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# Brain Drain in Sub-Saharan Africa
## Winners or Losers? Evidence from recent data

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# Brain Drain in Sub-Saharan Africa: Winners or Losers?

*Evidence from Recent Data*

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**Abstract**

SSA appears to be the second most affected region of the world by brain drain behind Caribbean; size of brain drain in SSA has been increasing overtime from 14.2% in 1980 to 17.4% in 2010. Moreover, it was more than 2 times the size in developing countries globally and more than 3 times the size at the world level. This study evaluates the net economic consequences of brain drain to determine whether SSA countries are net winners or net losers and then, how the net effect evolves overtime in a static comparative perspective. We show that SSA as a whole is a net winner but with gains declining overtime; at regional level, Southern and Western Africa are net winners with net gains declining overtime while Middle and Eastern Africa started net winners but end up net losers. We also show that there are more winners than losers, but the number of losers has been increasing (from 4 in 1980 to 20 countries in 2010) and the winners decreasing. Futhermore, we hightlight the persistence of losses in the sense that once a country becomes a net loser, it remains in that situation. Finally, We show that threshold size of BD in SSA is structurally explained by the increasing pattern of losses and decreasing pattern of gains with respect to the size of brain drain. This threshold stands between 20% and 25%.

JEL Classifications: D62, F22, F24, H22, J24, 015
Keywords: Brain drain, SSA, Net effect, Winners, Losers, Threshhold

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# Contents

# 1 Introduction

Until the late 1960s, there was an international consensus on the issue of South-North migration of elites, which was seen as an investment on the future. After the colonial and postcolonial periods, when it was practically instituted that children of the local elites should go abroad in developed countries to study and then take over from the colonial administrations, emigration for studies was considered as being one of the strong points of proactive development policies. In due course, this should enable countries of origin to build up a sufficiently large and qualified pool of human resources to stimulate development through the deployment of the educational system, technological development, improved health, among other things. However, while study abroad was widely viewed favorably in the aftermath of independence, it was still only a necessary evil until countries were able to institutionalize their higher education system.

Indeed, Africa experienced a particularly active phase of institutional creation (higher education and research institutions) during the 1970s and 1980s, accompanied by an explosion in the university population and a strong growth in the number of researchers (Gaillard and Waast, 1988). But it became clear in the mid-1980s that the cost of higher education were becoming problematic and were competing dangerously with those of primary and secondary education, even though the latter were proving to be more productive than those of higher education (World Bank, 1986). As a result of the economic crisis of the 1980s, programs for institutionalization of higher education were being revived, with the result that the temporary hope for dependence on northern education systems was increasing and the rate of attrition was accelerating as more and more young graduates (from secondary or university undergraduate level) had to seek ways to continue their studies abroad.

It gradually became apparent that the massive emigration of students from South was not compensated by a counter flow of return. As a result, the notion of exodus became necessary. Today, we are no longer talking only about students, but about professional trained in African universities and who respond to the demands of a globalized labor market. However, we have come out of the controversy that, during the 1950s, animated the debate around the questions of "losses" or "gains" that made the heyday of the famous "brain drain controversy" (Das, 1971) where two strands were clashing: the "internationalists" and the "nationalist" (Adams, 1968). The "internationalists", supporting the liberal economy, analyzed this migration to the North as a normal phenomenon in an international market because, according to them, skills go where their remuneration and productivity are optimal. The "nationalists" supported their thesis with arguments based on two assumptions: 1) international economy does not allow an equitable distribution

of skills (which go to the North and are cruelly lacking in the South); 2) migratory movements of skills are artificial because they are induced by the selective migration policies of the host countries, with a direct objective of profit. In many developed countries, highly skilled workforce (employed in knowledge- intensive activities) is recruited from poor or emerging countries and examples abound. If we can believe Brucker et al(2013) dataset, in 2010, in 16[1],out of 47 Sub Saharan African (SSA) countries with available data, highly skilled workers represented 50% or more of the expatriates living in OECD[2] countries; while they were only 4[3] in 1980. At least 10 SSA countries experienced large physician brain drain ranging from 21% with Malawi up to 51% in Liberia (Bhargava et al,2010). In those two countries, more than 10 physicians should be trained to expect 4 to remain in the country. According to UNESCO[4], every year, some 23 000 university graduates and 50 000 managers leave sub-Saharan Africa. More than 40 000 Africans PhD graduates are currently living outside Africa. Moreover, as argued by Benedict and Upkere (2012), around 40 percent of some Africa's brightest minds live outside of the continent. Taking the case of skilled migration toward United States, Kevin (2016) highlighted the fact that overall emigration flows of highly skilled Africans more than doubled between 1980 and 2010.

This situation raises on the one hand an important question regarding the consequences of this human capita flight in SSA, and on the other hand the question of whether positive effects of brain drain compensate its negative effects in the sending countries. Also the question of the pattern of this net effect overtime is raised. Except the recent trial by Docquier (2017) for the year 2010, the existing empirical literature has not yet properly addressed this issue such as to come out with an adequate answer which is to our view crucial design of adapted policy required to minimize loss of losers and mazime gains for winners.

As documented by Brucker et al (2013), over the period 1980-2010, skilled emigration rate all over the world remains almost stable (from 4.9% in 1980 to 5.3% in 2010) while it has been incresaing quite rapidly in SSA (from 14.2% in 1980 to 17.4% in 2010) making SSA the second most affected region of the world after the Caribbean (Brucker et al, 2013) with its brain drain in 2010 amounting more than 3 times the world average level (5.3%) and more than 2 times the developing countries average level (8.0%). Out of the 47 countries for which data are available, those exhibiting more than 20% brain drain moved from 13 to 24 between 1980 and 2010; in other words, 51% of SSA countries experienced a level

[1]Cameroon, Ethiopia, Gabon, Kenya, Lesotho, Liberia, Namibia, Niger, Nigeria, Rwanda, Sierra Leone, South Africa, Sudan,Tanzania, Zambia and Rwanda

[2]Organization for Economic Co-operation and Development

[3]Lesotho, Liberia, Namibia and Rwanda

[4]United Nations Educational, Scientific and Cultural Organization

of brain drain in 2010 high enough to becomes detrimental for them in the sense of Beine et al, (2008a). Those with more than 15% moved from 15 to 27 representing 57.4% of SSA countries. Putting in another way, the number of countries experiencing a low brain drain (BD below 15%) in SSA has been declining (from 32 in 1980 to only 20 countries in 2010). Those observations raise an important question: **What is the net impact of brain drain in SSA countries? In other words, are negative effects of brain drain fully compensated by its positives effects?**

The main objective of this study is to evaluate the net effect of brain drain in SSA over the period 1980 - 2010 for each country and each region. In order to achieve this goal, on the one side we evaluate the economic loss due to brain drain and on the other side, we evaluate the economic gain generated by skilled emigration in source countries. First, in order to evaluate skilled emigration loss, we use the labour demand - labour supply model introduced by Borjas(1995) and which has been adapted to emigration by Mishra (2007) in which we include education subsidies and change the production function from a linear form into a C.E.S form. We have considered three scenarios: i) skilled emigration loss in absence of externality, ii) skilled emigration loss in presence of externalities and iii) skilled emigration loss in presence of externalities and education subsidies. The third scenario gives the most complete skilled emigration loss function that we then estimate. Our quantitative assessment shows that the mechanical loss due to the reduction of the size of skilled labour force and the external effect it has on the productivity of those left behind both skilled and unskilled constitute the main share of losses in SSA while losses from education subsidies are rather limited.

In order to evaluate the skilled emigration gain, we first estimate remittances from skilled migrants and then we use development accounting model to account for i) endogenized education decision and ii) diaspora externalities. Once accounting for the three feedbacks mechanisms (remittances from skilled migrants, endogenized education decisions and diaspora externalities), it appears remittances are the lowest component of the brain gain and that endogenized education decisions constitute the main component of brain gain especially in countries combining low brain drain and low per capita income. But it declines with the size of brain drain and the level of development. It also reveals that gains from diaspora externalities increases with the size of brain drain and level of developement and outweigh gains from endogenized education decisions in countries exibiting more than 25% brain drain and with per capita income above 4000$

In short, we derive net effect (either net brain loss or net brain gain) by substracting brain loss to brain gain. It appears that remittances alone cannot offset losses from brain drain. In addition, a simple average analysis indicates that SSA is on average a net winner for the entire period covered by this study. At the

regional level, Southern Africa and Western Africa are net winners while Middle Africa and Eastern Africa end up being net losers (from 2005). But when those gains are weighted by the population size, both SSA and the differents regions are net winners. This mainly comes from the fact that five large countries (D.R. Congo,Ethiopia, Nigeria, South Africa and Tanzania) which account for 49.2% of SSA population are net winners and drive the results. In addition, it appears that there are more winners than losers. But these "a priori" optimistic results hide a very critical situation. Despite the fact that SSA has been a net winner for the entire period covered, those gains have been severely declining (from 12.8% of per capita income gain in 1980 to 1.2% in 2010) and this decreasing pattern is observed for all the regions (EA, MA, SA and WA). Even if there are more winners than losers, the number of losers is increasing with the natural consequence of a decrease in the number of winners and losses appear to be persistent in the sens that once a country becomes a loser, it remains there (there are only two exceptions which are Liberia and Mozambique).

The rest of the study is organized as follows: section 2 summarizes the existing literature, section 3 presents the magnitude of brain drain in SSA, section 4 presents the structural model developped in order to evaluate the net effect of brain drain, section 5 presents how parameters are calibrated, section 6 presents and discuss results and section 7 concludes.

# 2 Economic impact of Brain drain in source countries: A literature review

This section will provide an overview of the existing literature on the consequences of brain drain in the source countries. It will explore both theoretical and empirical literature. It is possible to identify three main strands of this literature: neutral strand (1), pessimistic strand (2) and optimistic strand (3).

## 2.1 Neutral strand of the 1960s

This view has been conducted in the late 1960s with authors such as Grubel and Scott (1966); Johnson (1967); Berry and Soligo (1969). It concluded that skilled migration were neutral in terms of compensating for the loss in human capital linked to migrants' departure by remittances and/or assets left behind. Thus, brain drain was considered at that time to be marginal and without much consequences.

In fact, the argument that a country loses from the brain drain is most

nearly always valid when a country whose national objective is to maximize its economic performance. From this point of view, brain drain reduces the country's mobilizable human capital and its national output is lowered by the amount the emigrants contributed to it. But, this view of national losses is "outmoded" and unrealistic because economic performance depends not so much in aggregate national output as it does on per capita income which may or not be affected by an individual emigration. In the place of this "outmoded" perspective, Grubel and Scott (1966), suggested to use another perspective according to which a country is an association of individuals. The country's leader objective is to maximize the collective welfare. Here, the most important determinant of welfare in the long run is standard of living. Brain drain will increase this standard of living under two conditions: first, if the emigrant improves its own income once abroad; and second, if the emigrant's departure does not reduce the income of those left behind. For the traditional analysis, labor migration raises the long run average income of those left behind. But, in case of skilled migration, this conclusion does not hold if human capital embodied in the emigrant is greater than the country's total per capita endowment of human and physical capital. This assume perfect substitutability in these two forms of capital in the long run. In this case, brain drain reduces total income to be distributed among residents, which leads to the reduction in per capita income and thereafter to the reduction of the welfare in that country. In a market economy where individuals are paid their marginal product, such a reduction in per capita income is only a statistical phenomenon which has no influence on the welfare of those left behind. There may be income redistribution effect through changes in the marginal product of the remaining people, but since a small number of people are involved in the brain drain, these effects are likely to be small enough to be safely considered as being "negligible".

Moreover, negative apprehension of brain drain is above all a nationalistic apprehension by which economic welfare is viewed in terms of welfare of the residents as being totally excluded from that of the outside world. This view completely ignores the principle that in every transaction, there is both a demand and a supply (Johnson, 1967). Under an international trade framework, this author concluded that brain drain is unlikely to produce world loss, and is rather likely to produce substantial increases in the world economic welfare. Any possibility of world loss must hinge on a loss of externalities to the country of emigration, unmatched by an offsetting gain of externalities to the country of immigration, and quantitatively large enough to outweigh the private income gains of the migrant. Two theoretical possibilities of such loss of externalities may be presented: (i) Individuals who might have made scientific discoveries or introduced improved methods of production or management that would have substantially increased the productivity of resources in developing countries, may be diverted to higher paid

activities of a more routine nature lacking such externality beneficial effects. But, one may also think that the country of emigration may have lacked the resources or failed to provide the social and economic climate necessary to successful innovation. In some cases, the individual migrates only because a developed country can provide him the required resources to solve his research problem or the freedom to experiment new production and management ideas. In other words, emigration may be the only way for an individual to create a positive externality for his home country. (ii) Members of a particular profession may generate externalities in a developing country that they do not generate in developed country. In this setting, brain drain will be a world loss if the contribution to world output does not outweigh their contribution when they were in their home country.

As a result, in a market economy, effects of brain drain must be sought only either in short run adjustment cost or in market failures. In addition, long run effects on welfare are associated with free market failure to allocate resources efficiently and the two main sources of such inefficiencies are externalities[5] and governmental education subsidies[6] . But, externality only imposed short run cost of adjustment and migrants provide remittances, support their native countries through counsels and advices (Grubel and Scott, 1966; Johnson, 1967) and most often, they have left assets behind (Berry and Soligo, 1969).

## 2.2 Pessimistic view of the 1970s

Central results of neutral view stating that brain drain should not be a worry as skilled migrant will only take away the value of its marginal product which himself earns anyway, can be subject to strong limitations. As argued by Bhagwati and Hamada (1974), there are three important limitations to this view.

[5]The market fails properly to compensate the individuals for the contributions they make to society. These externalities are usually associated with personal characteristics of the emigrants and not their profession. For example, doctor work contains a large measure of social benefits for which he is not compensated. If he migrates, these benefits are lost to the society only for the length of time required to train another medical doctor; brain drain thus impose only short run frictional cost to society and which disappear in the long run

[6]This category of losses stems from market failure remedied through activities of government. It is alleged that brain drain affect others mostly through changes in the cost of providing such government services. It is frequently suggested that public education is a social investment in individuals which emigrants fail to repay. But this "debt to society" (Grubel and Scoot, 1966) is based on misapprehension. In fact, society is a continuing organism, and the process of financing education represent an intergeneration transfer of resources under which the currently productive generation taxes itself to educate the young who in turn upon maturity provide for the next generation of children and so on. More importantly, average burden of financing education falling on the emigrant generation is not changed by his departure, because he takes along not only his contribution to tax revenue, but also his children, on whom this share of revenue would have been spent.

First, for large rather than infinitesimal shifts of labor, there would still be a loss for those left behind. Second, if social returns exceed private returns because of strong externalities, then again, there is a loss for those left behind. And third, if government has subsidized the education which is embodied in the skilled individual who migrates and if government would have taxed this skilled individual (realistic with progressive taxation) partially or wholly to recover the return on this investment, then, his emigration does deprive those left behind of this return and thus worsens their welfare.

Thus, this second strand will contrast a bit with the neutral's one. It explores the welfare effect of brain drain on those left behind in a more realistic setting. Studies conducted under this strand considered domestic labor market rigidities (Bhagwati and Hamada, 1974), informational imperfection (Hamada and Bhagwati, 1975) and fiscal losses (Bhagwati and Hamada, 1974; Bhagwati and Rodriguez, 1975) which have been introduced to emphasize the negative consequences of the brain drain on source countries. Brain drain was viewed as contributing to the increased inequality between developing and developed countries (McCulloch and Yellen, 1977) most often through important reduction in human capital already lacking in such countries (Haque and Kim, 1995) as well as other negatives consequences highlighted earlier.

**Labor market rigidies**: If the foreign wage level is taking into account when computing the expected wage of educated labor, this will increase the supply of educated labor and reduce national income by the incremental educational cost. If the foreign wage level is high enough, we could also have an increased unemployment of educated labor and reduced per capita income. The induced wage-increase of educated labor, further national income will also be likely to reduce. There could also have a "leap-frogging process" such that the wage of uneducated labor could rise in response to the rise in wage of educated labor. The net effect in this case can be to reduce the supply of educated labor. Thus, even in the absence of externalities, brain drain can easily lead to unfavorable effect on national income, per capita income and unemployment of educated labor.

**Informational imperfection**: In a very simplified form, "screening theory of education"[7] states that education is important, not so much because it increases the productivity of workers, but mainly because it plays the role of signaling efficient labor from labor in general. Hamada and Bhagwati (1975) used this approach and considered the case where brain drain serves to identify and thus screen, the more efficient from the less efficient workers. Then, if domestic market cannot discriminate as effectively as the international market for professionals, so the economy tends to lose because emigrants are picked up from the category of

[7]Developed by Arrow (1973) and Spence (1974)

the more efficient. So, since emigrants are chosen from the highly gifted category that domestic market fails to identify, brain drain could cause a welfare loss even with flexible wage rates.

**Fiscal loss**[8]: Educated emigrants do not pay taxes in their home country once they left. As education is partly or wholly subsidized by the government, emigrants leave before they can repay their "debt to society". This fiscal loss is likely to be increased by distortion in the provision of public education away from general skills when graduates emigrate with the source country ending up educating few physicians, engineers, scientists and too many lawyers, accountants.

**Increased inequality between developing and developed countries**[9] : By increasing the technological gap between developed and developing countries through the concentration of human capital in developed countries, brain drain exacerbate inequality between rich and poor countries.

**Reduction in human capital:** Brain drain is likely to reduce the growth rate of the human capital that remains in the economy and hence generates a permanent reduction in per capita growth in the home country as alleged by Haque and Kim (1995).

## 2.3 The optimistic strand of the mid 1990s

Due to the importance of human capital accumulation for economic performance in an economy, the pessimistic view has alleged that brain drain may leave developing countries in a kind of "poverty trap". This might be explained by the fact that the average level of human capital in the origin country (mainly developing country) will not grow because destination countries (mainly developed countries) will divert their highly educated workers, thus increasing the productivity of the developed countries at the expense of the developing countries. But, in the mid-1990s, a third strand of studies on development impact of brain drain in source countries has emerged. It builts its argument around the fact that, when emigration is not a certainty, brain drain can foster human capital accumulation, rising the productivity and consequently enhance economic performance in the source countries creating the possibility of a beneficial brain drain with "brain effect"[10] dominating "drain effect"[11] (Mountford, 1997; Stark et al, 1997, Beine et al, 2001).

In fact, if future emigration is not a certainty, and if the probability to migrate is not too high, brain drain would be likely to enhance human capital

[8]See Docquier (2014)
[9]See Docquier (2014)
[10]Migration prospects foster investment in human capital due to higher return abroad.
[11]Actual migration flows reduced the available stock of human capital

accumulation in the source country and then increase productivity. The rise in human capital accumulation (Mountford, 1997; Beine et al, 2001) driven by the rise in expected return of education also leads to an endogenous formation of educational classes (Mountford, 1997). From this perspective, brain drain may well be viewed as a "disguise blessing" (Stark et al, 1997) since it can result in a brain gain because of opportunities it creates, incentives in education investment it increases and information it provides for the identification and differentiation of individuals' productivities (Stark et al, 1997)[12]. Globally, there will be an optimal level of brain drain which weights the benefits of emigration with the cost of skill depletion of a brain drain. This might legitimate the use of emigration quota policies in source countries.

By relying on Haque and Kim (1995); Mountford (1997), Beine et al (2001) evaluated the impact of brain drain on human capital formation and growth in small opened developing economies, their results suggested that beneficial brain drain was possible. Their empirical investigation evidenced that beneficial brain drain dominates in developing countries under a global perspective (even if there were more losers than winners in terms of countries).

So far, the existing literature presented has been at the first stage descriptive (neutral view) and at a second stage theoretical (pessimistic and optimistic views) except the study by Beine et al (2001) which was both theoretical and empirical. After the pioneering study by Beine et al (2001), a wide range of empirical literature has tried to address the issue of impact of brain drain in source countries. Those studies have tried to investigate how brain drain affects human capital formation (Beine et al, 2007; 2008a), economic growth (Beine et al, 2003; Schiff,2006), welfare of those left behind (Di Jiovani et al, 2015; Schiff, 2006; 2018), offseting capacity of remittances (Mishra, 2007) and overall net effect of brain drain (Docquier, 2017). Those studies suggest that brain drain enhance human capital formation and economic growth in source countries combining low level of human capital and low skilled emigration rate while countries with high skilled emigration

[12]Using three important considerations such as opportunities, incentives and information, Stark et al (1997) showed that brain drain might rather be a disguised blessing since it could result in a brain gain in origin countries. In fact, faced with an opportunity to migrate and receive higher expected returns to investment in human capital, some workers in home countries acquire human capital and migrate. Employers in destinations countries initially pay all migrant workers the same wage based on the average product of the group of migrants. After identifying individual skills, employers adjust their wage payments to individual productivities such that relatively low skill-workers enjoy a pre-discovery high wage, but a lower wage following discovery. Such a wage is likely to prompt return migration by these workers. To end up, brain gain may occur without recourse to the argument that the gain arises from new skills that are acquired abroad and are brought home upon return. Since prospective migration favorably alters the incentives of poor's countries workforce to invest in human capital, origin countries' governments should reconsider before engaging on measures that hinder migration.

rate (above 20%) and proportion of highly educated in the total population above 5%. In terms of countries, they observed more losers than winners while in terms of population size, winners represent nearly 80% of the total population. It effects on welfare is rather ambiguous because even if brain drain induce net brain gain, source countries' residents are worse off under the brain drain than under a closed economy in many scenarios.[13] When residents are better off under migration, it is mainly through remittances in some large recipient countries[14], but, on average, remittances do not offset negative consequences of brain drain. By adding endogenized education decision and diaspora externality to remittances, Docquier (2017) concluded that all the developping countries with per capita income below 6000$ are net winners.

# 3 Magnitude of brain drain in Sub Saharan Africa: insights from recent data

## 3.1 How big is brain drain in SSA overtime and with respect to the rest of the world?

In 1975, United Nations Conference on Trade and Developement (UNTACD) estimated South-North skilled migration over the period 1961 - 1972 to be around only 300 000 individuals. Two decades later in 1990, US census estimated at 2.5 million highly skilled immigrants from developing countries living in United States. After Carrington and Detragiache (1998) as well as well as Docquier and Marfouk (2006) who tried to construct a wide dataset on immigration in OECD countries by level of education in 1990 for the first and 1990 as well as 2000 for the second, Brucker et al (2013) constructed an innovative panel dataset for 195 countries from 1980 to 2010 with 5 years interval in 20 OECD countries. Their data showed that the total number of skilled migrants from SSA living in OECD increased in a very sustainable way from 0.18 million in 1980 to 1.7 million in 2010 and those data strongly support the idea that there is a strong negative correlation between brain drain and the size of the population. In the remainder of this study, data considered on brain drain are from Brucker et al (2013).

As presented in table 1, at the world level, size of brain drain has remained almost constant (from 4.9% in 1980 to 5.3% in 2010) and this dynamic has been

[13] Schiff (2018) compare resident's welfare for an open versus closed economy under the presence or absence of education externality(1), with or without government intervention(2) and equal government concern for residents and migrants or greater for residents(3)

[14] Di Giovani et al, 2015

kept to some extend in developping countries which experienced a small increase in the size of brain drain (from 6.8% in 1980 to 8.0% in 2010). At the same time, SSA experienced a quite rapid increase in the size of brain brain moving from 14.2% in 1980 to 17.4% in 2010. So, size of brain drain in SSA was far above the world level (more than three time in 2010) as well as the developping countries level (more than 2 time in 2010). Moreover, in 2010, SSA was the second most affected region by brain drain (17.4%) behind Caribbean (56%); When Caribbean and Latin America are putting together (13.2%), SSA becomes the most affected region of the world.

Table 1: Distribution of Brain Drain by region in the world (1980 - 2010)

| **World distribution (BD)** | 1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|---|
| World | 4.9% | 4.8% | 4.2% | 4.1% | 4.1% | 5.0% | 5.3% |
| Developing countries | 6.8% | 7.0% | 6.5% | 6.2% | 6.5% | 7.8% | 8.0% |
| East Asian and Pacific | 5.0% | 5.2% | 4.7% | 4.7% | 4.6% | 5.2% | 4.8% |
| Europe and Central Asia | 3.2% | 3.1% | 2.8% | 3.7% | 4.5% | 6.8% | 7.7% |
| Latin America and Caribbean | 8.6% | 10.4% | 10.6% | 9.5% | 9.9% | 12.4% | 13.2% |
| Middle East and North Africa | 18.4% | 16.1% | 13.3% | 11.5% | 10.7% | 10.4% | 9.9% |
| South Asia | 4.2% | 3.7% | 3.1% | 3.6% | 3.7% | 5.1% | 5.3% |
| Caribbean | 49.3% | 55.3% | 55.9% | 53.8% | 52.3% | 55.9% | 56.9% |
| Sub Saharan Africa | 14.2% | 15.0% | 14.9% | 12.9% | 14.0% | 16.2% | 17.4% |

Source: Brucker, Capuano and Marfouk (2013)

This overall analysis hide a lot of disparities across SSA countries groups with respect to different characteristics (population size, income group and regions).

## 3.2 Size of brain drain in SSA by demographic, income and geographic characteristics

In order to make a kind of "anatomy" of brain drain in SSA over the considered period, we decompose SSA as depicted in table 2 below. Table 2 and figure 1 below provide us such an "anatomy".

When comparing skilled emigration rates by country size, it appeared that, in SSA over the period 1980 - 2010, all the country groups have experienced an increase in brain drain (BD) whatever the size of their population. But still, large countries (more than 25 million inhabitants) experienced the smallest increase in BD (2.4% increase on average per year) while small countries (between 2.5 and 10 million inhabitants) experienced the highest increase in BD (9.9% increase on

average per year). Medium (between 10 and 25 million inhabitants) and very small countries (less than 2.5 million inhabitants) experienced relatively large increase in BD (5.7% and 7.2% on average per year respectively). Large countries experienced both a low increase in the BD and the smallest level of observed BD suggesting that brain drain decreases as the size of population increases. Albeit large countries exhibited low brain drain and low increase in BD, the share of skilled among the migrants' population represented on average 50% of total of their emigrants while it was only 34%, 40.9% and 38.1% respectively for medium, small and very small countries. Moreover, large countries experienced the second fastest increase in the skilled migrants compared to unskilled (6.3%) behind medium countries (7.3%). In overall, it appeared that for large and medium countries, the pattern of brain drain has not been monotonic. After a period of increase (1980-1990), it declines (1990-1995) and then starts rising (1995-2010). But for small and very small countries, the trend has been quite monotonic: brain drain has been increasing over the entire period covered (1980 - 2010).

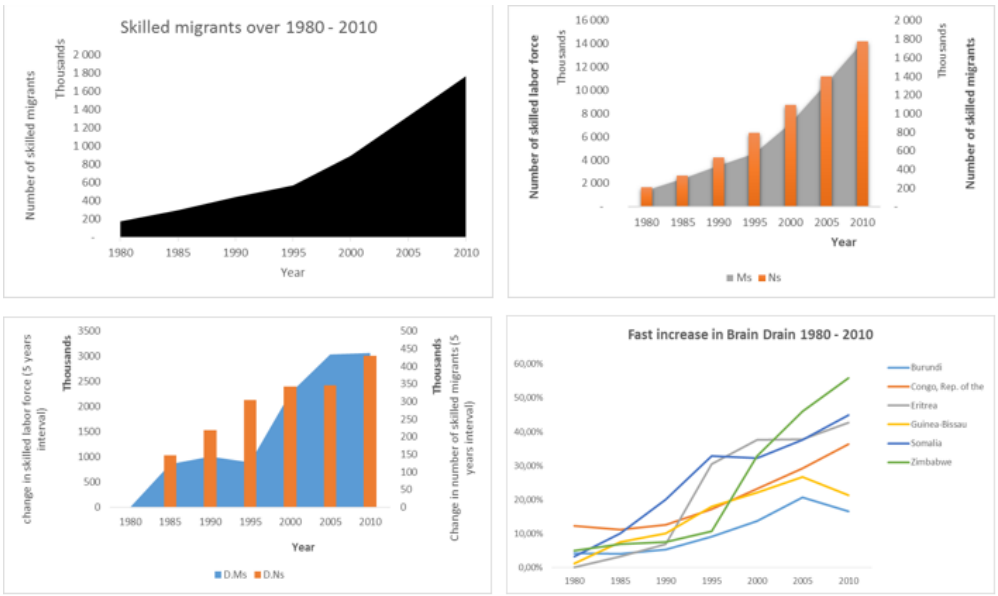
When comparing skilled emigration rates by income group, it appeared that, while upper middle income countries (UMIC) experienced a 4.9% decline in brain over the covered period (from 18.04% in 1980 to 13.37% in 2010), high income countries (HIC) by 2.7% (53.4% to 62.6%), low income countries (LIC) by 4.9% (from 15.2% to 20.3%) and lower middle income countries (LMIC) by 5.4% (from 12.1% to 16.6%) experienced an increase in BD. Moreover, LMIC has been the income group which experienced the fastest increase in BD . This supports the idea that in LMIC, skilled individuals have both incentives and means to emigrate. The interpretation of HIC group is hard because it contents only one country (Seychelles). Considering the share of skilled in the migrants' population suggests that middle income group (lower and upper) from 1990 up to 2010 experienced a migrants' population with more than half being skilled. moreover,the experienced the fastest increase in the skilled composition (10.3% and 6.7% for upper and lower middle income countries respectively). But it remains that all the income groups have experienced a change in skill composition of migrants in favour of skilled individuals.

When comparing skilled emigration rate by region, it appeared that while Southern Africa experience an average yearly decline in BD by 3.1% (from 17.0% in 1980 to 11.9% in 2010), the remaining regions experienced an important increase in BD by 4.9%, 4.8% and 4.8% respectively for Eastern, Western and Middle Africa). In other words, execepts Southern Africa, the dynamic of BD in SSA has been almost identical. Moreover, the structure of migrants' population accross regions indicated that more than 50% of migrants from Eastern, Western ans Southern Africa were skilled migrants in 2010 and this represented almost 40% in Middle

Africa. Dynamic of skill composition of migrants in favour of skilled individuals indicated that Southern Africa has experienced the most rapid change in migrant composition in favour of skilled on the covered period (8.4%) while Middle Africa has eperienced the slowest change in skill composition of the migrants (2.8%). Estern and Western Africa experienced a relatively large change in skill composition (6.5% and 6.2% respectively).

From figure 1 below, one may see that the number of skilled migrants has been increasing over the entire period covered by this study. We might also highlight three regimes with different slopes: the first regime hold over the period 1980 -1995 where the number of skilled migrants from SSA were increasing but very slowly. The second regime hold over the period 1995-2005 where the number of skilled migrants has been increasing at an increasing rate; and the third regime hold over the period 2005-2010 where the number of skilled migrants has stagnated. We might also see that the number of skilled migrants in the second regime has been growing faster than the number of skilled residents.

Figure 1: Dynamic of skilled migration in SSA (1980-2010)




Source: Authors' construction from BCM (2013)

Figure 2 strongly support the idea that brain drain is negatively correlated to the country size in SSA. In addition, the idea that brain drain is negatively correlated to the level of income is just partially admitted in SSA. In fact, out of

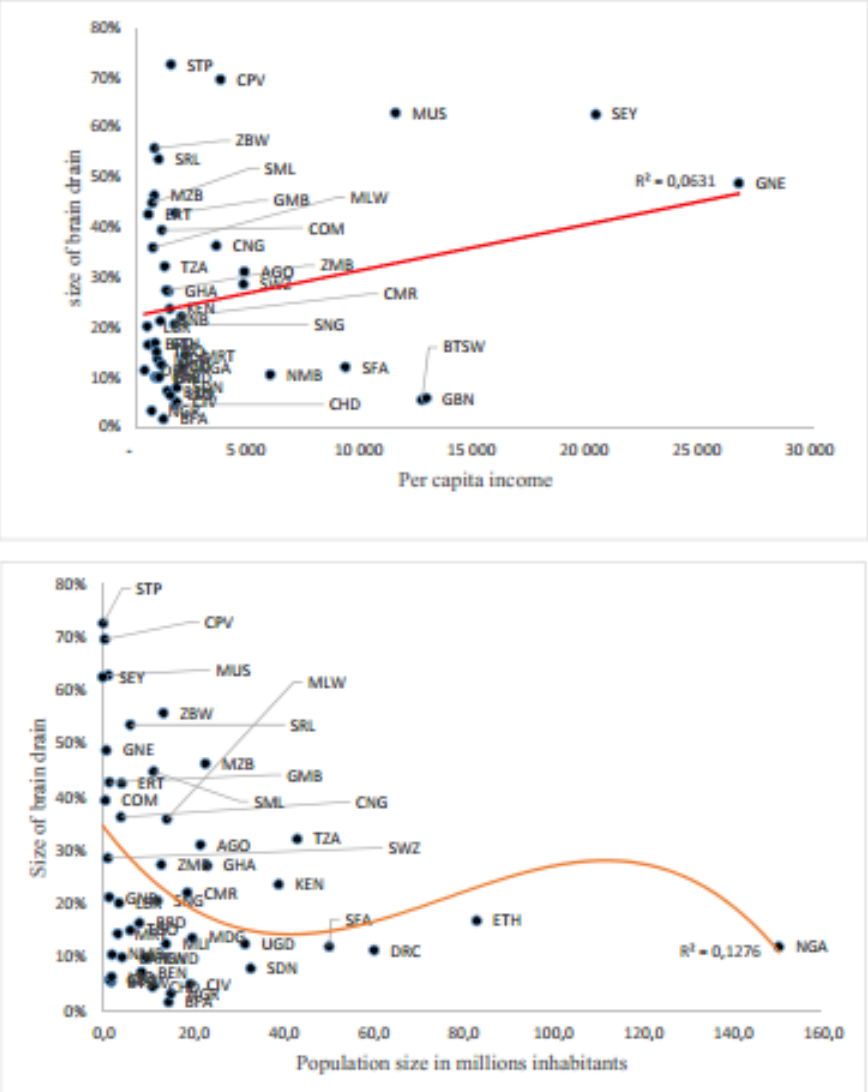
Table 2: Dynamic of brain drain and structure of migrants in SSA 1980-2010

| **Brain drain** | 1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|---|
| **By country size** | | | | | | | |
| Large countries | 13.21% | 14.04% | 14.16% | 11.28% | 12.05% | 14.29% | 15.26% |
| Medium countries | 16.70% | 17.68% | 16.86% | 15.04% | 18.14% | 20.98% | 23.28% |
| Small countries | 11.75% | 11.91% | 12.84% | 18.12% | 20.37% | 21.12% | 20.75% |
| Very small countries | 16.61% | 18.06% | 21.36% | 19.65% | 19.78% | 23.28% | 25.18% |
| **By income group** | | | | | | | |
| High income | 53.42% | 38.65% | 68.90% | 71.25% | 61.55% | 64.47% | 62.58% |
| Upper Middle income | 18.04% | 14.87% | 10.06% | 6.47% | 9.43% | 11.60% | 13.37% |
| Lower Middle income | 12.14% | 14.19% | 14.79% | 12.67% | 14.47% | 16.50% | 16.60% |
| Low income | 15.23% | 15.83% | 16.07% | 14.51% | 15.64% | 18.22% | 20.34% |
| **By region** | | | | | | | |
| East Africa-SSA | 17.0% | 18.3% | 19.4% | 17.0% | 19.2% | 21.9% | 23.5% |
| Western Africa-SSA | 10.1% | 11.1% | 11.1% | 10.1% | 11.6% | 13.8% | 13.8% |
| Middle Africa-SSA | 13.0% | 14.2% | 13.5% | 13.2% | 13.1% | 14.3% | 16.8% |
| Southern Africa-SSA | 17.0% | 14.2% | 9.2% | 5.3% | 8.2% | 10.2% | 11.9% |
| **Among migrants** | | | | | | | |
| **By country size** | | | | | | | |
| Large countries | 40.49% | 47.37% | 49.22% | 46.59% | 51.38% | 56.80% | 58.34% |
| Medium countries | 26.48% | 30.38% | 33.55% | 31.44% | 34.86% | 40.96% | 40.30% |
| Small countries | 42.06% | 38.90% | 40.85% | 36.35% | 38.93% | 43.89% | 45.29% |
| Very small countries | 33.65% | 32.21% | 37.45% | 33.16% | 39.13% | 45.04% | 45.97% |
| **By income group** | | | | | | | |
| High income | 36.16% | 24.43% | 23.90% | 30.40% | 28.59% | 34.27% | 39.63% |
| Upper Middle income | 37.22% | 46.98% | 55.01% | 53.76% | 60.02% | 64.54% | 67.18% |
| Lower Middle income | 38.85% | 47.37% | 48.80% | 45.92% | 51.13% | 55.85% | 57.49% |
| Low income | 33.86% | 35.27% | 37.40% | 34.87% | 38.15% | 44.77% | 44.92% |
| **By region** | | | | | | | |
| Eastern Africa | 34.50% | 37.50% | 39.40% | 37.80% | 42.10% | 48.40% | 50.40% |
| Western Africa | 38.00% | 46.40% | 47.50% | 44.10% | 47.90% | 53.70% | 54.50% |
| Middle Africa | 33.00% | 33.00% | 35.20% | 32.30% | 35.80% | 41.80% | 38.90% |
| Southern Africa | 39.30% | 46.10% | 53.70% | 51.10% | 57.80% | 60.80% | 63.60% |

Source: Authors' calculation from Brucker, Capuano and Marfouk (2013)
***Note:** *Large countries (Population above 25 million), Medium countries (population between 10 and 25 million), Small countries (Population between 2.5 and 10 million) and Very small countries (Population below 2.5 million). Among migrants denotes the share of skilled migrants' among total migrants' population. World bank classification of countries is the one used here.*

the 47 SSA countries considered, 4 countries (Cave Verde, Mauritius, Seychelles and Equatorial Guinea) belongs to upper middle income and high or upper middle income groups but exhibited extremely high brain drain (minimum of 50 percent). On the other hand, we can simply explain this by the fact that all of them belong to the group of small countries in terms of population size. For the remaining countries of the sample, it appears clearly that brain drain is strongly negatively correlated to the level of income.

Figure 2: Brain drain, income per capita and population size in 2010




Source Authors' construction from BCM (2013)

# 4 Evaluation of losses and gains from brain drain

There are several costs and benefits resulting from emigration and especially from skilled emigration that accrue to both host as well as source countries. This section provides step by step the methodology of how losses and gains are evaluated. in the losses side, we first consider the loss of the share of migrants in the home production due to their departure (scenario 1); then after, we take into account the effect their departure has on the productivity of those left behind (Scenario 2) and finally, we account for education subsidies on skilled migrants who got their education in the home country (Scenario 3). in the gain side, we first evaluate remittances from skilled migrants, then we account for endogenized education decision and finally, we account for diaspora externality.

## 4.1 Skilled emigration loss: labour demand- labour supply framework

We are considering three scenario here: model without externalities, model with externalities, model accounting for the cost of education of the migrant in the source country.

### 4.1.1 Scenario 1: Loss from brain drain in absence of externalities

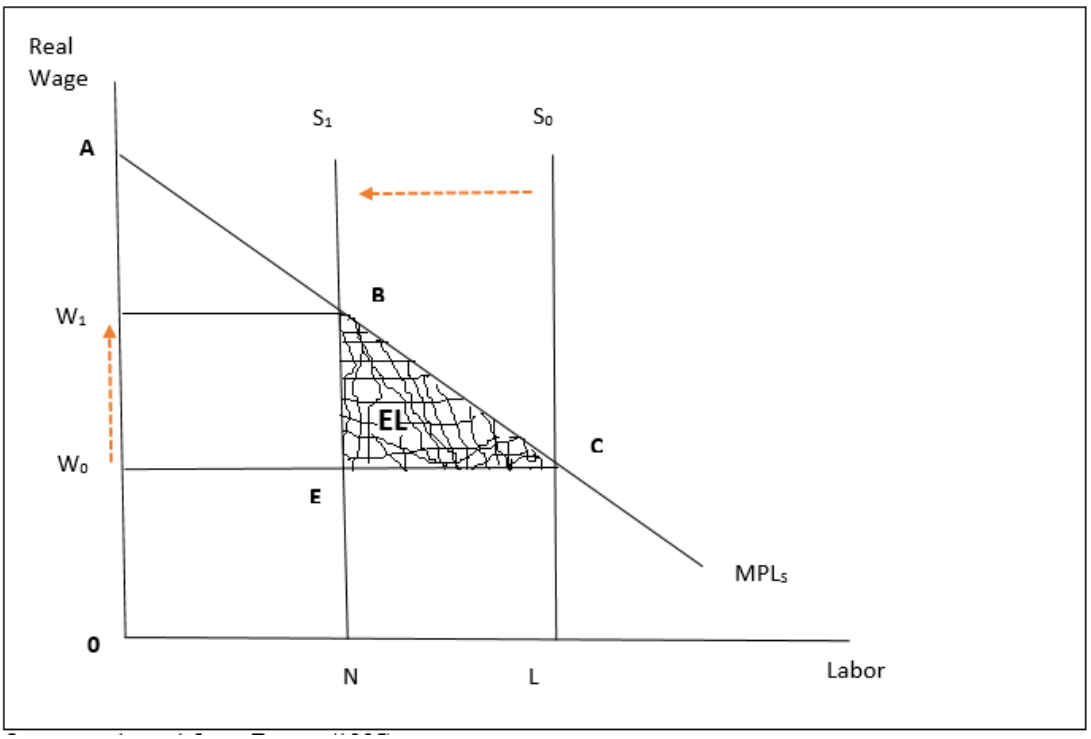
The simple economic model of labor demand and labor supply is an important starting point to quantify the economic implication of brain drain under the "certeris paribus" assumption. This framework has already been used in the literature (Borjas, 1995; Mishra, 2007). Economic measure used will be GDP accruing to those who have stayed in the source country. Let us consider a CES production function for a single good given as:

$$Y_i = [\pi_i K_i^{\rho} + (1 - \pi_i) N_i^{\rho}]^{1/\rho} \tag{1}$$

Where K is the fixed factor assumed to be internationally immobile, N is the labor employed in the production and Y is the gross domestic product, $\pi$ measures the preference for capital and $\rho = (\sigma - 1)/\sigma$, $\sigma$ being the elasticity of substitution between skilled labour and capital. The figure 4 below show our simple model.

Aggregate production function exhibit constant return to scale. As a result, total output is divided into the workers and the capital owners. Prior the emigration of M labors, the equilibrium required that each factor price equals the respective value of marginal product. Figure 3 illustrated this initial equilibrium

Figure 3: Labor demand-supply model economic impact of brain drain




Source: adapted from Borjas (1995)

in the labor market. Given that the supply of capital is considered inelastic, the era under the marginal product of labor curve gives the economy's total output given by the era ACL0. When M workers leave for abroad, economy's total output is now given by the era ABN0. The emigration loss is then given by the era BCE[15]. This era as a percent of production is obtained by the relation:

$$\frac{\Delta Y_N}{Y} = \left[K\frac{\partial r}{\partial N} + L\frac{\partial w}{\partial N}\right]\frac{\Delta N}{Y} \tag{2}$$

Change in labor supply depicted in equation (2) is supposed to be only due to emigration; otherwise, it represents the stock of emigrants. The equation (3) below (See appendix 1 for detailed calculation) gives the expression of loss from emigration under the scenario (1)

[15]This era represents the emigration loss for the source country which might also be expressed as:

$$Era(BCE) = \frac{1}{2}(w_1 - w_0) \times \Delta N$$

$$EL_i = \frac{\Delta Y_N}{Y} = \frac{1}{2}\frac{s(1-s)m^2}{\sigma} \tag{3}$$

Where s stands share of labor in the national production, m the total emigration rate and $\sigma$ the elasticity of substitution between capital and labor.
Since there is no externality here, the loss due to skilled emigration in country i will just be given by:

$$(EL_i)^{sc1} = \frac{\Delta Y_{N,i}}{Y} = \frac{1}{2}\frac{s_i^h(1-s_i^h)(m_i^h)^2}{\sigma} \tag{4}$$

Where $s_i^h$ stands for the share of skilled labor in the national production of country i; $m_i^h$ for the fraction of skilled labor in country i that has emigrated abroad and $\sigma$ the elasticity of substitution between labor and capital. Losses from brain drain will be evaluated under scenario 1 using equation (4)

### 4.1.2 Scenario 2: Loss from brain drain when account for externalities

Based on the argument that an increase in trade generates external returns in the aggregate economy[16], increase in emigration would reduce the size of the market and then the external returns in the aggregate economy. It can drastically reduce many interactions among workers and firms so that remaining workers and firms might lose something. As a result, even though the production technology at a firm level has constant return to scale, the externalities resulting from skilled emigration might lead to decreasing returns on the aggregate output for the whole economy. This hold under the argument that interactions between workers either skilled or unskilled affect their productivity in such a way that when skilled emigration occurs, the productivity of both skilled and unskilled workers left behind reduces. Medical doctors, nurses, engineers, researchers are not only more productive themselves, but they are also expected to make other workers more productive (Mishra, 2007). Borjas (1995) found that external effect might be substantial.

To represent those external effects, following Borjas (1995) and Mishra (2007), as emigrant reduces the scale of the economy, the marginal product of both labor and capital decreases. When ignoring capital, to illustrate how skilled composition of emigration affects emigration loss, we consider that there are only two skill classes in the workforce: high skilled workers $N_h$ and low skilled workers $N_l$. Production function will be given by $Y = F(N_h, N_l)$. If skilled labor is complementary to the other factors, then the production function of a representative firm

[16]See Helpman and Krugman (1985) for more details

can be expressed as $Y_F = f(n_h, n_h)$. Since external effects enters the production function through skilled labor, our function might be expressed as:

$$Y_F = f(n_h, n_l)N_h^{\gamma} \tag{5}$$

Where $Y_F$ stands for the representative firm's output,$n_h$ and $n_l$ are the high skilled and low skilled labor employed by the representative firm. $N_h$ stands for the aggregate stock of high skilled labor employed in the economy and $\gamma$ represents the percentage change in marginal product of high and low skilled labor caused by a 1 percent change in aggregate stock of high skilled labor. Figure 4 depicts the emigration loss when external effects are taken into account. When M skilled workers flight out of the economy, the supply curve of skilled workers moves toward the left (contraction of N) from $S$ to $S'$; and the marginal product curve of workers stayed behind also move toward the left (reduction) from $MPL_S$ to $MPL_S^{'}$. Emigration loss is now given by the era of the trapezoid ABDF plus the era of the triangle EBC (emigration loss = era ABDF + era EBC). It is easy to see that the added era (era ABDF) is the emigration loss due to the presence of external effect.

For analytical purposes, the new production function of the economy taking into account external effect is given as:

$$Y = F(K, N_h, N_l)^{1/(1-\gamma)} \tag{6}$$

Applying equation (1), emigration loss in presence of external effect is given by (see appendix 2 for calculation details):

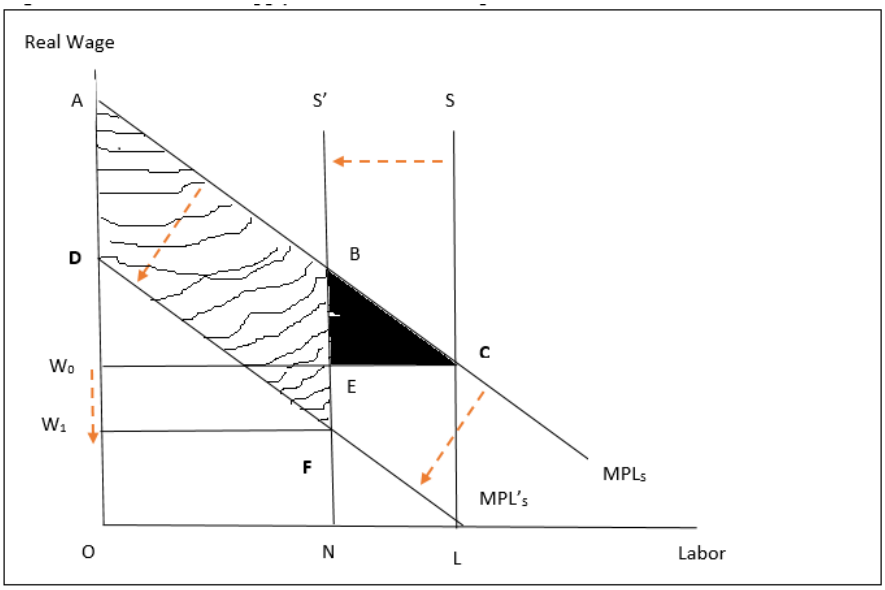
$$(EL_i)^{sc2} = \frac{\Delta Y_{N,i}}{Y} = \frac{1}{2}\frac{s_i^h(1-s_i^h)(m_i^h)^2}{\sigma} + \frac{\gamma\, s_i^h\, m_i^h}{1-\gamma}\left(1 - s_i^h\, m_i^h\right) + \frac{\gamma\, s_i^l\, m_i^h}{1-\gamma}\left(1 - s_i^l\, m_i^h\right) \tag{7}$$

The first term of this expression is identical to equation (4). The second and third terms of this expression denote the external effect of brain drain on skilled and unskilled labor respectively as documented by Mishra (2007). In other words, larger the external effects, greater the emigration loss. Losses from brain drain will be evaluated under scenario 2 using (7)

#### 4.1.3 Scenario 3:Loss from brain drain when account for the cost of schooling in the home country

Since governments cover a portion of the cost of education of their citizens in form of education subsidies (specially in the developing world), we include

Figure 4: Labor demand-supply model: economic impact of brain drain with external effect




Source: adapted from Borjas (1995)

government expenditure of highly educated individuals who migrate, if they got their education in the home country. This include primary, secondary and tertiary education expenditures of these migrants. The annual expenditure on education of skilled migrant who leave the country $E^{M_h}$ can be expressed as $E^{M_h} = C_h M_h$ where $M_h$ is the number of high skilled migrants and $C_h$ the cost supported by the government in subsidizing the education of one skilled individual who migrate. $C_h = \dfrac{T}{E^t}$ where $T$ is the total annual expenditure on education (primary, secondary, tertiary) and $E^t$ is the total annual school enrolment i.e

$$C_h = \sum_{j}^{p,s,t} (T_j/E_j)$$

Then, the public loss is then given by:

$$SL_i = C_i^h{}_s n \delta M_i^h \tag{8}$$

Where$SL_i$ stands for subsidy loss in country i, $n$ stands for the average number of years spent in schooling in the home country and $\delta$ is the share of migrants that has taken its education at home. Total skilled emigration loss is now obtained by combining equations (7) and (8).

$$(EL_i)^{sc3} = \frac{\Delta Y_{N,i}}{Y} = \frac{1}{2}\frac{s_i^h(1-s_i^h)(m_i^h)^2}{\sigma} + \frac{\gamma\, s_i^h\, m_i^h}{1-\gamma}\left(1 - s_i^h\, m_i^h\right) + \frac{\gamma\, s_i^l\, m_i^h}{1-\gamma}\left(1 - s_i^l\, m_i^h\right) + c_h^i n\delta\frac{M_i^h}{Y_i} \tag{9}$$

Equation (9) gives us the complete function of brain loss that will be estimated. Losses from brain drain will be evaluated under scenario 3 using equation (9).

Once, this loss function is estimated, we then convert it into a per capita income loss. From equation (9), the per capita loss is given by:

$$\frac{\Delta Y_{N,i}}{P_i} = \left[\frac{1}{2}\frac{s_i^h(1-s_i^h)(m_i^h)^2}{\sigma} + \frac{\gamma\, s_i^h\, m_i^h}{1-\gamma}\left(1 - s_i^h\, m_i^h\right) + \frac{\gamma\, s_i^l\, m_i^h}{1-\gamma}\left(1 - s_i^l\, m_i^h\right) + c_h^i n\delta\frac{M_i^h}{Y_i}\right]\frac{Y_i}{P_i}$$

Where P stands for the population. In a more simpler form, it gives:

$$\Delta y_i = \left[\frac{1}{2}\frac{s_i^h(1-s_i^h)(m_i^h)^2}{\sigma} + \frac{\gamma\, s_i^h\, m_i^h}{1-\gamma}\left(1 - s_i^h\, m_i^h\right) + \frac{\gamma\, s_i^l\, m_i^h}{1-\gamma}\left(1 - s_i^l\, m_i^h\right)\right] y_i + c_h^i n\delta\frac{M_i^h}{P_i}$$

From this expression, we can easily derive that:

$$\Delta y_i / y_i = \Delta y_i / \left(y_i + \Delta y_i\right) \tag{10}$$

The per capita income loss due to brain drain will finally be obtain using equation (10).

## 4.2 Skilled emigration gain: Development accounting model

As documented by the literature on migration, brain drain and developement, the main gains are remittances, endogenous education decisions and diaspora externalities (Docquier, 2017; Rapoport, 2010; Docquier et Rapoport, 2012; Beine et al, 2008; Mishra, 2007). The last two components of emigration gain are presented following the approach adopted by Docquier (2017) under the development accounting framework that we quickly summarize. Globally, brain gain is obtain in three step. At the first step, we evaluate remittances from skilled migrants. At the second step, we evaluate gain from endogenizing education decision and then, add it to remittances. At the third step, we evaluate gain from diaspora externality and then add it to remittances and endogenized education decision.

### 4.2.1 Development accounting framework

As highlited by Jones (2014), Hendricks and Schoelleman (2016), the goal of development accounting model is to decompose variation in output into variation

in three components: capital labor ratio, total factor productivity and human capital. So, let us consider a simple Cobb-Douglas production function given by:

$$Y_i = F\left(A_i, K_i, H_i\right) = A_i K_i^{\alpha} H_i^{1-\alpha}$$

where Y stands for total output, A: total factor productivity, K: total stock of physical capital and H: the aggregate human capital stock. $\alpha$ is the share of capital in total output and $(1-\alpha)$ is the share of aggregate human capital in total output. Moreover, $H_i = h_i L_i$ where h is the human capital per worker and L the number of workers.

In the intensive form, the above production function will be given by

$$y_i = A_i k_i^{\alpha} h_i^{1-\alpha}$$

In line with Jones (2014), let us desaggregate the human capital into two components, high and low skilled respectively:

$$h_i = G\left(h_i^L, (1-h_i^L)\right)$$

where $h_i^L$ denotes high skilled human capital and $(1-h_i^L)$ denotes low skilled human capital.

Under the hypothesis of perfect substitution within each skill group and imperfect substitution between the two skill groups, we consider human capital being a constant elasticity of substitution (CES). Our intensive form of per capita income becomes:

$$y_i = A_i k_i^{\alpha} \left[ \theta_i (h_i^L)^{\frac{(\sigma_L - 1)}{\sigma_L}} + (1-\theta_i)\,(1-h_i^L)^{\frac{(\sigma_L - 1)}{\sigma_L}} \right]^{\sigma_L(1-\alpha)/(\sigma_L - 1)}$$

Where $h^L$ is the proportion of the resident skilled labor force,$A_i$ the level of total factor productivity, $\theta_i$ the relative productivity parameters capturing the skilled biased in production.

Labor market and growth literature provides evidence that, in an openned economy, capital adjustment are quite rapid such that in presence of migration, since it affects one for one employment and capital stock, capital-labour ratio remains almost unchanged (Ortega and Peri, 2009; Kennan, 2013). In addition, this literature also supports the idea that C.E.S production explain well the disparity in macroeconomic performance between countries as well as the pattern of wage inequality accross skill groups, and then providing an additional reason for its use.

So, since we are investigating how per capita income changes because of a change in human capital accumulation and total factor productivity, capital-labour ratio is removed from the above function and it becomes:

$$y(h_i^L) = A_i \left[ \theta_i (h_i^L)^{\frac{\sigma_L - 1}{\sigma_L}} + (1 - \theta_i)\,(1 - h_i^L)^{\frac{\sigma_L - 1}{\sigma_L}} \right]^{\sigma_L/(\sigma_L - 1)} \tag{11}$$

Where $A$ stands for total factor productivity (TFP). The share of skilled labour force among resident labour force is

$$h_i^L = \frac{h_i^N (1 - m_i^h)}{h_i^N (1 - m_i^h) + (1 - h_i^N)(1 - m_i^l)}$$

In this expression, $h^L$, $m^h$ and $m^l$ are oberved. So, the only unobservable component is $h^N$ which stand for the counter-factual level of $h^L$ in absence of brain drain.

### 4.2.2 Brain gain as remittances

As argued by Grubel and Scott (1966), migration in general and skilled migration specifically normally raises long term average income of those left behing in home country, due to an increase in the country's capital-labor ratio through remittances. Nowadays, official remittances on average represented 2.4% of SSA GDP in 2010 (World Bank, 2016). So, emigration gain as remittances expressed in per capita term is given by:

$$R_{p,i} = \frac{REM_i}{P_i} \tag{12}$$

where $REM_i$ stands for aggregate volume of remittances received by SSA country i. Since skilled migrants are more likely to remit less at least in SSA (See Appendix 4); due to the absence of recorded statistics on remittances made by skilled emigrants, we can formulate the hypothesis that **remittances from skilled migrants are proportional to the share of skilled in the population of migrants**[17]. This hypothesis is over-optimal because results suggests that their remittances should be less than proportional to their share knowing that they remit less.

This hypothesis allows us to estimate the share of remittances which comes from

[17]This hyppothesis is rather too optimistic in our view regarding their lower propensity to remit

skilled migrants.

If $\psi_i^h$ stands for the share of skilled among migrants for a given country $i$, $M_i^h$ and $M_i^l$ the number of skilled and unskilled migrants respectively from country i,

$$\psi_i^h = \frac{M_i^h}{M_i^l + M_i^h}$$

and remittances from skilled migrant is given by: $R_{p,i}^h = \psi_i^h R_{p,i}$. Emigration gain becomes:

$$EG(1) = \psi_i^h \frac{R_{p,i}}{y(h_i^L)} \tag{13}$$

#### 4.2.3 Contribution of the endogenization of education decisions and diaspora externalities: counterfactual analysis

In this framework, the rise in human capital mechanically increases the income since skilled workers are more productive than unskilled. Per capita income and skilled specific wage ratio are given by:

$$y(h_i^L) = A_i \left[\theta_i (h_i^L)^{\frac{\sigma_L - 1}{\sigma_L}} + (1-\theta_i)(1-h_i^L)^{\frac{\sigma_L - 1}{\sigma_L}}\right]^{\frac{\sigma_L}{\sigma_L - 1}} \tag{14}$$

With the specific skill wage ratio expressed as:

$$\frac{w_i^h}{w_i^l} = \frac{\theta_i}{1-\theta_i}\left(\frac{h_i^L}{1-h_i^L}\right)^{\frac{-1}{\sigma_L}} \tag{15}$$

Where $h_i^L$[18] stands for the share of skilled labor force in the resident labor force.

The counterfactual per capita income is given by:

$$y(h_i^N) = A_i \left[\theta_i (h_i^N)^{\frac{\sigma_L - 1}{\sigma_L}} + (1-\theta_i)(1-h_i^N)^{\frac{\sigma_L - 1}{\sigma_L}}\right]^{\frac{\sigma_L}{\sigma_L - 1}} \tag{16}$$

Once counterfactual per capita income is determined, we can now compute the effect of skilled emigration on per capita income as a percentage of its

[18] $h_i^L$ is obtained from the expression $h_i^L = \frac{h_i^N(1-m_i^h)}{h_i^N(1-m_i^h) + (1-h_i^N)(1-m_i^l)}$. Moreover, the counterfactual level of $h$ in absence of migration is also expressed as: $h_i^N = \frac{h_i^L(1-m_i^l)}{1-m_i^h + h_i^L(m_i^h - m_i^l)}$

no-emigration level. This is expressed by:

$$\Delta_i = \frac{y(h_i^L) - y(h_i^N)}{y(h_i^N)} \tag{17}$$

#### 4.2.4 Gain from brain drain when account for endogenizing education decisions

Following Beine et al (2008a)[19] who demonstrated that by doubling the size of brain drain in a country, its stock of human capital will increase by 5% in a post migration setting, we assume that $h_i^N$ depends on skill-biased emigration prospects[20] and elasticity of $h_i^N$ to skill-biased migration prospects then equal to 5% (0.05). We are going to evaluate a new counterfactual level of human capital under that setting. The new counterfactual (i.e the human capital accumulation in absence of brain drain) is expressed as:

$$h_{cf,i}^N = \frac{h^N}{[m_i^h/m_i^l]^{e_h}} \tag{18}$$

Where $e_h$ stands for elasticity of $h_i^N$ to skilled biased migration prospects.

We will then use the result of equation (18) to estimate the counterfactual per capita income. So, the gain from endogenizing education decision is given by $\Delta_i^{\text{eed}}$ and obtained by applying equation(17) in which $h_i^N$ is replaced by $h_{cf,i}^N$.Total gain from brain drain will then be given by:

$$\text{EG (2)} = \psi_i^h \frac{R_{Pi}}{y(h_i^L)} + \Delta_i^{\text{eed}} \tag{19}$$

#### 4.2.5 Brain gain as remittances, endogenization of education decisions and diaspora externalities

Diaspora networks can help source countries to integrate more into the global economy through their contribution to bilateral trade, foreign directs investments and other financial flows. Moreover, they contribute to the diffusion of knowledge and technology between host and source country (Rapoport, 2018; Lodigiani, 2009; Docquier et Rapoport, 2012). Using the framework provided by Doquier (2017), diaspora externalities are integrated into the model through the total factor productivity (TFP). Thus, the new expression of TFP is given by:

$$A_i = A_{0i} \left( \frac{h_i^L}{1 - h_i^L} \right)^{\epsilon} (1 + \rho m_i) \tag{20}$$

[19] Also followed by Docquier (2017).
[20] $m_i^h/m_i^l$

From (20), elasticity of TFP with respect to emigration [21] is expressed as:

$$e_{de} = \frac{\rho m_i}{1 + \rho m_i} \tag{21}$$

We then use this new $A_i$ to calculate $y_i^{cf}$. Thereafter, we use it to calculate the new counterfactual per capita income which finally allow to evaluate change in per capita income due to brain drain now given by $\Delta_i^{\text{de}}$. Total gain from brain drain when account for diaspora externalities is:

$$\text{EG (3)} = \text{EG } (Total) = \psi_i^k \frac{R_{Pi}}{y(h_i^L)} + \Delta_i^{\text{eed}} + \Delta_i^{\text{de}} \tag{22}$$

Once this is done, since we have now identified negatives consequences and positives consequences from brain drain, we will just have to determine the net effect by doing the difference between equation (**??**) and equation (7). Equation (22) provides the total gain from skilled emigration.

# 5 Parameters calibration

We start by providing a summary of the main parameters calibrated and then after, we show how they have been calibrated.

## 5.1 Share of skilled workers educated in SSA ($\delta$).

In line with Beine, Docquier and Rapoport (2006), immigrants' age of entry is used as proxy for where they acquired their education. Those authors estimated that among immigrants aged 25 or more and working in OECD countries with tertiary education, 85.7% arrived after age 12, 78.2% after age 18 and 69.1% after age 22. So, we consider 69.1% as share of skilled emigrants from SSA to OECD countries who acquired their education at home and thus has beneficted from government education subsidy ($\delta = 0.691$).

## 5.2 Skilled labour share in national income ($s_i^h$)

Authors such as Guriero and Sen (2012) and Gueriero (2019) have estimated the labour share in national income for a set of countries over the period 1970-

[21] $e_{de} = \dfrac{\partial A_i}{\partial m_i} \times \dfrac{m_i}{A_i} = \rho A_{0i} \left( \dfrac{h_i^L}{1 - h_i^L} \right)^{\epsilon} \times \dfrac{m_i}{A_i = A_{0i} \left( \dfrac{h_i^L}{1 - h_i^L} \right)^{\epsilon} (1 + \rho m_i)} = \dfrac{\rho m_i}{1 + \rho m_i}$

Table 3: summary of parameters calibrated

| **Parameter** | **parameter value** | **Objective** |
|---|---|---|
| Share of migrants educated in the home country ($\delta$) | $\delta = 0.691$ | For evaluation of education subsidies loss |
| Skilled labour share ($s^h$) | Mean= 0.35<br>Min =0.14 ; Max=0.53 | Skilled emigration loss |
| Elasticity of substitution between K & L ($\sigma$) | Mean = 0.32<br>Min =0.17 ; Max = 0.71 | Skilled emigration loss |
| Elasticity of substitution between H & L skilled ($\sigma_L$) | $\sigma_L = 2$ | Allows to evaluate the counterfactual y |
| Yearly per capita subsidy in education ($C^h$) | Mean = 576\$<br>Min =22\$; Max = 4787.3\$ | education subsidy loss |
| External effect ($\gamma$) | $\gamma = 0.1$ | Evaluate how brain drain affect the prodctivity of those left behind |
| Wage ratio (wH/wL) | Mean = 5.9<br>Min =2.96 ; Max=13.99 | Allow to evaluate preference for skilled |
| Relative productivity ($\theta$) | Mean = 0.342<br>Min=0.203 ; Max=0.435 | Allow to evaluate the counterfactual y |
| Share of skilled among migrants($\psi^h$) | Mean = 0.364<br>Min=0.045 ; Max=0.714 | For evaluation of remittances from skilled migrants |
| Technological externality ($\epsilon$) | $\epsilon = 0.2$ | Aggregate TFP externality |
| Skilled biaised externality ($\kappa$) | $\kappa = 0.1$ | Directed technical changes |
| Diaspora externality ($\rho$) | $\rho = 0.618$ | Diaspora externality gain |

2006 for the first and 1970-2015 for the second. Their studies provide estimates for 33 SSA countries. In order to have data for the remaining 14 countries, we use average labour share of income group in which they belong (low income, lower middle income and upper middle income). Thereafter, we derive the skilled labour share. In line with Mishra (2007), we consider that highly educated belong to the top 20% of the income earners[22]. Finally, by just multiplying total labour share in national income and the average income share of the top 20%, we obtain the skilled labour share in national income.

[22]data on top 20% of income earners are from the World Bank World Development Indicators. Moreover, for countries like Somalia, Equatorial Guinea and Eritrea for which data are not available, we use the average income share of the top 20% estimated by Dollar and Kray (2002, 2014) which is about 40%

## 5.3 Elasticity of substitution between capital and skilled labour and between high and low skilled labour

Following Borjas (1995) and Faini (2007), the elasticity of factor price of skilled labour ($e_i^h$)[23] is given by $e_i^h = \frac{1 - s_i^h}{\sigma}$; where $\sigma$ is the elastcity of substitution between skilled labour and capital. When production function is CES, $e_i^h = 1$, then it is easy to derive that $\sigma = 1 - s_i^h$.

In line with labour market literature (Ottaviano and Peri, 2012), the elasticity of substitution ($\sigma_L$) between skilled and unskilled workers varies between 1.5 and 3. As Docquier(2017), we choose the average which is about 2 ($\sigma_L = 2$).

## 5.4 Yearly per capita public subsidy on education ($C_h$)

The annual expenditure on education of skilled migrant who leave the country $E^{M_h}$ can be expressed as $E^{M_h} = C_s M_h$ where $M_h$ is the number of high skilled migrants and $C_s$ the cost supported by the government in subsidizing the education of one skilled individual who migrate. $C_s = \frac{T}{E^t}$ where $T$ is the total annual expenditure on education (primary, secondary, tertiary) and $E^t$ is the total annual school enrolment i.e $c_s = \frac{T_{pr}}{E_{pr}} + \frac{T_{se}}{E_{se}} + \frac{T_{te}}{E_{te}}$.

## 5.5 External effect ($\gamma$)

External effect of skilled emigration captures the percentage change in the marginal product of skilled and unskilled workers due to 1% change in aggregate stock of skilled labour. In line with Borjas (1995) and Mishra (2007), we choose $\gamma = 0.1$.

## 5.6 Wage ratio, relative productivity and total factor productivity

In order to be able to calculate our counterfactual per capita income, we have to calibrate $\theta_i$ and $A_i$ such that they perfectly match with observed per capita income $y(h_i^L)$. Equation (15) will allow to calibrate $\theta_i$ once the value of skill specific

[23]Percentage change in the wage with respect of 1% change in the size of labour force

wage ratio is known.

The estimation of the skill specific wage ratio follows the approach adopted by Delogu, Docquier and Machado (2018). In fact, this ratio is proxied by

$$\frac{w_i^h}{w_i^l} = (1 + \mathrm{MR}_i)^{\Delta YE_i}$$

Where $\mathrm{MR}_i$ is the Mincerian returns to schooling in country $i$ (Hendricks,2004)and $\Delta YE_i$ is the difference in year of schooling between skilled and unskilled (Barro and Lee, 2013). For countries for which data are not available, we predict the wage ratio using a log linear function of the skill ratio in the resident labour force estimated by Delogu et al (2018).[24]. Preference for skilled workers $\theta_i$ is then calibrated to match the wage ratio. Equation (14) can be rewrite as: $y_i = A_i q_i$ where

$$q_i = \left[\theta_i (h_i^L)^{\frac{\sigma_L - 1}{\sigma_L}} + (1 - \theta_i)(1 - h_i^L)^{\frac{\sigma_L - 1}{\sigma_L}}\right]^{\frac{\sigma_L}{\sigma_L - 1}}$$

.

This allow to use labor composite of per capita income $q_i$ and observed per capita income $y_i$ to retrieve the country specific productivity level expressed as $A_i = y_i/q_i$.

## 5.7 Technological, skilled biased and diaspora externalities

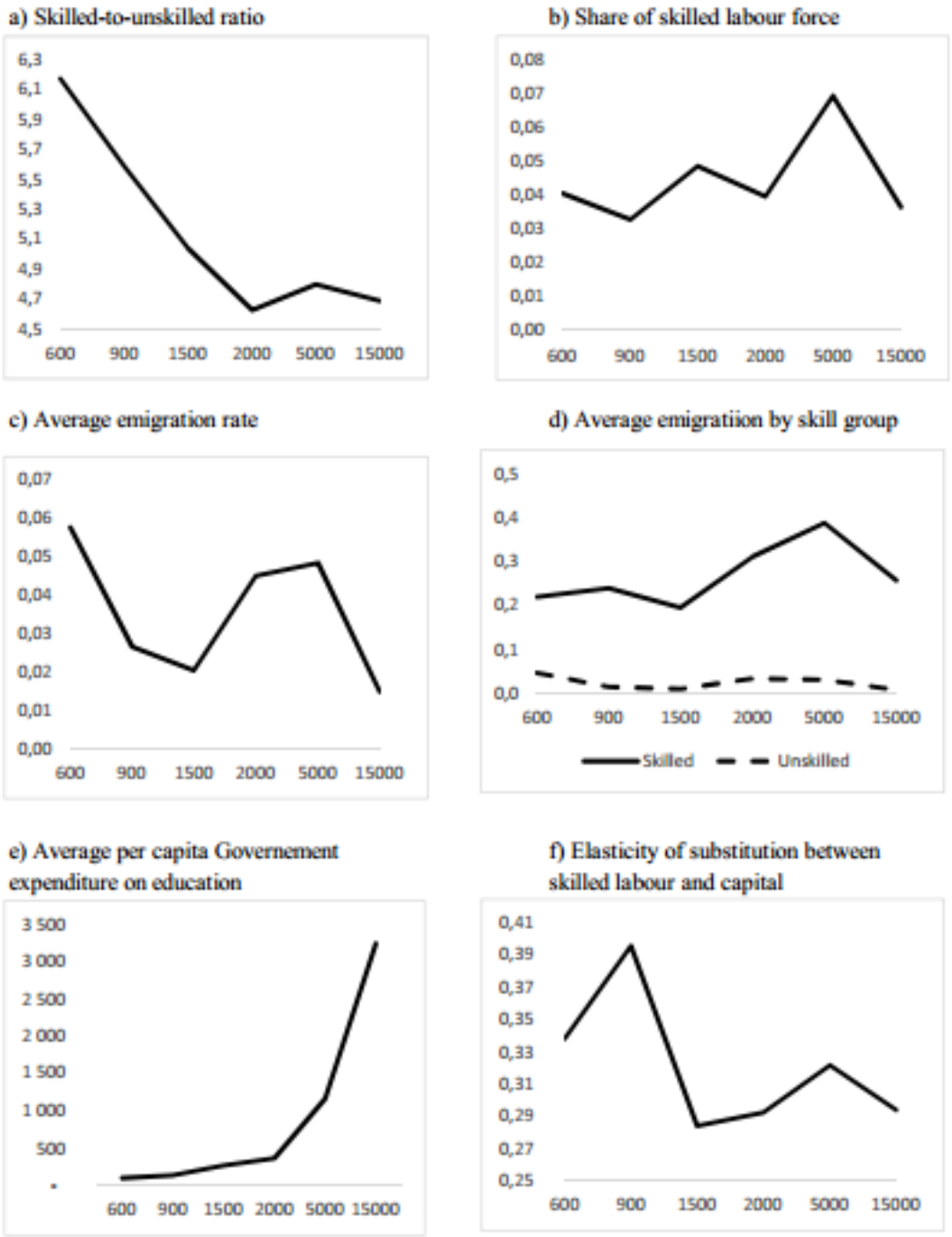
As Docquier (2017), we consider technological externality $\epsilon$ as being equal to 0.2 i.e $\epsilon = 0.2$ and skilled biased externality $\kappa$ as being equal to 0.1 i.e $\kappa = 0.1$.

A wide range of literature[25] has identified on the one side a causal relationship from migration to trade and foreign direct investment (with respective elasticities of 0.1 and 0.2) and on the other side, a causal relationship from trade and foreign direct investment to total factor productivity (with respective probability of 0.3 and 0.01). By combining these findings, Docquier (2017) obtain an elasticity of total factor productivity to emigration of 0.03 ($e_{de} = 0.03$). From equation(21), we easily obtain the diaspora externality which amount 0.618 (i.e $\rho = 0.618$).

[24] $\ln\left(\frac{w_i^h}{w_i^l}\right) = 0.25 - 0.31 \ln\left(\frac{h_i^L}{1 - h_i^L}\right)$ with $R^2 = 0.57$

[25] See Docquier (2017), pp 64 for details

Figure 5: Average characteristics by development level in 2010




***Note:*** *These average characteristics are obtained by simple average for the whole sample in 2010. And 2010 is chosen because it is the most recent period in this study.*

# 6 Results

In this section, we present results on losses, gains and finally net effect in SSA both at the global level, regional level and then country level. There after, we present the evolution of net effect over time

## 6.1 Broad picture in 2010

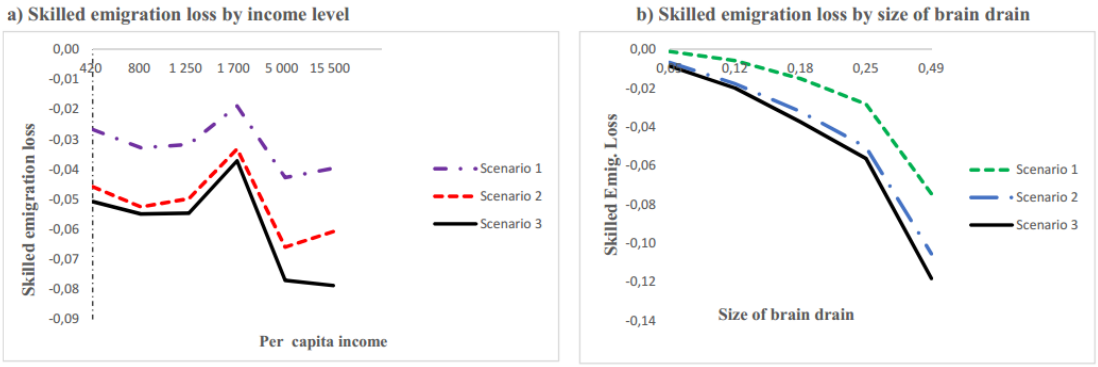
For a simple understanding, we present here only the situation of 2010 which is the most recent period in our study.

### 6.1.1 Average situation for the whole SSA in 2010

From considering the case of 2010, the pattern depicted in figure 6 below shows that on average, under the scenario 1 (absence of externality and education subsidy), for SSA countries with per capita income around 800$, income loss due to brain drain amount 3% of the counterfactual no migration level. This income loss amounts 2% for countries around 1700$ and reach 4% for countries above 5000$. When taking into account externality, (scenario 2), the income loss increases substantially and reach almost 5.2% for countries arount 800$; 4% for countries around 1700$ and 7% for countries above 5000$. Under the third scenario, income loss increases up to 5.5% for the first group, 4.2% for the second group and 8% for the third group. These findings suggest in overall that on average in SSA, low income countries and upper middle income countries experience important losses from brain drain with upper middle income countries being the most affected while losses in lower middle income countries are rather limited. Moreover, the presence of externality increases substantially the income loss due to brain drain in SSA (from 3% to 5% for the first group, 2% to 4% for the second group and from 4% to 6% for the last.) while income loss due to education subsidies is rather limited (less than 1%) except for countries with per capita income above 5000$ whose income loss increases by 2% due to government spending on education.

When analysing this average situation in 2010 with respect to the size of brain drain, pattern depicted in figure 6.b above shows that, in absence of externality and education subsidies, countries with brain drain less than 12% exhibit an income loss of 1%, those with brain drain between 12% and 18% exhibit an income loss of 2%. And then, 3% and 7% respectively for countries with brain drain between 18% and 25% and above 25%. (Green - dash curve). In presence of externality but without education subsidies (blue curve with long dash), we observe an income loss of 2%, 3%, 5% and 11% respectively for the four groups.

Figure 6: Loss from brain drain by income level and brain drain size in 2010




In presence of education subsidies, the situation remain almost unchanged for the first group while the remaining groups exhibit 4%, 6% and 12% of income loss respectively. In overall, income loss increases with the size of skilled emigration ranging from 1% for countries with low brain drain to 7% for countries with high brain drain. Futhermore, externality strongly increases the income loss for all the brain drain size with countries with brain drain above 25% being the most affected. The picture does not change that much when education subsidies are taken into account except for countries with high brain drain.

The situation we have just presented hide a lot of specificities given that it has just presented average figures. The next point will present insights at country's level.

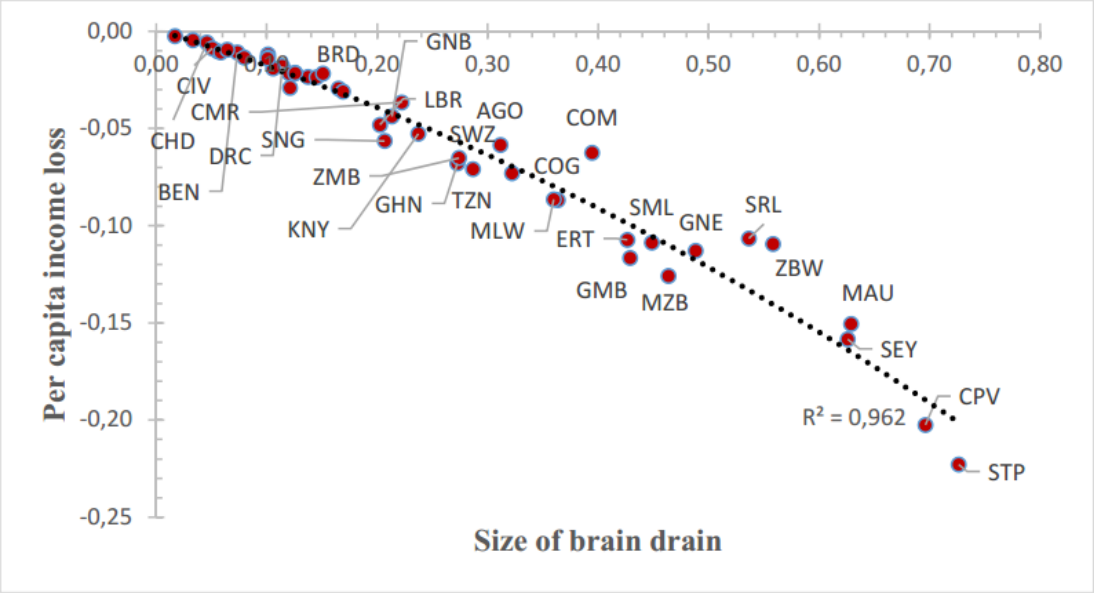
### 6.1.2 Countries and regions specific picture

Figure (7) depicts skilled emigration loss for each SSA country. The pattern strongly support the idea that per capita income loss from brain drain is positively associated to the size of the brain drain with a $R^2$ of 96.2% meaning that loss from brain brain increases as size of brain drain comes bigger and bigger. In addition, 53.2% of SSA countries exhibit an income loss less than 5% while 23.4% exhibit an income loss between 5% and 10% of counter-factual per capita income, and 23.4% exhibit an income loss above 10%. It is also important to highlight the fact that 4 countries experience very important income loss: Mautritius (15%), Seychelles (16%), Cape Verde (20%) and Sao Tome (22%).

At regional[26] level, figure 8 shows that, in Middle, Western and Southern

[26]Middle Africa, Western Africa, Southern Africa and Eastern Africa

Figure 7: Skilled emigration loss by country in 2010




Africa, more than 50% of the countries (25 countries) exhibit relatively small loss (less than 5%) from brain drain (55.6%, 68.7% and 83% respectively). However, in Eastern Africa, 62% of countries experience important loss (more than 5%) from brain drain. Moreover, among the 10 SSA countries with skilled emigration loss above 10%, 6 are from Eastern Africa (Erithrea, Somalia, Zimbabwe, Mozambique, Mauritius and Seychelles).

## 6.2 Skilled emigration gain in 2010

### 6.2.1 Average situation for the whole SSA in 2010

Figure 9.a shows that brain gain is on average negatively correlated to the level of per capita income ($R^2 = 26.2\%$) as well as negatively correlated to the size of brain drain ($R^2 = 38.5\%$). When only remittances (blue-long dash curve) are taken into account, that gain amounts 1% for countries with per capita income around 800$, 2% for countries around 1000$, 1% for countries around 1700$ and almost 0% for countries above 5000$. When we only consider gain from diaspora externality, situation remains almost unchanged except for countries above 5000$ where this gain amount on average 5% of per capita income. Moreover, diaspora externality increases with the level of development (black-dash curve)

Figure 8: Regional distribution of skilled emigration Loss in SSA in 2010

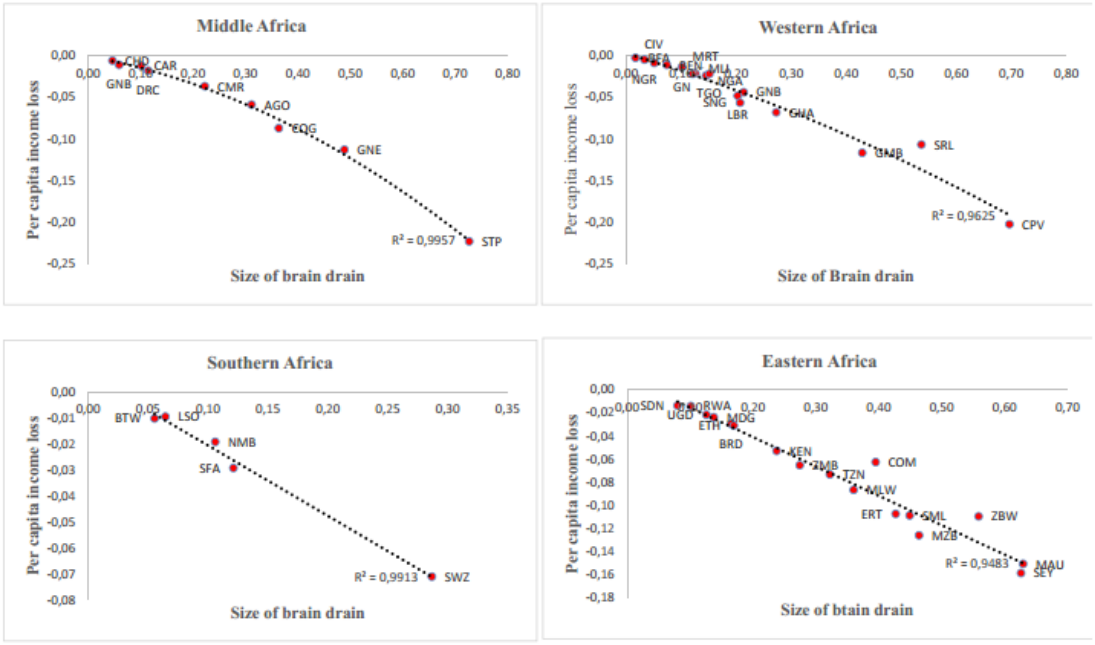
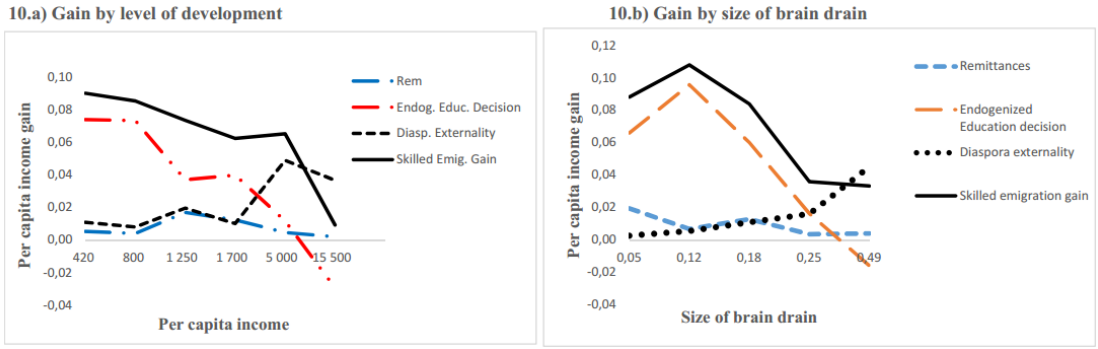



Figure 9: Average gain by level of developement and size of brain drain in 2010




while per capita remittances exhibit an inverted U-Shape pattern with countries around 1200$ experiencing the higest per capita benefit. When we individually consider gain from endogenized education decision (Orange-long dash), we do observe that, compared to the two other categories of gain (remittances and diaspora externality), this category of gain is the most important especially for countries with per capita income below 5000$. In fact, we can see that countries with per capita income around 800$ have a gain which amount 7% eventually because of

their low level of initial human capital as well as the schooling incentive created by the future migration prospect. Countries around 1200$ and 1700$ exhibit about 4% gains while countries above 5000$ exhibit negative education incentives. This observation suggests that gains from endogenized education are very important in low income countries and but vanish progressively as countries become richer. On average, for upper middle income countries, this gain is very limited and becomes even negative. The structure of the three categories of brain gain as well as the pattern of the overall brain gain (black-bolt curve) is driven by endogenized education decisions.

When we consider the size of brain drain, the structure of diffents category of gains remain almost identical (increasing pattern for diaspora externality, inverted U-shape for remittances and decreasing pattern for endogenized education decision). As depicted in figure 9.b, brain gain is on an increasing pattern (with an income gain up to 10% in average) for countries exhibiting around 12% brain drain while it is decreasing for countries between 12% and 25% (with an income gain of 8% around 18% BD and 4% around 25% BD on average) while remaining constant at 4% for countries with more than 25% BD.

This picture we have just presented is just the average picture and thus, hide a lot of specificities at country level. The next section will provide the situation of differents countries regions of SSA in order to charaterize the structure of brain gain.

### 6.2.2 Countries and regions specific picture

Our results show (See Figure 10) that brain gain is negatively correlated to the size of brain drain ($R^2 = 19.4\%$). Moreover, even in the gain side, 21.3% of SSA countries[27] exhibit negative gains driven by education desincentives. Those desincentives cost between 1% and 5% of per capita income except for Seychelles whose this cost amount up to 8% of per capita income. It then becomes easy to derive that those countries will be big losers in net terms. Among those 10 countries, 9 experience a brain drain above 25%.

Among the 37 countries experiencing a gain, Lesotho exhibit very high gain (29%) compared to the rest of the region. This gain is mainly driven by remittances[28] which represent 52% of that income gain (15% of per capita income).

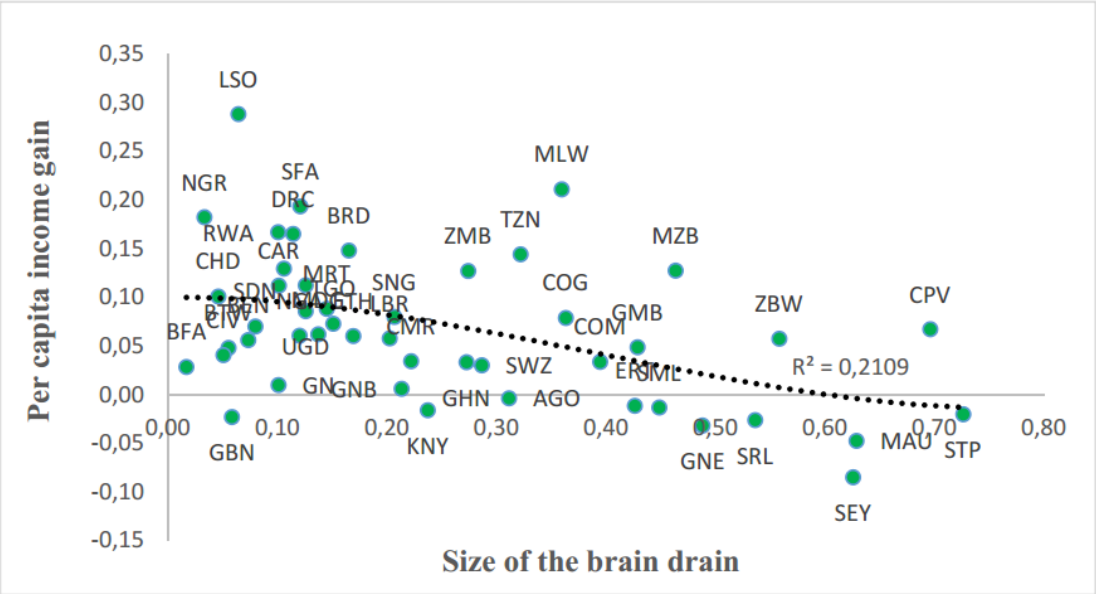
Overall, income gain is between 0.9% and 10% for 25 countries, between 10% and 15% for seven countries and above 15% for six countries. In addition,

[27] Gabon, Kenya, Angola, Erithrea, Somalia, Equatorial Guinea, Mauritius, Seychelles and Sao Tome

[28] As percent of GDP, in 2009 Lostho was the third largest remittances recipient in the world (24.8%) just behind Tajikistan (35.1%) and Tonga(27.7%)

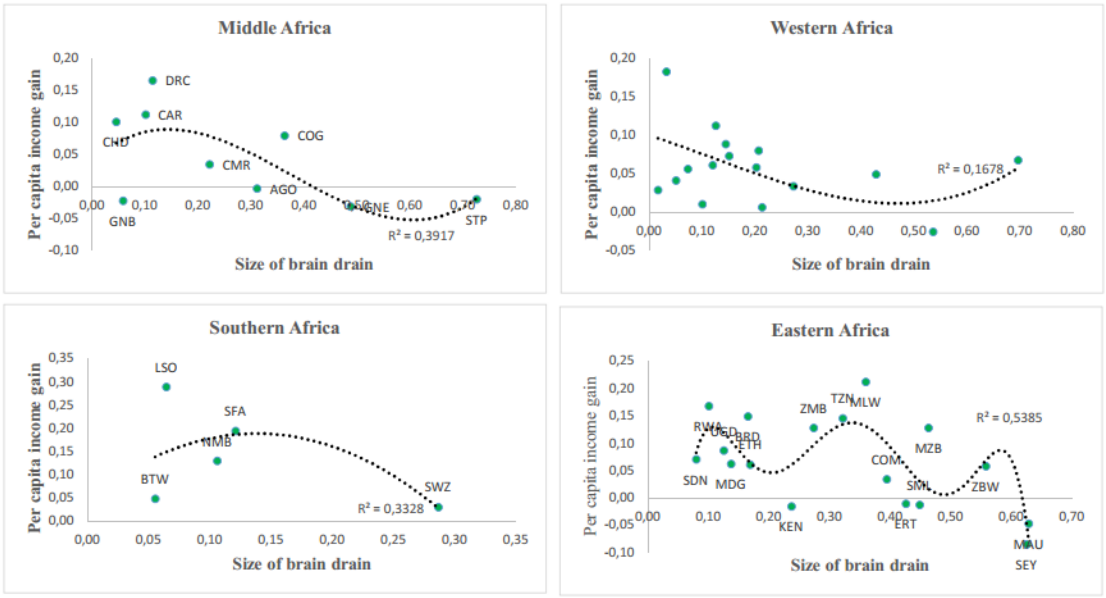
the pattern is more or less flat for size of brain drain below 20% and thereafter becomes negative when brain drain exceed 20%.

Figure 10: Skilled emigration gain by country in 2010




At sub-regional level, while brain gain exhibits an inverted U-shape pattern in Eastern Africa ($R^2 = 68\%$), it decreases with the size of brain drain in Western Africa ($R^2 = 51\%$), in Middle Africa ($R^2 = 48\%$) and in Southern Africa ($R^2 = 34\%$). In Eastern Africa, for countries with brain drain below 20%, brain gain exhibits a decreasing pattern, which becomes increasing for countries with brain drain between 20% and 35%; and then becomes decreasing for countries with brain drain above 60%. In Western Africa, the pattern of brain gain is decreasing with the size of brain drain. Countries exhibiting more than 10% income gain are those with brain drain below 10%; this income gain falls in the interval [5% - 10%] with brain drain between 10% and 25%. This income gain moves into income loss for countries with brain drain above 25%. In Southern Africa, income gain is substantial (more than 10%) for the majority of this sub-region. In Middle Africa, income gain is rather moderate (less than 4% for 77.8% of the sub-region's countries). We also observe countries with negative gain which mainly exhibit brain drain above 50%.

Figure 11: Distribution of brain gain by region in 2010




## 6.3 Net effect: Net Brain Gain versus Net Brain Loss

### 6.3.1 Picture of 2010 at global, regional and country's level

As depicted in figure 12, countries expriencing a brain drain lower than 25% are on average net winners. The pattern of net income response to brain drain is flat for brain drain lower than 12%[29]. Above 12%, net income response decreases with the level of brain drain. With brain drain above 25%, the net income response is negative meaning that SSA countries above that level are, on average, net losers[30].

With respects to country specifics net effects (see figure 12), our finding show that in 2010, net income response to brain drain is negatively correlated to size of brain drain ($R^2 = 64\%$). Moreover, they show that 20 out of 47 countries in SSA are net losers. 40% of those losers exhibit an income loss greater than 10% and 75% among them experience a brain drain higher than 25% and they are mainly small countries[31]. Among the 60% of winners, about 2/3 of them experience a relatively low brain drain (below 15%).

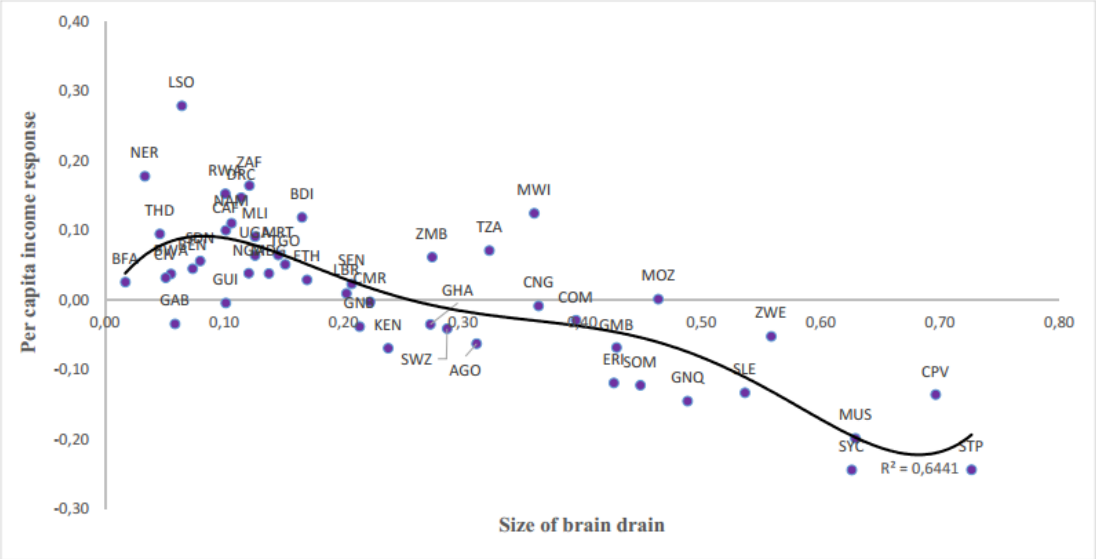
At subregional level (see figure 14), we do observe that in Eastern Africa,almost

[29]below 12% of brain drain, net per capita income gain is on average 8%

[30]Average net loss rich 8% of per capita income

[31]Eritrea, Somalia, Equatorial Guinea, Sierra Leone, Mauritius, Seychelles, Cape Verde, Sao Tome and Principe

Figure 12: Country net effect of brain drain in 2010



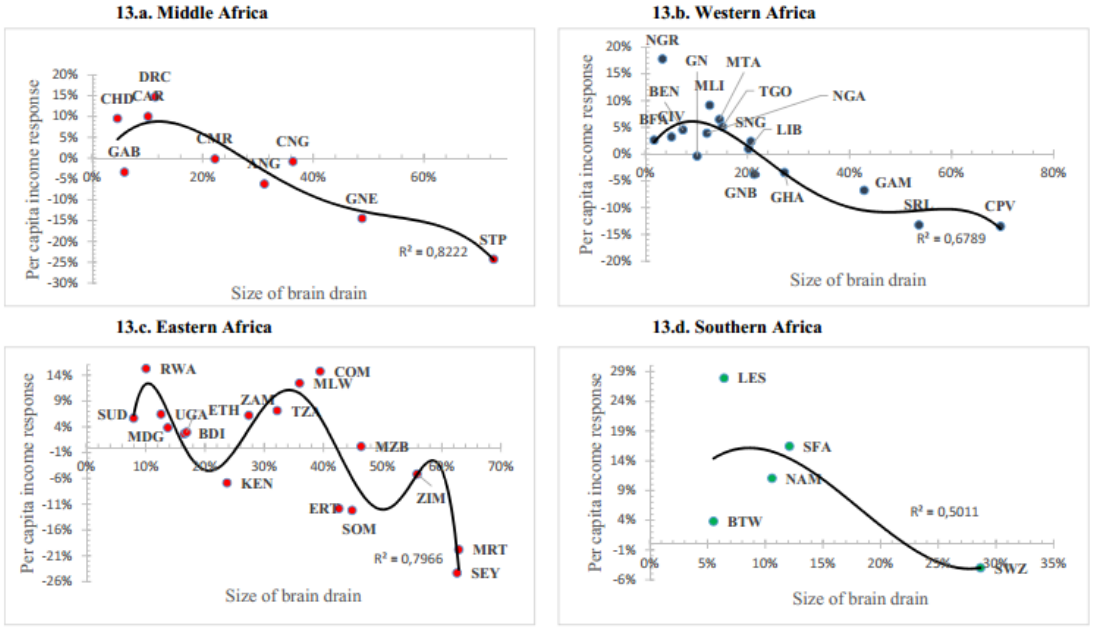

50% of countries are losers. In addition, the pattern of net income response shows that there are at least two interval of brain drain compatible with a net income gain. In fact, in the interval [0% - 18%] and [24% - 40%] of brain drain, countries in Eastern Africa are net winners while in the interval ]18% - 25%] and above 40% of brain drain, Eastern African countries are net losers.

In Western Africa, net income response is negatively associated to the size of brain drain ($R^2 = 67,9\%$). Almost 40% of countries in this area are net losers against 60% of net winners. Among winners, 70% experience substantial income gain above 5%. Net losers mainly experience a brain drain greater than 20%.

In Middle Africa, net income response to BD decreases with it size ($R^2 = 82.2\%$) and there are more losers than winners (6 countries out of the 9 in this subregion). 67% of countries in this area are net losers and net losses are substantial for some of them such as Sao Tome (25% of per capita income) and Equatorial Guinea (15% of per capita income). More over,Gabon with its low brain drain exhibits net income loss of about 5% which is rather a curiousity.

In Southern Africa, the pattern of net income response to brain drain is rather hard to identified because, if Swaziland is excluded of the sample, then the net income response is positively associated to brain drain while by integrating Swaziland, the reverse hold. But Swaziland is rather an outlier in this subregion. all the countries are net winners except Swaziland which exhibits a moderate loss (4%) with a high brain drain (29%). Moreover, this subregion is the only one

Figure 13: Regional distribution of Net income response to BD in 2010




which has observed a decline in brain drain over time and the only loser is a small country compared to a large country such as South Africa which is a big winner and at the same time account for more than 85% of the Southern Africa population.

### 6.3.2 Net effect of brain drain over time (1980 - 2010)

So far, we have focused on the year 2010 in order to dissect the structure of losses and gains from BD in SSA both at national and regional level. But, results show that net effect change over time. It appears that SSA as a whole is a net winner both with simple and weighted[32] average all over the period covered by this study. However, these net gains exhibit a decreasing pattern (table 3). Moreover, there is an increasing number of losers and a decreasing number of winners as a mechanical consequence (figure 14.f).

It is straight forward to understand that the difference in net positive income response between weighted and simple average is mainly driven by large countries[33]

[32] Weighted by the size of the population for each country

[33] D.R. Congo(6.91%), Ethiopia(10.12%), Nigeria(19,2%), South Africa(8%) and Tanzania (5%)

which are net winners and represent almost the half of the Sub Saharan African population (49.2%). At regional level, if each country is considerd as an equal unit, then, Middle Africa (MA) and Eastern Africa (EA) do not only observe a strong decline in their net income gain from brain drain, but they end up net losers from 2005 for MA and in 2010 for EA. The picture is slightly different with income gains weighted by population size because in these two areas, large countries are pulling the net effect upward. If we now turn to weighted average only, MA, EA and WA observe a strong decline in their net income gain from BD while for SA it is relatively flat. In addition, net income response in WA and EA are very close to the SSA level to some extend because they cover almost 70% of SSA population. It also apears that MA is far below the SSA level in non weighted average and above the SSA level in weighted average because it contents some small countries which are among big losers (Sao Tome, Equatorial Guinea with losses between 15% and 25% of their per capita income and at the same time represent only 0.65% of the MA population while only DRC which is the biggest winner in 2010 in this region alone accounts for 49% of the total population). SA which experienced the highest net income gain is the less affected area in SSA by BD; futhermore, results remain almost unchanged in SA between weighted and non weighted average because they are almost completely driven by South Africa which account for 87% of the SA population.

Regarding income group, big winners are countries with per capita income below 700$, followed by countries between 1500$ and 3000$. Countries with per capita income above 3000$ were globally net losers from 1990 with countries belonging to the income group above 6000$ experiencing the highest loss which has reached 6.5% in 2010. But, the structure of net income response has remained identical overtime. We have first observed a U-Shaped for countries below 2000$ (net gains were decreasing with countries below 800$, stable for countries between 800% and 1200% and then increasing) and then an inverted U-Shaped for countries between 1200$ and 5000$ (plot b. of figure 14). This plot also depicts that countries around 5000$ and more are likely to be net losers especially since 1990.

With respect to country size, pretty small countries (1.5 million$< POP <$ 2.5 million) are big winners in SSA followed by small (2.5 million $< POP <$ 10 million) and large countries ($POP >$ 25 million) and this hold over the entire period covered. But, gains in large countries have been less volatile compared to the other winners. Very small countries ($POP <$ 1.5 million) are the main losers with losses which have reached 10.1% in 2010 against 2% in 1985. Globally, except countries with population less than 1.5 million, net gains seem in average to move in opposite direction with the population size. Thus, albeit large countries are

winners, their net gains are lower than that of small and pretty small countries

With respect to the size of BD, countries experiencing low BD are big winners while countries experiencing high brain drain are losers. More practically, for countries with BD less than 5% net gains stand on average around 7% and remains more or less the same up to 13% BD, and then, net gains start decreasing up to 0% for BD size around 20% to 25%. This pattern is common to all the period covered, and the threshold (size of BD which generates neither gain nor loss) decreases from period to period (see plot c. of figure 14).

This threshold is structurally explained by the increasing pattern of losses from BD and the decreasing pattern of gains associated. So, when losses equalize the gains, this threshold is reached (plot b. of figure 14).

To synthesize, six importants obervations are drawn from these results. First, over the period 1980 - 2010, the number of losers has been increasing (from 04 countries in 1980 to 20 countries in 2010 out of the 47 considered) with the natural consequence of proportional decline in the number of winners (from 43 countries in 1980 to 27 in 2010) as depicted in figure 14.d. This might to some extend be explained by the important increase in the size of BD overtime. Second, some former winners have became losers with time but there are only three[34] countries which have been able to move sporadically from losers to winners showing thus the persistence of loss when it occurs (see appendix 6). Third, top winners[35] have experienced important decline in their net gain from BD (figure 14.c).Fourth, in SSA, the threshold size of brain drain above which a country is likely to experience net loss has been changing overtime[36].

Fifth, on the one side, large countries are net winners over time except Kenya which has been losing since 1990. On the other side, big losers are mainly small countries below 10 million inhabitants; but still, some relatively large countries are also losing (Somalia, Kenya, Angola). Sixth, it seems difficult to appreciate the pattern on net income response to BD in SSA with respect to the level of development (per capita income). As Appendix 5 shows, from 1990 to 2010, for the same level of per capita income, some countries are losers and some others are winners. This make a relevant conclusion difficult despite the observed weakly decreasing pattern.

[34]Liberia, Mozambique and Swaziland

[35]i.e winners with per capita income gain above 20% in 1980

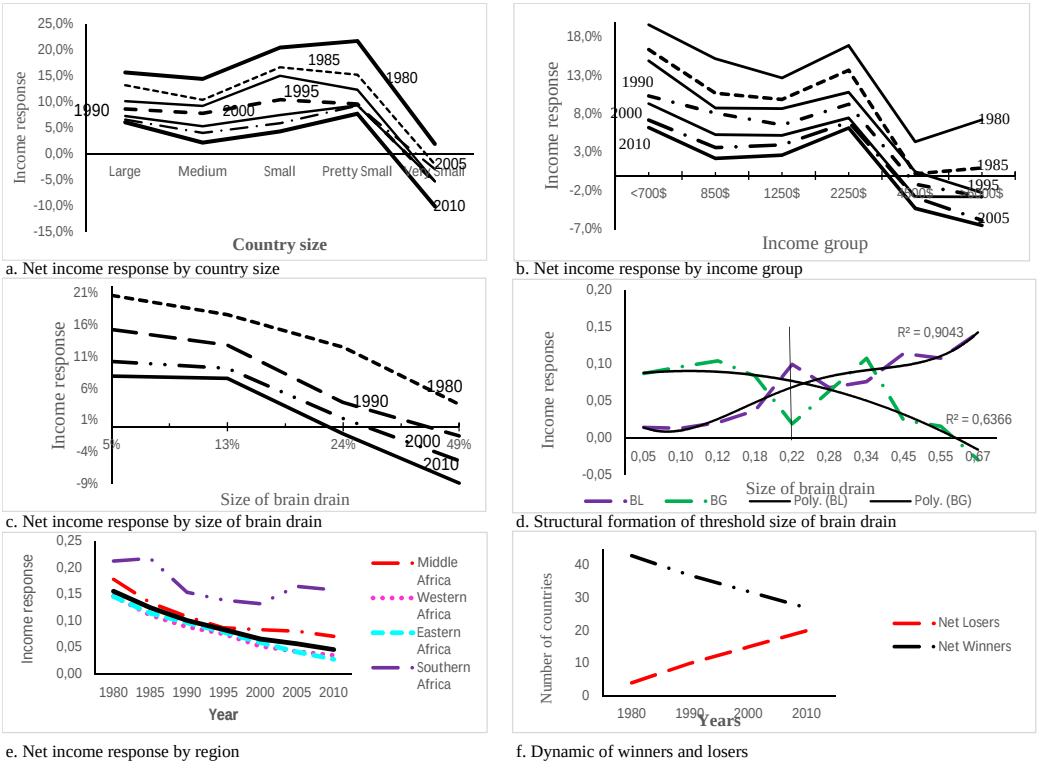
[36]53% in 1980, 24% in 1990, 21% in 2000 and 22% in 2010

Table 4: Regional distribution of net income response to brain drain [1980 - 2010]

| **Weighted average** | **1980** | **1985** | **1990** | **1995** | **2000** | **2005** | **2010** |
|---|---|---|---|---|---|---|---|
| Sub-Saharan Africa | 15.6% | 12.5% | 10.1% | 8.4% | 6.6% | 5.7% | 4.6% |
| Eastern Africa | 14.6% | 11.5% | 9.7% | 7.9% | 5.9% | 4.2% | 2.8% |
| Middle Africa | 17.8% | 13.4% | 10.8% | 8.7% | 8.3% | 8.1% | 7.1% |
| Southern Africa | 21.2% | 21.7% | 15.4% | 13.9% | 13.2% | 16.5% | 15.8% |
| Western Africa | 14.7% | 11.1% | 8.9% | 7.6% | 5.2% | 4.2% | 3.5% |
| **Simple average** | | | | | | | |
| Sub-Saharan Africa | 12.8% | 9.2% | 7.1% | 5.0% | 3.76% | 3.1% | 1.2% |
| Eastern Africa | 12.5% | 10.2% | 7.2% | 4.5% | 2.7% | 0.4% | -0.6% |
| Middle Africa | 9.1% | 4.3% | 3.5% | 1.6% | 0.4% | -1.1% | -1.7% |
| Southern Africa | 20.8% | 15.1% | 11.3% | 10.7% | 11.4% | 19.5% | 11.0% |
| Western Africa | 12.7% | 9.1% | 7.8% | 5.0% | 3.4% | 2.0% | 0.8% |
| **By Income group** | | | | | | | |
| Below 700% | 19.7% | 16.4% | 14.9% | 10.4% | 9.4% | 7.2% | 6.2% |
| 700$ to 1000$ | 15.2% | 10.7% | 8.8% | 8.1% | 5.3% | 3.6% | 2.2% |
| 1000$ to 1500$ | 12.7% | 9.9% | 8.7% | 6.6% | 5.2% | 4.0% | 2.7% |
| 1500$ to 3000$ | 17.0% | 13.7% | 10.8% | 9.3% | 7.5% | 7.0% | 6.2% |
| 3000$ to 6000$ | 4.4% | 0.2% | 0.5% | -1.1% | -2.8% | -2.9% | -4.3% |
| Above 6000$ | 7.3% | 1.0% | -2.2% | -2.8% | -2.8% | -5.8% | -6.5% |
| **By Country size** | | | | | | | |
| Large countries | 15.6% | 13.2% | 10.1% | 8.6% | 7.2% | 6.6% | 6.1% |
| Medium countries | 14.4% | 10.4% | 9.2% | 7.8% | 5.3% | 4.0% | 2.1% |
| Small countries | 20.4% | 16.6% | 15.0% | 10.4% | 7.4% | 5.9% | 4.3% |
| Pretty small countries | 21.7% | 15.2% | 12.3% | 9.6% | 9.3% | 9.2% | 7.7% |
| Very small countries | 1.9% | -2.0% | -5.3% | -5.6% | -5.3% | -3.0% | -10.1% |
| **By size of BD** | | | | | | | |
| Low ($BD < 10\%$) | 20.7% | 16.8% | 15.3% | 12.0% | 10.3% | 9.9% | 8.0% |
| Medium ($10\% < BD < 20\%$) | 17.6% | 15.1% | 12.8% | 10.8% | 9.2% | 8.4% | 7.6% |
| High ($20\% < BD < 30\%$) | 12.5% | 7.0% | 3.8% | 1.9% | 1.3% | 5.2% | -1.1% |
| Very High ($BD > 30\%$) | 3.5% | 0.1% | -1.4% | -4.0% | -5.3% | -8.5% | -8.9% |

Note: *Regarding country size, Large, Medium, Small, Pretty Small and Very Small stand for countries with more than 25 million, between 10 and 25 million, 2.5 and 10 million, 1.5 and 2.5 million and less than 1.5 million inhabitants respectively. In addition, regarding the distribution of net income response by income group, I have excluded South Africa in group of country with percapita income above 6000% because it represented alone more than 90% of the total population of the group; risk being that by integrating it, we could obtain the South Africa picture rather than the picture of countries belonging to that income group*

Figure 14: Distribution of net income response to brain drain




a. Net income response by country size

b. Net income response by income group

c. Net income response by size of brain drain

d. Structural formation of threshold size of brain drain

e. Net income response by region

f. Dynamic of winners and losers

**Note:** *In plot d, the exact pattern depicted by data for Brain Loss (BL) and Brain Gain(BG) are those in long dash curves, with BL in purple and BG in green. The two black curves denote the trend lines extimated using a polynomial function (because exact trends have generated three intersections) and which match correctly with observed BG* ($R^2 = 0.64$) *and almost perfectly with observed BL* ($R^2 = 0.90$). *Plot f, depicts the evolution overtime of the number of net losers with dash curve in red and the number of winners in dash curve in black.*

# 7 Concluding remarks

This study investigates whether positives consequences of skilled emigration fully compensate its negative consequences in SSA over the period 1980 -2010. We have derived a skilled emigration loss function from the labour demand - labour supply model and a skilled emigration gain function from the developement accounting model. Our model revealed on the one hand that mechanical loss due to outflow of human capital and effects it created on those left behind (in the home country) either skilled or unskilled (external effect) were the most important components of losses while loss from education subsidies were rather limited. On the other hand, structure of brain gain has clearly shown that remittances are very low and represent the smallest component of brain gain in SSA. The gains from endogenized education decisions were the most important for countries combining small per capita income and small size of brain drain and it was declining with the two facts while diaspora externality was small for countries combining low income and low brain drain and outweighted the other gains in countries with higher brain drain and higher per capita income. It came out that, structurally, losses from brain drain increase with the size of skilled emigration while gains from brain drain decrease with an increase in the size of skilled emigration. This is the mechanism generating the threshold level of brain drain because at a certain level of skill emigration, losses and gains are equal. Regarding the net effect of brain drain, our model has revealed that, on average, SSA is a net winner but the gain has been declining over time. Moreover, this declining pattern has been observed in three of the four regions of SSA (MA, EA,WA) while SA exhibited a relatively flat pattern. Those four regions were net winners for average net income response weighted with the population size; but a simple average has shown that MA and EA ended up net losers. Futhermore, even if the model revealed that SSA as a whole was a net winner, there were more winners than losers. Gains have been declining over time and the number countries loosing has been increasing with a mechanical decline in the number of countries winning. Finally, our findings pointed out the persistence of net loss showing that, most often in SSA, once a country has became a loser, it remains there.

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**Appendix 1: Mathematical calculation of Skilled emigration loss in absence of externality**

Let's consider $Y = f(K, N)$ where $N = L - M$, N being resident labour force in home country and M being the number of migrants. K is consider as being internationally immobile.

The change in national income due because of the départure of migrants is given by:

$$\Delta Y_N = \left[ K\frac{\partial r}{\partial N} + L\frac{\partial w}{\partial N} \right] \Delta N$$

Where $\Delta N = M$

**Prouv:**

$\frac{\partial r}{\partial N}$ and $\frac{\partial w}{\partial N}$ are define as average rate at $N = L$ and at $N = L - M$. This average is defined as:

$$Avg.\frac{\partial r}{\partial N} = \frac{1}{2}\left[ \frac{\partial r}{\partial N}^{N=L} + \frac{\partial r}{\partial N}^{N=L-M} \right]$$

$$Avg.\frac{\partial w}{\partial N} = \frac{1}{2}\left[ \frac{\partial w}{\partial N}^{N=L} + \frac{\partial w}{\partial N}^{N=L-M} \right]$$

So, knowing that at $N = L$, $\Delta Y_N = 0$ because the only change is supposed to come from emigration, we remain with:

$Avg.\frac{\partial r}{\partial N} = \frac{1}{2}\frac{\partial r}{\partial N}^{N=L-M}$ and $Avg.\frac{\partial w}{\partial N} = \frac{1}{2}\frac{\partial w}{\partial N}^{N=L-M}$

Thus, at $N = L - M$, $\Delta Y_N = \frac{1}{2}\left[ K\frac{\partial r}{\partial N} + L\frac{\partial w}{\partial N} \right] \Delta N$. As a share of national production, this emigration loss can be expressed as:

$$\frac{\Delta Y_N}{Y} = \frac{1}{2}\left[ K\frac{\partial r}{\partial N} + L\frac{\partial w}{\partial N} \right] \frac{\Delta N}{Y}$$

$$= \frac{1}{2}\left[ \frac{K}{Y}\frac{\partial r}{\partial N}\frac{N}{r}\frac{r}{N} + \frac{L}{Y}\frac{\partial w}{\partial N}\frac{N}{w}\frac{w}{N} \right] \Delta N$$

$$= \frac{1}{2}\left[ \frac{dlnr}{dlnN}\frac{rK}{Y} + \frac{dlnw}{dlnN}\frac{wN}{Y}\frac{L}{N} \right] \frac{\Delta N}{N}$$

$$= \frac{1}{2}\left[ \frac{dlnr}{dlnN}\left(1 - \frac{wN}{Y}\right) + \frac{dlnw}{dlnN}\frac{wN}{Y}\left(1 - \frac{M}{N}\right) \right] \frac{M}{N}$$

[37]

$$= \frac{1}{2}\left[(1-s)\, e_{KN} + s\,(1-m)\, e_{NN}\right] m$$

Thus,

$$\frac{\Delta Y_N}{Y} = \frac{1}{2}\left[(1-s)\, e_{KN} + s\,(1-m)\, e_{NN}\right] m$$

Where $s = wN/Y$; $m = M/N$; $e_{KN} = dlnr/dlnN$; $e_{KN} = dlnw/dlnN$. In line with Hamermesh(1993), a weighted average of factor price elasticities adds up to zero, so that $(1-s)\, e_{KN} + s e_{NN} = 0$. Thus, the emigration Loss is given by:

$$\frac{\Delta Y_N}{Y} = -\frac{1}{2} s e_{NN} m^2$$

For simplicity, we will consider $e$ instead of $e_{NN}$ so that $\Delta Y_N/Y = -1/2 sem^2$.
For a C.E.S production function, $e = \dfrac{1-s}{\sigma}$, thus

$$\frac{\Delta Y_N}{Y} = -\frac{1}{2}\frac{s\,(1-s)\, m^2}{\sigma}$$

Where $\sigma$ denotes the elasticity of substitution between capital and labor.
Now, if we consider only skilled migrants, the skilled emigration loss will become:

$$\frac{\Delta Y_N}{Y} = -\frac{1}{2}\frac{s^h\left(1-s^h\right)(m^h)^2}{\sigma}$$

We do obtain the expression of equation (4)

[37]Since the production function is homogenous of degre 1.

**Appendix 2: Mathematical calculation of Skilled emigration loss in presence of externality**

In presence of externalities, since firms ignore them, the production function of th representative firm will be given by $Y_F = f(K,N)Y_E^{\gamma}$ and inputs prices given by marginal productivity conditions: $r = (\partial f/\partial K)\, Y_E^{\gamma}$ and $w = (\partial f/\partial N)\, Y_E^{\gamma}$. Equation (2) still gives the emigration loss under the existence of externalities. Then, marginal products are calculated under the equilibrium conditions of

$$Y = f(K,N)^{1/(1-\gamma)}$$

; that is

$$Y = \left[\delta K^{\rho} + (1-\delta)N^{\rho)}\right]^{1/\rho(1-\gamma)}$$

.

When skill structure is taking in to account, and given that skilled emigration affects both skilled and unskilled workers left in the home country, our production function become:

$$Y = \left[\delta_1 K^{\rho} + \delta_2 (N^h)^{\rho} + (1-\delta_1-\delta_2)(N^l)^{\rho}\right]^{1/\rho(1-\gamma)}$$

$\dfrac{\partial w}{\partial N}$ and $\dfrac{\partial r}{\partial N}$ are calucalted using the equilibrium condition at point $N = L - M$. Then, once those partial derivatives are obtained, we therefore apply

$$\frac{\Delta Y_N}{Y} = \frac{1}{2}\left[K\frac{\partial r}{\partial N} + L\frac{\partial w}{\partial N}\right]\frac{\Delta N}{Y}$$

to obtain the expression of emigration loss reported in the text (equation 7):

$$\frac{\Delta Y_N}{Y} = \frac{1}{2}\frac{s^h(1-s^h)(m^h)^2}{\sigma} + \frac{\gamma\, s_i^h\, m_i^h}{1-\gamma}\left(1 - s^h\, m^h\right) + \frac{\gamma\, s^l\, m^h}{1-\gamma}\left(1 - s^l\, m^h\right)$$

**Appendix 3: Sample description**

| Total sample | Eastern Africa | Middle Africa | Southern Africa | Western Africa |
|---|---|---|---|---|
| Angola | Burundi | Angola | Botswana | Benin |
| Benin | Comoros | Cameroon | Lesotho | Burkina Faso |
| Botswana | Eritrea | Central Africa R. | Namibia | Cape Verde |
| Burkina Faso | Ethiopia | Chad | South Africa | Cote d'Ivoire |
| Burundi | Kenya | D. R. Congo | Swaziland | Gambia |
| Cape Verde | Madagascar | Congo | | Ghana |
| Cameroon | Malawi | Equatorial Gui. | | Guinea |
| Central African R. | Mauritius | Gabon | | Guinea Bissau |
| Chad | Mozambique | Sao Tome | | Liberia |
| Comoros | Rwanda | | | Mali |
| D. R. Congo | Seychelles | | | Mauritania |
| Congo | Somalia | | | Niger |
| Cote d'Ivoire | Sudan | | | Nigeria |
| Equatorial Gui. | Tanzania | | | Senegal |
| Eritrea | Uganda | | | Sierra Leone |
| Ethiopia | Zambia | | | Togo |
| Gabon | Zimbabwe | | | |
| Gambia | | | | |
| Chana | | | | |
| Guinea | | | | |
| Guinea Bissau | | | | |
| Kenya | | | | |
| Lesotho | | | | |
| Liberia | | | | |
| Madagascar | | | | |
| Malawi | | | | |
| Mali | | | | |
| Mauritania | | | | |
| Maurititus | | | | |
| Mozambique | | | | |
| Namibia | | | | |
| Niger | | | | |
| Nigeria | | | | |
| Rwanda | | | | |
| Sao Tomé | | | | |
| Senegal | | | | |
| Seychelles | | | | |
| Sierra Leone | | | | |
| Somalia | | | | |
| South Africa | | | | |
| Sudan | | | | |
| Swaziland | | | | |
| Tanzania | | | | |
| Togo | | | | |
| Uganda | | | | |
| Zambia | | | | |
| Zimbabwe | | | | |

**Appendix 4: Do skilled migrant remit less in SSA?**

One of the most important difficulty when researchers try to find out whether remittances offset losses due to brain drain in the source country is the lack of official data on remittances from skilled workers. So, those studies will mechanically overestimate the offsetting power of remittances. At least, one might argue that the largest share of remittances should come from skilled migrants since they earn higher wages in the host countries compared to unskilled migrants. While they typically earn more and so might be expected to remit more, skilled migrants are also more likely to stay in the host country for long and to reunite with their close family in the host country. This latter argument should be associated with smaller propensity to remit. So, the impact of brain drain on remittances remain an empirical question. Authors such as Faini (2002, 2006, 2007); Niimi, Odzen and Schiff (2010) have evidenced that skilled migrations are associated with a lower propensity to remit. But, a recent study by Bollard, Mckenzie and Morten (2010) using a large sample of about 12 000 Africans immigrants living in OECD countries have evidenced that remittances are positively and significantly associated to skilled emigration. Otherwise, skilled migrants remit more than unskilled. This opposition of view highlight the fact that the pattern of remittances with respect to skill structure (who remit more?) remains an opened question.

In this study, since we need to estimate the share of remittances sent by skilled migrants, we have to look some insights from our data (data from Brucker et al(2013)). Figure 6 below reports the scatter plot of per capita remittances on the share of skilled migrants in the total stock of migrants for different years 1980, 1990, 2000 and 2010.

From this figure, except for 1980, it is obvious to see that, remittances have been negatively associated to the share of skilled migrants (1990, 2000 and 2010); supporting the idea that skilled migrants are likely to remit less. Still, the slope of the curve is quite small (the curve is quite flat) and this make the conclusion very difficult. We have then chosen to verify it empirically using an econometric investigation.

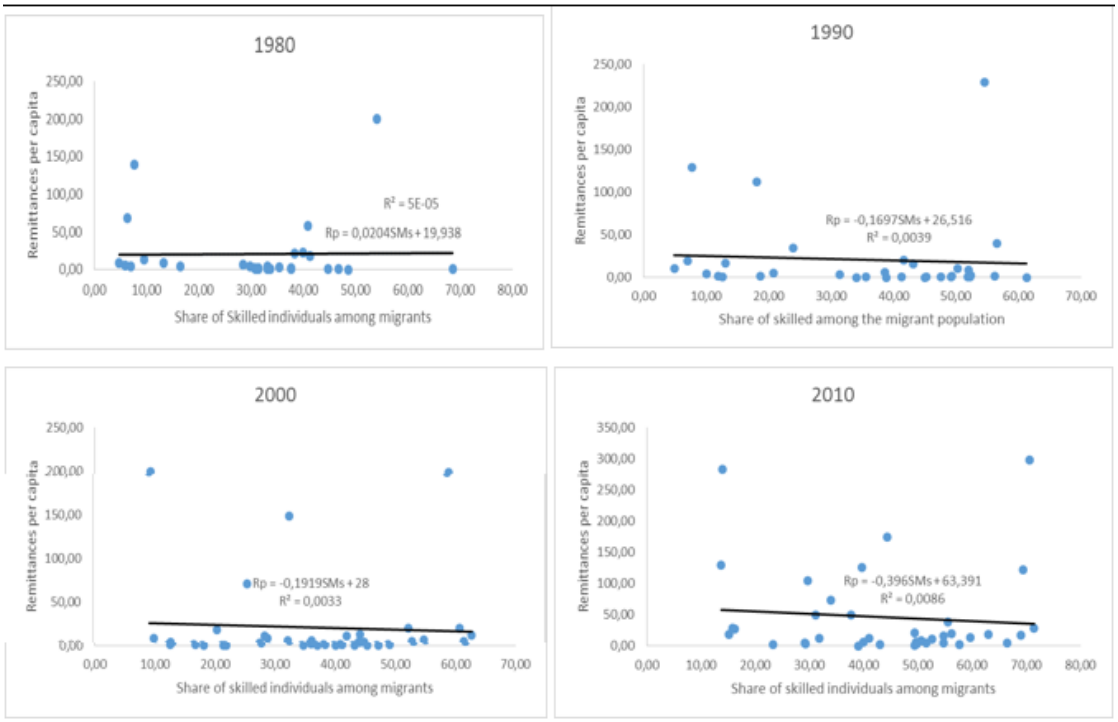
The equation describing determinants of remittances is inspired from studies of both Faini (2007) and Niimi, Odzen and Schiff (2010) and expressed as:

$$R_{pi,t} = \alpha_0 + \alpha_1 R_{pi,t-1} + \alpha_2 m^h_{i,t} + \beta' X_{i,t} + \epsilon_{i,t} \tag{23}$$

Where X is a vector of other explanatories variables used as determinants of remittances (migration rate, medium skilled migration rate, per capita income and population size).

As highlighted by Faini (2007), Niimi et al (2010), migration is endogenous

Figure 15: Per capita remittances and the share of skilled migrants




Source: Authors' construction from BCM (2013)

since sending remittances is one of the main reason of migration. So, instruments they use for migration in order to deal with the issue of endogeneity are distance between home and host country, cost of obtaining a passport as share of per capita income, dummies for landlock country, island, acceptance of dual citizenship, and where English is spoken. While those studies were almost cross sectional analysis even if Faini (2007) did a panel data with two period (1990 and 2000), our own study is an extended panel data study over the period (1980 - 2010) with five years interval. Both Faini (2007) and Niimi et al (2010) used instrumental variable (IV) technic. But regarding instruments they used, most of them are not likely to change over time (landlock, distance between home and host country, Island)while variable they are instrumented change with time and thus appears as being inefficient in a dynamic analysis. In order to deal with this issue, we use Arellano and Bond (1991)General Method of Moment (GMM) approach which use differentiated explanatories variables as instruments and then we include instruments present above as additional instruments. Results are presented in the table 5 below.

Table 5: Impact of brain drain on remittances in SSA (1980-2010)

| Dependent variable: | log of per capita remittances | | | |
|---|---|---|---|---|
| | OLS | FE | OS DGMM | TS DGMM |
| L.log per capita remittances | 0.795*** | 0.400*** | 0.749*** | 0.773*** |
| | (0.048) | (0.104) | (0.122) | (0.127) |
| log emigration rate | 0.141 | 0.710** | 0.216 | 0.014 |
| | (0.090) | (0.265) | (0.640) | (0.829) |
| log med skilled emigration rate | -0.125 | -0.632 | 0.113 | 0.206 |
| | (0.085) | (0.454) | (0.460) | (0.484) |
| log skilled emigration rate | 0.018 | 0.242 | -0.781* | -0.843** |
| | (0.131) | (0.449) | (0.446) | (0.395) |
| log per capita income | -0.054 | -0.833** | -0.562 | -0.580 |
| | (0.091) | (0.405) | (0.340) | (0.361) |
| log population | -0.047 | 1.501 | -0.511 | 0.479 |
| | (0.063) | (1.420) | (2.442) | (2.908) |
| Constant | -88.805*** | -101.877** | | |
| | (19.844) | (46.871) | | |
| Observation | 186 | 186 | 155 | 155 |
| Time dummy | YES | YES | YES | YES |
| AR2 (P-value) | N/A | N/A | 0.96 | 0.94 |
| Hansen (p-value) | N/A | N/A | 0.256 | 0.256 |
| Number of instruments | N/A | N/A | 29 | 29 |
| Number of country | N/A | 31 | 31 | 31 |
| R-Squared | 0.792 | 0.540 | N/A | N/A |

**Note:** *POLS: Pooled Ordinary Least Squares, FE for panel fixed effect, OS DGMM for One Step Difference Generalized Method of Moment, TS DGMM: Two Step D-GMM. The first three columns have allowed to choose between difference GMM and System GMM following the rule of Thumb. Difference GMM has been chosen. Final results intepreted are those in column four. Additional predefined instruments such as landlock, distance between home and host country, existence of dual citizenship, passport cost are used. Variables used are 5 years average values*

## Appendix 5: Evolution of NBG/NBL over the period 1980- 2010

**Appendix 6: Persistence of net losses [1980 - 2010]**

The table below present the persistence of losses from brain drain over the entire period covered by this study for each country experiencing at least one period loss.

Table 6: Persistence of net losses [1980 - 2010]

| | 1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|---|
| Angola | | X | X | X | X | X | X |
| Cape Verde | X | X | X | X | X | X | X |
| Cameroon | | | | | | | X |
| Comoros | | | | | X | X | X |
| Congo | | | | | | | X |
| Equatorial Guinea | | X | X | X | X | X | X |
| Eritrea | | | | X | X | X | X |
| Gabon | | X | X | X | X | X | X |
| Gambia | | | | | | X | X |
| Ghana | | | | | | X | X |
| Guinea | | | | | | | X |
| Guinea Bissau | | | | | | X | X |
| Kenya | | | X | X | X | X | X |
| Liberia | | | X | X | X | X | |
| Mauritius | X | X | X | X | X | X | X |
| Mozambique | | | | | X | X | |
| Sao Tome | X | X | X | X | X | X | X |
| Seychelles | X | X | X | X | X | X | X |
| Sierra Leone | | | | | X | X | X |
| Somalia | | | | X | X | X | X |
| Swaziland | | X | X | X | | | X |
| Zimbabwe | | | | | | X | X |
| Total | 4 | 8 | 10 | 12 | 14 | 18 | 20 |

**Appendix 7: Country specific net income response[1980 - 2010]**

The table below provides net income response in percentage of per capita income of each country for each year from 1980 to 2010 with 5 years interval.

| | 1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|---|
| Angola | 4.0% | -1.2% | -0.5% | -2.8% | -5.3% | -7.1% | -6.2% |
| Benin | 21.9% | 16.2% | 15.6% | 11.7% | 9.8% | 7.4% | 4.5% |
| Botswana | 25.0% | 9.8% | 7.6% | 5.2% | 5.4% | 4.9% | 3.8% |
| Burk. Faso | 17.5% | 14.6% | 12.8% | 10.0% | 8.0% | 7.0% | 2.6% |
| Burundi | 27.5% | 24.1% | 23.8% | 22.3% | 20.2% | 14.0% | 11.9% |
| Cape verde | -24.1% | -22.5% | -17.5% | -17.7% | -13.7% | -18.9% | -13.5% |
| Cameroon | 19.2% | 14.3% | 10.8% | 7.9% | 6.2% | 2.9% | -0.2% |
| Central Africa R. | 18.9% | 15.1% | 11.3% | 11.6% | 11.1% | 11.2% | 10.0% |
| Chad | 23.7% | 20.0% | 17.3% | 15.3% | 12.0% | 11.6% | 9.5% |
| Comoros | 11.4% | 9.7% | 7.9% | 3.5% | -1.0% | -1.1% | -2.9% |
| D. R. Congo | 22.3% | 18.1% | 14.6% | 12.5% | 13.9% | 15.3% | 14.7% |
| Congo | 6.3% | 6.5% | 5.8% | 3.6% | 2.6% | 1.7% | -0.8% |
| Cote d'Ivoire | 11.6% | 10.1% | 11.1% | 5.7% | 3.9% | 3.9% | 3.2% |
| Equa. Guinea | 15.1% | -0.8% | -4.7% | -5.9% | -8.7% | -15.4% | -14.5% |
| Eritrea | 16.0% | 14.1% | 10.9% | -5.2% | -11.3% | -11.5% | -11.9% |
| Ethiopia | 16.8% | 12.6% | 9.3% | 7.6% | 6.7% | 4.3% | 2.9% |
| Gabon | 1.1% | -0.3% | -0.1% | -1.6% | -2.2% | -2.2% | -3.4% |
| Gambia | 15.6% | 7.3% | 4.9% | 1.5% | 2.9% | -3.2% | -6.8% |
| Ghana | 8.2% | 5.2% | 3.2% | 2.6% | 0.3% | -2.8% | -3.5% |
| Guinea | 14.5% | 11.0% | 8.8% | 7.3% | 5.8% | 3.8% | -0.4% |
| Guinea-Bissau | 16.5% | 9.6% | 6.3% | 0.6% | -2.4% | -5.6% | -3.8% |
| Kenya | 5.3% | 1.5% | -0.8% | -2.6% | -4.1% | -6.3% | -6.9% |
| Lesotho | 39.7% | 35.7% | 30.8% | 25.9% | 25.4% | 29.3% | 27.9% |
| Liberia | 7.9% | 1.4% | -4.8% | -11.3% | -12.8% | -7.1% | 1.0% |
| Madagascar | 11.8% | 9.6% | 6.9% | 6.1% | 5.2% | 4.7% | 3.8% |
| Malawi | 23.3% | 18.9% | 19.8% | 17.2% | 18.5% | 17.0% | 12.5% |
| Mali | 24.1% | 21.1% | 19.6% | 17.6% | 13.1% | 10.1% | 9.1% |
| Mauritania | 15.6% | 13.5% | 12.6% | 8.8% | 6.3% | 5.6% | 6.5% |
| Mauritius | -7.4% | -6.4% | -13.4% | -11.3% | -10.8% | -18.8% | -19.8% |
| Mozambique | 10.3% | 0.9% | 1.5% | 9.7% | -3.0% | -1.8% | 0.2% |
| Namibia | 11.8% | 9.5% | 8.1% | 8.5% | 8.2% | 10.0% | 11.0% |
| Niger | 24.1% | 22.4% | 22.8% | 20.6% | 19.3% | 18.6% | 17.8% |
| Nigeria | 13.9% | 10.2% | 7.3% | 6.7% | 4.0% | 3.0% | 3.9% |
| Rwanda | 36.4% | 32.9% | 29.4% | 24.6% | 20.4% | 18.4% | 15.3% |
| Sao Tome | -28.9% | -32.6% | -22.9% | -25.8% | -26.0% | -28.1% | -24.3% |
| Senegal | 12.0% | 10.6% | 9.8% | 8.8% | 11.0% | 15.5% | 2.3% |
| Seychelles | -21.3% | -13.8% | -29.5% | -33.6% | -26.2% | -29.6% | -24.3% |
| Sierra Leone | 13.7% | 6.0% | 5.6% | 0.5% | -7.2% | -8.7% | -13.3% |
| Somalia | 12.1% | 9.0% | 2.6% | -6.9% | -7.5% | -12.3% | -12.2% |
| South Africa | 20.9% | 22.4% | 15.7% | 14.3% | 13.4% | 16.2% | 16.5% |
| Sudan | 21.4% | 22.9% | 19.8% | 15.3% | 10.9% | 8.3% | 5.7% |
| Swaziland | 6.5% | -1.8% | -5.7% | -0.5% | 4.9% | 37.0% | -4.1% |
| Tanzania | 13.0% | 12.9% | 11.9% | 11.9% | 12.1% | 10.9% | 7.1% |
| Togo | 12.1% | 10.9% | 9.8% | 7.1% | 6.2% | 5.5% | 5.1% |
| Uganda | 6.6% | 5.4% | 7.1% | 4.2% | 4.2% | 4.9% | 6.4% |
| Zambia | 24.5% | 15.4% | 11.8% | 10.0% | 7.5% | 7.7% | 6.2% |
| Zimbabwe | 5.6% | 3.6% | 3.9% | 4.2% | 3.3% | -1.4% | -5.2% |

**Appendix 8: Missing data management**

**Per capita GDP PPP**: For some countries in our sample like Eritrea, Somalia and Sao Tome, there were not data at all on the covered period and for countries like Ethiopia, Guinea, Tanzania and Uganda, some observations where missing. In order to cope with that, with use Gapminder dataset of per capita GDP PPP.

**Public spending in education by level of education**: This table contents the summary of actions undertaken to manage the missing data.

| **Country** | **Year(s) without data** | **Mitigation action** |
|---|---|---|
| Angola | 1980, 1995 | Moving average |
| Benin | 1980 - 1995 | Situation of 2000 replicated |
| Botswana | 2000 | Average between 1995 and 2005 |
| Cape Verde | 1980 - 1995 | Situation of 2000 replicated |
| Cameroon | 1980 | Situation of 1985 replicated |
| CAR | 1985 | Average 1980 and 1990 |
| Chad | 1980 - 1995 | Situation of 2000 replicated |
| Comoros | 1980 - 1995 | Situation of 2000 replicated |
| DRC | 1995 - 2005 | Situation of 2010 replicated |
| Congo | 1985 - 1990 | Moyenne mobile |
| CIV | 1985 - 1990 | Moyenne mobile |
| Equatorial Gui. | 1980 - 1995,200-2010 | Situation of 2000 replicated |
| Eritrea | 1980 - 1995 | Situation of 2000 replicated |
| Ethiopia | 1980 | Situation of 1985 replicated |
| Gabon | 1980 - 1990, 2005 | Replicated 1995 and moving average 2000 and 2010 |
| Gambia | 1980 | Situation of 1985 replicated |
| Guinea | 1980 - 1990 | Situation of 1995 replicated |
| Guinea Bissau | 1980 - 1995, 2005 | Replicated 2000 and average between 2000 and 2010 |
| Liberia | 1980 - 2000 | Replicated the situation of 2005 |
| Madagascar | 1990 | Average between 1985 and 1995 |
| Malawi | 1985 | Average between 1980 and 1990 |
| Mali | 1985 | Average between 1980 and 1990 |
| Mauritania | 1980 - 1995 | Situation of 2000 replicated |
| Mozambique | 1980 - 1995 | Situation of 2000 replicated |
| Namibia | 1980 - 1995 | Situation of 2000 replicated |
| Niger | 1980 - 1995 | Situation of 2000 replicated |
| Nigeria | 1985 - 2010 | Situation of 1980 replicated |

**Appendix 9: Distribution of SSA countries by country size and income group**

| **By Country Size** | |
|---|---|
| Large Countries | NGA, ETH, KEN, SFA, SDN, TZA, UGD, DRC |
| Medium Countries | AGO, BFA, CMR, THD, CIV, GHA, MDG, MLI,<br>MLW, MZB, NGR, SNG, SML, ZMB, ZMB, GN |
| Small Countries | BEN, BRD, CRA, CNG, ERT, LBR, MRT, RWD, SRL, TGO |
| Very small Countries | BTSW, CPV, COM, GNE, GMB, GBN, GNB, LSO, MUS<br>NMB, STP, SEY, SWZ |
| **By Income Group** | |
| LIC | BEN, BFA, BRD, CRA, CHD, COM, DRC, ERT, ETH, GMB, GN,<br>GNB, LBR, MDG, MLW, MLI, MZB, NGR, RWD, SNG, SRL, SML<br>TZA, TGO, UGD, ZMB |
| LMIC | AGO, CPV, CMR, CNG, CIV, GHA, KEN, LSO, MRT, NGA, STP<br>SDN, SWZ, ZMB |
| UMIC | BTSW, GNE, GBN, MUS, NMB, SFA |
| HIC | SEY |