (2007) version of Vergalli (2008) at the link http://www.sergiovergalli.it.

the host country and its labour market. We also assume that in the host country, a homogeneous group of people (a community/a network) exists that can help each immigrant to increase integration. The larger the community, the closer the ties among its members and then the higher the integration probability. The number of ties also depends on idiosyncratic characteristics of the immigrants, that we call "behavioural rationale" using the Bass terminology. That is, the more "sociable" an individual or a group of individuals, the stronger and more ties they have.

### *2.1 The basic assumptions*

Our main assumptions are the following:

(0) There exist two countries: the country of origin where each potential migrant takes decisions and the host country.

(1) At any time $t$ a risk-neutral[16] individual is free to decide to migrate to the host country discounting future benefits (the wage differential between the host country and the country of origin) at the constant interest rate $\rho$.

(2) When the migrant arrives in the host country, he/she receives only a percentage $\xi < 1$ of the host wage as first entry wage.[17] So defining $w_i^o$ as the wage of her country of origin (where $i$ is the country), we are able to write the wage differential as a percentage of the wage of the host country:

$$\xi w - w_i^o \equiv [\xi - w_i^o/w]w = \phi_i' w.$$

(3) In the host country there is a community of ethnically homogeneous individuals that helps each member to integrate with the host labour market (or to obtain a legal job if she is working on the illegal market). When the immigrant is completely integrated, he/she gets the difference between the legal host current market wage $w$ and the wage of the country of origin $w_i^o$, i.e.,

$$w - w_i^o \equiv [1 - w_i^o/w]w = \phi_i w.$$

16 See Burda (1995), Khwaja (2002), and Locher (2002) for the use of this assumption.

17 Empirical evidence shows that this is true whether the migrant finds a legal or an illegal job (see Chiswick 1978; Borjas 1990; Massey 1987).

(4) For the sake of simplicity, we assume that the country-specific percentages $\phi_i'$ and $\phi_i$ ($\phi_i' \leq \phi_i$) are constant over time.[18]
(5) Each individual enters a new country undertaking a single irreversible investment which requires an initial sunk cost $K$.
(6) The size of the immigrant $dn$ is infinitesimally small compared to the total number of previous immigrants $n$.
(7) Finally, the inverse labour demand for immigrants in the host country at time $t$ is an isoelastic function of the total number of previous immigrants $n(t)$:

$$w(t) = \theta(t)n(t)^{\zeta}, \tag{1}$$

where $\theta$ is a labour-demand-specific shock, $\zeta < 0$ is the elasticity and $w$ is the average wage of the host country.[19]

We introduce uncertainty into the model by assuming that:

(8) The labour-demand-specific shock $\theta$ follows a *Brownian motion*:

$$d\theta(t) = \alpha\theta(t)dt + \sigma\theta(t)dW(t) \tag{2}$$

with $\theta\ (t_0) = \theta$ and $\alpha, \sigma > 0$ are constant over time. The component $dW(t)$ is a Wiener disturbance defined as $dW(t) = \varepsilon(t)\sqrt{dt}$, where $\varepsilon(t) \sim N(0,1)$ is a white noise stochastic process (Cox and Miller 1965).
(9) The time taken to become perfectly integrated, say $\tau$, is stochastic and depends on a distribution of probability defined as:

$$1 - F_\tau(t) \equiv \Pr(\tau > t | t > 0) \tag{3}$$

and its corresponding *hazard rate is*:[20]

18 We calibrate them as the loss in Purchasing Power Parity with respect to the initial year of our dataset. See Sect. 5 below.

19 There are two implicit assumptions beyond (1). Firstly, that all incumbent immigrants have a job and that all future immigrants seek a job. Secondly, that $w$ refers to labour markets that are occupied mainly by immigrants so that we can ignore the role of native employees (Heitmueller 2003).

20 $p_\tau(t)$ is the migrant's conditioned probability of obtaining a better job at time $t + dt$, if he/she has worked at a low wage until $t$.

$$p_\tau(t) \equiv \frac{f_\tau(t)}{1 - F_\tau(t)}, \tag{4}$$

where $f_\tau(t)$ is the density function or *the likelihood of being perfectly integrated at t.*

Each immigrant decides when to enter a new country maximising his/her net benefit value defined as the expected discounted stream of wage differentials over the planning horizon (taken infinite for simplicity) minus the entry cost $K$.

By (1) and Assumptions 3–8 the benefits from being completely integrated at $\tau$ are given by:[21]

$$B(n(\tau), \theta(\tau)) = E_\tau\left\{\int_\tau^\infty \mathrm{e}^{-\rho(t-\tau)}\phi w(t)dt\right\}$$
$$\equiv E_\tau\left\{\int_\tau^\infty \mathrm{e}^{-\rho(t-\tau)}\phi\theta(t)n(t)^\zeta dt\right\}, \tag{5}$$

where $B(\bullet)$ accounts for the future evolution of the number of migrants $n(t)$, $t \geq \tau$. The expectation operator $E_\tau(\bullet)$ is taken with respect to the random variables $\tau$ and $\theta\ (t)$ [and then $n(t)$]. Next, taking into account the benefits the immigrant may gain before integrating, we end up with a total benefit value at the migration time zero as:

$$V(n, \theta) = E_0\left\{\int_0^\tau \mathrm{e}^{-\rho t}\phi' w(t)dt + \mathrm{e}^{-\rho\tau}B(n(\tau), \theta(\tau))\right\}, \tag{6}$$

where $n(0) = n$; $\theta\ (0) = \theta$. By using an indicator function $J_{[\tau>t]}$ that assumes the value one or zero depending on whether the argument is true or false, we can write (6) as:

21 If all immigrants face the same instantaneous probability of death $\lambda\ dt$, we can define $\rho = \widehat{\rho} + \lambda$, where $\widehat{\rho}$ is the market rate (Dixit and Pindyck 1994, p. 200).

$$V(n,\theta) = E_0\left\{\int_0^\infty e^{-\rho t} J_{[\tau > t]} \phi' \theta(t) n(t)^\zeta dt + e^{-\rho\tau} B(n(\tau), \theta(\tau))\right\}. \quad (7)$$

Since $E[J_{[\tau>t]}] = 1 - F_\tau(t)$, we can plug (3) in (7) to obtain:

$$V(n,\theta) = E_0\left\{\int_0^\infty e^{-\rho t}[1 - F_\tau(t)]\phi'\theta(t)n(t)^\zeta dt + \int_0^\infty e^{-\rho t} f_\tau(t) B(n(t), \theta(t)) dt\right\}, \quad (8)$$

where the expectation is now taken only with respect to $\theta(t)$ (and $n(t)$).

If the benefit value function $V(\bullet)$ is known, the optimal migration policy implies that the return from migration must be at least equal to cost $K$ at the entry point. In other words, we need to find the curve $\theta^*(n(t))$ (i.e., the value of the labour demand shock) at which the $n(t)$th migrant is indifferent between immediate entry or waiting:[22]

$$V[n(t), \theta^*((n(t))] - K = 0. \quad (9)$$

This is what we shall do in the next section.

### *2.2 The entry time τ and the network effect*

Before turning to the migrant's optimal policy, we need to model the probability of integrating (3). We have defined two different groups of migrants:

- *Innovators*: those individuals who decide to migrate independently of the decisions of other individuals in a social system. They are the pioneers or the individualists: their decision depends on their intrinsic characteristics.
- *Imitators*: those individuals influenced in the timing of migration by the number of previous migrants. In particular, we mean the individuals who follow the innovators. Their particular behavioural characteristic is

22 This condition is familiar in the real option theory with the name of matching value condition (see Dixit and Pindyck 1994).

their sociality: they have strong ties among themselves and tend to establish a network.[23]

Following Bass (1969), the probability that perfect integration occurs at $t$, given that no integration has yet occurred, is set as a linear function of the size of the community, i.e.,

$$p_\tau(t) = a + bF_\tau(t), \tag{10}$$

where $F_\tau(t)$ stands for the number of immigrants already entered; $a$ is the coefficient of innovation, the influence on entry regardless of the number of previous members; $b$ is the coefficient of imitation, the impact of previous members on the probability of entry at time $t$. By using algebraic operations (Bass 1969, p. 217), we get:

$$F_\tau(t) = \frac{m - n(t)}{m}, \tag{11}$$

and the fraction of the total immigrants integrating at time $t$ is:

$$f_\tau(t) = a + \frac{(b-a)}{m} n(t) - \frac{b}{m^2} n^2(t), \tag{12}$$

where $m$ is the (fixed) total number of immigrants over the planning horizon, which represents the critical "saturation" dimension of the community.[24] Finally, we get $\lim_{n \to m} f_\tau(t) = 0$ and $f_\tau(t)$ is concave iff $b > 0$.

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23 A recent economic approach calls a similar phenomenon *herd behaviour*, i.e., "I will go to where I have observed others go" (Bauer et al. 2002).

24 By observing that the cumulative function is a logistic curve, $m$ corresponds to the carrying capacity defined as "the number of individuals an environment can support without significant negative impacts to the given organism and its environment" (Vandermeer and Goldberg 2004). It corresponds to the congestion level of the community. Since $f_\tau(t)$ is the likelihood of being perfectly integrated at $\tau$, the total number of immigrants in $(0, \tau)$ is (See Bass 1969, p. 217):

$$mF_\tau(t) = m \int_0^\tau f_\tau(t)dt.$$

By plugging (12) and (11) into (8), we simplify (8) as:

$$V(n,\theta) = E_0\left\{\int_0^{\infty} e^{-\rho t} n(t)^{\zeta}\left[\frac{m-n(t)}{m}\phi' + \frac{[a+\frac{b-a}{m}n(t)-\frac{b}{m^2}n(t)^2]}{\rho-\alpha}\phi\right]\theta(t)dt\right\}. \tag{13}$$

## *2.3 The benefit function*

Network migration theory suggests that benefit is a positive function in both wages and network size (Massey et al. 1993). However, by (13), suppressing time for the sake of simplicity, we can write the benefit function per unit of time as:

$$\pi(n,\theta) \equiv u(n)\theta \tag{14}$$

where $u(n) \equiv n^{\zeta}\left[\frac{m-n}{m}\phi' + \frac{\mathrm{Bass}(n)}{\rho-\alpha}\phi\right]$ and $\mathrm{Bass}(n) \equiv \left[a + \frac{b-a}{m}n - \frac{b}{m^2}n^2\right]$.

Apart from shock $\theta$, each immigrant shares the same "utility" $u(n)$. The overall shape of $u(n)$ is ambiguous: it depends heavily on the *struggle* between the competitive effect (i.e., more immigrants reduce wages depending on the magnitude of the elasticity $\zeta$) and the network effect [i.e., individuals gain "utility" by increasing the number of fellow countrymen which in turn increases the probability of integration via the Bass function Bass($n$)]. According to the relative magnitude of these two effects, we can observe three shapes of $u(n)$ as in Fig. 3.

Let us analyse Fig. 3 from quadrant I to quadrant III for decreasing levels of elasticity, *ceteris paribus*:

*quadrant I:* This is the general case for a not very low level of elasticity $\zeta$. A relative minimum in $n''$ and a relative maximum in $\bar{n}$ exist that divide the function into three intervals:

(1) In the interval $n \in (0, n'')$, the competition effect prevails over the network effect: a new entry reduces the benefit more than the gain caused by cooperation among members of the community.

(2) In the interval $n \in (n'', \bar{n})$ the network effect prevails: the benefit increases with $n$ until the dimension of the network reaches level $\bar{n}$.

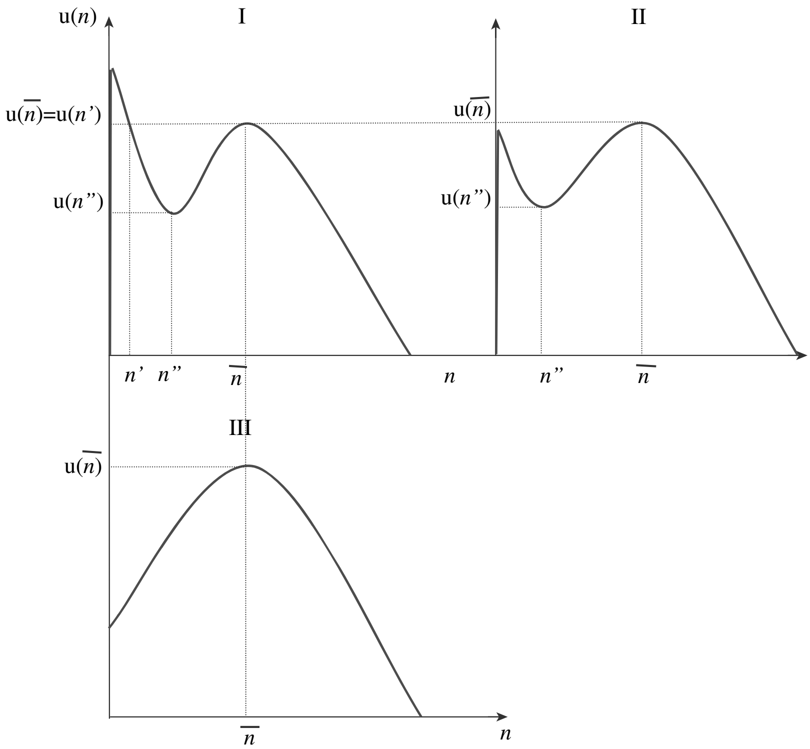


**Fig. 3.** Peculiar shape of $u(n)$

(3) In the interval $n \in (\bar{n}, m)$ the competition effect prevails: the benefit decreases with $n$ until the dimension of the community hits the saturation level $m$. Competition is coupled with a phenomenon of congestion as $n$ moves toward $m$.

As shown in Fig. 3, within the interval $(0, n'')$ a level $n'$ exists such that $u(n') = u(\bar{n})$. Further, for $n > n'$ each immigrant earns benefit lower than $u(n')$ until the community size reaches the relative maximum $\bar{n}$. Then each immigrant receives a lower benefit if he/she enters with a community population $n \in (n', \bar{n})$.

Since the critical level of $n'$ depends on the relative influence of the competition and network effects, for different levels of elasticity we can observe the following:

*quadrant II:* Even if for low value of $n$ competition prevails over the network effect, the latter dominates any other effect as $n$ increases. This implies that for each individual, it is expedient to wait for the maximum benefit $u(\bar{n})$ before entering.

*quadrant III:* Since $\zeta \to 0$ implies that $n' \to 0$, for very low levels of elasticity, the benefit function simply assumes an inverse U-shape.

## 3. Migration dynamics

Applying Itô's Lemma to (14) and substituting (2) to eliminate $d\theta$, we get an expression for the rate of change of $\pi$ in terms of the shock and the network size:

$$d\pi = \mu(n)\pi dn + \alpha\pi dt + \sigma\pi dw, \quad \text{with} \quad \pi_0 \equiv u(n_0)\theta_0 = \pi. \qquad (15)$$

In (15) the first term $\mu(n) \equiv u'(n)/u(n)$ shows the direct effect of migration flows. Migration influences the level of benefits through its effect on the labour market equilibrium depending on the dimension of the community. In particular, given any value of the shock $\theta$, more immigrants imply a higher or lower equilibrium level of benefits depending on the presence of positive $\mu(n) > 0$ or negative $\mu(n) < 0$ network externalities, respectively.

### *3.1 Optimal migration policy for $n > \bar{n}$ (and $<n'$)*

If the initial size of the community is $n \geq \bar{n}$ (or $n \leq n'$), we can expect migration to work in the following way. For any fixed $n$, the benefits per unit of time move according to the above stochastic process with $\mu(n)dn = 0$. If they climb to a certain level $\pi^* = u(n)\theta^*(n)$, migration becomes feasible, the network size increases from $n$ to $n + dn$ and the benefits go downward along the function $u(n)$. Benefits will then continue to move stochastically without the term $\mu(n)dn$, until another entry episode occurs.[25] This can be summarised by the following proposition:

25 In technical terms, the threshold $\pi^*$ becomes an upper reflecting barrier on the benefit process (see Harrison 1985).

*Proposition 1:* If $n \geq \bar{n}(or\ n \leq n')$, the optimal migration policy is described by the following upward-sloping curve (Fig. 4):

$$\theta^*(n) \equiv \frac{\beta_1}{\beta_1 - 1}(\rho - \alpha)\frac{K}{u(n)}, \quad \text{with} \frac{\beta_1}{\beta_1 - 1} > 1, \tag{16}$$

where $\rho > \alpha$ and $\beta_1 > 1$ is the positive root of the auxiliary quadratic equation $\Psi(\beta) = \frac{1}{2}\sigma^2\beta(\beta - 1) + \alpha\beta - \rho = 0$.

*Proof:* See Leahy (1993) and the Appendix. □

In the area above the curve, it is optimal to migrate: a wave of migrants will enter in a lump to move the benefit level immediately to the threshold curve. In the region below the curve the optimal policy is inaction. The individual waits until the stochastic process $\theta$ moves it vertically to $\theta^*(n)$ and then again a flow of migrants will jump into the host country just enough not to cross the threshold.

The "utility" threshold that triggers migration by individual immigrants is identical to that of the individual that correctly anticipates the other immigrants' strategies. This property, discovered by Leahy (1993), has an important operative implication: the optimal migration policy of each individual need not take account of the effect of rivals' entry. She/he can behave competitively as if he/she is the last to enter.[26]

26 In other words, when an individual decides to enter, by pretending to be the last to migrate, he/she is ignoring two things: (1) he/she is thinking that his/her benefit flow is given by $u(n)\theta$, with $n$ held fixed forever. Thus, as $u'(n) < 0$, he/she is ignoring that future entry by other members, in response to a higher value of $\theta$, will reduce "utility". All other things being equal, this would make entry more attractive for the migrant that behaves myopically. (2) He/she is unaware that the prospect of future entry by competitors reduces the option value of waiting. That is, pretending to be the last to migrate, the individual also believes he/she still has a valuable option of waiting before making an irreversible decision. All things being equal, this makes the decision to enter less attractive. The two effects offset each other, allowing the migrant to act as in isolation (see Dixit and Pindyck 1994, p. 291).

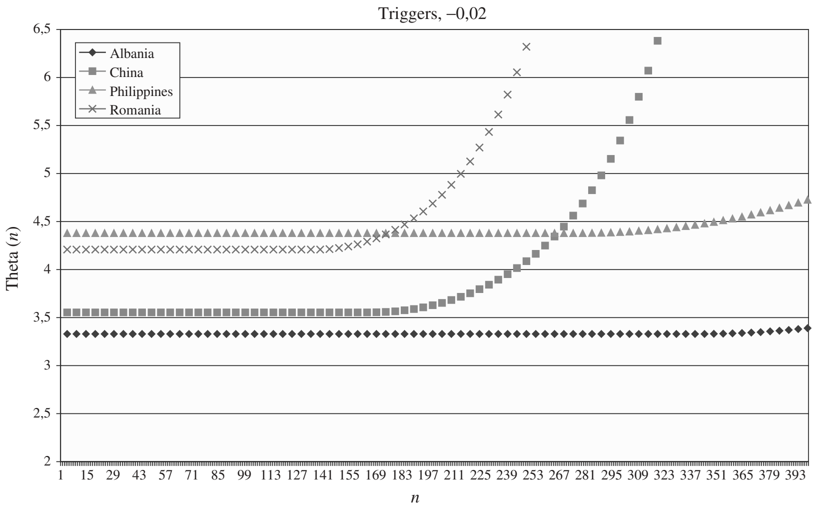


**Fig. 4.** Optimal triggers level for $\zeta_2 = -0.02$

### *3.2 Optimal migration policy for* $n' < n < \bar{n}$

For $n \in (n', \bar{n})$, the network benefit prevails over the competitive effect and then we expect the timing of an individual's entry is influenced by the entry decisions of others.

Intuition suggests that Leahy's result cannot be extended to cover this case. Since there are positive externalities, the higher the number of members in the community the greater the advantage in terms of benefit flow. This is evident in the case of an U-shaped benefit function (quadrant III in Fig. 3) but it also works for the general case as $u(n') = u(\bar{n})$ and the "utility" is lower in within (quadrant I in Fig. 3). Therefore, although entering may be profitable, it is more expensive to do so first than to enter later on, when others have already done so. This makes the trigger $\pi^* = u(n)\theta^*(n)$ no longer optimal: each migrant can do better by delaying entry.[27]

However, as all individuals are subject to the same labour demand stochastic shock, two equilibrium patterns are possible: either the community remains locked-in at the initial size $n' < n < \bar{n}$, sustained by

27 The decision problem involved here resembles one of *war of attrition* where each agent waits for rivals to concede (Moretto 2000).

self-fulfilling pessimistic expectations (infinite delay), or a mass of individuals simultaneously rushes to enter. Excluding the former,[28] we can expect entry to work in the following way: for a fixed size of the network, $\pi$ moves according to the process (15) with $\mu(n)dn = 0$. If benefits climb to $\pi^{**} = u(n)\theta^{**}(n)$, it will trigger an entry of discrete size $\bar{n} - n$ that raises the dimension of the community instantaneously by a jump. The exact form of the trigger $\theta^{**}$ is given in the following proposition.

*Proposition 2:* If $0 \leq n' < n < \bar{n}$, the optimal migration policy for a mass of individuals $\bar{n} - n$ is described by the following flat curve (Fig. 4):

$$\theta^{**}(n) = \theta^{*}(n') = \theta^{*}(\bar{n}) \equiv \frac{\beta_1}{\beta_1 - 1}(\rho - \alpha)\frac{K}{u(\bar{n})}, \tag{17}$$

*Proof:* See Moretto (2003, 2007) and the Appendix. □

Thus starting at $n$, if the initial shock is below the known trigger $\theta^{*}(\bar{n})$, all the migrants wait until $\theta$ rises to this level, and then *coordinate* their entry to bring the size to the optimal level $n$. Working back towards $n'$, it is verified for every $n$, as long as $\theta^{*}(n')$ is equal to $\theta^{*}(\bar{n})$. In fact, if it were $\theta^{*}(n') > \theta^{*}(\bar{n})$, it could be convenient to delay entry until $\theta^{*}(\bar{n})$, because of a higher obtainable benefit. Once the optimal size is reached and to the right of $\bar{n}$, further decision to enter proceeds as explained in the previous section without externalities. Intuitively, starting at any $n' < n < \bar{n}$, Proposition 2 locates the optimal entry threshold so as to maximise the total benefits of the incremental number of members that enter $(\bar{n} - n)$. The shock value $\theta^{*}(\bar{n})$ that triggers this individual's *competitive run*[29] is the same threshold that justifies further marginal entry under decreasing benefits.

28 We exclude the former by using the subgame-perfectness arguments (see Moretto 2003, 2007).

29 The term *competitive run* refers to Bartolini's definition (1993).

## 4. Calibration

To simulate the optimal migration policy we need values for the variables and parameters in Eq. (14). We could then calculate (16) and (17) and then solve for $n^*$. To perform this calibration we used the migration flows for Albanians, Filipinos, Chinese and Romanians and the wage levels (deflated using the Bank of Italy deflator) obtained from the ISTAT database.[30] As we show below, determining values for most of the model's inputs is reasonably straightforward. Estimating the coefficients of the labour demand's stochastic process $\theta$ and of the Bass probability of integration $a$ and $b$ is more complex as will be discussed below.

### *4.1 Basic inputs*

The parameters to be calibrated are listed in Table 2: for the discount rate we have used a basic level $\rho_2 = 0.03$ (Nordhaus 1996) and a higher level $\rho_1 = 0.05$.[31] We also add a mortality rate $\lambda = 0.001$ calculated by the *Istituto Superiore della Sanità*[32] on ISTAT data.

According to Assumptions 2 and 3, the differential wage is assumed to be a constant percentage of the wage of the host country and varies whether the immigrant is completely integrated in the host country or not: $\phi_i$ and $\phi_i^{'}$, respectively. The percentage for complete integration $\phi_i$ has been calibrated considering the GDP per capita based on the Purchasing Power Parity of the initial year 1993, as listed in the International Comparison Programme database of the World Bank. If the immigrant is not integrated, he/she earns only a fraction $\xi$ of the wage. We have calibrated $\xi$ and then the corresponding percentage $\phi_i^{'}$ referring to the

30 For the robustness of our analysis we have calibrated our parameters by using only the official data for the years 1994–2000.

31 Policy uncertainty regulating immigrants' flows can also explain the choice of two different discount rates. In particular, policy uncertainty acts as a scale factor on the optimal threshold and it can be modelised as a *poisson* process. See Vergalli (2007) and Rodick (1991).

32 http://www.iss.it.

**Table 2.** Parameters

| Parameter | Description | Symbol | Source |
|---|---|---|---|
| Discount rate | | $\rho_1 = 0.03$<br>$\rho_1 = 0.05$ | Nordhaus (1996) |
| Elasticity | Labour demand elasticity | $\zeta_1 = -0.2$<br>$\zeta_2 = -0.02$ | Borjas (1990), De New and Zimmermann (1997), Borjas (1994), and Bauer (1997) |
| Wage differential | $\phi_i = (1 - w^\circ/w)$ | $\phi_i$ | World Bank |
| Wage differential | $\phi_i = (\xi - w^\circ/w)$ | $\phi_i$ | World Bank |
| Entry salary | Average level | $\xi$ | Chiswick (1978)<br>Borjas (1990)<br>Massey (1987) |

works of Massey (1987), Borjas (1990) and Chiswick (1978).[33] The resulting $\phi_i^{'}$ and $\phi_i$ are shown in Table 3.

### *4.2 Demand volatility*

The calibration of Italian immigrants' labour demand elasticity has two problems: the lack of studies on Italy's demand function for immigrants[34] and the lack of work that isolates the effect of immigration inflow for foreigners and not only all (or native) workers. This problem can be overcome if we look at the EU and US work on the level of labour demand elasticity and standard deviation of the stochastic shock $\theta$. For European labour market (especially for Germany and France) some work shows elasticity levels between −0.021 (Bauer 1997) and −0.24 (De New and Zimmermann 1994), even if, also in these cases, some identification

33 Massey estimates that the illegal wage is 63% of the legal wage. Borjas and Chiswick show that the entry wage for each immigrant is 79 or 85% of the native one, respectively.

34 In this respect: Gavosto et al. (1999) show a positive elasticity for natives (+0.01) that the author justifies as a short-term effect; Venturini (1999) finds a long term elasticity in the non-regular labour market between −0.01 and −0.02; Venturini (1997) calculates an elasticity level of −0.3 and −0.5 among all the workers.

**Table 3.** $\phi_i$ and $\phi_i'$ calibration

| Country | $\phi_i'$ | $\phi_i$ |
|---|---|---|
| Albania | 0.639 | 29/33 |
| China | 0.649 | 8/9 |
| Philippines | 0.593 | 5/6 |
| Romania | 0.510 | 3/4 |

problems about immigrants elasticity, remain.[35] For the US there are many papers that try to estimate the peculiar effect of entering immigrants on labour wages. All the US elasticity levels seem to converge towards two representative values:[36] −0.2 (Borjas 1990) −0.02 (Borjas 1994). On this basis we use the following elasticities $\zeta_1 = -0.2$ and $\zeta_2 = -0.02$, that seem to be representative both for the US and for the EU labour market. To calculate an estimate of the variance of $\theta$, we used the boot-strap method,[37]

35 Furthermore, Peri (2005) shows an elasticity level of −0.4 among all European workers; De New and Zimmermann (1994) find an elasticity level for blue collar foreigners in Germany equal to −0.24; again in Germany, Bauer (1997) has a value of −0.021; Hunt (1992) about elasticity with respect foreigners share in occupation in France, shows a level between −0.139 and −0.08; Gang and Rivera-Batiz (1994) have a level between −0.01 and −0.11, while Garson et al. (1987) show a level included between −0.01 and −0.04 for the French labour market.

36 Borjas (1994) reviewing the literature argues that the value of the elasticity should be between −0.01 and −0.06. Dos Santos (2000) affirms that "from an empirical point of view, many studies attempt to estimate the impact of immigration on wages. The elasticity of wages with respect to the number of immigrants is generally found to be between −0.01 and −0.02″. Garson (1987), using 1985 data, coming from ISEE, finds a level of elasticity between −0.01 and −0.04. Borjas (1990), using data from the US census of 1990, shows a level around −0.2 and in a recent paper (Borjas 2003) he obtains an elasticity around −0.33. Antonji and Card (1991), using data of the US census 1970–1980, finds a level of −0.3.

37 The bootstrap method is a computer-based method for assigning measures of accuracy to sample estimates (Efron and Tibshirani 1994). This technique allows estimation of the sample distribution of almost any statistic using simple methods (Varian 2005), like resampling with replacement from the original sample, most often with the purpose of deriving estimates of standard errors and confidence intervals of a population parameter like a mean, median, proportion, odds ratio, correlation coefficient or regression coefficient. In our case, by using known parameters (elasticity level, wage level, number of immigrants), generating errors 1000 times, we have obtained two unknown levels of variance for each elaticity value.

**Table 4.** The Bass parameters for 1996, 1997 and 1998

| | Albania | China | Philippines | Romania |
|---|---|---|---|---|
| $\sigma_1$ | 0.063 | 0.061 | 0.057 | 0.047 |
| $\sigma_2$ | 0.055 | 0.055 | 0.056 | 0.054 |
| $b$ | 0.973 | 0.850 | 0.648 | 0.828 |
| $a$ | 0.110 | 0.117 | 0.141 | 0.123 |
| $m$ | 0.274 | 0.138 | 0.256 | 0.115 |

obtaining two levels of variance $\sigma_1$ and $\sigma_2$ for each flow, corresponding, respectively, to $\zeta_1 = -0.2$ and $\zeta_1 = -0.02$. These values are reported in Table 4.

### *4.3 Bass parameters*

Finally for the parameters of the Bass model (i.e., $a$, $b$, $m$), we employ the recursive method proposed by Bass (1969, p. 224) using the years 1996, 1997 and 1998 as initial conditions.[38] The results are described in Table 4. Simple observation shows that in all cases, the coefficient $b$ is greater than $a$, which guarantees the concavity of the Bass function $Bass(n)$.

## 5. Results

To compare different migration inflows, we simulate the optimal trigger levels Eqs. (16) and (17), for the four migration waves, in the case of elasticity levels −0.02 and −0.2. Because of the difficulty of perfectly quantifying the migration costs, we normalise $K$ to the same arbitrary

38 By Considering (12) as the basic equation, we know that: $n(t) = mf(t) = am + (b-a)n(t) - \frac{b}{m}n^2(t)$. In estimating the parameters from discrete time series data we use the following analogue: $n(t) = j + vn(t-1) + zn^2(t-1)$, for $t = 2, 3, \ldots$, where $n(t)$ immigrants at $t$, and $n(t-1) = \sum n(t)$ cumulative immigrants through period $t-1$. Since $j$ estimates $am$, $v$ estimates $(b-a)$, and $z$ estimates $-(b/m)$: $-mz = b, j/m = a$. Then $(b-a) = -mz - j/m = b$, and $zm^2 + vm + j = 0$, or $m = (-v \pm \sqrt{v^2 - 4zj})/2z$, and the parameters $a$, $b$ and $m$ are identified. See Bass (p. 219) for further details.

**Table 5.** Main results

| Parameters | $0^*$ | $n'/m$ | $n'$ | $n^*/m$ | $n^*$ | $n$, 1997 |
|---|---|---|---|---|---|---|
| Albania | | | | | | |
| 0.05; −0.2 | 83.95 | 0.008 | 2,275 | 0.33 | 91,000 | 101,634 |
| 0.05; −0.02 | 12.48 | 0.000 | 0 | 0.42 | 115,150 | |
| 0.03; −0.2 | 22.56 | 0.004 | 1,225 | 0.35 | 96,600 | |
| 0.03; −0.02 | 3.33 | 0.000 | 0 | 0.43 | 118,300 | |
| China | | | | | | |
| 0.05; −0.2 | 77.51 | 0.017 | 2,375 | 0.30 | 42,000 | 55,352 |
| 0.05; −0.02 | 13.26 | 0.000 | 0 | 0.41 | 56,000 | |
| 0.03; −0.2 | 20.97 | 0.008 | 1,125 | 0.33 | 45,500 | |
| 0.03; −0.02 | 3.55 | 0.000 | 0 | 0.42 | 58,000 | |
| Philippines | | | | | | |
| 0.05; −0.2 | 98.81 | 0.000 | 0 | 0.10 | 25,900 | 93,837 |
| 0.05; −0.02 | 16.19 | 0.000 | 0 | 0.36 | 91,700 | |
| 0.03; −0.2 | 27.58 | 0.066 | 16,975 | 0.23 | 59,850 | |
| 0.03; −0.02 | 4.38 | 0.000 | 0 | 0.38 | 96,250 | |
| Romania | | | | | | |
| 0.05; −0.2 | 85.85 | 0.023 | 2,625 | 0.29 | 34,000 | 44,413 |
| 0.05; −0.02 | 15.73 | 0.000 | 0 | 0.40 | 46,250 | |
| 0.03; −0.2 | 23.17 | 0.012 | 1,375 | 0.32 | 37,000 | |
| 0.03; −0.02 | 4.21 | 0.000 | 0 | 0.41 | 47,750 | |

level for all cases.[39] The principal results are shown in Figs. 4 and 5 and are displayed in Table 5.

Some remarks are in order:

(1) In all ethnic groups, the wave starts when the network size, $\left(\frac{n^*}{m}\right)$, reaches 30 or 40% of the critical saturation level $m$,[40] for $\zeta_1 = -0.2$ and $\zeta_2 = -0.02$, respectively. Yet, the lower the elasticity level the bigger the wave, that is, as market competition increases the network effect and the ties among immigrants reduce and they seem to be unable to coordinate entry perfectly.

(2) The higher the elasticity, the higher the threshold level $\theta^*$ and the lower the migration flow. This fact depends on the sum of two effects: (*i*) the *labour market competition*, increasing with the absolute level of $\zeta$; (*ii*) the *network effect* that depends on the probability of being

39 This permits comparison of the timing and the "behavioural rationale" among migration inflows.

40 The parameter $m$ is described in note 23 and its values are in Table 4.

completely integrated (i.e., Bass function). The combined effect defines the magnitude of the benefit perceived by every migrant in the host country. On the one hand, a high number of incumbent immigrants increases the total benefit due to the network effect. On the other hand, however, low wave dimensions require a high shock to trigger entry.

(3) A higher $\rho$ magnifies the optimal trigger as expected.

(4) The highest flows observed in the data are consistent with the predictions of the model (i.e., $n^*$ with respect to $n$, 1997 in Table 5): the real wave is between the upper and the lower simulated flow in every case studied.

(5) The higher $\phi_i^{'}$ or $\phi_i$, the lower the entry trigger $\theta^*$ as expected.

The Albanian flow is the first to start in the case of low demand elasticity and the second for high elasticity. This happens just behind the Chinese flow (the second and the first, respectively), with wide jump dimensions. Nevertheless, since the historical timing of the entries shows that the Chinese flow is more recent than the Albanian one, the level of elasticity on the labour market might be close to $\zeta_2$.[41]

The timing of the migration phenomenon also depends on the particular ethnic characteristics summarised in the Bass parameters: the higher the imitator's parameter $b$, the earlier the migration starts. This is due to a high network effect that offsets labour market competition with a larger wave. Moreover, the higher the innovator's parameter $a$, the lower the ties among immigrants and the higher the number of first entries. This can explain the differences in behaviour among the four migration inflows observable in Figs. 4 and 5. In fact, the Filipinos, characterised by strong individualist behaviour, showed a magnified first entry but a reduced jump size; vice versa, the Chinese, the Albanians and the Romanians were characterised by higher imitator parameters and a higher wave.

### *5.1 Entry costs*

So far, we have compared different entry triggers based on normalised sunk costs $K$. This normalisation allows the Bass model to describe the

41 We should remember that, since the labour demand shock is depicted as a Brownian motion (2), the higher the threshold level, the longer the time elapsed.

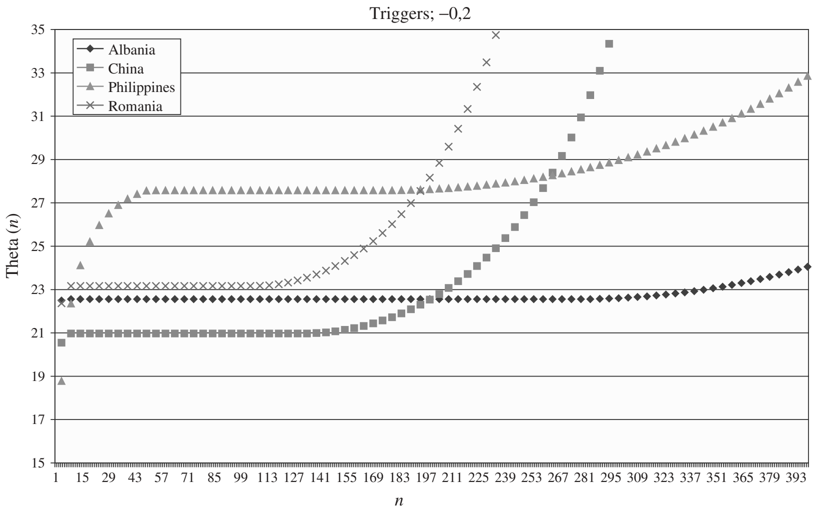


**Fig. 5.** Optimal triggers level for $\zeta_1 = -0.2$

migration behaviour of the flows, by defining the percentage of innovators and imitators in each flow, thus showing the implicit signals that drive the waves.

We can now step back and following the theory, "quantify" the entry costs faced by the four different ethnic groups by inverting (16) and (17) and evaluating them at their minimum level.[42] The results are shown in Table 6 from which we derive two main points: (1) the geographical distance is not the focal element of sunk costs, as generally stressed in the economic literature. In fact, the Philippines and Romania face a $K$ similar to Albania and China. This implies that the sunk cost faced by the immigrant must be a wider basket of socio-economic elements; (2) it is important to stress that the sunk costs displayed correspond to the optimal threshold. In all cases, since the migration occurred in the same year (i.e.,

42 In fact, if the jump started when the trigger reached the minimum level, we can take the value of the observed flows (see the 7th column in the Table 4) and the level of the wage in the year of the peak and substitute these values in the following equation:

$$K^* = w^* \frac{\beta_1 - 1}{\beta_1(\rho - \alpha)} \left[ \frac{m - \bar{n}}{m} \phi_i' + \frac{\mathrm{Bass}(\bar{n})}{(\rho - \alpha)} \phi_i \right].$$

**Table 6.** Different relative entry costs

| $K^*$ | Albania | China | Philippines | Romania |
|---|---|---|---|---|
| $\rho_1 = 0.05$ | 1.29 | 1.21 | 1.00 | 1.01 |
| $\rho_2 = 0.03$ | 1.30 | 1.22 | 1.00 | 1.02 |

**Table 7.** Caritas report. Number of residents per million of inhabitants, 2004

| Country | Number of residents |
|---|---|
| Albania | 0.234 |
| China | 0.100 |
| Philippines | 0.074 |
| Romania | 0.239 |

1997), the migrants entered a labour market with the same shock magnitude. This fact meant that all immigrants gained a similar labour market benefit but faced different costs: for the same level of wages some ethnic groups were able to face higher costs. Which element made the difference? The answer is in the "behavioural rationale": high cooperative behaviour helped each individual to face a higher cost. Therefore, the timing of the entry should be inversely related to the sunk cost in the optimum, i.e., Albania first, China, Romania and then the Philippines. Comparing this rank with Figs. 3 and 4, it appears that the true labour demand elasticity should be nearer $-0.02$.

### *5.2 Saturation level*

Although the simulations appear to be consistent with the ISTAT data between 1994 and 2000, we wanted to check whether the model was also consistent over time, by displaying the results of the 2004 CARITAS migration report in Table 7. According to our model, the Romanian community should be near saturation level, but this fact does not correspond to current data by CARITAS that shows an increase in Romanian immigration waves.

We suggest two explanations for this. First, our analysis uses the whole national migration flow as a single community, and this surely overestimates the alienation effect. We should consider single regional homogeneous ethnic groups. Secondly, due to the particular method used

**Table 8.** The Bass parameters for 1996, 1997 and 1999

| $t_1$ | Albania | China | Philippines | Romania |
|---|---|---|---|---|
| $b$ | 0.991 | 0.883 | 0.652 | 0.835 |
| $a$ | 0.097 | 0.103 | 0.137 | 0.108 |
| $m$ | 0.312 | 0.157 | 0.262 | 0.132 |

to calibrate the Bass parameters, the critical saturation level $m$ is strongly time-dependent. To overcome this problem we have calibrated the Bass coefficients one and two steps ahead displaying the changes in "behavioural rationale" of the procedure.

### 5.2.1 Forward projection technique

In the Bass methodology, $m$ depends on the years (initial condition) used to calculate the parameters $a$ and $b$. In particular we used 1996, 1997 and 1998. We then repeated the analysis by using 1996, 1997 and 1999 and then 1996, 1997 and 2000. Values for $a$, $b$ and $m$ are reported in Tables 8 and 9, respectively.

In Fig. 6, we show three curves for the Albanian triggers. *theta*98 is the benchmark case calibrated with the years 1996, 1997 and 1998, *theta*99 with 1996, 1997 and 1999 and finally *theta*00 with 1996, 1997 and 2000. The same method applied in Fig. 7 for the Romanian flow.

Moving ahead, the last year in calibrating the Bass parameters caused a substantial change in the shape of the entry trigger functions. In particular, in both the figures, $m(t)$ increases from *theta*98 to *theta*00 which implies, *ceteris paribus*, an increase in the size of the jump. Yet, the network effect is magnified, diluting the innovators' weight (this is why $\theta^*$ increases for $n \to 0$).

The higher the imitators' coefficient, the greater the perceived saturation dimension will be.[43] Therefore, if an ethnic group has strong ties, its community will probably increase more than other groups, *ceteris paribus*. Another effect of the increasing imitator's coefficient with time,

43 Comparing the Filipino flow to the Albanian flow we notice that the Albanian growth rate in the saturation level is higher than the Filipino one (see Tables 7 and 8).

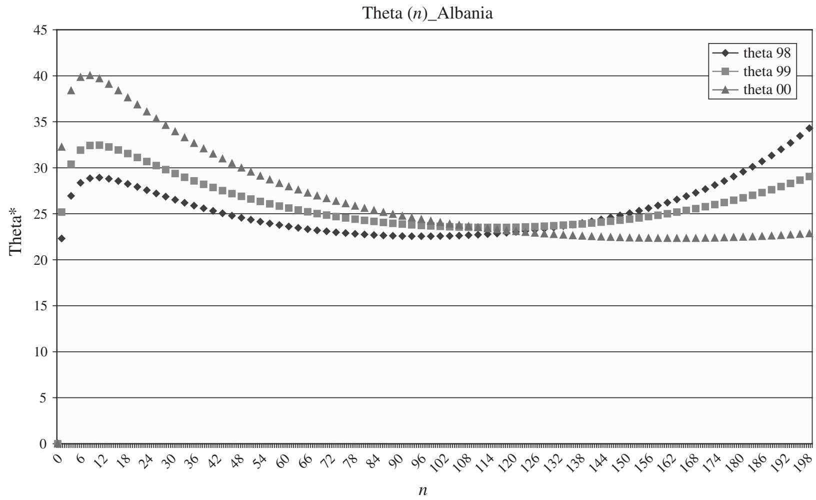


**Fig. 6.** Forward projection technique: Albanian threshold

is that, the stronger the network effect, the lower the shock required to migrate. This result is clearly shown in Fig. 6, but it does not emerge from Fig. 7. The explanation of this odd result depends on the peculiar

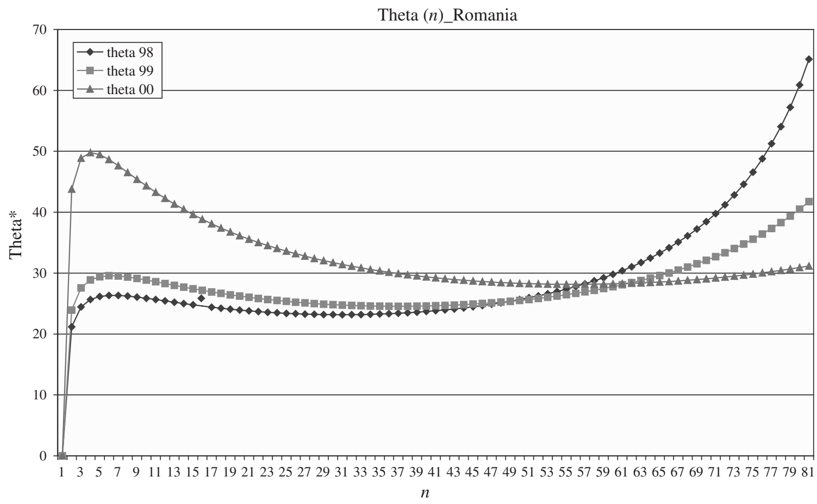


**Fig. 7.** Forward projection technique: Romanian threshold

**Table 9.** The Bass parameters for 1996, 1997 and 2000

| $t_2$ | Albania | China | Philippines | Romania |
|---|---|---|---|---|
| $b$ | 1.194 | 1.077 | 0.667 | 0.952 |
| $a$ | 0.073 | 0.086 | 0.122 | 0.059 |
| $m$ | 0.412 | 0.189 | 0.294 | 0.242 |

Romanian flows characterised by two jumps. In particular, moving ahead to the last year, the Bass parameters incorporate even the second jump.

Finally, comparing Tables 4, 8 and 9, we can highlight how the "behavioural rationale" changes for the four flows: the Chinese, Albanians and Romanians become more cooperative, whereas the Filipinos seem to remain more individualists. This may explain why some communities tend to explode and others increase at a constant rate.

## 6. Conclusions

This paper has tried to explain why migration flows are characterised by observable jumps. Real option theory suggests that migration may be delayed beyond the Marshallian trigger since the option value of waiting may be sufficiently positive in the face of uncertainty. Possibly, waiting may resolve uncertainty and thus enable avoidance of the downside risk of an irreversible investment. Burda (1995) was the first to use real option theory to explain slow migration rates from East to West Germany despite a large wage differential. Subsequent work (Khwaja 2002; Anam et al. 2004) has developed this approach describing the role of uncertainty in the migration decision. Recent papers (Moretti 1998; Bauer et al. 2002) show, however, that the role of the community is important in the migration decision. In this paper, we have shown a real option model where the choice to migrate depends on the differential wage and on the probability of being integrated into a host country. The corresponding integration probability is modelled following the Bass model (1969) where the "behavioural rationale" of the migration flows is shown by two kinds of immigrants: *innovators* or individualists and *imitators*. The weight of each different type influences the timing of migration and the size of the community. The closer the ties among the individuals, the higher the dimension of the wave and the higher the entry cost faced, *ceteris paribus*.

Furthermore, we have highlighted two opposing forces that influence entry: on the labour market side, strong *competition* among workers in the host country delays entry; at the same time, the more immigrants, the higher the *network effect* that reduces the optimal threshold and anticipates entry.

Simulations of some migration flows into Italy over the last twenty years fit the theoretical approach and replicate the observable migration jumps at least in the short-term. The model is able to project the induced labour demand elasticity level of the host country and the "behavioural rationale" of the migrants. Nevertheless, the use of national flows, as a proxy for the size of the communities, probably overestimates the results, suggesting future disaggregation of the ethnic flows.

## Appendix A

This appendix is dedicated to proving Propositions 1 and 2 in the text. To do this we rely on the work of Leahy (1993), Bartolini (1993), Dixit and Pindyck (1994), and Moretto (2003, 2007).

To determine the migrant's optimal entry policy, the first thing to do is to find his/her value of being perfectly integrated given each individual's optimal future entry policy. A solution for Eq. (8) can be obtained starting within a time interval where no entry occurs ($n$, $\theta < \theta^*$). By the typical methodology of real options, we obtain the general solution for Eq. (8) as (Dixit and Pindyck 1994, p. 181):

$$V(n,\theta) = A_1(n)\theta^{\beta_1} + A_2(n)\theta^{\beta_2} + v(n,\theta), \tag{18}$$

where $1 < \beta_1 < \rho/\alpha$, $\beta_2 < 0$ are, respectively, the positive and the negative root of the characteristic equation $\Psi(\beta) = \frac{1}{2}\sigma^2\beta(\beta - 1) + \alpha\beta - \rho = 0$, and $A_1$, $A_2$ are two constants to be determined.

To keep $V(n, \theta)$ finite as $\theta$ becomes small, i.e., $\lim_{\theta\to 0} V(n,\theta) = 0$, we discard the term in the negative power of $\theta$ setting $A_2 = 0$. Moreover, the boundary conditions also require $\lim_{\theta\to\infty}\{V(n,\theta)-v(n,\theta)\}=0$, where the second term in the limit is the discounted present value of the benefit flows over an infinite horizon starting from $\theta$ with $n$ fixed. By Eq. (13) we get:

$$v(n,\theta)=\frac{m-n}{m}\frac{\phi'\theta n^{\zeta}}{\rho-\alpha}+\left[a+\frac{b-a}{m}n-\frac{b}{m^2}n^2\right]\frac{\phi\theta n^{\zeta}}{(\rho-\alpha)^2}. \tag{19}$$

Remembering that $u(n)=n^{\zeta}\left[\frac{m-n}{m}\phi'+\frac{Bass}{\rho-\alpha}\phi\right]$ and $Bass(n)\equiv[a+\frac{b-a}{m}n-\frac{b}{m^2}n^2]$, the general solution of Eq. (18) becomes:

$$V(n,\theta)=A_1(n)\theta^{\beta_1}+\frac{\theta u(n)}{\rho-\alpha}. \tag{20}$$

It is worth noting that for $a\leq b$ the function $u(n)$, is shaped according to Fig. 3. Since the last term represents the value of being in the community in the absence of new entry, then $A_1(n)\theta^{\beta_1}$ must be the correction due to the new entry, therefore $A_1(n)$ must be negative. To determine this coefficient for each $n$, we need to impose suitable boundary conditions. First of all, free entry requires the (idle) migrant to expect zero benefits on entry. Then, indicating with $\theta^*(n)$ the value of the shock $\theta$ at which the $n$-th individual is indifferent to immediate entry or waiting for another opportunity, the condition (9) in the text (*matching value condition)* becomes:

$$V(n,\theta^*(n))\equiv A_1(n)\theta^*(n)^{\beta_1}+\frac{u(n)\theta^*(n)}{\rho-\alpha}=K. \tag{21}$$

Secondly, the number of migrants $n$ affects $V(n,\theta)$ depending on the sign of $\theta^*(n)$. Since $\theta^{\beta_1}$ is always positive, any change in $n$ either raises or lowers the whole function $V(n,\theta)$, depending on whether the coefficient $A_1(n)$ increases or decreases. Therefore, by totally differentiating Eq. (21) with respect to $n$ we obtain:

$$\frac{dV(n,\theta^*(n))}{dn}=V_n(n,\theta^*(n))+V_\theta(n,\theta^*(n))\frac{d\theta^*(n)}{dn}=0 \tag{22}$$

$$=V_\theta(n,\theta^*(n))\frac{d\theta^*(n)}{dn}=0, \tag{23}$$

where, (since each individual rationally forecasts the future path of new entries by competitors), $V_n(n, \theta^*(n)) = 0$ (Bartolini 1993, Proposition 1).[44]

In conjunction with the Eq. (21), the above *extended smooth pasting condition* states that either each migrant exercises his/her entry option at the level of $\theta$ at which the value is tangent to the entry cost, i.e., $V_\theta(n, \theta^* n)) = 0$, or the optimal trigger $\theta^*(n)$ does not change with $n$. While the former means that the value function is smooth at entry and the trigger is a continuous function of $n$,[45] the latter case states that, if this condition is not satisfied, an individual would benefit from marginally anticipating or delaying the entry decision. In particular if $V_\theta(n, \theta^*(n)) < 0$, it means that the value of staying in the host country is expected to increase if $\theta$ falls (investing now will be expected to lead to almost certain benefits), on the contrary if $V_\theta(n, \theta^*(n)) > 0$ it means that a member would expect to make losses because of a decrease in $\theta$. In both situations Eq. (23) is satisfied by imposing $\frac{d\theta^*(n)}{dn} = 0$, therefore the same level of shock may either trigger entry by a positive mass of migrants or lock-in the community at the initial level of members.[46]

It should be noted that using Eqs. (20), (21) and (23), it is possible to find the optimal threshold function. The solution depends on the concavity of $u(n)$. As we have seen in the previous part, a generic representation of $u(n)$ distinguishes three intervals for the particular shape of the benefit function. Let us now solve the model backwards.

### *A.1 Proof of Proposition 1*

For the case of $n \leq n'$ or $n \geq \bar{n}$ we show two things: (*i*) the smooth pasting condition (23) reduces to $V_\theta(n, \theta^*(n)) = 0$; (*ii*) the optimal trigger $\theta^*(n)$ is

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44 Note that this is a generalisation of the condition in Dixit (1993, p. 35). If the migrant pretends to be unique or the last entering the host country, then $u'(n) = A'(n) = 0$ and the first-order condition reduces to $V_\theta(n, \theta^*(n)) = 0$

45 Moreover, as we assumed that the individual's size is infinitesimal, then the trigger level $\theta^*(n)$ is also a continuous function in $n$.

46 If this condition does not hold, the expected benefit gain or loss at $\theta^*(n)$ would be infinite due to the infinite variation property of the stochastic process $\theta$.

equivalent to that of an individual in isolation, that is of a migrant pretending to be the last to immigrate.

For ($i$), let us consider the value of a migrant being in the host country starting at point ($n$, $\theta < \theta^*$), and subject to the possibility of new entries when $\theta$ hits $\theta^*$. Indicating with $T$ the first time that $\theta$ reaches the trigger $\theta^*$, the optimal entry policy must then satisfy:

$$V(n,\theta)=\max_{\theta^*} E_0\left[\int_0^T \mathrm{e}^{-\rho t}\{(1-F_\tau(t))\phi'\theta(t)n^\zeta+f_\tau(t)B(n,\theta(t))\}dt\right.$$

$$\left.+\int_T^\infty \mathrm{e}^{-\rho T}\left\{(1-F_\tau(t))\phi'\theta(t)n(t)^\zeta+f_\tau(t)B(n(t),\theta(t))\right\}dt\right]$$

$$=\max_{\theta^*} E_0\left[\int_0^T \mathrm{e}^{-\rho t}\left\{\frac{m-n}{m}\phi'\theta(t)n^\zeta+[a+\frac{b-a}{m}n-\frac{b}{m^2}n^2]\phi\frac{\theta(t)n^\zeta}{\rho-\alpha}\right\}dt.\right.$$

$$\left.+\mathrm{e}^{-\rho T}V(n,\theta^*(n))\right], \tag{24}$$

where $V(n, \theta^*(n))$ represents the optimal continuation value of staying in the host country. Because, by Eq. (21), the present value of benefits at $T$ is $K$, the above value can be written as:

$$V(n,\theta) = \max_{\theta^*}\left[u(n)E_0\left[\int_0^{\mathrm{T}} \mathrm{e}^{-\rho t}\theta(t)dt\right] + KE_0[\mathrm{e}^{-\rho \mathrm{T}}]\right]$$

or, after simplification (Moretto 2003, 2007):

$$V(n,\theta) = \max_{\theta^*}\left[\frac{u(n)\theta}{\rho-\alpha} - \left(\frac{u(n)\theta^*}{\rho-\alpha} - K\right)\left(\frac{\theta}{\theta^*}\right)^{\beta_1}\right]. \tag{25}$$

The value of being perfectly integrated Eq. (25) is the difference between the value of a migrant with a myopic strategy pretending to be the last to have to migrate $\frac{u(n)\theta}{\rho-\alpha}$ and the value of an idle individual pretending to be the last to migrate as expressed by $\left(\frac{u(n)\theta^*}{\rho-\alpha}-K\right)\left(\frac{\theta}{\theta^*}\right)^{\beta_1}$. To choose optimally $\theta$*, the first-order condition is:

$$\frac{\partial V}{\partial \theta^*}=\left[(\beta_1-1)\frac{u(n)}{\rho-\alpha}-\beta_1\frac{K}{\theta^*}\right]\left(\frac{\theta}{\theta^*}\right)^{\beta_1}=0 \tag{26}$$

and the optimal threshold function takes the form:

$$\theta^*(n)\equiv\frac{\beta_1}{\beta_1-1}(\rho-\alpha)\frac{K}{u(n)}, \quad \text{with} \quad \frac{\beta_1}{\beta_1-1}>1. \tag{27}$$

Since $u(n)$ decreases in the interval $[\bar{n}, m]$, $\theta^*(n)$ increases. Moreover, substituting Eq. (27) into Eq. (25) we can solve for $A(n)$ which is negative as required by Eq. (20):

$$A(n)=-\frac{[\theta^*(n)]^{1-\beta_1}}{\beta_1(\rho-\alpha)}<0. \tag{28}$$

Finally, substituting Eq. (28) into Eq. (25) and rearranging we obtain Eq. (20):

$$V(n,\theta)=A(n)\theta^{\beta_1}+\frac{u(n)\theta}{\rho-\alpha}\equiv-\frac{[\theta^*(n)]^{1-\beta_1}}{\beta_1(\rho-\alpha)}\theta^{\beta_1}+\frac{u(n)\theta}{\rho-\alpha} \tag{29}$$

from which it is easy to verify that $V_n(n, \theta) \neq 0$ within the interval $\theta < \theta^*(n)$ and zero at the boundary.

Now for (*ii*), let us suppose that all individuals have decided to enter at $\hat{\theta}$, with $\theta^* < \hat{\theta}$. This cannot be a (Nash) equilibrium because a single migrant can do better by entering at $\theta^*$. In fact, the flow of benefits that each individual is able to obtain following the policy $\theta^*$ is the best that they can do, at least till *T*. However, by the principle of optimality, this choice is also optimal for the rest of the period as (24) shows: if the optimal policy of the single migrant calls for them to be active at $\hat{\theta}$ tomorrow, it immediately follows that the optimal policy today is to enter at $\theta^*$. As (24) is a continuous function in $\theta^*$, the limit as $\hat{\theta} \to \theta^*$ shows that $\theta^*$ is a Nash equilibrium (Leahy 1993, proposition 1).

If the elasticity is not too low we obtain an interval $n \in (0, n')$ where the competitive effect prevails over the network effect. Therefore, with these results, within the interval $(0, n')$ the optimal threshold is still given by Eq. (27) until $n'$. Finally, for $\zeta \to 0$, $n' \to 0$.

*A.2 Proof of Proposition 2*

For $0 \leq n' < n < \bar{n}$ we have to show three things: (*i*) that an individual cannot pretend to be the last to migrate and, therefore, the optimal competitive trigger is no longer equivalent to that of a migrant in isolation; (*ii*) that the candidate policy, described in the Proposition 2, satisfies the necessary and sufficient conditions of optimality; (*iii*) that it is a sub-game perfect equilibrium.[47]

Let us assume that $u(n)$ is U-shaped as in the quadrant III of Fig. 3. For (*i*) and (*ii*), let us begin with an idle individual that follows the optimal policy $\theta^*(n)$. Since $\theta^*(n)$ is decreasing in the interval $n < \bar{n}$: the higher the number of members in the community the greater their entry value. In other words, an idle migrant would maximise his/her entry option by pretending always to be the last to migrate. In fact a migrant that pretends to be the last to enter expects an inadmissible upward jump in benefits following the policy $\theta^*(n)$. To see this, consider an individual that pretends to have been the last to enter at $\theta = \theta^*(n)$; by Eq. (19) his/her value is simply $V(n, \theta^*(n)) \equiv v(n, \theta^*(n)) = \frac{u(n)\theta^*(n)}{\rho - \alpha}$. Then we can see that:

$$V(n, \theta^*(n)) - \lim_{\theta \to \theta^*(n)} V(n, \theta) = \frac{\theta^*(n)}{\beta_1(\rho - \alpha)} > 0, \tag{30}$$

This contradicts the *smooth pasting condition* $V_\theta(n, \theta^*(n)) = 0$ and then the optimality of $\theta^*(n)$.

To verify that the necessary conditions are satisfied, let us calculate the value of an (incumbent) immigrant in the host country starting at the point $(n, \theta)$, that would follow a policy defined by two parameters: wait until the first instant $T$ at which the process $\theta$ rises to a level $c > \theta$, corresponding to an immediate increase in the community size to $b > n$. Making use of Eq. (24) the expected payoff $V(n, \theta)$ from this policy is equal to:

$$\begin{aligned} V(n, \theta; b, c) &= E_0\left[u(n)\int_0^{\mathrm{T}} \mathrm{e}^{-\rho t}\theta_t dt + \mathrm{e}^{-\rho \mathrm{T}} V(b, c)\right] \\ &= \frac{u(n)\theta}{\rho - \alpha} - \left[\frac{u(n)c}{\rho - \alpha} - V(b, c)\right]\left(\frac{\theta}{c}\right)^{\beta_1}. \end{aligned} \tag{31}$$

47 See Moretto (2003) for a conjecture of how this can be proved.

If each individual were able to choose the best moment for the community's size as well as the dimension of the jump, the first-order condition would be:

$$\frac{\partial V(n,\theta;b,c)}{\partial c}=\left[(\beta_1-1)\frac{u(n)}{\rho-\alpha}-\beta_1\frac{V(b,c)}{c}+\frac{\partial V(b,c)}{\partial c}\right]\left(\frac{\theta}{c}\right)^{\beta_1}=0$$

$$\frac{\partial V(n,\theta;b,c)}{\partial b}=\frac{\partial V(b,c)}{\partial b}\left(\frac{\theta}{c}\right)^{\beta_1}=0.$$

When $b$ and $c$ are chosen according to the candidate policy so that $b=\bar{n}$ and $c=\theta^*(\bar{n})$ the value function reduces to (20) and the *matching value condition* requires $V(b,c)=K$. These properties verify that the candidate policy satisfies these conditions.

Let the immigrant, as in Eq. (31), wait until the first time the process $\theta$ rises to the trigger level $c\equiv\theta^*(b)$, corresponding to an immediate increase of the network size to $b>n$, and assume also that he/she expects no more entry after $b$. Therefore the expected payoff $V(b,\theta)$ from this time onwards equals the discounted stream of benefits fixed at $u(b)$, i.e., by Eq. (19):

$$V(b,\theta)=\frac{u(b)\theta}{\rho-\alpha}. \tag{32}$$

Comparing Eq. (32) with Eq. (20) gives $A_1(b)=0$. Therefore to obtain the constant $A_1(n)$, subject to the claim that beyond $b$ no other immigrants will enter, we substitute Eq. (20) into the condition $V_n(n,\theta^*(n))=0$ to get $A_1'(n)\theta^*(n)^{\beta_1}+\frac{u'(n)\theta^*(n)}{\rho-\alpha}=0$ resulting in:

$$A_1'(n)=-\frac{\theta^*(n)^{1-\beta_1}u'(n)}{\rho-\alpha}\equiv-\frac{(\pi^*)^{1-\beta_1}}{\rho-\alpha}\frac{u'(n)}{u(n)^{1-\beta_1}}. \tag{33}$$

Integrating Eq. (33) between $n$ and $b$ gives:

$$\int_n^b A_1'(x)dx=-\frac{(\pi^*)^{1-\beta_1}}{\rho-\alpha}\int_n^b\frac{u'(x)}{u(x)^{1-\beta_1}}dx.$$

Taking account of the fact that $A_1(b)=0$, this integral gives the constant $A_1(n)$ as:

$$A_1(n) = \frac{(\pi^*)^{1-\beta_1}}{\beta_1(\rho - \alpha)}\left[u(b)^{\beta_1} - u(n)^{\beta_1}\right]. \tag{34}$$

Substituting Eq. (34) into Eq. (20), which we rewrite to make its dependence explicit on the end size $b$, gives:

$$V(n, \theta; b, \theta^*(b)) = \frac{(\pi^*)^{1-\beta_1}}{\beta_1(\rho - \alpha)}\left[u(b)^{\beta_1} - u(n)^{\beta_1}\right]\theta^{\beta_1} + \frac{u(n)\theta}{\rho - \alpha}. \tag{35}$$

As long as $u(b) > u(n)$ the first term in Eq. (35) is positive and it forecasts the advantage the immigrant would experience by the entry of $b - n$ new immigrants when $\theta$ hits $\theta^*(b)$. That is, if he/she were able to choose the optimal dimension of the jump, it would be $b \to \bar{n}$ which happens the first time that $\theta$ reaches $\theta^*(\bar{n})$. Thus, as opposed to before non-sequential entry are possible, the necessary conditions would coordinate an optimal simultaneous entry by $\bar{n} - n$ new immigrants. If $u''(n) < 0$ the necessary conditions are also sufficient. Furthermore, substituting Eq. (35) into the *extended smooth pasting condition* (23) and letting $b \to \bar{n}$, we obtain:

$$\left[\frac{(\pi^*)^{1-\beta_1}}{\beta_1(\rho - \alpha)}\left[u(\bar{n})^{\beta_1} - u(n)^{\beta_1}\right]\beta_1 {\theta^*}^{\beta_1} + \frac{u(n)}{\rho - \alpha}\right]\frac{d\theta^*}{dn} = 0. \tag{36}$$

The term inside square brackets is always positive (i.e., there is no value $n^\circ \in (n, \bar{n})$ that makes it nil), and Eq. (36) holds with $\frac{d\theta^*}{dn} = 0$. That is, all immigrants in the range $(n, \bar{n})$ must enter at $\theta = \theta^*(\bar{n})$.

In other words, as the stochastic process $\theta$ is common knowledge, each immigrant can foresee the benefit from the entry of others and observing the realization of the state variable $\theta$ instantaneously considers when to enter by maximizing Eq. (35). Then, with simultaneous entry, the immigrants' optimal strategies are easy to find: each individual enters as if he/she were the only person to enter but with the expectation of earning all the network benefits, i.e., $\theta^*(\bar{n})$ is a (symmetric) Pareto-dominant Nash equilibrium for all $n < \bar{n}$ (see Moretto 2003, 2007). In addition, as the reaction lags are literally nonexistent, none have the incentive to deviate from the entry strategy $\theta \to \theta^*(\bar{n})$ and $b \to \bar{n}$ given that the others do not deviate. Finally, since $\theta$ is a Markov process in levels (Harrison 1985, p. 5–6), the conditional expectation (31) is in fact a function solely of the starting states so that, at each date $t > 0$, the immigrant's values resemble those described in Eq. (35) which makes the equilibrium subgame perfect.

Finally, we can to deal with the general case (quadrant I and II in Fig. 3). If $n \in (n', n'')$ we need first to find a network size $n^{\circ}$ such that $u(n) = u(n^{\circ})$ with $u'(n^{\circ}) > 0$ and then to perform the same policy as in Eq. (35) or Eq. (36). That is, the optimal entry would be of $(\bar{n} - n^{\circ}) + (n^{\circ} - n)$ immigrants the first time that $\theta$ reaches $\theta^{*}(\bar{n})$.

where:

- *Parameters*: are, respectively, the discount factors (i.e., $\rho_1 = 0.05$; $\rho_2 = 0.03$) and the elasticity levels (i.e., $\zeta_1 = -0.2$; $\zeta_2 = -0.02$);
- $\theta^{*}$: represents the optimal trigger level at which the migration wave starts;
- $n'/m$: is the critical level that "*triggers*" the network effect as a percentage of the saturation dimension $m$;
- $n^{*}/m$: is the optimal dimension of the community in percentage of the theoretic maximum dimension $m$;
- $n^{*}$: is the level of the community that triggers the migration flow;
- *n_year* (i.e., n_1997) is the empirical jump observed in our data (see Fig. 1).


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