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*The impact of MENA-to-EU migration in the context of demographic change**

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Abstract

We analyze the consequences of increasing MENA-to-EU migration on both sending and receiving regions. Using a general equilibrium model, we find that increasing MENA-to-EU migration generates significant changes in EU15 tax rates and income per capita. Compared to a non-selective immigration shock, selecting immigrants leads to a moderate reduction in tax rates, but to a greater impact on income per capita in the EU15. Emigration, especially if high-skilled, has a detrimental impact on MENA tax rates. Finally, the negative effects in MENA are mitigated if the brain drain leads to side-effects or is accompanied by increased education attainment at origin.

1 Introduction

The decrease in fertility and mortality rates induces a progressive and inescapable *graying* of European nations. The economic effects of an aging population are considerable. Changes in the demographic structure are likely to affect the amount of capital per worker (with induced effects on interest rates and wages), the demand for some types of goods or the rate of economic growth. However, population aging also raises the average amount of public expenditures per capita. The largest areas of public expenditure in many countries are now health care and pension benefits. Both

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are expected to increase dramatically as the population ages. Governments then face hard choices between higher taxes (including a possible reweighting of taxes from earnings to consumption), increasing debt (which could jeopardize the welfare of future generations) and a reduced government role in providing health care and social security.

Another option is to find policies that increase the supply of labor and the tax basis. Over the last few years, economists and policymakers have discussed the opportunity to define a new labor-market-oriented policy of immigration. Immigration appears as a potential solution to reduce the burden of aging. This is especially the case in Europe where the European Commission has suggested to conduct a *blue card* policy facilitating the entry of foreign high-skilled workers. Following the examples of the German *green card* or UK points-based system, many countries are now considering the possibility to select immigrants. Clearly, we should not expect immigration to totally solve the problem. In their report on replacement migration, the United Nations (2000) demonstrate that keeping the dependency ratio constant over the period 2000–50 requires multiplying European annual immigration flows by 50 (by 15 in the United States). In many countries, the immigration rates would then reach unrealistic values that are not politically, economically and demographically sustainable.

Nonetheless, a decent increase in immigration flows or a change in the schooling level of immigrants could attenuate the burden supported by future generations of European natives. Given its economic (low skill premia, high tax rates, generous welfare programs) and linguistic characteristics, it is very hard to believe that continental European nations are able to attract many (skilled) migrants from the rest of the world. However, given its colonial links and geographical proximity, European countries are the main destinations of African emigrants, especially those from the Maghreb and a couple of Middle East countries. In fact, migrants originating from the Middle East and Northern Africa (MENA) represented the largest shares among migrants (33.1 %) and also among *high-skilled* migrants (19.7 %) originating from less advanced countries and living in the EU in 2000. In comparison, MENA citizens constituted only 5 % of all migrants and only 7.7 % of all high-skilled migrants from less advanced countries living in North America (United States and Canada), where Latin American citizens are proportionally the largest group (53.6 % of all migrants and 33.1 % of all high-skilled migrants).[1] Given the large diasporas resulted from guest-worker bilateral programs of the post-World War II and given that diasporas attract further migrants (see Beine *et al.*, 2010), European countries could probably increase the number of immigrants from the MENA or even conduct more selective policies toward these immigrants. Would such policies be optimal for European countries? What would be their implications for MENA origin countries? These are the questions addressed in this paper.

[1] In fact, MENA citizens living in the EU15 exceeded migrants originating from Eastern Europe (21.6 %), South Asia (12.7 %), sub-Saharan Africa (11.2 %), East Asia (9.7 %), Latin America and Caribbean (8.9 %) and the former Soviet Union (2.9 %), see Docquier *et al.* (2007).

Different approaches have been used in the economic literature to study the implications of replacement migration. Beyond numerous theoretical analyses[2], economists have also quantitatively assessed the fiscal effect of immigration. One strand of this literature relies on the generational accounting (GA) methodology and delivers mixed results concerning the impact of immigration on public finance.[3] Auerbach and Oreopoulos (1999) stress that the net benefit of immigration on the fiscal balance is small relative to the size of the overall imbalance itself, while Collado *et al*. (2004) find a significant positive impact of immigration on intertemporal public finance in Spain. Other GA studies reveal that policies acting upon migrants' characteristics can lead to important fiscal gains. For instance, Bonin *et al*. (2000) suggest that the skill structure of future immigrants can have a considerable impact on public finance. A similar conclusion is drawn by Chojnicki (2006) for France. However, the GA methodology relies on many restrictive assumptions. For instance, since it works in a partial equilibrium setting, it cannot account for the indirect effect of immigration on public finance via its impact on factor prices.

Some authors claim therefore that the use of a general equilibrium approach is more accurate to quantitatively measure the fiscal effect of immigration. Only few (dynamic) general equilibrium studies investigate if *future* immigration can contribute to reduce today's and tomorrow's fiscal burden.[4] The standard reference is Storesletten (2000), who sets up a closed-economy general equilibrium model with overlapping generations of the US economy. He finds that immigration does little to reduce the fiscal burden of aging in the United States, but a rise in the number of *high-skilled* immigrants may be beneficial. A similar conclusion is provided by Fehr *et al*. (2004), who study the fiscal effects of immigration within a three-regional model (US, Europe and Japan) to account for the potential fiscal effects of induced capital movements.[5]

Studies on the fiscal effects of immigration focus exclusively on the implications for host countries. However, in an increasingly globalized world, advanced countries cannot anymore ignore the consequences of their political decisions on other countries. It would therefore be instructive to evaluate the impact of immigration policies in developed countries on migrants' sending countries. Fehr *et al*. (2004) stress that increasing the number of immigrants is not unproblematic. They conjecture that if high-skilled migrants' would come from developing regions, it may worsen the brain drain 'that is already greatly depleting the human capital of developing regions'. This claim is hazardous and requires an analysis accounting for the impact of migration both on migrants' destination and origin countries.

In fact, the brain drain literature shows that the impact of skilled emigration on the level of human capital in sending countries and on their economy, in general, is not

[2] See among others, Razin and Sadka (1999), Krieger (2004), Kemnitz (2003, 2008), Sinn (2001), Leers *et al*. (2004), Scholten and Thum (1996) and Lagos and Lacomba (2010).

[3] The generational accounting approach consists in investigating the long-run sustainability of fiscal policies, accounting for the needs of present and future generations (Auerbach *et al*., 1994).

[4] Chojnicki *et al*. (2011) assess the impact of immigration on the overall US economy over the 20th century, including the impact on public finance.

[5] Within a large-scale computable general equilibrium model for the Danish economy, Schou (2006) finds that immigration can alleviate the fiscal sustainability problem only when immigrants and their children have participation and productivity levels close to those of natives.

clear-cut. Early studies on skilled emigration emphasize the direct negative effect induced by the loss of a highly productive labor force, a scarce resource in developing countries (Bhagwati and Hamada, 1974). However, a recent wave of papers highlights several positive side effects of skilled emigration for migrants' source countries.[6] One benefit from high-skilled emigration is that it fosters human capital formation (Mountford, 1997; Beine *et al.*, 2001, 2008; Stark and Wang, 2002). Higher migration prospects for high-skilled migrants induce greater incentives for individuals to educate because of a higher expected skill premium. If the incentive effect (brain gain effect) compensates the loss of high-educated workers (brain drain effect), then human capital is enhanced compared to a situation without high-skilled emigration. Beine *et al.* (2008) show that regions with the largest high-skill emigration rates are those that do not benefit from brain gain but suffer brain drain. Moreover, besides the positive impact of remittances sent home by emigrants, one benefit of the brain drain is attributed to increased FDI inflows favored by migrant networks, which reduce informational barriers and thus enhance the attractiveness of the home country to foreign investors (Kugler and Rapoport, 2007). Also, several authors suggested that a high-skilled diaspora facilitates international technology diffusion raising total factor productivity in immigrants' home countries (e.g. Kerr, 2008).

To the best of our knowledge, our study is the first to evaluate the implications of high-skilled migration both on migrants' receiving countries and on migrants' sending countries in a unified framework. To perform this analysis, we employ a multi-region general equilibrium model of the world economy (both developed and developing regions) and calibrated to real data. The model is characterized by overlapping-generations (OLG) dynamics and features high- and low-skilled individuals. We study the consequences of increased South–North migration, i.e. from the MENA to the EU15. First, we compare the consequences of an immigration policy favoring the arrival of high-skilled migrants ('High-Skilled' scenario) with a policy allowing the entrance of low-skilled migrants ('Low-Skilled' scenario) into the EU15.

Another originality of our study is that it encompasses various ways in which high-skilled migrants may affect their host and sending countries. In a subsequent analysis, we consider therefore several scenarios of high-skilled migration. Along with the 'High-Skilled' scenario, we investigate a 'Brain Gain' scenario, which accounts for several externalities of high-skilled migration identified in the brain drain literature. To do so, we calibrate these various side effects using existing empirical estimates.[7] Moreover, we compare the results of the 'High-Skilled' scenario, which assumes that migrants' human capital acquired in the MENA is perfectly transferrable to the EU15, with the ones of a 'Brain Waste' scenario, which hypothesizes that high-skilled migrants are employed as low skilled at destination. A last scenario, 'Expansionary', allows for the possibility where MENA countries prepare for greater skilled migration to Europe by accelerating their human capital formation.

[6] See Commander *et al.* (2004) and Docquier (2007) for surveys of the literature.

[7] This procedure is employed in Marchiori *et al.* (2011) to assess the isolated effect of various externalities of skilled emigration as well as their global impact on sending countries' GDP per capita.

The main insights of our analysis can be summarized as follows:

- The MENA region sends about 15 million emigrants abroad, including 5.1 million to the 27 countries of the European Union. For 9 countries of the region, the EU27 (and foremost the EU15) is a particularly important destination. We refer to MENA9 as a group that includes Algeria, Djibouti, Egypt, Iran, Lebanon, Libya, Malta, Morocco and Tunisia. These 9 countries send 9.2 million emigrants abroad, and for more than half (50.5% of them), the EU27 is the migration destination. Within this group, there is a subset of countries we refer to as MENA4, including Algeria, Morocco, Tunisia and Egypt, in which the flows to EU27 as a group are particularly high (either in numbers or proportions of their population). MENA4 sends 4.2 million migrants to Europe, representing 56% of their diaspora. In any discussions about increased migration flows from MENA to Europe, these are the countries that would be particularly affected.
- Previous macro-econometric studies suggest that the 'brain drain' – the loss of high-skilled labor due to migration – begins to demonstrate harmful impacts on development if it exceeds a threshold of 10–15% (see Docquier, 2007*a*, *b*). With the exceptions of Djibouti, Libya and Egypt, all of the MENA9 are already above that level (Lebanon, Malta, Morocco, Algeria, Egypt and Iran are at the border). As a result, for the sending countries of MENA, increasing the levels of high-skilled migration are likely to have damaging impacts on growth and development without accompanying policies to mitigate these harmful effects.
- Demographically, increasing migration flows from MENA4 or MENA9 to EU27 countries would clearly attenuate the deterioration of the European population structure. However, MENA countries themselves expect serious demographic strains after 2030 and will need pension reforms to minimize the risk of a financial crisis. The MENA4 age-dependency ratio (ADR) in 2050 will exceed the current ratio observed in the EU. Hence, 'replacement or selective migration' policies encouraging MENA-to-EU flows of working-age people should ideally be structured to be temporary (not beyond 2050).
- Our general equilibrium analysis reveals that an increased MENA-to-EU migration would generate considerable changes in EU tax rates and GNI per capita, significantly smoothing the fiscal and economic burdens of aging. Contrary to pure fiscal studies (such as GA), selecting immigrants has only a moderate impact on tax rates. This can be explained by induced effects on wage rates, skill premium and interest rates. However, selection has a strong and positive impact on GNI per capita. In MENA, however, increases in emigration have a strong detrimental impact on tax rates, especially if emigrants are skilled. Moreover increasing low-skilled emigration in MENA leads to improvements in GNI per capita and inequality (mainly due to remittances) while increasing high-skilled emigration induces detrimental consequences.
- The analysis also accounts for different variants of the high-skilled migration scenario. A 'Brain Waste' variant (in which high-skilled migrants are employed as low skilled at destination) combines the worst effects of the selective and non selective shocks, since MENA losses its most productive workers, who are

employed as low skilled in Europe and thus contribute poorly to the EU's economy. In a second variant accounting for positive externalities of the brain drain ('Brain Gain' scenario), the negative impact of high-skilled migration on income per capita and inequality in MENA are mitigated. Still, MENA would suffer from an enlarged brain drain.

- Finally, we consider a possibility where MENA countries prepare for greater high-skilled migration to Europe by accelerating their human capital formation. In this case ('Expansionary' scenario), a high-skilled emigration shock could go along with a rise in education levels of the MENA population and income per capita. This suggests that a stronger partnership between EU15 and MENA countries, involving more high-skilled migration and a greater cooperation in human capital formation, can raise the welfare of all parties concerned. For instance, such an initiative could be designed in the framework of the '*Union pour la Méditerranée*' initiated in late July 2008 by French President Nicolas Sarkozy. The goal of this Union is explicitly to promote a development of the Euromediterranean Partnership.

The remainder of this paper is organized as follows. Section 2 provides a detailed snapshot of the current MENA-to-EU labor mobility by education level and its demographic impact on both regions. In Section 3, we use a computable general equilibrium (CGE) model of the world economy to simulate the impact of increased migration flows from MENA to the EU on tax rates (reflecting the burden of aging), productivity, GDP–GNI levels and demographic variables in both regions Section 4 concludes.

2 MENA-to-EU migration and demographic effects

In this section, we take advantage of two recent studies sponsored by the World Bank, to describe the MENA-to-EU labor mobility. These statistics provide a snapshot on the number of migrants by country of origin and destination (Section 2.1) and on their skill characteristics (Section 2.2). Moreover, based on these data, we evaluate the impact of the MENA-to-EU migration on the demographic structure of both regions (Section 2.3).

2.1 Global situation of the MENA-to-EU migration in 2000

To assess the magnitude of MENA-to-EU migration, we first rely on the dataset described in Parsons *et al.* (2007).[8] From Table 1, we see that the 21 MENA countries sent 15 million emigrants abroad in 2000. Since the resident population amounted to 316 million, this gives an emigration 'rate' of 4.5%. Countries of the Gulf

[8] Parsons *et al.* (2007) provide a 226×226 matrix of origin-destination stocks by country and territories. Four versions of the database are available, giving increasing levels of completeness, but decreasing levels of accuracy as more missing data are interpolated or constructed with each successive version. Our analysis is based on version 4 of this dataset, which provides a single comprehensive bilateral matrix of migrant stocks. As this version contains many estimated cells, the results listed in Tables 1 and 2 should only be considered as approximations. In particular, the fact that West Bank and Gaza appears as the main destination of many Middle East countries should be taken with caution.

Table 1. *Emigration from MENA countries in 2000*

	Total migration			Main destination		
	Stock	Rate	Herfin	Country	Stock	Share
MENA4						
Algeria	207,0840	6.8 %	0.428	France	1333587	64.4 %
Egypt	217,3711	3.2 %	0.232	Saudi Arabia	1015124	46.7 %
Morocco	2589,108	8.9 %	0.131	France	759011	29.3 %
Tunisia	607,491	6.4 %	0.373	France	364498	60.0 %
MENA9						
Djibouti	16,990	2.4 %	0.208	France	6093	35.9 %
Iran	926,312	1.4 %	0.133	USA	291625	31.5 %
Lebanon	577,123	17.0 %	0.084	USA	111142	19.3 %
Libya	78,109	1.5 %	0.098	Israel	19200	24.6 %
Malta	113,094	28.9 %	0.261	Australia	46998	41.6 %
Others						
Bahrain	128,719	19.2 %	0.262	W. Bank Gaza	54230	42.1 %
Iraq	1109,957	4.4 %	0.163	Iran	413710	37.3 %
Israel	956959	15.7 %	0.374	W. Bank Gaza	567467	59.3 %
Jordan	667,754	13.4 %	0.277	W. Bank Gaza	319367	47.8 %
Kuwait	486,861	21.8 %	0.244	W. Bank Gaza	210594	43.3 %
Oman	17,881	0.7 %	0.219	W. Bank Gaza	7841	43.9 %
Qatar	15,958	2.6 %	0.224	W. Bank Gaza	7065	44.3 %
Saudi Arabia	243,258	1.2 %	0.214	W. Bank Gaza	106230	43.7 %
Syria	423,764	2.5 %	0.100	Saudi Arabia	109048	25.7 %
United Arab Em	123,886	3.8 %	0.218	W. Bank Gaza	53883	43.5 %
W. Bank Gaza	1065,224	33.8 %	0.368	Syria	630725	59.2 %
Yemen	603,173	3.4 %	0.371	Saudi Arabia	360438	59.8 %

Source: Parsons *et al.* (2007).

Cooperation Council (GCC) sent 1 million emigrants abroad, representing 3.3 % of the native population. Countries with the highest emigration rates were West Bank and Gaza (33.8 %), Malta (28.9 %), Kuwait (21.8 %) and Bahrain (19.2 %). As shown in Docquier *et al.* (2007), there is an obvious link between population size in country of origin and number of migrants abroad. In absolute numbers, the main emigration countries are the largest ones, while the smallest numbers of emigrants comes from small countries. However, an increase in population generates a less than proportional increase in emigration. The emigration rate decreases with population size in the country of origin. Table 1 confirms this result. In absolute terms, the main exporters of migrants are large countries such as Morocco, Egypt and Algeria. In relative terms, these countries exhibit lower emigration rates. In the fourth column, we also report a concentration index of emigrants by country of destination (Herfindahl index). Emigrants from Algeria, Israel, Tunisia, Yemen and West Bank and Gaza are highly concentrated. On the contrary, emigrants from Lebanon, Libya, Syria, Iran and Morocco are more geographically dispersed.

Table 2. *Location of MENA emigrants in 2000*

	OECD	EU15	NAM	PAC	EU27	MENA	GCC
MENA4							
Algeria	81.0%	79.0%	1.8%	0.1%	79.1%	9.2%	0.9%
Egypt	17.8%	8.7%	7.4%	1.6%	8.9%	75.8%	51.6%
Morocco	74.9%	71.9%	2.8%	0.1%	71.9%	16.5%	1.7%
Tunisia	77.7%	75.0%	2.3%	0.1%	75.1%	12.8%	2.6%
MENA9							
Djibouti	51.3%	46.1%	4.7%	0.4%	46.1%	11.2%	0.9%
Iran	76.3%	31.4%	39.6%	2.2%	31.5%	45.9%	1.5%
Lebanon	64.7%	20.3%	31.2%	12.4%	20.9%	38.9%	9.0%
Libya	45.0%	23.4%	14.7%	2.0%	24.6%	53.2%	2.3%
Malta	92.8%	34.3%	16.5%	41.9%	34.4%	9.5%	0.7%
Others							
Bahrain	8.5%	4.7%	3.1%	0.7%	4.8%	57.7%	3.0%
Iraq	34.9%	19.3%	10.7%	2.7%	19.5%	66.7%	2.7%
Israel	21.5%	5.5%	14.6%	0.7%	5.8%	83.4%	3.1%
Jordan	11.9%	2.9%	8.2%	0.5%	3.0%	88.3%	24.7%
Kuwait	10.2%	3.0%	6.5%	0.6%	3.1%	86.6%	25.1%
Oman	30.1%	16.6%	10.7%	2.5%	16.7%	72.1%	5.7%
Qatar	32.4%	11.5%	18.4%	1.9%	11.8%	73.7%	4.3%
Saudi Arabia	25.5%	7.2%	15.5%	0.8%	7.2%	74.5%	5.4%
Syria	36.8%	16.2%	17.0%	1.6%	18.0%	62.1%	28.1%
United Arab Emirates	20.6%	7.3%	11.5%	1.5%	7.5%	64.0%	1.8%
W. Bank Gaza	2.6%	1.7%	0.6%	0.3%	1.7%	90.6%	12.2%
Yemen	7.7%	3.9%	3.6%	0.1%	4.0%	88.7%	63.3%

Legend: NAM = US + Canada; PAC = Australia + New Zealand.
Source: Parsons *et al.* (2007).

Unsurprisingly, the main destination varies by country. France is the main destination of emigrants from Algeria, Djibouti, Morocco and Tunisia. Emigrants from Bahrain, Israel, Jordan, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates are mostly residing in West Bank and Gaza. Saudi Arabia and the US appear twice in the list of main destinations. For Algeria, the main destination drains 64.4% of total emigration. On the contrary, the main destination represents less than one-fourth of the total emigration stock originating from Lebanon and Libya.

Table 2 provides more details on the location of emigrants. We distinguish emigration to the members of the OECD (including the EU15, North America and Oceania), to the EU27 and to other MENA countries (including GCC members). Migration to the OECD (South–North migration) is dominant (i.e. larger than migration to other MENA countries) in 7 cases: Algeria, Djibouti, Iran, Lebanon, Malta, Morocco and Tunisia. In all these cases, the share of EU27 host countries is important. If we add Libya (sending one-fourth of emigrants to the EU27) and Egypt (sending about 200,000 migrants to the EU27) to the above seven countries, we can define a MENA9 sub-group for which EU27 is an important destination, in absolute or relative terms. Within this group, we define the MENA4 sub-group including four important emigration countries (Morocco, Algeria, Tunisia and Egypt). In 2000, MENA4 sent 4.15 million emigrants to EU27, i.e. 90% of MENA9 and 81.5% of MENA emigrants to EU27.

If one had to increase the flows of MENA-to-EU migration in the future, these sub-groups countries would be seriously concerned. The other 12 countries mainly send migrants to other MENA nations. In particular, GCC countries attract the majority of emigrants from Yemen and, to a lower extent, Syria, Kuwait and Jordan.

2.2 Migration from MENA by educational attainment

To characterize the skill structure of migration, we build on Docquier *et al.* (2007) who use data on the immigration structure by educational attainment and country of birth from all OECD receiving countries.[9]

More precisely, Docquier *et al.* (henceforth DLM) collected gender-disaggregated data from the 30 members of the OECD, with the highest level of detail on birth countries and three levels of educational attainment: $s=m$ for immigrants with upper-secondary education, $s=h$ for those with post-secondary education and $s=l$ for those with less than upper-secondary education (including lower-secondary, primary and no schooling). Let $M^{i,j}_{t,s}$ denote the stock of adults 25+ born in j, of skill s, living in country j at time t. Aggregating these numbers over destination countries j gives the stock of emigrants from country i:

$$M^{i}_{t,s} = \sum_{j} M^{i,j}_{t,s}.$$

Obviously, the stock of high-skilled emigrants (absolute measure brain drain) is positively correlated with the size of the country and its level of development (reflecting the average educational level of natives). The pressure exerted on the sending country's labor market is better captured by comparing the emigration stocks to the total number of people born in the source country and belonging to the same gender and educational category. Hence, the DLM dataset also provides a relative measure of the brain drain, defined as the ratio of the stock of high-skilled emigrants to the educated population born in the source country. Although their analysis is based on stocks (rather than flows), DLM refers to these proportions as emigration rates. Denoting $N^{i}_{t,g,s}$ as the stock of individuals aged 25+ at time t, of skill s, gender g, born in source country i, the emigration rate is defined as

$$m^{i}_{t,g,s} = \frac{M^{i}_{t,g,s}}{N^{i}_{t,g,s}},$$

where the native population $N^{i}_{t,g,s}$ is proxied by the sum of the resident population living in country i ($R^{i}_{t,g,s}$) and the stock of emigrants: $N^{i}_{t,g,s} \equiv R^{i}_{t,g,s} + M^{i}_{t,g,s}$.

[9] The dataset of Docquier *et al.* (2007) is based on the aggregation of harmonized immigration data collected in host countries, where information about the birth country, gender, age and educational attainment of immigrants is available. This information is found in national population censuses (or samples of them) and registers.

To compute $R^i_{t,g,s}$, DLM use population data by age provided by the United Nations and several sources on the average educational attainment of the resident population.[10]

In this paper, we have extended DLM work by adding immigration data and estimates for 14 non-OECD host countries:

- The OECD group includes 19 EU countries. We have added 8 non-OECD EU countries (Bulgaria, Cyprus, Estonia, Latvia, Lithuania, Malta,[11] Romania and Slovenia) to have a comprehensive view of the brain drain to the EU27.
- We have also added estimates of the immigration structure for the GCC. For Saudi Arabia, we have collected labor force survey data on the age and education level of guest workers in 1990 and 2000. In the remaining GCC countries (Bahrain, Kuwait, Oman, Qatar and United Arab Emirates), we start from Parsons *et al.* bilateral stocks and apply the age and educational structure observed in Saudi Arabia. This gives reasonable estimates of the brain drain to GCC nations.

Table 3 presents the results on the brain drain from the MENA.[12] The first column gives the total brain drain rates to the 44 host countries (30 OECD + 14 non-OECD). High-skilled emigration rates are particularly high in Malta, Lebanon, Yemen or West Bank and Gaza. The brain drain is quite important in large countries such as Iran, Morocco or Algeria. Given its size, Egypt is also suffering from a relatively high brain drain.

There is a hot debate in the literature on the global implications of the brain drain for developing countries. It is more than likely that high-skilled migration induces some positive effects on developing countries. The question is: Are these effects significant and sufficiently large to turn the brain drain into a brain gain? Recent empirical studies based on aggregate data suggest that these positive effects are of significant size. From the macro-econometric studies reviewed in Docquier (2007), the average threshold emigration rate above which the brain drain becomes harmful for development can be estimated to 10–15% in developing countries. The 'optimal emigration rate' (which maximizes country gains) probably lies between 5 and 10%. Except for Djibouti, Libya and Egypt, all MENA9 are above the potentially optimal level and many are above the maximal level (Lebanon, Malta,

[10] A more detailed description of the methodology can be found in Section A of the appendix available on the authors' webpage.

[11] Malta belongs to both EU27 and MENA groups. Obviously, we do not count Malta residents as migrants from MENA to EU27.

[12] To provide a detailed overview of the MENA brain drain in this section, we have extended the DLM work by adding immigration data and estimates for 14 non-OECD host countries. First, the OECD group includes 19 EU countries. We have added eight non-OECD EU countries (Bulgaria, Cyprus, Estonia, Latvia, Lithuania, Malta[12], Romania and Slovenia) to have a comprehensive view of the brain drain to the EU27. (It can be noted that Malta belongs to both EU27 and MENA groups. Obviously, we do not count Malta residents as migrants from MENA to EU27.) Second, we have also added estimates of the immigration structure for the GCC. For Saudi Arabia, we have collected labor force survey data on the age and education level of guest workers in 1990 and 2000. In the remaining GCC countries (Bahrain, Kuwait, Oman, Qatar and United Arab Emirates), we start from Parsons *et al.* (2007)'s bilateral stocks and apply the age and educational structure observed in Saudi Arabia. This gives reasonable estimates of the brain drain to GCC nations.

Table 3. *High-skilled emigration rates of MENA countries in 2000*

	Total	to EU27	to NA	to GCC	to OECD	EU27 %
MENA4						
Algeria	9.6 %	7.1 %	2.1 %	0.2 %	9.4 %	73.7 %
Egypt	8.3 %	0.9 %	3.5 %	3.8 %	4.5 %	11.3 %
Morocco	18.5 %	13.3 %	4.3 %	0.6 %	17.9 %	72.0 %
Tunisia	12.9 %	9.6 %	2.3 %	0.6 %	12.3 %	74.6 %
MENA9						
Djibouti	3.9 %	3.0 %	0.7 %	0.1 %	3.8 %	77.0 %
Iran	14.4 %	3.3 %	10.6 %	0.1 %	14.2 %	23.3 %
Lebanon	45.1 %	10.5 %	32.2 %	1.8 %	42.7 %	23.3 %
Libya	4.8 %	2.3 %	2.3 %	0.1 %	4.3 %	47.2 %
Malta	58.4 %	24.7 %	32.8 %	0.2 %	58.1 %	42.3 %
Others						
Bahrain	6.0 %	1.8 %	3.3 %	0.9 %	5.1 %	30.0 %
Iraq	11.5 %	5.1 %	5.6 %	0.4 %	10.8 %	44.2 %
Israel	8.2 %	1.0 %	6.7 %	0.3 %	7.8 %	12.3 %
Jordan	11.3 %	1.5 %	5.8 %	4.0 %	7.1 %	12.8 %
Kuwait	12.6 %	0.8 %	5.9 %	5.9 %	6.7 %	6.1 %
Oman	0.5 %	0.2 %	0.2 %	0.1 %	0.4 %	34.1 %
Qatar	2.3 %	0.4 %	1.7 %	0.2 %	2.0 %	18.7 %
Saudi Arabia	1.1 %	0.1 %	0.8 %	0.1 %	0.9 %	12.0 %
Syria	7.8 %	2.3 %	3.8 %	1.5 %	6.0 %	29.7 %
United Arab Em	0.9 %	0.2 %	0.6 %	0.1 %	0.7 %	20.1 %
W. Bank Gaza	19.3 %	1.0 %	9.9 %	8.2 %	11.0 %	5.0 %
Yemen	31.3 %	1.9 %	2.5 %	26.8 %	4.4 %	6.0 %

Source: Docquier *et al.* (2007) + Extension.

Morocco and Iran are at the border). Increasing the brain drain from these countries could have damaging effects on the economy.

2.3 Aging in European and MENA countries

The decrease in fertility and mortality rates induces a progressive and inescapable *graying* of European nations. On the contrary, all countries in the MENA share a relatively young population. However, a rapid increase in old-ADRs will take place in 15–20 years, putting the pension systems under growing financial stress. In this section, we briefly analyze the demographic trends in the EU and in the MENA. Our analysis relies on the 2006 Revision, which is the 20th round of official United Nations population estimates and projections prepared by the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat.

The direct impact of demographic change occurs through the so-called dependency ratio. The total dependency ratio (TDR) is the ratio of the economically dependent part of the population to the productive part. The economically dependent part is recognized to be children who are too young to work, and individuals who are too old, that is, generally, individuals under the age of 15 and over the age of 65. The

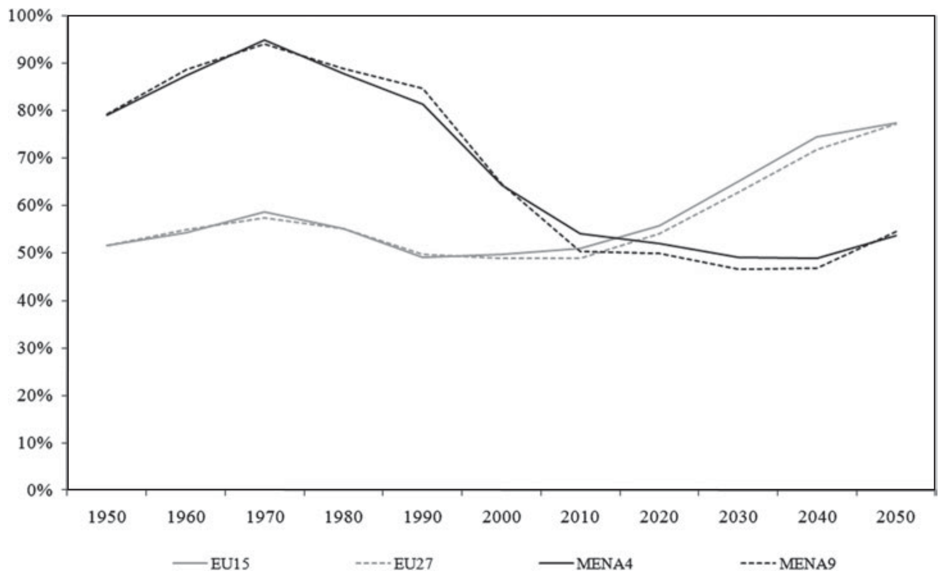

Figure 1. TDR by region (1950–2050).

productive part makes up the gap in between (ages 15–64). The TDR is expressed as a percentage. This gives:

$$\text{TDR} = \frac{\text{POP}_{0-14} + \text{POP}_{65+}}{\text{POP}_{15-64}}.$$

This ratio is important because as it increases, there is increased strain on the productive part of the population to support the upbringing and the pensions of the economically dependent. There are direct impacts on financial elements like social security.

The (total) dependency ratio can be partitioned into the child dependency ratio and the ADR. The latter is defined by

$$\text{ADR} = \frac{\text{POP}_{65+}}{\text{POP}_{15-64}}.$$

Figure 1 shows that the TDR has been higher in the MENA than in the EU since 1950 and is still expected to remain higher until 2020. After 2020, the rise in life expectancy will push the EU ratio upward while the drop in fertility rates will push the MENA ratio downward. The conclusion obtained for the EU15 or EU27 are very similar. In the same vein, the evolutions observed in the MENA4 and MENA9 groups are almost identical.

In the EU, the deterioration of the dependency ratio is exclusively due to the *graying* of populations. Figure 2 shows that the EU ADR is expected to double between 2010 and 2050, after having doubled between 1950 and 2010. In the MENA, aging is hardly perceptible before 2030. But after 2030, the ADR will be multiplied by 3 in the MENA4 and MENA9.

Figures 3 and 4 give the evolution of total and ADRs for consolidated regions, i.e. aggregating EU and MENA4 or MENA9 countries. Clearly, this consolidation

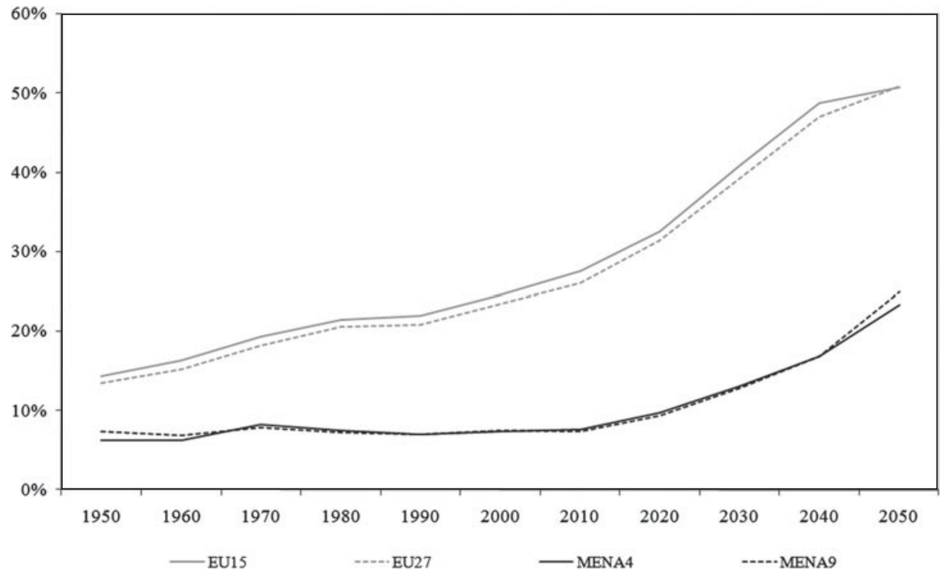

Figure 2. ADR by region (1950–2050).

smoothes the trends and attenuates the rise in dependency. However, the change observed in the EU27 + MENA4 hypothetical region remains important. This can be explained by the relative size of these regions. The population of the EU27 is around 500 million. Although the 21 countries of the MENA represent more than 300 million inhabitants, the population of the MENA4 group amounts to 136.5 million, i.e. about 27 % of the EU27. The population of the MENA9 group (212.7 million) represents 42.5 % of the EU27.

From these figures, we conclude that increasing migration flows from MENA4 or MENA9 to EU27 countries would clearly attenuate the deterioration of the European demographic structure. However, we should keep in mind that MENA countries also expect serious demographic problems after 2030 and need pension reforms to minimize the risk of a financial crisis (see Robalino, 2005).[13] In particular, the MENA ADR in 2050 will approximately be equal to the current ADR observed in the EU. Hence, 'replacement or selective migration' policies encouraging MENA-to-EU flows of working-age people should not be permanent. It should be limited in size and in time.

The above analysis delivered some insights on the demographic implications of MENA-to-EU migration. But what are the economic consequences of increased migration? What would be the lessons of a general equilibrium analysis, with endogenous wages, pension benefits and interest rates? What would be the outcomes of a change in immigration policy for sending countries? These are the issues that we address in the next section.

[13] It can be noticed that public pension expenditures (in percent of GDP) are lower in MENA (2.8 %) than in the EU15 (9.2 %), see OECD (2005) and Palacios (1996). Robalino *et al.* (2005) provide more detailed information on pension systems in various countries of the Middle East and North Africa, such as on coverage rates, gross replacement rates, normal retirement age, etc.

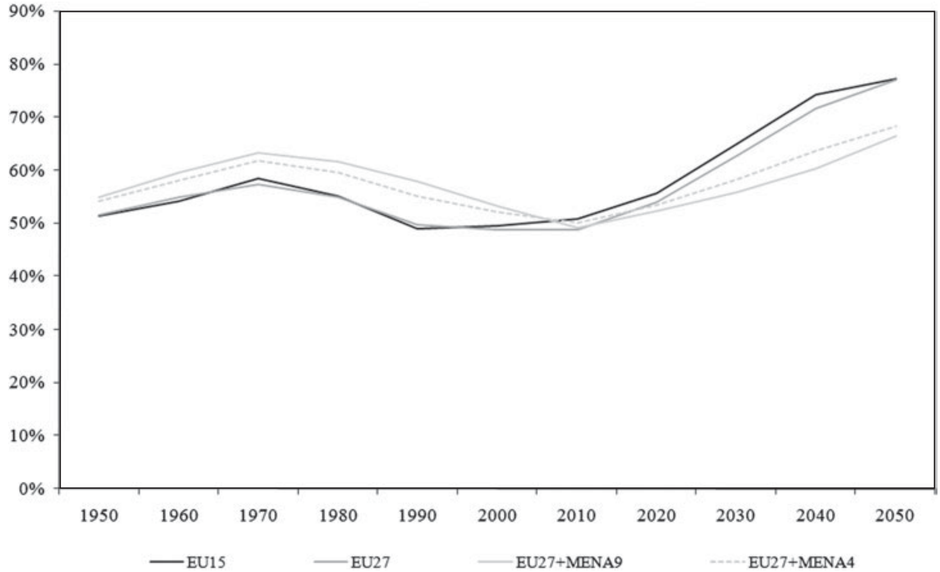

Figure 3. TDR by consolidated region.

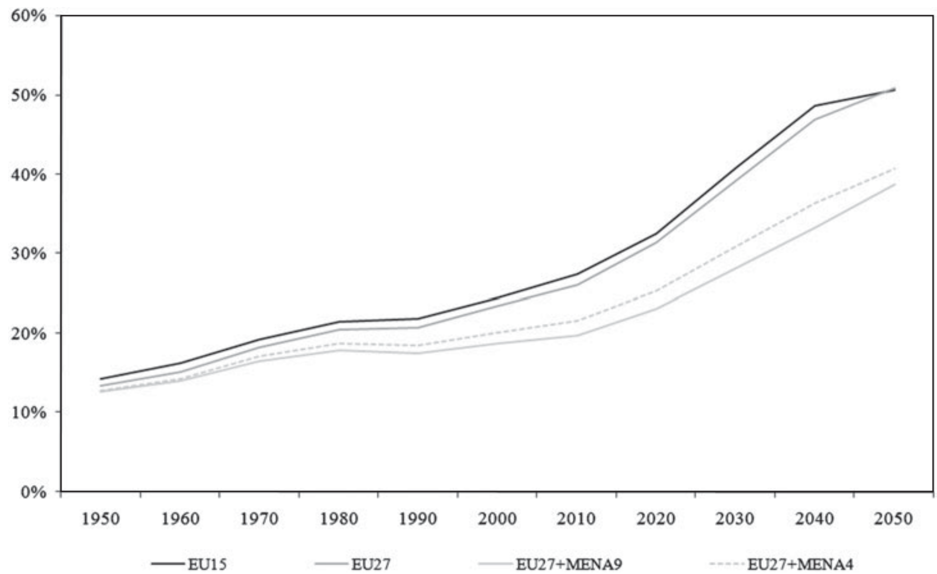

Figure 4. ADR by consolidated region.

3 General equilibrium analysis

Our purpose here is to analyze the impact of a doubling of migration flows from the MENA to the EU15 on demographic variables, on the tax rate, on GDP per capita, on GNI per capita and on the high-skilled to low-skilled income ratio in both regions.[14] The shock occurs between 2000 and 2050. We distinguish various scenarios regarding the education level of additional migrants, the way educated migrants are 'economically assimilated' at destination, the ties between migrants and their origin country (affecting the feedback effects of international migration) and the progress in education attainment in the MENA region.

For this purpose, we use a CGE model with overlapping generations of individuals who are heterogeneous in skills, date and place of birth.[15] In the model, countries from the MENA and the EU15 are aggregated into two regions: we disregard the heterogeneity between countries and compute the impact on the aggregate MENA and EU15 regions.

We provide a brief introduction of the model structure in Section 3.1. Section 3.2 describes our five alternative scenarios. The demographic effect of our shock is constant across scenarios; it is discussed in Section 3.3. Then, in Section 3.4, we first analyze the economic impact at origin and destination comparing two simple scenarios: one considers that additional migrants are high skilled and one assumes that they are low skilled. Our comparison disregards two types of feedback effects of international migration that have been stressed in the literature (i.e., diaspora externalities and brain gain mechanisms) and assumes that human capital acquired in the MENA is perfectly transferrable to the EU15 labor market. In Section 3.5, we focus on the case of high-skilled migration and relax the above hypotheses in three alternative scenarios: (i) one in which additional migrants are high skilled but employed as low-skilled laborers in the EU, (ii) one is based on the recent literature on the beneficial effects of the brain drain and (iii) one assumes that the MENA region experiences a stronger rise in the education levels of its native population.

3.1 The model

Each region has three types of agents: households, firms and the public sector. The adult population is divided into eight overlapping generations, from age 15–24 to age 85–94. Individuals have uncertain lifetime and can die at the end of every period. In each generation, we have time-varying proportions of low-skilled and high-skilled individuals. Due to data availability constraints, the high skilled are those with post-secondary education. Migration occurs at the first period of life and is

[14] A policy aiming at increasing immigration may obviously create political tensions. Explaining how such a doubling of immigration flows arises or whether it is politically feasible is however beyond the scope of our analysis. For a political economy approach of immigration one can refer to Scholten and Thum (1996), who use a model where migrants have a negative effect on wages. Natives (i.e. the median voter) can choose the immigration policy, the outcome of which will depend on the age of the natives. Krieger (2003) as well as Lagos and Lacomba (2010) also study the preferences toward immigration of various age groups of the population.

[15] The economic model is based on previous work by Marchiori (2011), who analyzes the impact of demographic trends on current accounts but disregards labor mobility. Moreover, the present work also integrates various side effects that high-skilled emigration has on developing regions (see scenario 'Brain Gain'). The calibration of these effects is detailed in Marchiori *et al.* (2010). Section 3.1 provides only the essential elements of the model's structure, but a more complete description of the model and the calibration of the side effects of the brain drain can be found in sections B.2 and B.3 of the appendix.

permanent.[16] Moreover, migrants have the same fertility rate as natives and their children the same educational achievement as natives' offspring.[17]

Migrants remit a fraction of their consumption. This proportion is calibrated to match the amounts remitted by the migrants from MENA living in developed countries to their origin country. While high-skilled migrants remit a larger amount than low-skilled migrants (as suggested by Bollard *et al.*, 2009), it is assumed, based on Faini (2007) or Nimii *et al.* (2008), that their propensity to remit is lower (only 70%) than the one of low-skilled migrants.[18] The production process of the firms in each region is characterized by a constant elasticity of substitution (CES) transformation function for efficient labor, which defines the mix of high-skilled and low-skilled labor forces to produce a homogenous good. The parameters of the production process are dynamically calibrated to match the income disparities between and within regions (i.e. distance to the frontier and skill premium).

The government levies taxes on labor earnings and consumption expenditures to finance general public consumption, pension benefits and other welfare transfers. Moreover, the government issues bonds and pays interests on public debt. The government's budget constraint is satisfied in each period by adjusting the tax rate on labor income.

Finally, capital is perfectly mobile in the model and the arbitrage condition on capital markets requires the equality of the expected returns to capital given region-specific risk premia.

3.2 Scenarios

In the baseline, the model is calibrated in such a way that it matches the world disparities between and within regions over the period 1950–2000. Our period of interest is 2010–50, or the period corresponding to the first wave of additional migrants in the developed regions. Our baseline predictions are based on official demographic forecasts and extrapolates the trends observed in the last few decades (in terms of educational attainment, productivity growth, public consumptions and

[16] Allowing for return migration would considerably complicate the computation of the transitional dynamics and steady states, because migrants returning to their region of origin have accumulated a different wealth than similar aged, similar skilled nationals who never left their region of origin. Thus, introducing return migration in our multi-regional framework implies that we need to deal with another dimension of agent heterogeneity, along with the ones that are already present in the model (i.e. skills, age and place of birth). Return migration poses therefore fewer problems in a single country model, like Storesletten (2000). Moreover, our analysis focuses on the impact of high-skilled migrants, which are less prone to return to their region of origin than low-skilled migrants (see, for instance, Faini 2007). Return migration is however an important issue in the study of international migration, see Krieger (2008) for a theoretical analysis and Winters *et al.* (2003) for a quantitative assessment of the impact of temporary migration.

[17] In some EU countries, migrants' children are assumed to be natives by the national legislation, as e.g. the 'right of the soil' in France (see Krieger 2008). It can be observed that under these two assumptions (migrants have the same fertility rate as natives and their children the same educational attainment as natives' offspring), immigration will have an impact on the tax rate as long as the additional migrants increase the work force. Relaxing these assumptions would imply that immigration has a longer-lasting effect on the tax rate (see Krieger, 2005) and on other indicators. These assumptions also allow keeping the smaller degree of agent heterogeneity in the model (see footnote 14). Furthermore, our focus is on the impact of *high-skilled* migrants, who have quite similar characteristics than natives.

[18] Our results are robust to that the alternative assumption that high skilled have the same propensity to remit as low-skilled.

generosity of welfare programs, etc.). More precisely, the evolution of the size and structure of the population is based on the United Nations' 'World Population Prospects, the 2006 Revision' (United Nations, 2007), which cover the period 1950–2050. The size of the population at each period, according to the data and forecasts of the United Nations, is calibrated through the growth rate of the youngest cohort of individuals. To match the predictions of U.N. Population Prospects in terms of the population *structure* of each region, we use the probabilities of being alive for each age class of individuals at each period. After 2050, the growth rate of the youngest cohort is held constant over time. Given this hypothesis, the population structure reaches a steady state in 2130, because individuals live for 8 periods of 10 years.

In the baseline scenario, the technical progress of each region (expressed as a percentage to North America) is assumed to be constant after 2000. In addition, we hold the proportion of high-skilled individuals among each new generation constant from 2000 onwards. As young cohorts are more educated than older cohorts, it implies that the proportion of educated workers in the MENA will progressively increase from 11.5% in 2000 to 15% in 2050. In comparison, the rise in educational attainment observed in the MENA between 1975 and 2000 corresponds to +3.5 points of percentage.

Our immigration shock consists in a 100% increase (i.e. doubling) in the emigration flows from the MENA to EU compared to the baseline over the period 2000–50. In the baseline, the estimated migration flow from the MENA to EU15 corresponds to 1.67 million in 2010, 1.73 million in 2020 and 1.79 million from 2030 onwards.[19] Thus, doubling these flows over the period 2000–50 implies that an additional number of 8.77 million migrants from MENA would arrive to the EU by 2050. These newcomers emigrate in the first period of their life and acquire higher education in the EU. Hence, in case of high-skilled migration, we underestimate the actual fiscal cost of the MENA brain drain.

Along with the magnitude of this migration shock, the skill structure of the additional migrants might also play a role. Four immigration shocks are considered; they mainly differ with respect to the skill composition of the additional migrants and their assimilation in EU host countries:

- The '***High-Skilled*' *scenario*** assumes that the 8.77 million additional migrants arriving from the MENA to the EU from 2010 until 2050 are highly skilled and employed as high-skilled workers in the EU (i.e. perfect assimilation).
- The '***Low-Skilled*' *scenario*** considers that all additional migrants are low skilled and employed as low-skilled workers in the EU.
- The '***Brain Waste*' *scenario*** assumes that all additional migrants are highly skilled and employed as low-skilled workers in the EU.

[19] U.N. Population Projections provide the estimated number of migrant flows to the EU15 for the first half of the 21st century. We can retrieve the number of migrants coming from the MENA by applying the shares of migrants by origin of Docquier *et al.* (2007). From these datasets we can also compute the total number of migrants (stock) from MENA living in the EU15 in the baseline: 8.14 million in 2000, 9.56 million in 2010, 10.98 million in 2030 and increases up to 16.08 million after 2100.

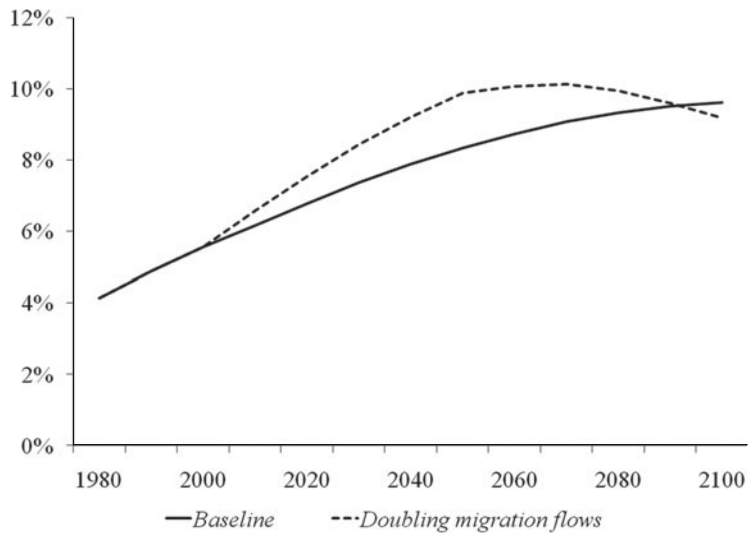

Figure 5. Share of foreigners in EU15 (in percent).

- The '***Brain Gain*' *scenario*** is equivalent to the 'High-Skilled' scenario but accounts for the *ex-ante* effect of high-skilled migration prospects on human capital formation at origin and various diaspora externalities.
- The '***Expansionary*' *scenario*** is similar to the 'High-Skilled' scenario but assumes that the population in MENA regions becomes more and more educated during the first half of the 21st century. In the baseline, the proportion of high skilled among youngest cohort is constant at 15% from 2000 onward. This means that the proportion of high skilled in the workforce and in the population reaches 15% in the long run. In this scenario, a brain drain occurs while the share of high skilled among the youngest cohort continues to rise after 2000 to reach 20% in 2030, with the consequence that 20% of the population will be educated in the long run.

The latter three scenarios will be explained in more details in Section 3.5.[20] In Figures 5–8 as well as in Tables 4 and 7, we distinguish between the impact on the EU15 and the MENA regions. As mentioned above, we first focus on the demographic (section 3.3) and economic (section 3.4) impacts of the 'High-Skilled' and 'Low-Skilled' scenarios and then turn to the consequences of different variants of the high-skilled scenario (section 3.5).

3.3 Demographic impact

Before turning to the implications on economic indicators, let us comment on the demographic situation in EU and MENA forecasted for 21st century and the implications of our migration shock on the demographics of both regions. Indeed, the

[20] A more technical description of the 'Brain Gain' scenario can be found in Section B.3 of the Appendix available on the authors' webpage.

skill composition of future migration flows has a negligible impact on demographic indicators.[21] In this section, we disregard differences in skill composition and compare demographic trends obtained in the baseline and after doubling immigration flows.

The migration flows in our baseline result from the United Nations' 'Trends in Total Migrant Stock' (United Nations 2005), which predict that the share of foreigners in the EU population evolves from 3.5 % in 2000 to 8.3 % in 2050 and to 9.6 % in 2100 (Figure 5). If migration flows from MENA to EU are doubled from 2010 to 2050, this ratio reaches 10.1 % in 2050 instead of 8.3 % in the baseline. From 2050 onwards, the migration shock is ended and the stock of immigrants progressively converges to its baseline value. The migration shock progressively increases the EU population size, while the proportion of foreigners in the EU15 falls slightly below the baseline value in 2100. This is because when the shock ends, no more additional migrants, but, at the same time, children of the additional migrants arrived from 2010 to 2050 are considered as EU natives.

In the MENA, the global emigration rate (the ratio of emigrants to the residents plus emigrants) to the North (which comprises all OECD countries) is around 2.5 % during the 21st century (Figure 6). Doubling migration flows to EU would bring the emigration rate to more than 4 % in 2050.

The support ratios (i.e., the share of working aged-to-total population) are depicted in Figures 7 and 8. The baseline is calibrated to match the UN Population Projections until 2050. After this date, the population size in both regions slowly stabilizes as the youngest cohort is held constant from 2050 onwards. The forecasts reveal that both regions will face an aging of their population during the 21st century.[22] Since migrants are young individuals, increasing MENA-to-EU migration will obviously improve the support ratio in the EU15 and deteriorate it in the MENA. In the EU15, the effect of immigration is rather small compared to general impact of aging in the first half of the century, but becomes significant after 2040. In the MENA, the effect of emigration is not very significant. Our shock is compatible with our recommendations to limit emigration from the MENA in size and in time as explained in Section 2.

3.4 Economic impact – high-skilled versus low-skilled migration

In this section, we analyze the impact of the first two scenarios ('High-Skilled' versus 'Low-Skilled'). Table 4 presents their implications for the EU15 and the MENA in terms of key economic indicators (Tax rate, GDP per capita, GNI per capita and high- to low-skilled income inequality). It turns out that the skill composition of immigration flows does not appear to be so important when dealing with the fiscal consequences of migration.

[21] The only variable to be slightly affected is the support ratio. This is due to the fact that, in the first period of life, high-skilled immigrants supply less labor than low-skilled ones as they spend more time in education. Nevertheless, the difference between the 'High-Skilled' and 'Low-Skilled' scenarios is hardly perceptible.

[22] The support ratio in EU increases again after 2050 because of our assumption that the population is constant after 2050, while population growth is negative before 2050.

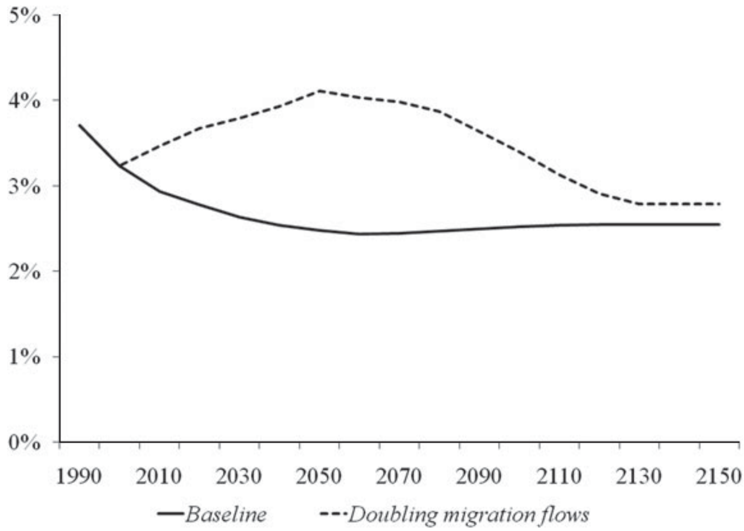

Figure 6. Emigration rate in MENA (in percent).

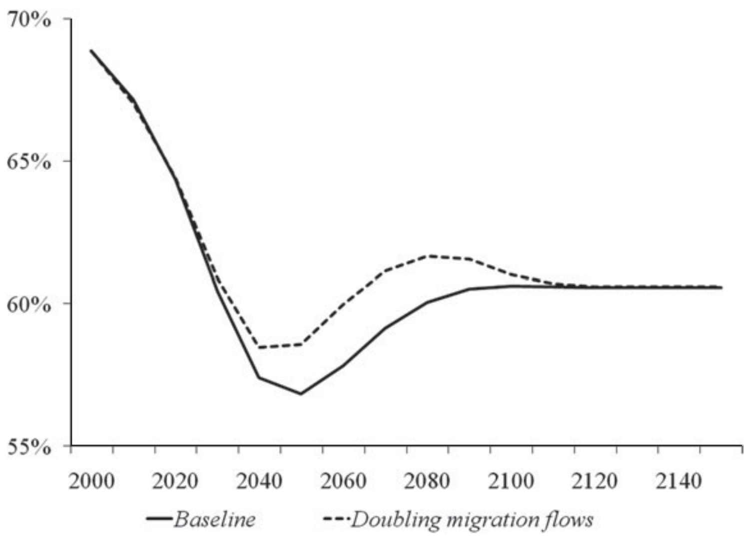

Figure 7. Support ratio in EU15 (population aged 15–64/total population).

3.4.1 Tax rate

As mentioned before, the labor income tax rate balances the government budget. The main driving force of the model over the 21st century is the evolution of the population structure. In particular, aging will put a strong pressure on pension systems that will be reflected by rising tax rates. The fiscal effects of migration are presented in panel 'Tax Rate' of Table 4. In the EU, the income tax rate needs to increase by

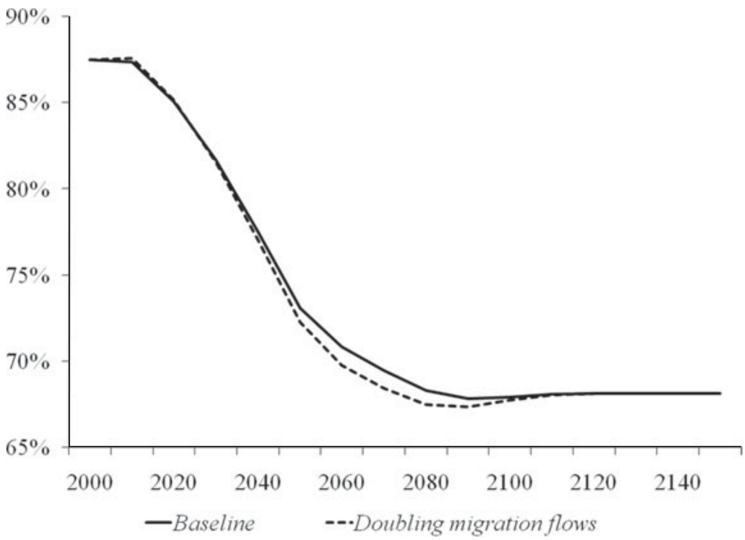

Figure 8. Support ratio in MENA (population aged 15–64/total population).

around 12.5 percentage points from 2010 to 2050 to maintain the public budget balanced in the baseline (row 'EU15 Baseline'). In the long run, the fiscal impact is mainly explained by the progressive rise in life expectancy due to the *greying* of the baby boom generations.

Since the population is younger in the MENA, increasing migration flows from the MENA to the EU15 could help to mitigate the consequences of aging on European pension systems. However, the aging process of the population will be also a critical issue for the MENA countries. In fact, as shown in Table 4 (row 'MENA Baseline'), the tax rate also augments in the MENA.

Increasing MENA-to-EU migration raises (respectively reduces) the size of youngest cohorts at destination (respectively origin). Table 4 represents the resulting changes in tax rates in terms of *deviations* in percentage points from the baseline (while changes in the other indicators are depicted in terms of relative changes compared to the baseline). We see that both immigration shocks reduce the tax rate in the EU15 and raise it in the MENA. At destination, the 'High-Skilled' scenario is unsurprisingly the most effective one in relieving the pressure on the pension systems since high-skilled individuals contribute more to and benefit less from welfare programs. In 2050, increasing high-skilled immigration induces a reduction in the EU15 tax rate that is 0.97 percentage points higher than the one induced by the 'Low-Skilled' immigration shock (a 6.07 percentage point decrease compared to the baseline under a 'High-Skilled' versus 5.10 percentage point under the 'Low-Skilled' scenario). Obviously, the immigration policies undergone in Europe have reversed consequences in migrants' origin countries. In fact, the MENA will have to cope with a higher tax rate if it losses part of its labor force and the 'High-Skilled' scenario will have the worst fiscal implications.

Table 4. *Impact of the 'High-Skilled' and 'Low-Skilled' scenarios*

			2010	2020	2030	2040	2050
Tax rate							
EU15	Baseline		46.88 %	49.34 %	53.75 %	58.22 %	59.36 %
	High-Skilled	(% deviation)	−0.43 %	−1.15 %	−2.41 %	−4.24 %	−6.07 %
	Low-Skilled	(% deviation)	−0.35 %	−0.94 %	−1.99 %	−3.53 %	−5.10 %
MENA	Baseline		19.03 %	20.08 %	21.52 %	23.24 %	25.18 %
	High-Skilled	(% deviation)	1.16 %	2.92 %	4.85 %	7.10 %	9.22 %
	Low-Skilled	(% deviation)	0.76 %	1.83 %	3.35 %	5.31 %	7.36 %
GDPper capita							
EU15	Baseline		0.159	0.159	0.157	0.156	0.155
	High-Skilled	(% change)	0.02 %	0.63 %	1.60 %	3.06 %	4.55 %
	Low-Skilled	(% change)	−0.07 %	−0.07 %	0.29 %	1.05 %	1.89 %
MENA	Baseline		0.035	0.035	0.034	0.033	0.031
	High-Skilled	(% change)	−0.14 %	−0.98 %	−1.76 %	−2.78 %	−3.60 %
	Low-Skilled	(% change)	0.04 %	0.03 %	−0.15 %	−0.56 %	−1.07 %
GMper capita							
EU15	Baseline		0.140	0.138	0.133	0.130	0.127
	High-Skilled	(% change)	−0.39 %	−0.16 %	0.49 %	1.77 %	3.40 %
	Low-Skilled	(% change)	−0.27 %	−0.51 %	−0.41 %	0.18 %	1.04 %
MENA	Baseline		0.036	0.036	0.035	0.033	0.032
	High-Skilled	(% change)	0.14 %	−0.33 %	−0.86 %	−1.62 %	−2.36 %
	Low-Skilled	(% change)	0.17 %	0.32 %	0.33 %	0.15 %	−0.18 %
Inequality							
EU15	Baseline		2.91	2.85	2.69	2.50	2.36
	High-Skilled	(% change)	−1.55 %	−2.82 %	−3.93 %	−5.04 %	−6.61 %
	Low-Skilled	(% change)	0.18 %	0.45 %	0.79 %	1.30 %	2.36 %
MENA	Baseline		2.45	2.54	2.56	2.54	2.52
	High-Skilled	(% change)	3.27 %	4.82 %	5.69 %	6.25 %	7.14 %
	Low-Skilled	(% change)	−0.35 %	−0.54 %	−0.66 %	−0.81 %	−1.05 %

However, the difference between these two scenarios appears to relatively small. This contrasts with earlier findings of GA studies, which predict that selective immigration policies have a significant fiscal effect while non-selective policies have a rather negligible impact on public finance. What explains our result? Compared to a GA analysis, our analysis also includes general equilibrium effects. In fact, when the additional immigrants are highly skilled, the skill premium decreases (−6.27 % change compared to the baseline in 2050) and this reduces the average contribution of a high-skilled worker in financing pension systems (while the one of a low-skilled worker is augmented). Conversely, when the additional migrants are low skilled, a high-skilled employee will pay more taxes since the skill premium is enhanced (+3.86 % in 2050).

Another feature of the model is that the debt is defined as a fraction of GDP assuming a constant debt/GDP ratio. When additional migrants come to Europe (or leave the MENA), it leads to an increase (decrease) in the GDP and thus in the debt.

Since GDP rises more rapidly under the 'High-Skilled' scenario (11.20% in 2050) than under the 'Low-Skilled' scenario (8.37%), the public deficit to be financed will be larger when additional migrants are high skilled. To assess the magnitude of this mechanism, we simulated our model assuming that the public debt is held constant at the baseline level. It comes out that this effect is less important than the general equilibrium effect on wages and on the skill premium.[23] Still, a high-skilled emigration policy would reduce taxes by an additional 1.74 percentage points compared to a low-skilled immigration policy in 2050 when the debt is held constant at the baseline level (with a varying debt, the additional tax cut is 'only' 0.97).

To be complete, another general equilibrium effect is that the inflow of workers will raise the interest rate that contributes to increase the public deficit. However, the impact on the interest rate is negligible, because it is determined at the international level. This general equilibrium effect plays therefore also a minor role in the small fiscal difference between the 'High-Skilled' and 'Low-Skilled' scenarios.

3.4.2 GDP per capita

GDP per capita is defined as total domestic production divided by total population. The reallocation of labor from the MENA to the EU15 leads to higher returns to capital in Europe. Since Europe is technologically more advanced, labor outflows from the MENA induce a more than proportional reallocation of physical capital to Europe. Thus, increased migration to the EU15 acts to enhance GDP per capita and to reduce it in the MENA (Table 4, panel 'GDP per capita'). This effect is particularly strong if the additional migrants are high skilled and employed as such at destination ('High-Skilled' scenario). This is obviously due to the fact that high-skilled workers are more productive. In addition, the agglomeration of high-skilled labor in EU does increase the marginal productivity of capital in this region even more than the 'Low-Skilled' scenario.

It can be observed that, in the first periods of the intensification in migration flows, the impact on GDP per capita in the EU is quite small ($<1\%$) and even slightly negative in the 'Low-Skilled' scenario until 2020 (-0.07%). One obvious reason is that the number of additional migrants is relatively low in the beginning of the concerned period. Another explanation is that when they are young, migrants spend part of their time educating and do not add fully to the labor force in the EU15, while contributing to increase the population (and thus the denominator in GDP per capita).

The impact of additional migrants on GDP per capita turns to be positive and considerable when they become fully 'operational' and reach a critical mass. In the MENA, similar reasons explain the relatively small initial effects on GDP per capita and the slight increase in it when additional migrants are low-skilled.

[23] With the 'High-Skilled' scenario the variations in the tax rate represent -5.97 percentage points in 2050 when the debt is constant and -6.07 percentage points when the debt varies with the GDP; with low-skilled migration these changes are -4.94 and -5.10 percentage points, respectively.

3.4.3 GNI per capita

GNI is composed of GDP minus consumption taxes plus foreign aid, remittances and net inflows of capital income, divided by total population. The channels at work are the same as for GDP per capita, except that remittances also come into play.

Then GNI per capita will follow a similar pattern than GDP per capita, but compared to the change in GDP per capita, the change in GNI per capita shifts down for the EU15 and shifts up for the MENA.

The reason is that an enlarged diaspora induces an increase in the amount of remittances from the EU to the MENA. Therefore, the increase in GNI per capita will be lower than the one in GDP per capita for the EU15, while for the MENA, the reduction in GNI per capita is lower than in GDP per capita. In the first periods, GDP per capita experiences small changes in both regions. Then the additional migration remittances contribute to depress GNI per capita in the EU15 and to increase it in the MENA. Besides, we may observe that under 'Low-Skilled' scenario in MENA, changes in GNI per capita remain below a 1% change in the first periods of the shock as well as in the later periods.

3.4.4 High-low-skilled inequality

Finally, high-/low-skilled inequality is defined as the ratio of high- to low-skilled GNI per capita. Table 4, panel 'Inequality', shows that immigration has different effects on the high- to low-skilled income inequality. The impact is mainly driven by the change in the skill premium since the immigration policies affect the skill composition of the labor force. For instance, under the 'High-Skilled' scenario, high-skilled labor becomes scarcer in the MENA: the skill premium goes up and high- to low-skilled income inequality worsens. In contrast, in the EU, high-skilled labor becomes more abundant leading to less inequality since the skill premium declines. The 'Low-Skilled' policy has reverse consequences compared to the 'High-Skilled' policy and will deteriorate inequality in the EU15 and improve it in the MENA.

3.4.5 Preliminary conclusion

The conclusion of the previous analysis is that increasing immigration leads to a considerable beneficial impact in terms of fiscal pressure and of GDP/GNI per capita in Europe. However, a selective immigration policy does not involve a significantly greater tax relieving effect than a non-selective one: an inflow of high-skilled migrants leads to less than 1 percentage point higher tax-cut than an inflow of low-skilled ones. However, the rise in GDP per capita and GNI per capita would be more than twice as high with a brain drain as with a non-selective policy.

In the MENA, the loss of workers renders the financing of the fiscal systems more complicated and the situation would be even more dramatic when selecting immigrants. Moreover, differences in the skill composition of migration flows yield considerable differences in income. GNI per capita is strongly reduced by increased high-skilled emigration but only slightly by a low-skilled immigration policy. Besides, it would even be enhanced by the non-selective immigration policy at the beginning of the increased migration period.

3.5 Variants of the 'High-Skilled' scenario

The previous section shows that selecting migrants generates much more positive (respectively negative) effects on GDP/GNI per capita at destination (respectively at origin) than increasing low-skilled migration. Concerning such a brain drain, several factors could affect the magnitude of the responses in both sending and receiving regions. First, it is widely documented that high-skilled migrants are not necessarily employed as high-skilled workers at destination. Second, the recent 'brain drain literature' claims that the movement of high-skilled people goes along with diverse positive side effects incurred by the countries of origin. Third, an increased movement of high-skilled workers from the MENA to the EU15 could be accompanied by a more generous assistance or a greater cooperation in education policies. In other words, we might also take into account the fact the population in the MENA could become more and more educated. How do these aspects alter the consequences of increased high-skilled emigration from the MENA?

This section examines different variants of increased high-skilled emigration. We only consider the case of high-skilled migration and compare the different variants described in Section 5.2, i.e. the traditional 'High-Skilled', the 'Brain Waste', 'Brain Gain' and 'Expansionary' scenarios. Let us describe the differences between these scenarios in more detail.

The '***Brain waste***' scenario is simple. It assumes that high-skilled migrants are employed as low skilled at destination.

The '***Brain Gain***' scenario deserves more explanations. It is basically identical to the 'High-Skilled' scenario in terms of numbers of high-skilled people who migrate. However, it differs from the 'High-Skilled' scenario in that it follows the recent literature and accounts for three externalities associated with high-skilled emigration:

- A first externality of the brain drain is the role of high-skilled diasporas in reducing transaction costs, informational costs and risk inducing a lower risk premium in the MENA countries. In the model, the risk premium is represented by a governmental tax on investment and a lower risk premium then leads to higher capital inflows. This effect is calibrated by using the findings of Docquier and Lodigiani (2010).
- Second, total productivity may be affected in two ways by high-skilled emigrants living in rich countries: (i) directly, because they induce improvements in the capacity of their origin country to adopt modern technologies (via a diaspora externality) and (ii) indirectly, by affecting the level of human capital, which is essential for productivity. The calibration of the effect of high-skilled migration on productivity estimates of a reduced form equation by Lodigiani (2008), who follows the methodology in Vandenbussche *et al*. (2006).

- Finally, selective immigration policies at destination raise the probability for educated people to leave their home country and induce therefore a higher expected return to education. As a consequence, a brain drain may enhance the formation of human capital at origin (incentive mechanism). This *ex-ante* additional skill acquisition may alleviate the *ex-post* loss of high-skilled individuals. Calibration of this effect is based on estimates by Beine *et al*. (2008).

The effect of high-skilled emigration on human capital formation, risk premium and technology is computed outside the core of the micro-founded model, using elasticities estimated in the empirical literature. The resulting paths of these three variables (risk premium, productivity and human capital) are then introduced into the model along with the migration shock.

Table 5 presents the change in technology adoption and in network effects under the 'Brain Gain' scenario. While technology is deteriorated (variable A) due to increased high-skilled emigration, information costs are reduced (variable π) and FDI to MENA are favored by high-skilled emigration. Table 6 depicts the effect of high-skilled emigration on the third affected variable: human capital. It can be observed that the ratio of high-skilled to total labor force (human capital) drops under the 'Brain Gain' but less than under the 'High-Skilled' scenario (because of the incentive effect).

Finally, the 'Expansionary' scenario is the last variant of the 'High-Skilled' scenario. It is similar to the latter scenario but assumes that the population in the MENA becomes more and more educated during the first half of the 21st century. In the baseline, the proportion of high-skilled among youngest cohort is constant at 15% from 2000 onward, which means that the proportion of high skilled in the workforce and in the population reaches 15% in the long run. In the 'Expansionary' scenario, a brain drain occurs while the share of high skilled among the youngest cohort continues to rise after 2000. It is assumed that 16.7% of the youngest individuals become educated in 2010, 18.4% in 2020 and finally 20% from 2030 onward. Consequently, 20% of the labor force will be high skilled in the long run. As stated above, the rationale of this human capital expansion is that an increased movement of high-skilled workers from the MENA to the EU15 could be accompanied by a more generous assistance or a greater cooperation in education policies. Under the 'Expansionary' scenario, even with the increased departure of high-skilled individuals, human capital is improved compared to the baseline (see the last line of Table 6).

In the EU15, the 'Brain Gain' and the 'Expansionary' scenarios have an identical impact to the 'High-Skilled' scenario, while a 'Brain Waste' would lead to less optimistic results and has actually the same impact as the 'Low-Skilled' scenario.[24] If high-skilled migrants arrive in the EU15 under the 'Brain Waste' scenario, they will

[24] In theory, general equilibrium effects could induce differences between these scenarios; in practice, these differences are negligible.

Table 5. *High-skilled migration externality on technology* (A) *and network effects* (π)

	2010	2020	2030	2040	2050
A	−0.04 %	−0.09 %	−0.12 %	−0.13 %	−0.15 %
π	−4.16 %	−7.21 %	−9.61 %	−11.71 %	−13.78 %

The table displays percentage point differences to the baseline.
Source: Docquier and Lodigiani (2010), Lodigiani (2007) and own computations.

Table 6. *Human capital in the 'High-Skilled' (HS), 'Brain Waste' (BW) 'Brain Gain' (BG) and 'Expansionary' (EXP) scenarios*

	2010	2020	2030	2040	2050
HS = BW	−0.48 %	−0.81 %	−1.06 %	−1.30 %	−1.58 %
BG	−0.41 %	−0.63 %	−0.72 %	−0.76 %	−0.79 %
EXP	0.05 %	0.50 %	1.29 %	1.94 %	2.57 %

The table displays percentage point differences to the baseline.
Source: Beine *et al*. (2008) and own computations.

be employed as low skilled and will have a similar contribution as the latter ones in financing the public budget and in improving the GNI per capita.

In the MENA, a 'Brain Waste' scenario has a similar impact as the 'High-Skilled' scenario, because the same people leave this region but are employed differently at destination. The 'Brain Gain' scenario has a less damaging impact in the MENA than the 'High-Skilled' scenario. The improvement in the risk premium and in human capital partly compensates the negative side effect of high-skilled emigration on technology adoption, labor and capital productivity. We see that, when considering the side effects of high-skilled emigration, i.e. under the 'Brain Gain' scenario, the tax rate increases less and GNI is less reduced than under the 'High-Skilled' scenario. Finally, since more individuals acquire higher education, inequality increases less under the 'Brain Gain' scenario.

The 'Expansionary' scenario generates a much lower rise in the tax rate than the 'High-Skilled' scenario since the level of human capital is enhanced even compared to the baseline (see Table 7). Obviously, in such a context, as per worker productivity increases, income per capita improves (contrary to the drop in GNI per capita obtained under the 'High-Skilled' scenario). This scenario also results in a reduction in inter-household inequality as more people belong to the better-off group. The 'Expansionary' scenario involves a win–win situation, since besides improving the situation in the MENA it also leads to similar beneficial effects in the EU as under the 'High-Skilled' scenario. Clearly, this suggests that a stronger partnership between

Table 7. *Results under the 'High-Skilled', 'Brain Waste', 'Brain Gain' and 'Expansionary' scenarios*

Tax rate	(% *deviation*)	2010	2020	2030	2040	2050
EU15	High-Skilled	−0.43 %	−1.15 %	−2.41 %	−4.24 %	−6.07 %
	Brain Waste	−0.36 %	−0.94 %	−1.99 %	−3.53 %	−5.10 %
	Brain Gain	−0.43 %	−1.15 %	−2.40 %	−4.23 %	−6.07 %
	Expansionary	−0.43 %	−1.14 %	−2.40 %	−4.23 %	−6.08 %
MENA	High-Skilled	0.22 %	0.59 %	1.04 %	1.65 %	2.32 %
	Brain Waste	0.21 %	0.57 %	1.03 %	1.64 %	2.33 %
	Brain Gain	0.18 %	0.53 %	0.94 %	1.48 %	2.07 %
	Expansionary	0.13 %	0.34 %	0.59 %	0.93 %	1.42 %

GDP per capita	(% *change*)	2010	2020	2030	2040	2050
EU15	High-Skilled	0.02 %	0.63 %	1.60 %	3.06 %	4.55 %
	Brain Waste	−0.07 %	−0.06 %	0.30 %	1.06 %	1.90 %
	Brain Gain	0.02 %	0.62 %	1.59 %	3.04 %	4.53 %
	Expansionary	0.02 %	0.62 %	1.58 %	3.02 %	4.52 %
MENA	High-Skilled	−0.14 %	−0.98 %	−1.76 %	−2.78 %	−3.60 %
	Brain Waste	−0.12 %	−0.91 %	−1.68 %	−2.69 %	−3.53 %
	Brain Gain	0.00 %	−0.76 %	−1.31 %	−1.94 %	−2.30 %
	Expansionary	0.02 %	0.01 %	0.43 %	1.07 %	1.52 %

GNI per capita	(% *change*)	2010	2020	2030	2040	2050
EU15	High-Skilled	−0.39 %	−0.16 %	0.49 %	1.77 %	3.40 %
	Brain Waste	−0.28 %	−0.51 %	−0.41 %	0.19 %	1.05 %
	Brain Gain	−0.38 %	−0.16 %	0.49 %	1.77 %	3.39 %
	Expansionary	−0.37 %	−0.15 %	0.49 %	1.76 %	3.38 %
MENA	High-Skilled	0.14 %	−0.33 %	−0.86 %	−1.62 %	−2.36 %
	Brain Waste	0.13 %	−0.34 %	−0.87 %	−1.63 %	−2.37 %
	Brain Gain	0.14 %	−0.32 %	−0.70 %	−1.17 %	−1.52 %
	Expansionary	0.11 %	0.24 %	0.69 %	1.33 %	1.83 %

Inequality	(% *change*)	2010	2020	2030	2040	2050
EU15	High-Skilled	−1.55 %	−2.82 %	−3.93 %	−5.04 %	−6.61 %
	Brain Waste	0.18 %	0.46 %	0.80 %	1.30 %	2.35 %
	Brain Gain	−1.56 %	−2.83 %	−3.94 %	−5.05 %	−6.62 %
	Expansionary	−1.56 %	−2.83 %	−3.95 %	−5.05 %	−6.62 %
MENA	High-Skilled	3.27 %	4.82 %	5.69 %	6.25 %	7.14 %
	Brain Waste	3.28 %	4.85 %	5.72 %	6.28 %	7.16 %
	Brain Gain	2.87 %	3.78 %	3.87 %	3.60 %	3.50 %
	Expansionary	0.08 %	−2.50 %	−6.02 %	−7.80 %	−8.95 %

the EU15 and the MENA countries, involving more high-skilled migration and a greater cooperation in human capital formation, can raise the welfare of all parties concerned. For instance, such an initiative could be designed in the framework of the '*Union pour la Méditerranée*' initiated in late July 2008 by French President Nicolas Sarkozy. Indeed, the goal of this Union is to promote a development of the Euromediterranean Partnership.

4 Conclusion

This paper examines the consequences of increasing MENA-to-EU migration flows in the coming decades on both sending and receiving regions. Different approaches are adopted to address this issue. First, from a pure demographic point of view, replacement migration policies encouraging MENA-to-EU flows of working-age people should not be permanent and be limited in size and in time. The reason is that, as Europe, MENA will also have to cope with the aging of its population.

Second, the paper also bases its conclusions on a general equilibrium analysis, which reveals some important insights. While selecting immigrants has a small additional impact in reducing tax rates (compared to a non-selective policy), it leads to significant additional increments in income in aging Europe. In the MENA, emigration increases the economic burdens of aging, and even more if emigrants are high skilled. Thus, while high-skilled emigration would contribute to alleviate the aging problem in Europe, it would have negative consequences in terms of tax rates and income in the MENA.

Finally, we consider different variants of a selective policy within our analysis. The reasons are: (i) that high-skilled migrants might not necessarily be employed as high-skilled workers at destination, (ii) that high-skilled emigration entails different side effects on origin countries and (iii) that education in the MENA countries could be boosted by an increased cooperation with Europe. The first variant of the 'High-Skilled' scenario, the 'Brain Waste' scenario, combines the worst effects of the selective and non-selective policies explained before, since, under such a brain waste, high-skilled migrants leave the MENA and contribute as low-skilled workers to the European economy. The two other variants affect Europe in the same manner than a selective immigration policy, but considerably mitigate its effects in the MENA. The side effects of high-skilled emigration contribute to moderate the increase in the tax rate, the drop in income per capita and the rise in inequality.

In a scenario in which high-skilled emigration is accompanied by an increase in education levels of the MENA labor force, income per capita would be even positively affected and inequality reduced. Such a situation results in a win–win situation, since besides improving the situation in the MENA, it also leads to similar beneficial effects in the EU as high-skilled migration alone. However, it leaves the question open on how such education improvements can be achieved. An increasing cooperation in education policies and managed migration flows could be designed in the framework of the '*Union pour la Méditerranée*', whose explicit goal is to promote a development of the Euromediterranean Partnership.

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Appendix A – Methodology used in DLM

A.1 Emigration stocks

It is well documented that statistics provided by source countries do not provide a realistic picture of emigration. When available, which is very rare, they are incomplete and imprecise. While detailed immigration data are not easy to collect on a homogeneous basis, information on emigration can only be captured by aggregating consistent immigration data collected in receiving countries, where information about the birth country, gender and education of natives and immigrants is available from national population censuses and registers (or samples of them). More specifically, the receiving country *j*'s census usually identifies individuals on the basis of age, gender g, country of birth i, and skill level s. The DLM method consists in collecting (census or registers) gender-disaggregated data from a large set of receiving countries, with the highest level of detail on birth countries and three levels of educational attainment: $s=h$ for high skilled, $s=m$ for medium skilled and $s=l$ for low skilled. Let $M^{i,j}_{t,g,s}$ denote the stock of adults 25+ born in j, of gender g, skill s, living in country j at time t. Aggregating these numbers over destination countries j gives the stock of emigrants from country i: $M^{i}_{t,g,s}=\sum_j M^{i,j}_{t,g,s}$.

By focusing on census and register data, the methodology badly captures illegal immigration for which systematic statistics by education level and country of birth are not available,[25] except in the USA. Demographic evidence indicates most US illegal residents are captured in the census. However, there are no accurate data about the educational structure of these illegal migrants. Hence, the number of unskilled in the immigrant population is probably underestimated, assuming that most illegal immigrants are uneducated. Nevertheless, this limitation should not significantly distort the estimates of the migration rate of highly skilled workers.

Here are the main methodological choices of DLM:

- The term 'source country' usually designates independent states. They distinguish 195 source countries: 191 UN member states, Holy See, Taiwan, Hong Kong, Macao and Palestinian Territories. They aggregate North and South Korea, West and East Germany and the Democratic Republic and the Republic of Yemen. They consider the same set of source countries in 1990 and 2000, although some of them had no legal existence in 1990 (before the secession of the Soviet block, former Yugoslavia, former Czechoslovakia and the German and Yemen reunifications) or became independent after January 1, 1990 (Eritrea, East-Timor, Namibia, Marshall Islands, Micronesia, Palau). In these cases, the 1990 estimated stock is obtained by multiplying the 1990 value for the pre-secession state by the 2000 country share in the stock of immigrants (the share is gender- and skill-specific).
- The set of receiving countries is restricted to OECD nations. Generally speaking, the skill level of immigrants in non-OECD countries is expected to be very low, except in a few countries such as South Africa, the six member states of the GCC, some Eastern Asian countries. To allow comparisons between 1990 and 2000, they consider the same 30 receiving countries in 1990 and 2000. Consequently, Czechoslovakia, Hungary, Korea, Poland and Mexico are considered as receiving countries in 1990 despite the fact that they were not members of the OECD.
- They only consider the adult population aged 25 and over. This excludes students who temporarily emigrate to complete their education. In addition, as it will appear in the next section, it allows comparing the numbers of migrants with data on educational attainment in source countries.
- Migration is defined on the basis of the country of birth rather than citizenship. While citizenship characterizes the foreign population, the 'foreign-born' concept better captures the decision to emigrate.[26] Usually, the number of foreign-born is much higher than the number of foreign citizens (twice as large in countries such as Hungary, the Netherlands and Sweden).[27] Another reason is that the concept of country of birth is time invariant (contrary to

[25] Hatton and Williamson (2002) estimate that illegal immigrants residing in OECD countries represent 10–15 % of the total stock.

[26] In some receiving countries such as Germany, immigrants' children (i.e. the second generation) usually keep their foreign citizenship.

[27] In contrast, in other OECD countries with a restricted access to nationality (such as Japan, Korea and Switzerland), the foreign population is important (about 20 % in Switzerland).

citizenship that changes with naturalization) and independent of the changes in policies regarding naturalization.[28] The number of foreign-born can be obtained for a large majority of OECD countries although in a limited number of cases the national census only gives immigrants' citizenship (Germany, Hungary, Italy, Japan and Korea). It is worth noting that the concept of foreign-born is not fully homogeneous across OECD countries. In most receiving countries, foreign-born are individuals born abroad with foreign citizenship at birth. In a couple of countries, 'foreign-born' means 'overseas-born', i.e. an individual simply born abroad.

- They distinguish three levels of education. Medium-skilled migrants are those with upper-secondary education completed. Low-skilled migrants are those with less than upper-secondary education, including those with lower-secondary and primary education or those who did not go to school. High-skilled migrants are those with post-secondary education.[29] This assumption is compatible with Barro and Lee's human capital indicators (based on the 1976-ISCED classification). Some migrants did not report their education level. As in DM06, they classify these unknowns as low-skilled migrants.[30] Educational categories are built on the basis of country specific information and are compatible with human capital indicators available for all sending countries. A mapping between the country educational classification is sometimes required to harmonize the data.[31]

A.2 Emigration rates

They count as migrants all adult (25 and over) foreign-born individuals living in an OECD country. A more meaningful measure can then be obtained by comparing the emigration stocks to the total number of people born in the source country and belonging to the same gender and educational category. This method allows to evaluate the pressure imposed on the labor market in the source country.

In the spirit of Carrington and Detragiache (1998), Adams (2003), Docquier and Marfouk (2006) or Dumont and Lemaitre (2004), the second step consists in calculating the brain drain as a proportion of the total educated population born in the source country. Although their analysis is based on stocks (rather than flows), they refer to these proportions as emigration rates. Denoting $R^i_{t,g,s}$ as the stock of resident individuals aged 25+, of skill s, gender g, living in source country i, at time t,

[28] The OECD statistics report that 14.4 million foreign born individuals were naturalized between 1991 and 2000. Countries with a particularly high number of acquisitions of citizenship are the US (5.6 million), Germany (2.2 million), Canada (1.6 million) and Australia and France (1.1 million).

[29] In the US case, this includes those with one year of college.

[30] Country specific data by occupation reveal that the occupational structure of those with unknown education is very similar to the structure of low-skilled workers (and strongly different from that of high-skilled workers). See Debuisson *et al.* (2004) on Belgium data.

[31] For example, Australian data mix information about the highest degree and number of years of schooling.

emigration rates are defined as

$$m^i_{t,g,s} = \frac{M^i_{t,g,s}}{R^i_{t,g,s} + M^i_{t,g,s}}.$$

In particular, $m^i_{t,g,h}$ can be used as a proxy of the brain drain in the source country i.

This step requires using data on the size and the skill and gender structure of the adult population in the source countries. Population data by age are provided by the United Nations.[32] They focus on the population aged 25 and more. Data are missing for a couple of countries but can be estimated using the CIA world factbook.[33] Population data are split across educational group using international human capital indicators. Several sources based on attainment and/or enrollment variables can be found in the literature. As in Docquier and Marfouk (2006), human capital indicators are taken from De La Fuente and Domenech (2002) for OECD countries and from Barro and Lee (2001) for non-OECD countries. For countries where Barro and Lee measures are missing, they predict the proportion of educated using Cohen–Soto's measures (see Cohen and Soto, 2007). In the remaining countries where both Barro–Lee and Cohen–Soto data are missing (about 70 countries in 2000), they transpose the skill sharing of the neighboring country with the closest enrolment rate in secondary/tertiary education, the closest gender gap in enrollment rates and/or the closed GDP per capita.

Appendix B – Description of the CGE model

The CGE analysis can be resumed in three different steps: calibration of the demography, construction of the CGE model and introducing the side effects of skilled migration. Before focusing on the CGE model, we constructed the evolution of the population over the 2000–2100 period based on UN population forecasts. The evolution of the population (as well as of international migration) enters then the model and determines the path of the economy over the 21st century. The CGE model is characterized by overlapping generations of individuals with skill heterogeneity, a production sector and a government. At this point, we provide first evaluations of the implications of increased migration on destination and origin regions. A last step is to include in the model diverse side effects of skilled emigration on source countries. The elasticities used for such an analysis were estimated in various articles of the brain drain literature.

B.1 Demography

The population structure relies on the UN Population projections that are available between 1950 and 2050. We also use this data to identify the migrants from developing to developed regions.

[32] See http://esa.un.org/unpp.
[33] See http://www.cia.gov/cia/publications/factbook.

B.1.1 Population

Individuals reaching age 0 at year t belong to the generation t. The size of the young generation increases over time at an exogenous growth rate:

$$N_{\mathbf{0},t} = m_{t-1} N_{\mathbf{0},t-1},$$

where $N_{\mathbf{0},t}$ measures the initial size of generation t and m_{t-1} is one plus the demographic growth rate, including both fertility and migration.

At every period, agents of the same age class ($a = 0, 1, \ldots, 7$) face an identical cumulative survival probability, which decreases with age. Hence, the size of each generation declines deterministically over time:

$$N_{a,t+a} = P_{a,t+a} N_{\mathbf{0},t},$$

where $0 \leqslant P_{a,t+a} \leqslant 1$ is the fraction of generation t alive at age a (at period $t+a$). Obviously, we have $P_{\mathbf{0},t} = 1$.

Denoting by ϕ_t the proportion of skilled (post-secondary educated) among the first cohort, the skilled and unskilled cohort sizes are given by:

$$N^s_{\mathbf{0},t} = \phi_t N_{\mathbf{0},t}$$

$$N^u_{\mathbf{0},t} = (1-\phi_t) N_{\mathbf{0},t}.$$

We assume an exogenous participation profile per age and education group, $\lambda^j_{a,t}$. Hence, labor supply of type j at time t is given by

$$L^j_t = \sum_a \lambda^j_{a,t} N^j_{a,t}, \quad j = u, s.$$

Specifically, we assume full participation except for the following three groups. First, young skilled spend a fraction of their time in obtaining education and do not fully participate in the labor market ($0 \leqslant \lambda^s_{\mathbf{0},t} \leqslant 1$). Second, part of the population aged 55–64 years old are retired ($0 \leqslant \lambda^j_{4,t} \leqslant 1$). Lastly, all individuals aged above 65 are retired ($\lambda^j_{a,t} = 0$ for all $a > 0$).

Demographic changes affect the economic performances of the economy (GDP or GNI per capita) through the support ratio, defined as the ratio of labor force to population:

$$\mathrm{SR}_t = \frac{\sum_a \sum_j \lambda^j_{a,t} N^j_{a,t}}{\sum_a \sum_j N^j_{a,t}}.$$

And through human capital, defined as the proportion of skilled in the residents labor force:

$$HC_t = \frac{\sum_a \lambda^s_{a,t} N^s_{a,t}}{\sum_a \sum_j \lambda^j_{a,t} N^j_{a,t}}.$$

In the baseline, we compute $P_{a,t+a}$, the probability for an individual of generation t of being alive at time $t+a$ and the population growth rate m_t for the period 1950–2050 from the United Nations data of World Population Prospects, the 2000 Revision. In order to compute the share of skilled individuals of a generation ϕ_t, we use the

Barro-Lee Dataset (2001), which provides data on the educational attainment of individuals aged 25–74 for the years 1950–2000 per country.[34] In the future, we assume that the young cohorts are educated as the young one in 2000.

B.1.2 South–North migration

In order to calibrate migration stocks and flows for the baseline, we explicitly track migrants from the seven developing regions into the three developed regions. North–North and South–South migrants are implicitly dealt with through the U.N. population data and forecasts. Our calibration strategy is based on immigrant-to-population ratios, or the proportions of stock of immigrants to total population observed in the three developed regions. To begin with, we use statistics on the number, age structure and education levels of immigrants in 2000 (combining the U.N. and the Docquier–Marfouk datasets). From the gross number of immigrant stock in each region, we subtract the number of 0–14 years old migrants, and then we subtract all North-to-North migrants. Based on the Docquier–Marfouk dataset, we calibrate the shares of immigrants by education level and by region of origin. To construct the number of migrants before 2000, we use survival probabilities as well as the growth rate of the immigrant population. For immigration forecasts, we start from the 2000 numbers and let migrants die according to the survival probability forecasts. Assuming that all future migrants are aged 15–24, we let the change in the stock of immigrants follow the UN forecasts (from which we subtract the 0–14 years old and North-to-North migrants using the 2000 proportions). We assume that future migrants are distributed by educational level and by origin as in 2000.

B.2 The model's structure

B.2.1 Preferences

The expected utility function of our agents is assumed to be time-separable and logarithmic:

$$E(U_t^j) = \sum_{a=0}^{7} P_{a,t+a} \ln (c_{a,t+a}^j), \quad j = s, u,$$

where $c_{a,t+a}^j$ represents expenditures of age class a at time $t+a$. For natives in both developing and developed regions, $c_{a,t+a}^j$ is equivalent to goods consumption.

[34] We firstly aggregate this dataset by region and then partition it to obtain shares of skilled per age group. We proceed as follows to dis-aggregate the Barro–Lee data by age group. First, it is reasonable to assume that, at each period, the share of skilled individuals is higher for the younger age class. In particular, we assume that the share of skilled individuals aged 85–94 corresponds arbitrarily to 80 % of the share of skilled aged 75–84, which in turn is equal to 80 % of that of the next younger age class, and so forth. As all the shares of skilled per age class then depend on the share of skilled aged 25–34, we compute this share to match the total share of skilled in 1950, as given by the Barro–Lee dataset. Second, we report the values of the shares of the age classes 25–34 to 65–74 of the following years. For example, the share of skilled aged 35–44 in 1960 is equal to the share of skilled aged 25–34 in 1950, as we assume that the skilled and unskilled individuals have the same probability to be alive at the beginning of each period. Third, for all the following years, we compute the share of skilled aged 25–34 in the same way as for the year 1950. Lastly, the share of skilled aged 15–24 in 1950 is simply equal to the share of skilled aged 25–34 in 1960.

However, for immigrants in the developed regions, $c^j_{a,t+a}$ is a Cobb–Douglas combination of goods consumption ($c^{M,j}_{a,t+a}$) and remittances ($RM^{M,j}_{a,t+a}$).

$$c^j_{a,\,t+a} = (c^{M,j}_{a,\,t+a})^{1-\gamma^j_t}(RM^{M,j}_{a,\,t+a})^{\gamma^j_t}, \quad j = s, u,$$

where γ^j_t is an age-invariant propensity to remit that determines the proportion of expenditures a migrant of generation t and skill group j sends as remittance to his/her region of origin. Moreover, we assume that this parameter varies with country of origin.[35]

Furthermore, following de la Croix and Docquier (2003), we postulate the existence of an insurance mechanism à la Arrow–Debreu. As an individual dies, her/his assets are equally distributed among individuals belonging to the same age class. Individuals thus maximize their expected utility subject to a budget constraint requiring equality between the discounted expected value of expenditures and the discounted expected value of income, which consists of net labor income, pension benefits, other welfare transfers and/or net remittances.

B.2.2 Firms

At each period of time and in each region, a representative and profit-maximizing firm uses efficient labor (L_t) and physical capital (K_t) to produce a composite good (Y_t). We assume a Cobb–Douglas production function with constant returns to scale,

$$Y_t = K^{\alpha}_t (A_t L_t)^{1-\alpha},$$

where α measures the share of capital returns in the national product, and A_t is an exogenous process representing the Harrod neutral technological progress. Total efficient labor force combines the demands of skilled (L^s_t) and of unskilled labor (L^u_t) according to the transformation function characterized by a CES:

$$L_t = [\upsilon_t (L^s_t)^{\sigma} + (1-\upsilon)(L^u_t)^{\sigma}]^{1/\sigma}, \quad \sigma < 1,$$

where υ_t is an exogenous skill-biased technological progress, and σ is defined as $\sigma = 1 - (1/\varepsilon)$, with ε being the elasticity of substitution between skilled and unskilled labor. The capital share in output α is set to one-third, as estimated in the growth accounting literature. We follow Acemoglu (2002) in fixing the elasticity of substitution to 1.4 and thus the parameter σ equals to 0.2857 in the CES function.

There is one leading regional economy, North America (NAM), in the sense that the Harrod neutral technological progress of each region is a fraction of A_t^{NAM}, namely that the leader is always ahead of other regions in terms of production technology. Exogenous paths for the Harrod neutral technological progress A_t, the skill-biased technical change υ_t and growth of the leading economy are unobservable and/or must be properly calibrated.

To obtain A_t for non-leading regions, we use the observed paths of GDP ratio, Y_t/Y_t^{NAM}, where Y_t^{NAM} is the leader's GDP. We proceed as in de la Croix and

[35] We model remittances in this way so that migrants and natives have identical asset accumulations. The age-invariance of propensity to remit comes from our assumption that there is no remittances decay.

Docquier (2007), who use a backsolving identification method to calibrate total factor productivity. It consists of swapping the unobserved exogenous variables A_t for the observed endogenous variables Y_t/Y_t^{NAM} and then solving the identification step with the Dynare algorithm (Juillard, 1996). The ratio of GDP's is computed by employing the data of the GDP per purchasing power parity from the World Development Indicators (WDI) for the three years 1980, 1990 and 2000. We adopt the value of 1980 for the years preceding 1980 and the value of 2000 for those following 2000. We apply the same procedures for skill-biased technological change by using skill wage premiums, $h_t = w_t^s/w_t^u$. The skill premiums for each region in year 2000 are arbitrarily fixed.[36]

Then, we let these values vary according to the pattern of the US college wage premium for the period 1950–2000 in Acemoglu (2003). Finally, the leader's growth of Harrod neutral technological progress, is calibrated on real observations, and for future years, the value is calibrated such that the annual growth rate is equal to 1.84%.

B.2.3 Government

The government levies taxes on labor earnings and on consumption expenditures to finance general public consumption, pension benefits and other welfare transfers. The government surplus (S_t) can be written as (for $j=s,u$):

$$S_t = \tau_t^w \sum_{j=\{s,u\}} L_t^j w_t^j + \tau_t^c \sum_{j=\{s,u\}} \sum_{a=0}^{7} \varphi_{t-a}^j N_{a,t} c_{a,t}^j - \sum_{j=\{s,u\}} b_t^j \sum_{a=0}^{7} \varphi_{t-a}^j N_{a,t}(1-e_t^j)(1-\lambda_{a,t}^j)$$
$$- \psi_t \sum_{j=\{s,u\}} w_t^j \sum_{a=0}^{7} \varphi_{t-a}^j N_{a,t}(1-e_t^j)\zeta_a^j - c_t^g Y_t,$$

where $\lambda_{a,t}^j$ is the labor participation rate for a j-type individual of age class a, w_t is labor income, τ_t^c is consumption tax, τ_t^w income tax, b_t^j (individual) pension benefits, ζ_a^j are other welfare transfers received by an individual of type j and they are represented as a time-constant fraction of labor income, the generosity factor ψ_t is the factor by which these other welfare transfers are multiplied at time t, c_t^g is a part of national income used to finance general public spending. Education is exogenous and individuals spend a fraction e_t^j of their total time (which is only positive in their first period of life), ϕ_t^j is the proportion of individuals of skill type j among generation t ($\phi_t^j = \phi_t$ when $j=s$ and $\phi_t^j = 1-\phi_t$ when $j=u$).

The government also issues bonds and pays interests on public debt. The government's budget constraint is satisfied at each period by adjusting the wage tax rate τ_t^w. Public debt d_t is computed from the WDI Database.

B.2.4 Equilibrium

A competitive equilibrium of the economy with perfect capital mobility is characterized by (i) households' and firms' first-order conditions, (ii) market-clearing con-

[36] h_{2000} is fixed at 2.35 in EU and 3 in MENA.

ditions on the goods and labor markets, (iii) budget balance for each regional government, (iv) the equality between the aggregate quantity of world assets and the quantity of the world capital stock plus the sum of public debts of all regions, and finally (v) the arbitrage condition of the rates of return to capital. The equilibrium on the goods market is achieved by Walras' law.

The arbitrage condition in an integrated economy with perfect capital mobility requires the equality of the expected returns to capital up to region-specific risk premium.

B.3 Side effects of migration

Migration, and especially skilled migration, has been found to have diverse side effects on the migrant's source countries. In particular, human capital formation, technology adoption and informational costs can be affected by skilled emigration. The following paragraphs we explain how we integrate these effects in the 'Brain Gain' scenario.

B.3.1 Human capital

A recent wave of theoretical contributions demonstrates that skilled migration can raise the average of human capital in the sending countries (Mountford, 1997; Stark *et al*., 1997, 1998; Vidal, 1998; Beine *et al*., 2001; Stark and Wang, 2002). These papers assume that the return to education is higher abroad and that skilled workers have a much higher probability to emigrate than unskilled workers (a hypothesis strongly supported by the data). Hence, migration prospects raise the expected return to human capital and induce more people to invest in education at origin. *Ex-ante*, more people opt for education. *Ex-post*, some of them will be leaving. Under certain conditions detailed in these models, the incentive effect (or brain effect) dominates that of actual emigration (or drain effect), which creates the possibility of a net brain gain for the source country.

Beine *et al*. (2008) found evidence that the prospect of skilled migration is positively associated with gross (pre-migration) human capital levels in cross-country regressions. They used a β-convergence empirical specification:

$$\Delta \ln (HC_t^a) = \alpha - \beta \ln (HC_t^a) + \gamma \ln (m_t^s) + \sum \eta_i X_{i,t},$$

where $\Delta\ln(HC_t^a)$ is the growth rate of human capital between t and $t+1$, HC_t^a denotes human capital measured as the proportion of skilled among natives at time t (superscript a stands for natives or human capital *ex-ante*, before emigration occurs), m_t^s is the skilled emigration rate, $X_{i,t}$ is a vector of other control variables, $(\alpha,\beta,\gamma,\eta_i)$ is a set of parameters. The long-run elasticity of natives' human capital to the skilled emigration rate is equal to γ/β. It amounts to 9.6% in the parsimonious IV model.

In our simulations, we build on Docquier *et al*.'s data and compute the relative change in skilled emigration rates resulting from the rise in emigration flows to the North. We assume that these relative changes are experienced by all the countries belonging to the region. Using the above long-run elasticity, we compute the change in human capital of natives and residents (natives minus migrants). Assuming that the long-run level of human capital is reached in 2050, we compute the proportion of skilled among remaining residents, denoted by HC_t. We first do it country by country and then aggregate countries by region. The convergence to the 2050 level of human capital level is linear. Finally, we compute the change in ϕ_t required to obtain the desired levels of human capital. After 2060, the skilled emigration rates and the ϕ_t come back to their baseline value.

B.3.2 Total factor productivity (TFP)

Following Benhabib and Spiegel (2005), themselves building on Nelson and Phelps (1966), we consider an endogenous Harrod-neutral technical progress of the neo Schumpeterian type. Technical changes are determined by the regional capacity to innovate and to adopt modern technologies. Vandenbussche *et al.* (2006), henceforth VAM, estimated a neo-Schumpeterian model using panel data on OECD countries. More recently, Lodigiani (2008) has extended the framework by adding a diaspora externality: skilled emigrants living in rich countries increase the capacity to adopt modern technologies. She re-estimated the model on a larger sample of countries (including developing countries) and obtained the following specification:

$$\Delta \ln (A_t) = 0.59 - 0.28 \ln\left(\frac{A_t}{A_t^*}\right) + 1.43 HC_t - 0.10 \ln (M_t^s) + .87 \ln\left(\frac{A_t}{A_t^*}\right) HC_t - 0.06 \ln\left(\frac{A_t}{A_t^*}\right) \ln (M_t^s) + \varepsilon_t,$$

where $\Delta\ln(A_t)$ is the rate of technical progress, A_t^* is the technological level of the leader (typically, the NAM region), M_t^s is the stock of skilled emigrants living in the leading economy and ε_t is an exogenous component. Confirming VAM, the interaction effect between proximity and the proportion of workers with tertiary education is positive, meaning that skilled workers are more important for growth in economies closer to the frontier. On the contrary, the interaction effect between proximity and the log of skilled emigrants is negative, implying that skilled emigration has a decreasing effect on growth when a country approaches the frontier or that migration is more important for countries far from the frontier. Backward countries that rely more on adoption can benefit more from skilled diaspora as it facilitates technology and knowledge transfer from abroad.

In the baseline, we plug the human capital and migration forecasts in the above equation to predict the evolution of the technology. On the period 1950–2000, we calibrate ε_t so that our baseline simulations perfectly match the GDP observations (as percentage of the leading economy). The calibrated path for ε_t is rather stationary and distributed around zero.

Since our shock modifies human capital and the number of skilled emigrants abroad, it affects the rate of technical progress as well. Given the specification above, $\Delta\ln(A_t)$ increases in HC_t when $\ln(A_t/A_t^*) > -1.64$, i.e. when the economy is not too far from the frontier. Moreover, $\Delta\ln(A_t)$ increases in M_t^s if $\ln(A_t/A_t^*) < -1.67$, i.e. when it is far from the frontier.

B.3.3 Risk premium

A large sociological literature emphasizes that the creation of migrants' networks facilitates the further movement of persons, the movement of goods, factors and ideas between the migrants' host and home countries. Several studies investigated whether FDI and migration are substitutes (as one would expect) or complements. Using cross-section data, Docquier and Lodigiani (2010) find evidence of significant network externalities in a dynamic empirical model of FDI-funded capital accumulation. Their analysis confirms that business networks are mostly driven by skilled migration. Using bilateral FDI and migration data, Kugler and Rapoport (2007) also found strong evidence of a complementarity between FDI and skilled migration with a similar elasticity.

In our model, we assume that physical capital is mobile across regions, the optimal marginal productivity of capital is equal to the international interest rate r_t* augmented of country-specific premium π_t reflecting informational costs or risks. The premium level is endogenous and depends on the size of the skilled diaspora abroad (M_t^s). We have:

$$r_t^*(1+\pi_t)=\alpha K_t^{\alpha-1}(A_t L_t)^{1-\alpha}-d,$$

$$(1+\pi_t)=(1+\pi_{0,t})(M_t^s)^{-\varphi},$$

where d is the capital depreciation rate, $\pi_{0,t}$ is an exogenous variables used to calibrate the baseline level of the premium and $-\varphi$ is the elasticity of the premium to the skilled diaspora size.

Using panel data, Docquier and Lodigiani (2010) have estimated that the long-run elasticity of foreign direct investments to the skilled diaspora is equal to 0.75. Using the specifications above and relying on the fact that foreign direct investments represent 12.5% of total investments in developing countries, the calibrated value for φ is equal to 0.05.

In the year 2000, we calibrate $\pi_{0,2000}$ in such a way that the regional premium reflects country risk rating. The risk premium is modeled here as a governmental tax on investment. In a risky region, a part of an investor's returns to capital is collected by the government, who uses it for non-productive purposes (e.g. extra goods consumed by corrupted civil servants). We use data available from the OECD for region-specific risk, which in turn rely upon the Knaepen Package methodology. To compute the risk classification per region, we take an arithmetic mean of ratings of the available countries.[37] In the baseline scenario, $\pi_{0,t}$ is adjusted to keep the regional premium constant over time.

[37] The Knaepen Package is a system for assessing country credit risk and classifies countries into eight-country risk categories (0–7), from no risk (0) to high risk (7). Basically, it measures the credit risk of a country. In our calibration, there is no risk for EU, whereas the risk classification of MENA is of 4.2.