Global Trade Analysis Project
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This paper is from the
GTAP Annual Conference on Global Economic Analysis
https://www.gtap.agecon.purdue.edu/events/conferences/default.asp

Endogenous determination of migration flows between Africa and European Union by interlinking demographic dynamics and labor market liberalization in a modified version of the GTAP model

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1. Introduction

Migration flows from Africa to European Union represent a major issue in the current political debate between the two shores of the Mediterranean Sea. The number of African immigrants in the EU is increasing over the years, especially in some countries as France, Italy and Spain. According to the OECD dataset from 2000 to 2010 the annual flow of African immigrants has increased by more than 50% in France and Spain and more than 30% in Italy (OECD, International Migration Database).

This work aims at shedding some light on the combined economic effects of labor market liberalization and demographic patterns across Africa and Europe. The reference framework is a modified version of the GTAP model, where unskilled labor, skilled labor and capital can move within the Africa-European Union macro-region.

Walmsley et al. (2007) have already created a modified version of the GTAP model named GMig (*Global Migration*) to study the migration process from a general equilibrium perspective. The GMig tool incorporates information about bilateral labor flows across countries at the global level. It allows the economic assessment of a policy reform which, for example, lifts restrictions on the movements of natural persons.[1]

Another interesting approach stems from Shi and Tyers (2005). The authors deepen the analysis by including in the GTAP model a demographic module which considers four age groups and two genders for 14 regions.

The focus of this work is limited to the Africa-EU28 macro area. As a consequence, the opportunity to migrate is geographically restricted. However we integrate the analysis on international labor mobility by considering also the international capital mobility. The interaction between the two factors is very important not only for GDP growth but also for their remuneration which involves the issue of inequality.

The above-mentioned dynamic, in turn, interacts with the demographic patterns which are very different between Africa and Europe. In general, demographic forecasts are more reliable than economic forecasts because the generation of future mothers is already born and there is empirical

[1] The GMig model has been applied to the study of the US immigration reform affecting the inflow of Mexican workers (Aguiar and Walmsley, 2013) and to the investigation of labor migration in East and Southeast Asia (Walmsely et al., 2013).

evidence that the fertility rates tend to change slowly. Africa and Europe are in two different points of demographic transition. Europe has completed it while Africa is still going through.

In this paper we distinguish the short run impact on population covering the period 2015-2020 and the long run impact covering the period 2015-2050. These numbers are based on United Nations projections (UN, World Population Prospects).

It is worth noting that the results of the analysis do not claim to be realistic in magnitude but reliable in the direction and in the clarification of the underlying economic mechanism determining the migration flows.

The paper is organized as follows. Section 2 presents the main theoretical changes with respect to the standard GTAP model. Basically imperfect international substitution is introduced in the capital endowment supply, skilled and unskilled labor supply. In addition the new equation for population is explained. Section 3 describes the policy experiment while section 4 reports the results and their explanation for the short-run and the long-run, respectively. Section 5 concludes.

2. Theoretical changes in the standard GTAP model

In the standard GTAP model factor endowments are geographically immobile. We model an integrated Africa-EU market for labor and capital by using CET (*Constant Elasticity of Transformation*) functions. These equations determine endogenously the skilled/unskilled labor supply and the capital supply in Africa and Europe.

Different from GTAP the population growth rate becomes endogenous in Europe and Africa because it is the result of interaction between the UN demographic forecasts and the endogenous supply of skilled and unskilled labor. However the overall population growth rate in the macro-area is exogenous as in the standard GTAP model.

Migration flows are also the consequence of the above-mentioned interaction.

2.1 Integrated Africa-EU capital market

We use a simple CET function to model the supply of capital in Africa and Europe. The maximization problem is the following

$$\max \sum_{r} QK_r PK_r = QK_{AEU} PK_{AEU} \qquad (1)$$

$$\text{s.t.} \quad QK_{AEU} = \left(\sum_{r} QK^{\rho_K} \right)^{\frac{1}{\rho_K}} \quad \text{with} \quad \rho_K > 1 \qquad (2)$$

where r is the regional index (Africa or Eu28), AEU represents the Africa-Europe macro-area, ρ_K is a parameter in the CET technology, QK is the capital supply and PK the associated price.

The resolution of the maximization program allows determining the FOC for capital supply at the regional level:

$$QK_r = QK_{AEU} \left(\frac{PK_{AEU}}{PK_r} \right)^{\sigma_K} \quad \text{with} \quad \sigma_K = \frac{1}{1-\rho_K} < 0 \qquad (3)$$

where σ_K is the elasticity of substitution between African and European capital. The value of σ_K is arbitrarily set equal to -10 in all the simulations.

2.2 Integrated Africa-EU labor market

The CET function is also used to model the supply of skilled and unskilled labor in Africa and Europe. The maximization problem is the following

$$\max \sum_r QL_r PL_r = QL_{AEU} PL_{AEU} \quad (4)$$

$$\text{s.t.} \quad QL_{AEU} = \left(\sum_r QL^{\rho_L} \right)^{\frac{1}{\rho_L}} \quad \text{with} \quad \rho_L > 1 \quad (5)$$

$$\max \sum_r QH_r PH_r = QH_{AEU} PH_{AEU} \quad (6)$$

$$\text{s.t.} \quad QH_{AEU} = \left(\sum_r QH^{\rho_H} \right)^{\frac{1}{\rho_H}} \quad \text{with} \quad \rho_H > 1 \quad (7)$$

where QL and QH are the unskilled and skilled labor supply and PL and PH the associated prices.

FOCs are:

$$QL_r = QL_{AEU} \left(\frac{PL_{AEU}}{PL_r} \right)^{\sigma_L} \quad \text{with} \quad \sigma_L = \frac{1}{1-\rho_L} < 0 \quad (8)$$

$$QH_r = QH_{AEU} \left(\frac{PH_{AEU}}{PH_r} \right)^{\sigma_H} \quad \text{with} \quad \sigma_H = \frac{1}{1-\rho_H} < 0 \quad (9)$$

where σ_L and σ_H are the elasticity of substitution between African and European unskilled and skilled labor. The value of σ_L and σ_H is chosen according to the policy scenario in which the demographic impact is implemented, as it will be explained in section 3.

2.3 Endogenous migration flows and population growth rate

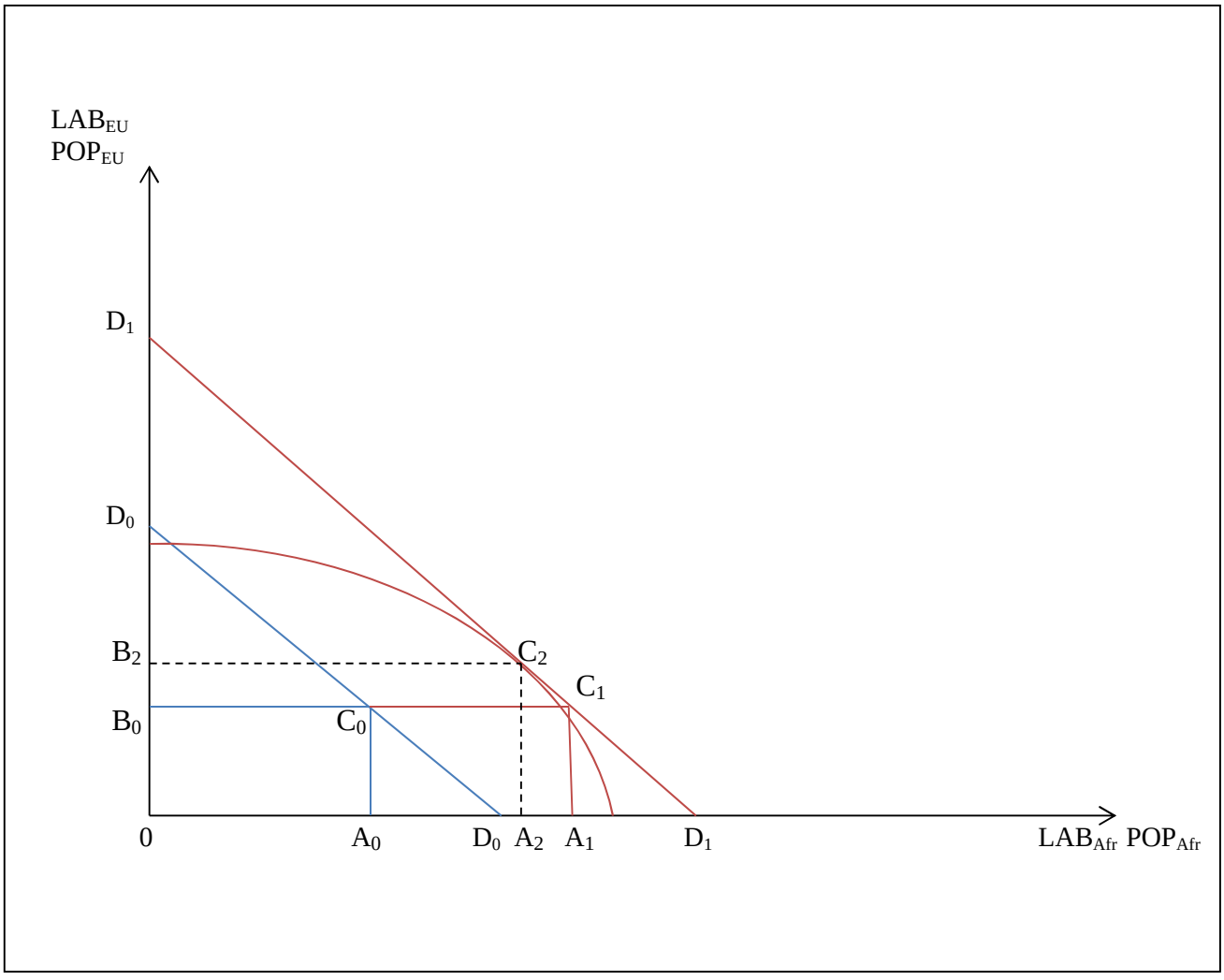
From the modelling perspective the most difficult task to achieve in this work is to find a good way to transform the movements of labor in movements of people. Two main issues arise when addressing this kind of problem.

The first one is related to productivity: as worker from Africa/Europe is transformed into a worker in Europe/Africa by using the CET function does s/he take on the characteristics (wage and productivity) of a European/African?

The second one refers to the technology which sums the labor and the population of the two regions to obtain the total quantity of workers and people in the Africa-EU macro-area. While it is evident that the latter must require perfect substitution between African and European persons, this is not the case for labor. We rule out the possibility of perfect substitution ($\sigma \rightarrow -\infty$) in the CET function, which drives the movement of workers according to change in the relative wages. This is to prevent unrealistic migration overflows which would occur in the case of a unique wage in the Africa-EU macro-area. In addition migration always implies transition costs and we try to take them into account by the CET modelling.

The Figure 1 below shows the basic facts about the relation between labor and population. For sake of simplicity, we ignore the distinction between skilled and unskilled labor and we assume that one person correspond exactly to one worker. At this stage we neglect also the productivity differentials across workers from different regions because it will be analyzed in detail in section 3.1.

On the horizontal axis the level of population and labor is depicted for Africa, on the vertical axis the level of population and labor is depicted for Europe.



A_0, B_0 and C_0 are our starting points. They represent the total population in Africa, EU28 and the Africa-EU28 macro-area, respectively, before the demographic shock. The point C_0 is the intersection between the CET level set for labor and the 45-degree population line (both in blue color). We can observe perfect complementarity ($\sigma_L = \sigma_H = 0$) between African and European workers and perfect substitution between African and European persons. This simply means perfect

labor immobility in the region as in the standard GTAP model and perfect substitution in the computation of the total Africa-EU28 population, that is the sum of A_0 and B_0.

The following identities are verified:

$$A_0 + B_0 = C_0 = D_0 \quad (10)$$

where D_0 is the extreme case in which full migration process occurs in one of the two possible directions.

In this illustrative figure we just apply a demographic impact consisting in increasing the total African population from point A_0 to point A_1 while the European population is unchanged in point B_0. This tries to capture in a very rough way the different demographic patterns between the two Continents.

When the perfect complementarity assumption across workers is kept, the demographic shock determines the new equilibrium in point C_1. C_1 is the intersection between the new CET level set for labor and the new 45-degree population line (both in red color).

The following identities are verified:

$$A_1 + B_0 = C_1 = D_1 \quad (11)$$

The consequence of this assumption is that the population growth rates in Africa and Europe are exogenous and equal to the labor force growth rates. No endogenous mechanism is working in this case and the opportunity to migrate is excluded.

As the migration dynamic is introduced and the perfect complementarity hypothesis across workers relaxed ($\sigma_L = \sigma_H < 0$), the population growth is no more exogenous in Africa and Europe. It continues to be exogenous only for the macro-area. In this case the CET level set is a curve (in red color) and its intersection with the population line identifies the new equilibrium in point C_2.

In C_2 the population decreases in Africa and increases in Europe. The endogenous mechanism which causes these population changes is the reallocation of labor between the two regions. The reallocation is driven by the change in relative wages. In turn, the change in the relative wages is determined by the exogenous demographic shock, which make labor more abundant in Africa relative to Europe. As a result the labor factor migrates towards Europe where it is scarcer and more valuable.

In C_2 the following identities are verified:

$$A_1 + B_0 = C_1 = C_2 = A_2 + B_2 = D_1 \quad (12)$$

The Figure 1 is more complex than it seems and implies some approximation. In fact we are assuming that one worker exactly corresponds to one person but the imperfect substitution introduced by the CET function necessarily breaks this hypothesis.

It is possible to understand this by looking at the following equations:

$$POP_{Afr} + POP_{EU} = POP_{AEU} \quad (13)$$

$$LAB_{Afr} + LAB_{EU} = LAB_{AEU} = POP_{AEU} \quad \text{if } \sigma = 0 \quad (14)$$

$$LAB_{Afr} + LAB_{EU} < LAB_{AEU} \quad \text{if } -\infty < \sigma < 0 \quad (15)$$

$$LAB_{Afr} + LAB_{EU} < POP_{AEU} \quad \text{if } -\infty < \sigma < 0 \quad (16)$$

Equation (13) shows the computation of the overall population in the Africa-EU macro-area. By assuming perfect immobility at the regional level (perfect complementarity, $\sigma = 0$), Eq. (14) is met and it is possible to skip the above-mentioned issue about different degrees of substitution across workers and people.

Nevertheless, when imperfect substitution is introduced for labor ($\sigma < 0$) Eq. (14) does not hold anymore and we need to insert three additional conditions to be respected:

$$LAB_{Afr} \cdot \varepsilon = POP_{Afr} \quad (17)$$

$$LAB_{EU} \cdot \varepsilon = POP_{EU} \quad (18)$$

$$(LAB_{Afr} + LAB_{EU}) \cdot \varepsilon = POP_{Afr} + POP_{EU} = POP_{AEU} \quad (19)$$

where $\varepsilon > 1$ is a correction factor which is used to satisfy Eq. (19). Referring to Figure 1, this means that point C_2 includes the correction factor ε. The point identifying the real labor supply in Africa and Europe is slightly below the population red line and the CET red curve is not actually tangent to it. We draw it this way just to make easier the theoretical explanation.

3. Policy experiment implementation

We have three scenarios. In the first one it is assumed only an integrated capital market between Africa and EU28. This is the benchmark scenario. In the second scenario the liberalization process involves not only the capital market but also the skilled labor market. Finally in the third scenario a full liberalization takes place in the capital, skilled and unskilled labor market.

In each scenario two types of demographic exogenous shock are simulated. The first one is the short run impact on population and covers the period 2015-2020. The second one is the long run impact and refers to the period 2015-2050.

We use the GTAP 8 database (Narayanan et al., 2012), the base year is 2007. Given the inconsistency between the reference year in GTAP 8, 2007, and the starting year of the exogenous drivers, 2015, we implicitly assume that the economic structures in 2007 and 2015 are similar and we carry out a comparative static exercise by implementing the demographic impacts in the base year 2007. We prefer this simplification because otherwise it would be complicated replicating the historical migration flows in the period 2007-2014 and inserting them in the three different scenarios. As a consequence, all the results must be interpreted as per cent changes with respect to the year 2015.

The regional and sectoral aggregations are not very relevant for the scope of this analysis. However I report them in Table 1 for further information.

Table 1: regional and sectoral aggregations

	Regions	**Sectors**
1	Australia, New Zealand	Grains and Crops
2	East Asia	Livestock and Meat Products
3	Southeast Asia	Mining and Extraction
4	South Asia	Processed Food
5	North America	Textiles and Clothing
6	Latin America	Light Manufacturing
7	**EU28** (European Union 28)	Heavy Manufacturing
8	Middle East	Utilities and Construction
9	**Africa**	Transport and Communication
10	Rest of World	Other Services

3.1 The demographic shocks

According to the United Nations projections, population in Africa is expected to grow by about 12.5% and 105.2% in the period 2015-2020 and 2015-2050, respectively. On the contrary, population in Europe will not grow in the period 2015-2020 and will decrease by about 4.6% in the period 2015-2050. The underlying assumption is that these relative changes affect in the same proportion skilled and unskilled labor.

To sum up in the short-run our exogenous drivers are:

```
qoreg("unskilled", "Africa") = qoreg("skilled", "Africa") = 12.5     (20)

qoreg("unskilled","EU28") = qoreg("skilled","EU28") = 0.06           (21)
```

In the long-run they are:

```
qoreg("unskilled", "Africa") = qoreg("skilled", "Africa") = 105.2    (22)

qoreg("unskilled","EU28") = qoreg("skilled","EU28") = -4.58          (23)
```

where qoreg is the exogenous demographic impact (percent change of the population derived from UN projections).[2]

In the GEMPACK version of the standard GTAP model equations are expressed as the FOCs linearized form. The labor and capital supply is fixed at the regional level. In our modified version of the GTAP model, we allow for labor and capital displacement from one shore to the other in the Mediterranean Sea. Below the new mathematical expressions for the unskilled and skilled labor supply and the (shadow) price of the unskilled and skilled labor in the Africa-EU28 macro-region:

```
FACSHR(i,r) = EVOA(i,r) / sum(r,REG, EVOA(i,r))                      (24)

poaeu(i) = sum(r,REG, FACSHR(i,r)* po(i,r))                          (25)

qo(i,r) = qoreg(i,r) + FACE(i)*[poaeu(i) - po(i,r)]                  (26)
```

where index i = (unskilled lab, skilled lab), r = (Africa, EU28), qo is percent change in the endogenous labor supply, po is the percent change of the associated price, poaeu is the percent change of the (shadow) price in the Africa-EU28 macro-region, FACE is a parameter representing the elasticity of substitution across workers (σ_L, σ_H), EVOA is the value of labor in 2007$, coefficient FACSHR is the regional labor share in the Africa-EU28 macro-region. Eq. (26) is the linearized form of Eqs. (8) and (9) in subsection 2.2 while Eq. (25) is the linearized form of Eqs. (4) and (6). The term qoreg(i,r) takes into account the fact that the population change is not uniform in the Africa-EU28 macro-region and for this reason it is linked to the index r.

At this point it is important to recall the issue of the productivity differentials between African and European workers, mentioned in subsection 2.3. The GTAP database does not report the volume of skilled and unskilled workers but only its monetary value in 2007$. The dataset considers also the level of total population which is consistent with the UN data. In the EU28 the value of unskilled and skilled labor is respectively eight and fifteen times higher than the value in Africa even if the number of population is almost two times higher in Africa than in Europe for the

[2] The different type is the GEMPACK code. GEMPACK is the software used in our simulations. Capital green font represents coefficients or parameters, small green font represents percent linear variables

same year. It is clear that value of labor incorporates the different levels of productivity in Africa and Europe.

Overlooking this aspect can lead to severely skewed results in the migration process. It is possible to understand this by applying the exogenous demographic shocks to Eq. (26). If we do this *sic et simpliciter* and then we take the percent changes in labor and translating them in migration movements, the results are meaningless. What we get is that a 40% decrease in the unskilled African population is equivalent to a one per cent increase in the European unskilled population. This is due to the FACSHR shares which do not reflect the real population's weights but the value of labor which, in turn, includes the different productivity levels.

In a competitive labor market the real salary is equal to the marginal productivity and it is reasonable that changes in labor supply behave consistently with the level of productivity. However we should correct Eq. (26) when we handle population's change. The easiest way to do it consists in replacing the factor's shares with the population's shares as described in the following equations:

```
POP(i,r) = POPTOT(r)*[EVOA(i,r)/sum(i,EVOA(i,r)]                    (27)

POPSHR(i,r) = POP(i,r)/[POP(i,"Africa") + POP(i,"EU28")]            (28)

ppaeu(i) = sum(r,REG, POPSHR(i,r)*po(i,r))                          (29)

pop(i,r) = qoreg(i,r) + FACE(i)*[ppaeu(i)-po(i,r))] + epsi(i)       (30)
```

where POPTOT is the total GTAP population in Africa and Europe, POP is the unskilled and skilled population obtained multiplying the total population in Africa and Europe by the ratio of skilled/unskilled value over the total labor value in the two regions as shown in Eq. (27), POPSHR is the regional share of skilled/unskilled population over the total skilled/unskilled population in the macro-area, pop is the percent change in the unskilled/skilled population, ppaeu is the percent change of the (shadow) price for population in the Africa-EU28 macro-region and epsi is the percent change of the correction factor ε such that Eq. (19) is met.

3.2 First scenario: capital market liberalization

The benchmark scenario is the capital market liberalization. The capital mobility should be modelled at the global level. However, as the focus of the analysis is Africa and Europe we limit it to this macro-area to better isolate the economic effects of the policy experiment.

Practically, the demographic shocks take place in an economic environment where the capital is free to move within the African-European macro-area according to Eq. (3). This seems to represent in a more realistic way the increasing mobility of capital (both physical and financial) which can be observed in the last decades.

The mobility of capital is not perfect. The value of σ_K is arbitrarily set equal to -10 in all the simulations. This number should represent a medium/high level of capital mobility as it corresponds to a value of ρ_K equal to 1.1, that is only 10% greater than 1 (perfect capital substitution across regions).

A better solution would be to carry out an econometric estimation of σ_K in order to get a more robust guess. To the best of our knowledge no estimation of this type exists and consequently we are forced to do an arbitrary choice.

In this scenario perfect immobility is assumed in the skilled and unskilled labor market:

$$\sigma_L = \sigma_H = 0 \qquad (31)$$

For this reason no migration opportunity is given to African and European workers/persons.

3.3 Second scenario: capital and skilled labor market liberalization

The further step consists in implementing skilled labor liberalization together with capital market liberalization in the Africa-EU28 macro-region given the same exogenous drivers.

In this scenario the elasticity of substitution in the three factors market are the following:

$$\sigma_K = -10\ ,\ \sigma_H = -1\ ,\ \ \sigma_L = 0 \qquad (32)$$

This means that migration process occurs only for skilled workers while unskilled workers are forced to stay at home. The value σ_H is set to be one tenth of σ_K. A smaller value for labor mobility results evident from the fact that the international capital mobility is much stronger than labor mobility because higher transition costs are associated with labor displacement while capital flows are very mobile worldwide, in particular if we consider financial capital flows.

A partial proof of this is the trend in the last twenty one years of FDI (Foreign Direct Investments) and international migration. FDIs have increased in real terms by about 264% at the global level in the period 1990-2011 (WB, World Bank Open Data) while annual international migration flows in the OECD countries have increased by 46% in the same period (OECD, International Migration Database).[3]

The liberalization of the skilled labor market is implemented by increasing from 0 to 1 the value of σ_H. Opening the market for skilled workers and not for unskilled can be considered a realistic option as preferential treatments exist in different developed countries for skilled workers.

3.4 Third scenario: capital, skilled and unskilled labor market liberalization

Finally, in the last scenario we simulate a simultaneous liberalization in the capital, skilled and unskilled labor market. The values for the elasticity of substitution are reported below:

$$\sigma_K = -10\ ,\ \sigma_H = -1\ ,\ \ \sigma_L = -1 \qquad (33)$$

As a consequence, all African and European workers (both skilled and unskilled) can cross the Mediterranean Sea with a certain level of freedom. The third scenario is the most unrealistic as we know from the news report how much trouble this crossing means in reality.

However it is fundamental to complete the intellectual exercise and to get insight on which economic forces are at work in this type of experiment.

[3] The FDIs represent only a part of the entire capital flows and they are very likely to be less mobile than other capital flows as portfolio investments.

4. Results

As explained, we distinguish short run effects (2015-2020) and long run effects (2015-2050) in each scenario by shocking our modified version of the GTAP model using Eqs. (20) and (21) for short run and Eqs. (22) and (23) for the long-run.

The results are comparative statics and no transitional dynamics is considered in this context, as well as catching up process between Africa and Europe. In addition we ignore the role carried out by capital accumulation.

In order to assess in some way inequality we establish a very rough rule. In general if capital price increases and labor price decreases inequality increases; if capital price decreases and labor price increases inequality decreases.

To sum up we show six sets of results, short and long run consequences for each one of the three scenarios.

4.1 Short run effects

We start from the short run effects in the benchmark scenario where only capital liberalization occurs together with the demographic impacts. Results are displayed in Table 2.

It is possible to note that the real GDP increase by 6.79% in Africa and slightly decreases in Europe (-0.08%). Capital moves from Europe to Africa and there is no migration process.

Interestingly, the capital liberalization determines a greater inequality both in Africa and Europe because labor price goes down and capital price goes up.

The interpretation of these results is not complicated. When the migration option is precluded Africa grows much because of the increase in the population and labor stock. In addition the capital flow from Africa to Europe strengthens the African growth and it is to detriment of Europe. Capital moves in this direction because African firms use more labor and this boosts also demand for capital. The price of capital rises and attracts additional capital from Europe.

Inequality increases in both Continents for specular reasons. In Africa wages go down because of the demographic shock while capital price goes up as the increased demand of firms overcompensates the capital inflows from Europe. In Europe the capital outflows cause an increase in the capital price while wages go down because of the lower demand faced by firms.

In Africa and Europe the population growth rates coincide with the UN demographic forecasts.

In the second scenario (Table 3), the liberalization in the skilled labor market determines a smaller increase of GDP in Africa with respect to the benchmark scenario, around 6.25% and a smaller loss in Europe (-0.02%). This is due to skilled net migration from Africa to Europe, about 129000 persons each year from 2015 to 2020.

In this second scenario it is not possible to clearly identify the dynamic of inequality with respect to the benchmark scenario essentially because unskilled and skilled wages follow divergent patterns.

The main difference between the first and second scenario is the possibility for skilled workers to migrate. The results are similar across the two specifications but the introduction of skilled movements within the Africa-EU28 macro-area is beneficial to Europe.

The reason for this is simple. The demographic shock affects also the stock of skilled workers in Africa and it reduces their wage. As a consequence they migrate toward Europe making the GDP loss smaller in the EU28.

In Africa and Europe the population growth rates become endogenous because it is the result of the interaction between the UN demographic forecasts and the endogenous supply of skilled labor. It continues to be exogenous for the macro-area. In Africa population increases by 12.03% while in Europe it grows by 0.97%.

Table 2: results in the first scenario ($\sigma_K = -10$, $\sigma_H = 0$, $\sigma_L = 0$)

	Africa	EU28	Africa-EU28 macro-area
Real GDP % Var wrt basedata	6.79	-0.08	0.42
Capital % Var wrt basedata	3.00	-0.27	0
Annual Skilled net migration (thousands)	0	0	0
Annual Unskilled net migration (thousands)	0	0	0
Annual net migration (thousands)	0	0	0
Population growth rate % (2015-2020)	12.50	0.06	8.25
Capital price % Var wrt basedata	0.57	0.25	0.27
Skilled price % Var wrt basedata	-6.44	-0.01	-0.41
Unskilled price % Var wrt basedata	-6.64	-0.02	-0.75

Table 3: results in the second scenario ($\sigma_K = -10$, $\sigma_H = -1$, $\sigma_L = 0$)

	Africa	EU28	Africa-EU28 macro-area
Real GDP % Var wrt basedata	6.25	-0.02	0.44
Capital % Var wrt basedata	2.80	-0.25	0
Annual Skilled net migration (thousands)	129	0	129
Annual Unskilled net migration (thousands)	0	0	0
Annual net migration (thousands)	129	0	129
Population growth rate % (2015-2020)	12.03	0.97	8.25
Capital price % Var wrt basedata	0.57	0.26	0.29
Skilled price % Var wrt basedata	-3.84	-0.16	-0.38
Unskilled price % Var wrt basedata	-6.86	0.02	-0.74

Table 4: results in the third scenario ($\sigma_K = -10$, $\sigma_H = -1$, $\sigma_L = -1$)

	Africa	EU28	Africa-EU28 macro-area
Real GDP % Var wrt basedata	4.40	0.18	0.49
Capital % Var wrt basedata	1.81	-0.16	0
Annual Skilled net migration (thousands)	153	0	153
Annual Unskilled net migration (thousands)	265	0	265
Annual net migration (thousands)	418	0	418
Population growth rate % (2015-2020)	10.99	2.98	8.25
Capital price % Var wrt basedata	0.52	0.32	0.34
Skilled price % Var wrt basedata	-4.37	-0.07	-0.33
Unskilled price % Var wrt basedata	-4.45	-0.21	-0.67

Finally, in the third scenario (Table 4) the complete liberalization of the labor market produces an average annual net flow from Africa to Europe of about 418000 migrants (265000 unskilled and 153000 skilled) in the period 2015-2020.

The result of these migration flows is that the African population will grow by about 11% in the period 2015-2020 and European population will grow by about 3%.

In this last scenario the African and European GDP will increases by 4.40% and 0.18%, respectively.

Turning to the primary factor prices, we can note that the full labor liberalization tends to reduce inequality in Africa with respect to the benchmark scenario. On the other hand the inequality increases in Europe.

The explanation is straightforward. In Africa wages go down but less than in the benchmark scenario as workers can migrate toward Europe. On the other side capital price increases but less than in the benchmark scenario because the demand faced by firms is now smaller.

In Europe wages decrease more than in the benchmark scenario as new workers are coming from Africa. On the other hand the capital price is greater than in the benchmark scenario because the increase in the demand faced by firms adds to the effect of the capital outflows, which is now less pronounced.

4.2 Long run effects

Regarding the long run effects in the benchmark scenario (Table 5), it is possible to note that the real GDP increase by 55% in Africa and decreases by 3.52 in Europe. The dynamic of capital moving from Europe to Africa is confirmed.

In Africa and Europe the population growth rates are the same of the UN demographic forecasts. As a consequence African population grows by 105.2% and European population decreases by 4.58% in the period 2015-2050.

In the second scenario (Table 6), the GDP rises by about 50% in Africa and reduces by about 3% in Europe. Europe experiences a better performance thanks to skilled migrants from Africa. The annual average of net skilled migration is around 1083000 persons from 2015 to 2050. This causes a population increase in Africa and Europe by 101.31 and 2.96, respectively. Interestingly, Europe is able to invert its negative demographic trend.

In the third scenario the average annual net flow from Africa to Europe is about 3450000 migrants (2167000 unskilled and 1283000 skilled) in the period 2015-2050.

The result of these migration flows is that the African population will grow by about 92.6% and European population will grow by about 19.63%. Clearly the redistribution process lowers the demographic pressure in Africa while slowing down the European aging.

In this last scenario the African GDP will increase by 34.41% while European GDP will decrease by 1.54%. The unskilled market liberalization makes less uneven the GDP outcomes across Africa and Europe.

It can be useful to carry out a comparison between short and long run. As expected the magnitudes in changes are bigger in the long run than in the short run. This is due to the stronger and divergent demographic impacts across Africa and Europe, which characterize the long run. However, the direction of the economic effects and their interpretation basically do not change between short and the long run as the fundamental forces which are working are the same.

This is mostly true for inequality. In the long run inequality increases in Africa but reduces in Europe in the benchmark scenario. Its direction is ambiguous in the second scenario. It decreases in Africa and increases in Europe in the third scenario with respect to the benchmark, exactly the same dynamic observed in the short run.

Table 5: results for the first scenario (σ_K = -10, σ_H = 0, σ_L = 0)

	Africa	EU28	Africa-EU28 macro-area
Real GDP % Var wrt basedata	55.02	-3.52	0.71
Capital % Var wrt basedata	24.74	-2.12	0
Annual Skilled net migration (thousands)	0	0	0
Annual Unskilled net migration (thousands)	0	0	0
Annual net migration (thousands)	0	0	0
Population growth rate % (2015-2020)	105.20	-4.58	67.63
Capital price % Var wrt basedata	2.12	-0.45	-0.24
Skilled price % Var wrt basedata	-43.32	1.46	-1.56
Unskilled price % Var wrt basedata	-44.35	1.52	-4.05

Table 6: results for the second scenario (σ_K = -10, σ_H = -1, σ_L = 0)

	Africa	EU28	Africa-EU28 macro-area
Real GDP % Var wrt basedata	50.22	-3.07	0.78
Capital % Var wrt basedata	23.13	-1.99	0
Annual Skilled net migration (thousands)	1083	0	1083
Annual Unskilled net migration (thousands)	0	0	0
Annual net migration (thousands)	1083	0	1083
Population growth rate % (2015-2020)	101.31	2.96	67.63
Capital price % Var wrt basedata	2.08	-0.32	-0.12
Skilled price % Var wrt basedata	-26.40	0.32	-1.38
Unskilled price % Var wrt basedata	-45.67	1.81	-3.98

Table 7: results for the third scenario (σ_K = -10, σ_H = -1, σ_L = -1)

	Africa	EU28	Africa-EU28 macro-area
Real GDP % Var wrt basedata	34.41	-1.54	1.05
Capital % Var wrt basedata	15.22	-1.33	0
Annual Skilled net migration (thousands)	1283	0	1283
Annual Unskilled net migration (thousands)	2167	0	2167
Annual net migration (thousands)	3450	0	3450
Population growth rate % (2015-2020)	92.60	19.63	67.63
Capital price % Var wrt basedata	1.74	0.13	0.27
Skilled price % Var wrt basedata	-29.92	1.04	-0.96
Unskilled price % Var wrt basedata	-30.30	0.08	-3.45

It is also worth noting that the overall welfare in the Africa-EU28 macro-area (measured in terms of real GDP changes) improves when increasing the (capital and labor) factors mobility both in the short and long run.[4] If we look at the short run, the increase in real GDP moves from 0.42 in Table 2 to 0.49 in Table 4 for the macro-area. If we refer to the long run, the increase in real GDP moves from 0.71 in Table 5 to 1.05 in Table 7 for the macro-area. These results are consistent with the neoclassical theory of competitive markets on which the CGE models are essentially based.

4.3 Sensitivity analysis

The elasticities σ_K, σ_H and σ_L regulate the geographical substitution of capital, skilled and unskilled labor in the Africa-EU28 macro-region. They are clearly the key parameter in this work. Unfortunately we cannot find econometric estimation to properly calibrate these coefficients. For this reason we carry out a sensitivity analysis in order to assess how results change according to different values of σ_H and σ_L.

We keep fixed to -10 the value of σ_K and we try to establish a reasonable range for σ_H and σ_L. The determination of the lower bound is simple as it corresponds to the case of perfect labor immobility ($\sigma_H = \sigma_L = 0$). To identify the upper bound we decide to use the value of σ_K as threshold. The underlying assumption is that the mobility of labor cannot be bigger than the mobility of capital.

The results are displayed in Table 8 for the long run demographic impacts. By looking at the Table 8 it is immediately evident that population changes are very sensitive to the choice of these parameters.

Table 8: Population growth rate % (period 2015-2050)

	Africa	Eu28
$\sigma_K = -10, \sigma_H = \sigma_L = 0$	105.2	-4.58
$\sigma_K = -10, \sigma_H = \sigma_L = -1$	92.60	19.63
$\sigma_K = -10, \sigma_H = \sigma_L = -5$	78.26	46.90
$\sigma_K = \sigma_H = \sigma_L = -10$	73.7	56.16

[4] It is possible to show that the welfare changes measured by the standard measure of Equivalent Variation (EV) have the same directions.

Conclusion

In this work we have tried to assess possible migration flows between Africa and European Union by interlinking demographic patterns and labor market liberalization within a general equilibrium framework.

The modified version of the GTAP model is able to replicate endogenously the current direction of these flows (from Africa to Europe). Nevertheless the magnitudes strongly depend on the value of the elasticity parameter regulating the factors mobility.

Even if the list of the results is long, the interpretation is not complicated because it is based on the international trade theory of comparative advantages applied to capital and labor endowments. As the Heckscher-Ohlin Theorem states that the country exports the good which uses more intensively the relative abundant factor, similarly in a context of geographically mobile endowments the country "exports" the relative abundant factor.

To simplify, in this analysis the demographic impacts disrupt the economic system in Africa and Europe. These shocks make labor the relative abundant factor in Africa and make capital the relative abundant factor in Europe.

Ruling out the possibility to migrate and on the other hand making possible the capital movement it is beneficial only for Africa. Liberalizing the labor market allows also Europe to take advantage from the trade in the factor endowments. This explains the endogenous migration from Africa to Europe and the effects on GDP.

However it is worth noting that a direct relationship between GDP growth and inequality can be observed with respect to the benchmark scenario when the labor market is fully liberalized both in Africa and Europe and both in the short and long run. Interestingly, the capital liberalization in the benchmark scenario causes an increase in inequality for Africa both in the short and long run while Europe experiences a decrease of inequality in the long run and an increase in the short run.

This assessment presents a not negligible drawback because it does not consider the role carried out by remittances. Their inclusion in the model would be important to give more realism to the analysis.

Further development could try to take into account a catching-up mechanism between Africa and Europe by considering for example the skilled/unskilled composition rather than the technological progress.

The econometric estimation of the elasticity parameter which causes the factors mobility is also worthy because we have seen that results are very sensitive to different values of it.

In addition it would be interesting to extend the geographical opportunity to migrate outside the Africa-EU28 macro-region. The approach of Walmsley et al. (2007) and Shi and Tyers (2005) could be a good starting point.

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