Population growth and migration in Northern and Western Africa

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1. INTRODUCTION

This paper sets out to assess the role of the demographic transition in the formation of what Hein de Haas (2007, 2008, 2009) calls the Trans-Saharan-Trans-Mediterranean (TSTM) migration system. This system is made up of two interconnected sub-systems: the Trans-Mediterranean (TM) system links most of Northern Africa (especially Morocco, Tunisia, and Egypt) to Southern Europe, while the Trans-Saharan (TS) system connects Western Africa (especially Senegal, the Ivory Coast, Nigeria, Mali, and Mauritania) to Northern Africa and also, though to a lesser extent, to Southern Europe. Northern Africa is thus both the origin of the migration flows towards Europe, and a transit and destination area for migrants coming from Western Africa. The formation of the TSTM migration system was slow and complex: the TM part came first, in the late 1960s (de Haas, 2007, 2008, 2009; Gesano *et al.*, 2007), followed by the TS system, which dates back to the 1980s (Bensaad, 2003, 2008; Pliez, 2000; Bredeloup and Pliez, 2011). Migration between the Maghreb and Europe was already important in colonial times, but the increase registered later on was such that it can be considered the start of a new phase (de Haas, 2005:4).

The key hypothesis that we test in this paper is that the remote cause behind the emergence of the TSTM migration system is rapid population growth, triggered by the demographic transition. But the link between the two phenomena (population growth and international emigration) is not direct, and cannot be fully understood if one ignores the role of some fundamental environmental constraints. International migration is the ultimate response of a society to population growth, most of which takes place in rural areas. If other safety valves are effective in alleviating population pressure (e.g., the availability of free land, an increase in rural production, or urbanization) international emigration may not ensue, or at least not immediately, but if it does, it need not be as strong as in other apparently similar cases.

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2. POPULATION GROWTH AND INTERNATIONAL MIGRATION: A CRITICAL REVIEW OF THE LITERATURE

Migration is not mentioned in the original formulation of the demographic transition theory (Thompson, 1929; Landry, 1934; Davis, 1943; Notestein, 1945) and studies focusing on the connections between the demographic transition and international migration are still relatively rare, though there are a handful: see, e.g., Easterlin (1961), Davis (1963), Zelinsky (1971), Chesnais (1992), Skeldon (1997), Hatton and Williamson (1998), Reher (2004), Clark (2007), and de Haas (2009).

The prevailing interpretation offered for international migration today places relatively little emphasis on population growth in the sending countries: economic conditions, it is claimed, matter more than demography, and population growth is seen as a consequence of economic development (Massey, 1988; Massey *et al.*, 1998:11). Formerly, instead, even economists conceded that population growth was at the root of international migration, with a lag of some 20 to 30 years, when an increasing number of newborns, now surviving to adulthood, reached the typical migration ages (Easterlin, 1961).

Empirical research on this topic has yielded contradictory results, and several papers on the macro demographic characteristics of the sending countries conclude that neither population growth nor fertility exerts any significant effect on international migration (e.g. Zlotnik, 2004; de Haas, 2009). Zlotnik (2004:25), for instance, writes: “In sum, the relation between net migration and natural increase according to the only global set of estimates available does not seem to be strong enough to merit further exploration”.

In the same collection of essays, however, Adepoju (2004:59) argues that population growth is one of the main determinants of African emigration, while Malmberg (2006) using the same data as Zlotnik, but a different methodology, claims that cohort growth has a strong predictive power on net migration.

In the economic literature, results are at least as contradictory. Several authors fail to identify any significant effect of population growth on international migration (Faini and Venturini, 1994; Hatton and Williamson, 1998; Vogler and Rotte, 2000; Clark, Hatton and Williamson, 2007; Mayda, 2010), while others come to the opposite conclusion (Bean, Browning and Frisbie, 1990; Fertig and Schmidt, 2000; Gallina and Gesano, 2002; Mitchell and Pain, 2003; Hatton and Williamson, 2003, 2009; Hanson and McIntosh, 2010).

In part, this difference depends on the choice of the demographic variables: the current or the lagged rate of natural increase; the proportion of the population aged 15-24, or 20-24, or 20-29; more rarely, total fertility, or crude birth rate, or some other *ad hoc* measure. On the left side of the equation, "migration" sometimes means gross, sometimes net emigration rates, and sometimes their logs. Table 1 tries to reduce this heterogeneity in two ways. First, and in line with Easterlin’s hypothesis, it excludes all the papers where the current, instead of the past, values of natural increase or fertility are used as possible determinants of current migration. Of the papers that we reviewed, only 15 pass this test (see Table 1). Second, Table 1 orders the papers according to the length of the time window covered in the analysis. All the papers listed in the table deal (sometimes among other things) with the connection between past population growth and current migration, and all use aggregate data. But nine of them find that past population growth has a significant effect on current migration, while the remaining six claim that this effect is not significant. This inconsistency can be explained in two non-alternative ways.

Table 1 – *Aggregate level analyses of the effect of past population growth on migration*

	Author	Epoch	Spacing (years)	Demographic variable used as independent	Sign. (a)
1	Bean *et al* (1990)	1977-1989	0.083 (1 month)	Population aged 15-34	Yes
2	Vogler and Rotte (2000)	1981-1995	1	Growth labor force	No
3	Vogler and Rotte (2000)	1981-1995	1	Growth labor force	No
4	Mayda (2010)	1980-1995	1	Share of young population	No
5	Hatton and Wilson (2003)	1977-1995	1	Share of population aged 15–29	Yes
6	Mitchell and Pain (2003)	1980-2005	1	Share of population aged 15–29	Yes
7	Malmberg (2006)	1975-2000	5	Cohort growth	Yes
8	Faini and Venturini (1994)	1962-1988	1	Share of population aged 14-29	No
9	Clark *et al* (2007)	1971-1998	1	Share of population aged 15–29	No
10	Hatton and Williamson (2003)	1971-1998	1	Share of population aged 15–29	Yes
11	Hatton and Williamson (2009)	1970-2004	5	Lag Birth, share of pop. aged 0-14, 15 years earlier	Yes
12	Hatton and Williamson (1998) - Italy	1878-1913	1	Lagged rate of natural increase	No
13	Fertig and Schmidt (2000)	1960-1997	1	Share of core-age population	Yes
14	Hanson and McIntosh (2010)	1960-2000	10	A proxy for migration	Yes
15	Hatton and Williamson (2009)	1860-1913	10	Birth rate lagged 20 years	Yes

Notes: (a) Significant at 5%.
The list was compiled as follows. We started with Google Scholar, with a combination of some specific keywords (migration determinants, population growth, lagged birth rate, demographic transition, fertility transition, vital transition, migratory transition, share of young population, Easterlin, fixed effects, within estimator, panel analysis). Then we selected only the papers employing some proxy of past population growth and panel data analysis of aggregate time series on migration. Each independent analysis carried out in each paper has been considered as a unique entry in the table. For instance, Vogler and Rotte (2000) performed three different analyses of migration: a) From Africa to Germany; b) From Asia to Germany; c) From Africa and Asia to Germany. In our list we included a) and b), but not c). Faini and Venturini's (2010) paper on Italy was very similar to that of Hatton and Williamson (1998) (same period and area; same conclusions), and has been considered redundant and excluded from the analysis. Note that the original articles sometimes considered parameter estimates "significant" at 10%, which is below the standard (5%) retained here.

1) *The constant-effect assumption*. Most aggregate-level papers on international migration assume that the effect of the independent variables is constant across different environmental conditions and time. But is this really the case? Empirically, in our sample, only two papers (Mitchell and Pain, 2003; Mayda, 2010) explicitly test this hypothesis, and both reject it. Theoretically, there are reasons to think that rural population growth can trigger different reactions (Boserup, 1965). For instance, when free land is available, an extension of any cultivated land may constitute a valid alternative to emigration. If land is scarce, but cities are developing quickly, there may be urbanization without (or with little) international migration. Emigration is merely one of the possible consequences of population growth and, in all cases; its occurrence and intensity depend on several other conditions (Davis, 1963).

2) *The short-term bias*. Working with short-time series of data creates two problems. One is that the variability of migration rates is high, which blurs the picture. The other is that "the migration hump" (a long historical phase, of 30 to 90 years[1], during which emigration rates first increase and then decline) may go unnoticed. "Fixed" effects are frequently introduced in the regression: these are region-specific dummy variables, intended to capture the effects of all the omitted, time-independent variables that influence migration: e.g. distance, climate, law provisions, etc. If the time series used in the analysis is shorter than what is needed for the migration hump to form and vanish, the effect of population growth may be unidirectional, and may easily be (mis)interpreted as a fixed, country-specific effect. Of the papers listed in Table 1, for instance, only 40 per cent find a significant association between past population growth and migration when the observation period is short (20 years or less). But this proportion rises to 60 per cent when the period spans 20 to 30 years, and exceeds 80 per cent for time intervals of 30 years or more.

Spacing also matters, probably because of random errors ("noise"), which tend to be strong in the field of international migration: in 11 of the papers listed in Table 1, the time lag between observations is 1 year (or less), and only 45 per cent of these papers find a significant association between past population growth and migration. Conversely, all the papers where observations are spaced by 5 years or more find a significant connection between these two phenomena.

3. INTRODUCING INTERACTIONS IN INTERNATIONAL MIGRATION MODELS

The theoretical framework for our analysis derives from the theory of multiphasic response (Davis, 1963). It states that populations react to the strains produced by mortality decline and demographic increase in several ways: lim-

[1] It lasted about 30 years in South Korea, and about 90 in the case of the migration from Europe to the Americas (Massey, 2003:17).

iting their fertility through abortion or contraception; giving rise to internal or international migration; intensifying agricultural activity and production (e.g. extending cultivated land), etc. These reactions, the combination of which may vary depending on circumstances, tend to compete with each other: the stronger and the more effective the results for one, the weaker the results for the others.

In this paper we concentrate on two types of responses to population growth:

a) intensified agricultural output, through an increase in working hours and an extension of cultivated land, along the lines originally suggested by Boserup (1965);

b) more internal (rural to urban) migration, which alleviates population pressure in rural areas (Dyson, 2010, 2011).

The rationale of the multiphasic response theory can be formalized through a multiplicative interaction model. In order to see this more clearly, let us first imagine a simplified, theoretical situation where only two reactions to population increase are possible: urbanization or emigration. These, it can be assumed, tend to compete with each other: more urbanization is associated with less emigration. The effect of population growth on emigration is, therefore, conditioned by the intensity of urbanization: if this is weak, emigration will be relevant; conversely, if it is strong, emigration may be negligible. If urbanization is ignored, the statistical relationship between past natural increase and emigration becomes spurious, and may appear as insignificant.

A multiplicative interaction model may help solve the problem:

$$E_t = \beta_0 + \beta_1 N_{t-k} + \beta_2 U_t + \beta_3 (U_t N_{t-k}) + \varepsilon_t \quad [1]$$

where E_t stands for emigration between t-1 and t, U_t stands for urbanization (variation in the proportion of urban population), and N_{t-k} stands for the natural increase between t-k-1 and t-k (that is, k years before). Equation [1] can be rewritten as follows:

$$E_t = (\beta_0 + \beta_2 U_t) + (\beta_1 + \beta_3 U_t) N_{t-k} + \varepsilon_t \quad [2]$$

which shows that the overall marginal effects ($\beta_1 + \beta_3 U$) of natural increase (N) on emigration (E), depends on urbanization (U) and on the value of the interaction coefficient β_3.

Equation [1] can be extended to allow for multiple forms of interaction, considering that, beyond urbanization, there may be other reactions to increased population pressure: for instance more rural productivity, or an extension of cultivated land (Boserup, 1965). The process may then be modeled as follows:

$$E_t = \beta_0 + \beta_1 N_{t-k} + \sum_{i=1}^{4} \beta_{i+1} A_{i,t} + \sum_{i=1}^{4} \beta_{i+5} (A_{i,t} N_{t-k}) + \sum_{i=1}^{2} \beta_{i+9} P_{i,t} + \varepsilon_t \quad [3]$$

where A_i are the alternative responses to population growth, of which we consider four (see further in the text), and P_i are variables intended to capture political crises, which are frequent in Sub-Saharan Africa (see below). In this model there are four sets of independent variables (see Table 2 for the details):

- the mean value of natural increase (*N*), *k* year before, where *k* means 15 to 20, i.e. the time needed for a newborn to reach working age. We expect its coefficient, β_1, to be positive: a strong natural increase today leads to potential emigration in 15 to 20 years' time;
- the potential alternative responses (A_i) to population growth, assumed to moderate the effects of natural growth on international migration. We consider four such alternative responses: 1) increasing food supply per person (*F*); 2) increasing arable land per person (*L*); 3) urban growth (*U*); and 4) economic growth (*Y*, GDP growth per person);
- the interactions between these responses and population growth (A_iN);
- finally, in order to include the effects of the (frequent) political crises in the region (especially in Sub-Saharan Africa) we include two more variables: the share of refugees R_i and the share of asylum seekers S_i in the total population.

4. THE DATA

Time is important in this type of analysis because, as discussed in Section 2, the "migration hump" needs some 30 to 90 years to fully develop. Taking lags into account, this requires the use of very long time series, which are only rarely available. We selected the longest series that we could find and that could be considered internationally comparable (UN, 2010).

Net migration is the difference between natural and total population increase. The notion of net migration has been criticized, sometimes harshly (Rogers, 1990). However, in practice, researchers continue to refer to it (Jennissen, 2003; Hatton and Williamson, 2003; Zlotnik, 2004; Malmberg, 2006; Hanson and McIntosh, 2010; Naudé, 2010), in part for lack of alternatives and in part because this variable does make sense at the aggregate (if not at the individual) level. Its main shortcoming is that it is obtained by the difference between total and natural growth, which normally amplifies measurement errors, though the use of five-year periods (instead of single year intervals) limits this shortcoming. We changed its sign, in order to facilitate interpretation: in this paper *E* measures net emigration, and a positive coefficient means "more (net) emigration".

In order to check the reliability of these data we also considered an alternative source on emigration from the countries covered in this analysis. The UN collected and, within certain limits, harmonized, data on the migration flows towards a limited number of economically-developed countries (UN 2008). For seven countries (Belgium, Canada, Germany, the Netherlands, Spain, Sweden

[2] The Spanish series starts only in 1982. Before 1982, however, immigration to Spain was negligible: we retained the data then for Spain and imputed zero immigration for the preceding years.

and the United States) there are annual time series dating back to the 1970s, where immigrants are classified by place of birth or nationality. On this basis, the migration flow originating from Western and Northern Africa and heading towards each of these seven countries is known with small margins of error. This is not all the emigration from our region, of course, but it gives a sense of the general trends. We call this variable *G*, for gross emigration. Note that when emigration increases, both *E* and *G* increase.

Table 2 – *Description of the variables employed in the model*

Classification	Variable	Description	Source
Dependent variable 1	E	Net emigration rate (= natural increase – population growth)	UN (2010)
Dependent variable 2	G	Gross emigration rate (towards selected countries)	UN (2008)
Key independent variable	N	Previous mean rate of natural increase (difference between birth and death rate, 20 years before)	UN (2010)
Competitive responses (A_i)	F	Per head daily food supply growth rate (= increase in the number of kilocalories per day per individual)	FAO (2009)
	L	Per head arable land permanent crops growth rate (= increase in the ratio arable land / rural population)	FAO (2009)
	Y	Per head GDP growth rate	Maddison (2004)
	U	Rate of increase in the proportion of population living in "urban agglomerations" (i.e. "the de facto population contained within the contours of a contiguous territory inhabited at urban density levels without regard to administrative boundaries")	UN (2011)
Interactions	$N \cdot F$	Rate of natural increase times per head daily food supply growth	–
	$N \cdot L$	Rate of natural increase times per head arable land permanent crops growth	–
	$N \cdot Y$	Rate of natural increase times growth in the number of tractors	–
	$N \cdot U$	Rate of natural increase times growth in the proportion of population living in urban agglomerations	–
Political tensions (P)	R	Share of refugees (average between t and t+5).	UNHCR (2009)
	S	Share of asylum seekers (average between t and t+5)	UNHCR (2009)

Our analysis covers 17 countries, in different phases of the migration transition process (and therefore also of the migration hump): 5 countries from Southern Europe (Greece, France, Italy, Portugal and Spain), 4 from Northern Africa (Algeria, Morocco, Tunisia and Egypt) and 8 from Western Africa (Benin, Burkina Faso, Cameroon, the Ivory Coast, Ghana, Mali, Nigeria and Senegal). The analysis spans over 35 years, from the 1970-1975 period to the 2000-2005 period. For each country, 7 observations are therefore available.

All the variables that we use are listed in Table 2, together with their labels and the sources from which they derive. Illustrative values for the initial, the final and an intermediate 5-year period are reported in Table 3.

Table 3 – *Migration, urbanization and natural increase in Northern and Western Africa: descriptive statistics*

Country	Rates 1970-1974				Rates 2000-2004			
	E	*G*	*N*	*U*	*E*	*G*	*N*	*U*
				Northern Africa				
Algeria	2.1	0.0467	29.6	185.1	0.9	0.3631	27.5	96.9
Egypt	3.3	0.1408	26.6	166.7	0.8	0.1288	28.4	59.9
Morocco	5.4	0.5082	27.7	252.0	3.7	2.3191	23.4	78.1
Tunisia	4.8	0.7517	26.4	88.6	1.7	0.4451	23.4	42.7
				Sahel				
Benin	1.7	0.0176	15.0	470.5	-2.7	0.0612	30.6	112.7
Burkina Faso	5.8	0.0038	20.3	395.8	-1.6	0.0532	30.0	380.8
Mali	3.0	0.0054	20.2	402.1	2.4	0.1456	25.1	219.7
				Western Africa				
Cameroon	-0.3	0.0095	19.7	518.9	0.1	0.2535	29.9	248.0
Ivory Coast	-11.8	0.0108	27.6	779.5	3.7	0.0858	31.4	227.9
Ghana	3.5	0.1336	27.2	260.0	-0.1	0.3874	28.5	230.9
Nigeria	0.1	0.0280	21.2	303.4	0.3	0.1114	26.9	171.0
Senegal	-2.9	0.0211	23.6	291.8	1.9	0.4102	30.3	201.7

Notes: *t* = initial year of the 5-year period over which rates (or average values) are calculated. *E* = Net emigration rates; *G* = Gross emigration rate towards selected countries; *N* = Natural increase; *U* = Rate of increase in the proportion of population living in “urban agglomerations”. All rates are per thousand population, per 5 years.
Sources: see Table 2.

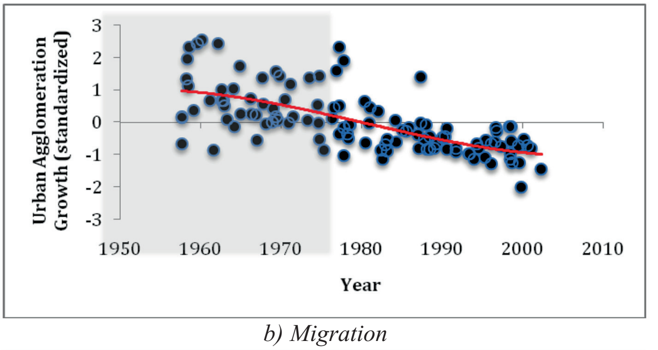
5. THE EFFECT OF POPULATION GROWTH

At the beginning of the 1980s there was a *relative* slowdown in urbanization in Northern and Western Africa, which, in some cases (e.g., Burkina Faso and the Ivory Coast; see Beauchemin, 2005), led to counter urbanization, with net emigration from the cities (Figure 1.a). There were several possible causes for the slowdown of urbanization in Northern and Western Africa in those years, but two main factors stand out: the general saturation of urban places produced by the rural-urban exodus during decolonization, and the explosion of the debt crises at the end of the 1970s, which led to substantial cuts in public spending, traditionally benefitting cities much more than rural areas.

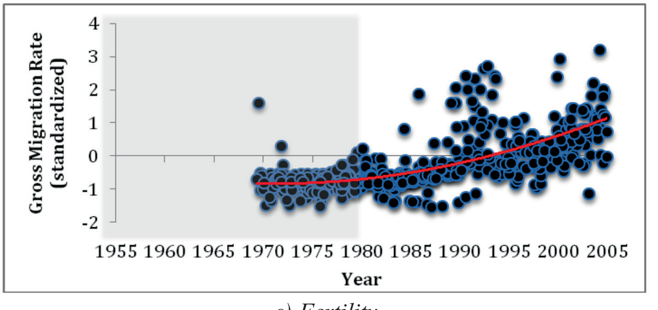
The data from the UN Population Division shows that the slowdown of urbanization was followed, a few years later, by an increase in emigration (Baldwin-Edwards, 2006; Thomas, 2011) and also by a reduction in fertility (Figure 1.c and 1.b. Figure 1.b represents our "gross migration rate" *G*), although we do not explicitly consider this here (see, on this topic, Cohen and Montgomery, 1998; Courbage, 1999; Fargues, 2000; Rashad, 2000; Eltigani, 2001; Garenne and Joseph, 2002).

Figure 1 – *Standardized measures of urbanization (U), emigration (E) and fertility (F) in Northern and Western Africa*

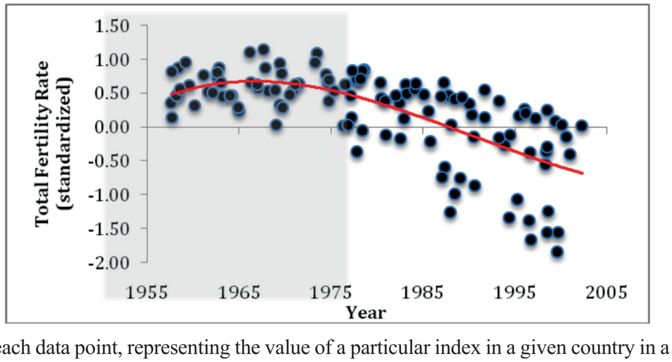
a) Urbanization



b) Migration



c) Fertility



Notes: To each data point, representing the value of a particular index in a given country in a specific year, we have subtracted the country mean and the results have been divided by the country standard deviation.

5.1 *A multiphasic response to population growth*

Let us now try to model the effect of population growth on international migration, starting with the simplest case, where only two determinants of net emigration are considered: population growth and urbanization (Table 4, Model 1).

Ignoring interaction, as in Model 1, neither population growth nor urbanization are significant. The reason for this is that urbanization interacts with population growth in influencing net migration. With the introduction of the interaction term (equation [2] and model 2), all the coefficients of the model become significant and the overall predictive power of model 2 with respect to model 1 increases considerably (the ANOVA test has a p-value lower than 0.001).

Table 4 – *Population growth effect: basic models*

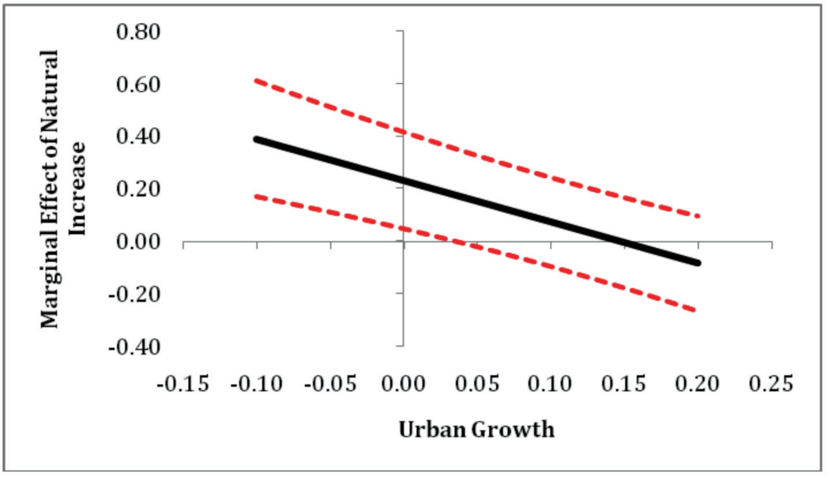
Dependent variable	Model 1 E = net emigration rate		Model 2 E = net emigration rate			Model 3 G = Gross emigration rate		
Independent var.	Est.	Std. err.	Est.	Std. err.		Est.	Std. err.	
N (natural increase)	0.0651	0.0936	0.2327	0.0927	*	0.1194	0.0263	***
U (urbanization)	-0.0026	0.0028	0.0322	0.0080	**	0.0094	0.0023	***
$N \cdot U$ (interaction)			-1.5832	0.3434	***	-0.3515	0.0974	***
R (refugees)	0.0004	0.0003	0.0003	0.0003		0.0001	0.0001	
S (asylum seekers)	-0.0001	0.0001	-0.0000	0.0001		0.0000	0.0000	
Adjusted R^2	0.03		0.17			0.18		

Notes: - All the variables of the models are rates, as previously defined. Positive values of E indicate net emigration (same sign as G). G is gross emigration towards only a few selected countries (see text).
- N is the rate of natural increase 20 years before. In model 2, for instance, the positive value of the coefficient (0.23) signals that, without urbanization (U = 0), about a quarter of the overall natural increase transforms, 20 years later, into emigration.
-The analysis covers 17 countries over the period 1970-2004. Each observations in our dataset refers to a five year period (1970-75, 1975-79, ..., 2000-2005). Our dataset covers therefore 119 observations (17 countries x 7 periods).
- In all three models, Breusch and Pagan's test accepts the hypothesis of country effect, but rejects the hypothesis of a significant period effect, and Wooldridge's test accepts the hypothesis of significant serial correlation. Therefore, we used the "within" estimator (the countries' means have been subtracted from the series) and then we applied OLS with robust clustered standard errors. A difference emerges with Pesaran's CD: for models 1 and 2, the hypothesis of a significant cross-correlation in the data is rejected, while for model 3 it is accepted.
- Asterisks indicate significance: *< 0.05; **< 0.01; ***< 0.001.
Sources: See Table 2.

The coefficient of the interaction term ($U \cdot P$) is negative and significant: this suggests that urbanization reduces the pressure of population growth on emigration. On the basis of these regression coefficients, Figure 2 shows, for different levels of urbanization, the part of the overall natural increase that, some 20 years later, translates into net international migration. The effect of population increase on net migration is null if the 5-year increase in the proportion of the population living in urban agglomerations reaches 15 per cent or so;

below this threshold, past population growth fosters emigration. When the 5-year increase in the proportion of urban population is lower than 4 per cent the effect of past population increase on emigration becomes highly significant (at 5 per cent). The same model with a different dependent variable, *G* (gross emigration), yields basically the same results (Table 4, model 3), which corroborates our claim that the model is robust, and that the interaction factor is worth considering.

Figure 2 – *Marginal effect of population growth for different urbanization values*



Note: With reference to equation 2 and model 2 the marginal effect of natural increase on net migration is calculated as $\beta_1 + \beta_3 \cdot U$ (β_1 = 0.23 and β_3 = -1.58).
In order to calculate the confidence intervals at a 5 per cent threshold we used the formula $\hat{\sigma}_{\frac{E}{N}} = \sqrt{\text{var}(\hat{\beta}_1) + U^2 \text{var}(\hat{\beta}_3) + 2\,\text{cov}(\hat{\beta}_1 \hat{\beta}_3)}$ (Braumoler, 2004; Brambor *et al*., 2006)

Let us now move on and introduce other variables and other interactions: *F* (Food), *L* (Land) and *Y* (Income) – all of them measuring increases in per person values, as explained in Table 2. Without interactions (Table 5, model 4) none of the coefficients is significant, as in model 1. With interactions, however, most of the coefficients become significant (model 5). Before turning to their interpretation, which presents several difficulties, let us first note that the inclusion of the interaction terms significantly improves the fit (or, better, the likelihood) of the model (p-value < 0.001). Moreover, the coefficients of three of the interaction terms (natural increase with food per person, land per person and urban population) are significant and with the expected sign, which reinforces our conjecture that these variables mitigate the effect of population increase on international migration.

As for the interpretation of the estimated coefficients, the effect of natural

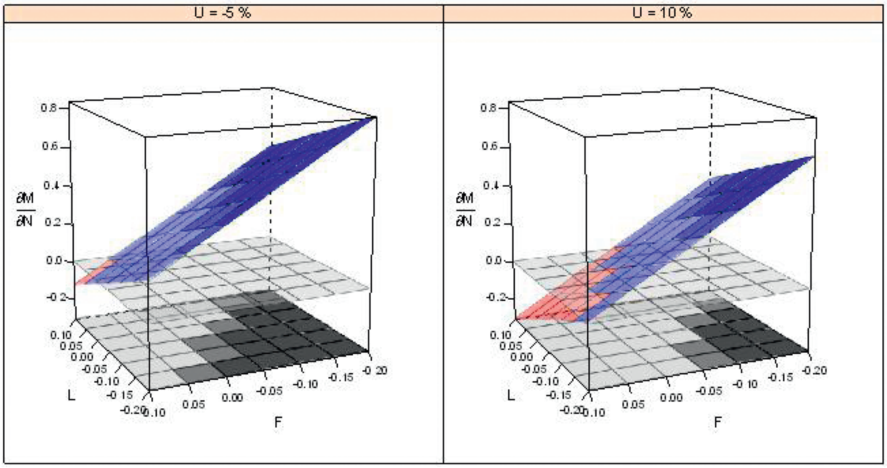
Table 5 – *Population growth effect: extended models*

Dependent variable	Model 4 E = net emigration rate		Model 5 E = net emigration rate			Model 6 G = Gross emigration rate		
Independent var.	Est.	Std. err.	Est.	Std. err.		Est.	Std. err.	
N (natural increase)	0.0539	0.0976	0.1452	0.0860	·	0.0927	0.0278	**
U (urbanization)	-0.0032	0.0029	0.0291	0.0073	***	0.0077	0.0024	**
F (Food supply)	0.0005	0.0036	0.0608	0.0108	***	0.0009	0.0035	
Y (GDPpc growth)	0.0023	0.0026	-0.0063	0.0068		0.0049	0.0022	*
L (Land available)	-0.0004	0.0035	0.0280	0.0094	**	0.0055	0.0022	·
$N{\cdot}U$ (interaction)			-1.5099	0.3184	***	-0.2962	0.1027	**
$N{\cdot}F$ (interaction)			-2.2933	0.4268	***	-0.0675	0.1374	
$N{\cdot}Y$ (interaction)			0.4005	0.2798		-0.1646	0.0903	
$N{\cdot}L$ (interaction)			-0.0012	0.0004	**	-0.0002	0.0001	
R (refugees)	0.0004	0.0003	0.0004	0.0002		0.0001	0.0001	
S (asylum seekers)	-0.0001	0.0001	-0.0000	0.0001		0.0000	0.0000	
Adjusted R^2	0.04		0.35			0.23		

Notes: - All the variables of the models are rates, as previously defined. Positive values of E indicate net emigration (same sign as G). G is gross emigration towards only a few selected countries (see text).
- N is the rate of natural increase 20 years before. In model 5, for instance, the positive value of the coefficient (0.15) signals that, when all other variables are set to 0 ($U = F = Y = L = 0$), about 15 per cent of the overall natural increase transforms, 20 years later, into emigration.
- The analysis covers 17 countries over the period 1970-2004. Each observations in our dataset refers to a five year period (1970-75, 1975-79, …, 2000-2005). Our dataset covers therefore 119 observations (17 countries x 7 periods).
- In models 1 and 3 Breusch and Pagan's test accepts the hypothesis of country effect, but rejects the hypothesis of a significant period effect. Wooldridge's test accept the hypothesis of significant serial correlation. Pesaran's CD test rejects the hypothesis of a significant cross-correlation in the data. The coefficients were estimated with the within estimator (the countries' means have been subtracted from the series) and OLS has been applied with robust clustered standard errors.
- In models 2 Breusch and Pagan's test accepts the hypothesis of country effect, but rejects the hypothesis of a significant period effect. Wooldridge's test rejects the hypothesis of significant serial correlation. Pesaran's CD test rejects the hypothesis of a significant cross-correlation in the data. For this reason we used the within estimator (the countries' means have been subtracted to the series) and then we applied OLS with robust clustered standard errors. The coefficients were estimated with the within estimator and OLS applied with robust clustered standard errors.
- Asterisks indicate different degrees of significance: · < 0.1; *< 0.05; **< 0.01; ***< 0.001.
Sources: See Table 2.

population growth on net emigration is positive (i.e., population growth encourages emigration) and slightly significant (at 10 per cent). In order to interpret this result correctly, it should be remembered that the coefficient here indicates the conditional effect of population growth on migration when all the other variables (including interactions) are zero. In other words: when the per person growth in food and land fully compensates population growth and there is no urbanization, one sixth of natural population growth will, with a lag of 20 years, be transformed into out-migration. This is consistent with our theoretical framework: when alternative responses fully compensate for the effect of population increase, emigration is weak.

Figure 3 – *Marginal effects of population growth on international migration under different scenarios*



Notes: The two panels show the effect of population growth on international migration for different values of arable land growth (*L*), food supply growth (*F*) and urbanization (*U*). In each panel, the oblique plane indicates the estimated effect of population growth on international migration for a given value of urbanization (model 5). Darker shadings highlights the points on the plane significant at a 5 per cent or 1 per cent threshold. These shadings are also projected on the floor of each graph, in different grey scales, with the same meaning.

Model 5[3] can also be used to test the effect of population increase on migration when some or all of the concurrent responses do not compensate for population growth, or, at least, when they fail to do so in full. The difficulty here is that the effect of population growth on emigration can be significantly affected by three different phenomena: per person land increase, per person food supply increase and urbanization. Figure 3 can help visualize how this multi-dimensional interaction process works. Its two panels show the marginal effect of population growth on international migration for different values of arable land growth, food supply growth and urbanization. In each panel, the oblique plane indicates the (average, model) effect of population growth on international migration for a given value of urbanization. Colors are darker when the points on the plane are significant at a 5 per cent or at a 1 per cent threshold. In order to facilitate the reading of the graphs we also projected, on the floor of each graph, in different shades of grey, the degree of the significance of the estimated coefficients.

Three main conclusions emerge from Figure 3:

a) without a significant reduction in (per person) land and food availability, population growth produces only a weak effect on international emigration;

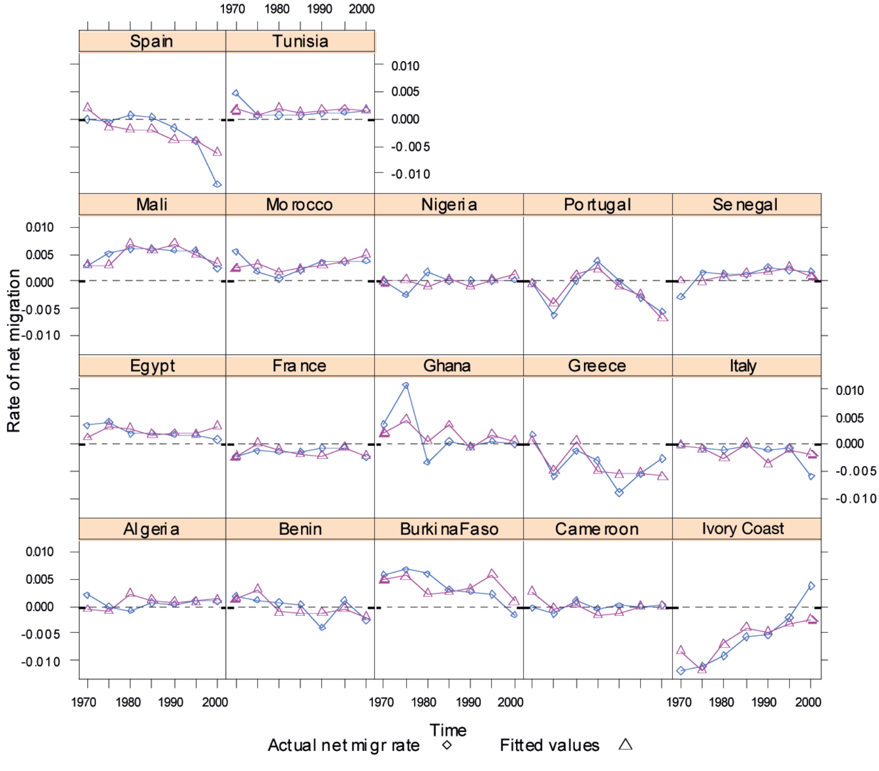
[3] Model 6 uses *G* (gross migration rate) instead of *E* (net migration rate) as a dependent variable. The results are basically the same (although the coefficients turn out to be somewhat less significant) and we will, therefore, not comment on them here.

b) even in cases where there is a significant reduction in land and food availability, urbanization may counter international migration by absorbing the bulk of rural exodus;

c) only when all these alternative responses to population growth fail, does international migration ensue.

Figure 4 compares the actual (net) emigration rates with those predicted by model 5: the two series are in general very similar (except for occasional deviations: e.g. Ghana, around 1975) and the trend is always the same.

Figure 4 – *Actual and predicted values of net migration rate (1970 to 2005, 17 countries)*



5.2. *The short-term bias*

In section 2 we argued that contradictory results in the literature about the effect of past population growth on international migration may depend, in part, on what we called the short-term bias. In order to avoid this, the present paper includes countries in different phases of their demographic (and emigration) transition, and uses the longest available time series on international migration.

Let us test to what extent these strategies influence the results of our analysis.

Model 5 (in Table 5) can be run on several sub-samples of our dataset. Using only Northern and Western African countries, and excluding Southern Europe, leads to model 7, where the parameters have the same signs as those of model 5, but with lower significance, and where the overall fit of the model is worse. Models 8 and 9, instead, refer to shorter periods: model 8 covers only 25 years (from 1980 to 2005), and model 9 covers only 15 years (from 1990 to 2005), whereas our preferred model (model 5) spans 35 years, from 1970 to 2005. Model 8 (25 years) suffers from only a slight reduction in the explained variance (the adjusted R^2 drops to 0.33), and the signs and the significance of the coefficients are not affected much. Conversely, with model 9 (15 years) major effects on the estimated coefficients emerge: the explained variance declines considerably (Adjusted $R^2 = 0.25$), and almost all the coefficients lose their significance, even if they preserve their sign. Short-term political shocks (as measured by refugees and asylum seekers) occasionally seem to play a role.

Table 6 – *Testing the population growth effects on shorter time series (short-term bias)*

Dependent variable	Model 7 *E* = net emigration rate			Model 8 *E* = net emigration rate			Model 9 *G* = Gross emigration rate		
Period	1970-2005			1980-2005			1990-2005		
Region	North & West Africa			South EU, North & West Africa			South EU, North & West Africa		
Independent var.	Est.	Std. err.		Est.	Std. err.		Est.	Std. err.	
N (natural increase)	0.1238	0.1875		0.2057	0.1273		0.5070	0.3724	
U (urbanization)	0.0305	0.0140	*	0.0601	0.0141	***	0.0558	0.0701	
F (Food supply)	0.0452	0.0187	*	0.0531	0.0149	***	0.0846	0.0280	**
Y (GDPpc growth)	-0.0064	0.0142		-0.0002	0.0083		-0.0014	0.0145	
L (Land available)	0.0449	0.0226	·	0.0245	0.0107	*	0.0175	0.0127	
N·U (interaction)	-1.5666	0.5355	**	-2.6989	0.6084	***	-2.5181	2.4324	
N·F (interaction)	-1.7160	0.7063	*	-1.7454	0.5552	**	-2.8134	0.9799	**
N·Y (interaction)	0.3960	0.5420		0.1438	0.3181		0.0333	0.5154	
N·L (interaction)	-0.0019	0.0009	*	-0.0009	0.0004	*	-0.0007	0.0005	
R (refugees)	0.0003	0.0003		0.0006	0.0003	*	0.0006	0.0004	
S (asylum seekers)	-0.0000	0.0001		-0.0000	0.0001		-0.0004	0.0002	*
Adjusted R^2	0.29			0.33			0.25		

Notes: - All the variables of the models are rates, as previously defined. Positive values of *E* indicate net emigration (same sign as *G*).
- *N* is the rate of natural increase 20 years before. In model 7, for instance, the positive value of the coefficient (0.12) signals that, when all other variables are set to 0 ($U = F = Y = L = 0$), about 12 per cent of the overall natural increase transforms, 20 years later, into emigration.
- Model 7 covers 12 countries during the period 1970-2005 (84 observations); Model 8 covers 17 countries during the period 1980-2005 (85 observations); Model 9 covers 17 countries during the period 1990-2005 (51 observations).
- Asterisks indicate different degrees of significance: · < 0.1; *< 0.05; **< 0.01; ***< 0.001.

Sources: See Table 2.

In short, two main conclusions emerge. The first is that our model appears to be rather robust, because none of the alternative limitations introduced in our dataset significantly change the signs of the coefficients. Second, the short-term bias emerges as a serious problem only when the temporal extension of the analysis falls below 20 years, which is consistent with our tentative systematization of the surveyed literature (Table 1).

6. RESULTS

Population growth began in Northern and Western Africa long ago: probably sometime in the 1920s through to the 1950s. Mass emigration started much later: in the 1980s. The time lag between the two processes is substantial. But, on the other hand, it is hard to believe that population growth, frequently more than 30 per thousand, had no effect on the emergence of the Trans-Saharan and the Trans-Mediterranean migration systems, as certain analyses suggest.

The apparent paradox can be solved if one assumes that the timing of the migration transition is also influenced by specific environmental and historical conditions, among which the availability of arable land, the increase in rural productivity or urbanization. These "safety valves" may offer alternatives to international emigration in case of rapid population growth, as Davis conjectured back in 1963. His "multiphasic" theory can be formalized and it works satisfactorily if interactions between each of these alternatives and population growth are explicitly introduced. All of the interaction terms estimated in this paper are highly significant, which strengthens our claim that these safety valves (urbanization, expansion of arable land, etc.) were at work in Northern and Western Africa between 1950 and 1980. Population growth resulted in strong international emigration flows only subsequently, when these safety valves ceased to work.

This paper does not, and cannot, provide conclusive evidence on the matter, in part because of data limitation. For instance, the "demographic push" that we suggest constitutes the ultimate source of international emigration is only imperfectly measured by the past rate of population growth - but no alternative is fully convincing (e.g. the share of population of working age depends on recent emigration, and introduces and endogeneity problem), especially considering that we need a long and comparable time series of data. Internal migration is surely a complex process, and the rate of urbanization that we use here is but a pale proxy for it. We do not take into consideration the educational level or the (potential) wage of migrants, and therefore implicitly assume that they are all equal - which is surely not the case.

Unfortunately, until major breakthroughs materialize in data availability, most of the subtler curiosities that one may have about the causes of international migration flows are likely to remain unanswered. But the available evidence that this paper has collected and elaborated offers, we believe, a consistent (and, all in all, highly expected) conclusion overall: population pressure creates problems. When cheaper solutions are available (e.g. more land to cultivate, or internal migration, e.g. to towns), populations resort to them. When this is not the case, international emigration ensues.

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