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# Brain Gain, Technology Transfer and Economic Growth: Case of Tunisia

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**Abstract**

This paper deals with a technological transfer channel from the developed North, and more specifically from Europe and America, towards Tunisia, through brain gain which includes both the "return option" as well as the "diaspora option". This idea has been the subject of this research with the aim of determining the technological diffusion vector for Tunisia, especially in front of the ineffectiveness of technology transfer channels commonly recognized as international trade, intra-industry trade and foreign direct investment. Within this framework, the empirical findings have globally shown, till 2010 which is the pre-revolution year, that Tunisia can garner benefits from Northern research and development via a return of Tunisian competencies to their country of origin (return option) while staying in the country of residence (diaspora option), by taking into consideration some categories in Europe such as teachers & researchers and other skilled executives. However, these results would be promising for the other categories of Tunisian competencies in Europe like engineers and architects, doctors and chemicals, computer scientists and lawyers and for all categories of Tunisian competencies in America, who are not so far involved in the development of their country of origin, by taking into account the post-revolutionary period that has begun in 2011, and that will extend over the medium and above all the long term. These results would be predicting a significant improvement in political and economic situation in Tunisia and therefore a favorable climate for technology transfer.

**Keywords:** brain gain, technology transfer, economic growth, Tunisia, bootstrap

## 1. Introduction

The imitation of the South is achieved through the international technology diffusion from the North, which is considered the principal real contribution of the North-South free trade area, however there has been changes in the capacity and strength of diffusion over time. Indeed, today, the economic integration level in the world is important: international trade is growing more rapidly than income, and transportation costs for goods are decreasing; multinational activity is increasing more rapidly than trade, partly explained by the development of new communication technologies, and the Internet is considered as the main symbol of a globally integrated world. Thus, it seems that North-South research and development (R&D) spillovers are ensured by international exchanges (including intra-industry trade) and by foreign direct investment (FDI), which is proved by many recent works (Note 1). However, in the case of Tunisia, the results found previously (Note 2) are not completely verified due to weak absorptive capacity. Thus, among the proposed suggestions for Tunisia, and for developing countries in general, is to include the setting-up of public policies designed to improve the level of education and skills of the labor force in order to better assimilate opportunities offered by technological progress. For instance, the State must become more engaged financially in the educational system through an intensive investment in universities, particularly in relation with the manufacturing sector, through which most of the technology transfer is done. It is true there is a temporary or permanent drain of Tunisian skills towards the North (with more favorable working conditions), but we can expect a technology transfer from these Northern countries to Tunisia both through either a return of these skills to their country of origin with all their knowledge and experience acquired abroad (return option), or even by staying in their country of destination (diaspora option). The main question that arises at this level is: Can brain gain, including return option and diaspora option, be actually an

alternative to international trade, to intra-industry trade and to FDI in technology transfer from the North to Tunisia, and consequently be a driving force for economic growth?

Many authors like Nelson (1976) and Hugo (1982) noted an unprecedentedly large scale circular migration, implying a larger sample of groups and providing a variety of forms broader than before. Therefore, the movement of skilled persons can certainly take place within the country (i.e., between different firms), but also on the international level. The second case refers to temporary and permanent movement of qualified persons between countries. Generally speaking, the migration of skilled people has different determinants, longer-term consequences and policy implications on countries of origin and destination.

In this context, the most important issue for the long-term development of the countries is the net effect of migratory flows. Although the net impact of migration of qualified people centered around brain drain and brain gain on countries of origin was not clearly identified in the theoretical and empirical literature, "optimistic" models like those of Mountford (1997) and Stark (2004) stress the dynamic effects of migration. They focus on the positive impact of remittances and the impact on the development of human capital in home countries as a result of an increasing demand for and access to education. The scope of the migration has expanded to include the technology and knowledge transfer, both through the physical return of expatriates (return option) as well as through remittances, links with international trade and FDI, and diaspora networks (Diaspora option). This last point will be of a core importance in our work because it could allow us to discover or confirm another channel of technology transfer from North to South, apart from the commonly known traditional channels namely international trade and FDI.

Accordingly, two main parts will be dealt with: the first part will be a literature review, in which we will focus on the positive analysis of the brain drain through the phenomenon of brain gain, by highlighting both the "return option" and "diaspora option" and their positive impact on economic growth through technology transfer. As for the second part, it will be an attempt of econometric estimation in Tunisia, as a Southern country affected by the phenomenon of brain drain and at the same time working hard to benefit from brain gain. In such estimation, the OLS method, with the technique of bootstrapping, which is a preferred one, will be used in order to confirm the contribution of the brain gain as a technology transfer channel and especially to better precise the category (or the categories) of skills or brains that can contribute the most to the Tunisian economy growth through technology transfer.

## 2. Brain Gain, Technology Transfer and Economic Growth: Literature Review

Technology is enclosed in human capital, and the technology diffusion requires communication between agents. At this level, Arrow (1969) showed the importance of interpersonal communication to facilitate the technology diffusion. This communication can be either face to face in the context of return option or at a distance in the framework of the diaspora option. The return option is associated with temporary emigration while the diaspora option is associated with permanent emigration. Some migrants plan to return to their country of origin while others decide to stay in the host country and that brings about heterogeneity in their behavior. Decisions are based on a comparison of discounted utility flow between staying in the host country for another year and returning to the country of origin on a permanent basis. They also depend on the capital invested within each country as well as stochastic shocks series.

Unexpected shocks usually have to do with income which is very crucial for emigrants to revise their plans of immigration and change their preferences: staying in the host country or returning to their country of origin. All in all, this heterogeneity is a consequence of different economic situations which are taken into account by emigrants when making current decisions. The "return option" and "diaspora option" are brain gain concepts but along with their advantages there are some limitations too. Their success and effectiveness will depend significantly on both the internal dynamics of the domestic country and on the way to tackle some main causes leading to emigration of the qualified labor force.

Moreover, the feedback effects of the brain drain are not restricted to the technology transfer, but also extend to include remittances. Here we can name two feedback effects of skilled emigration: one, emigrants bring their skills and work experience from abroad to improve the productivity of their country of origin. Two, expatriates who are staying abroad transfer not only remittances but also knowledge or technology to developing countries, consequently improving their productivity and their economic development. According to Khadria (2007), the Southern countries which suffer from brain drain are expected to gain back three types of economic benefits: remittances, technology transfer and the return of workers with skills improved from host countries of the North to their countries of origin in the South. Consequently, Burns and Mohapatra (2008) perceive the diaspora as a brain bank.

*2.1 Return Option, Technology Transfer and Economic Growth*

Whatever types of migrants return, they can represent a vehicle for technology transfer. As a concrete example,

according to Martin Rovet et al. (1998), evidence from both the United States and France, the major countries in terms of the number of foreign students, is that two thirds of the foreign-born scientists and engineers working in the former earned their doctorate in the United States and that half of the foreign students receiving a doctorate or a post-doctorate in the latter return to their native country within two years. In other words, a large number of foreign students from developing countries get their PhDs in the United States and finally return home equipped with advanced technological knowledge. They represent an important channel for technology transfer to the developing countries. Consequently, with the return of migrants or national diaspora members who are still abroad, they have made major contributions to technological progress in their country of origin. More precisely, the return option presents returning migrants as highly educated and possible leading force to improve productivity of source countries. According to Kapur (2001) and Brinkerhoff (2006 a, b), the return of migrants can be a major source of entrepreneurship and capital investment (direct investments). At this level, emigrants are supposed to invest in their country of origin or even in their area of origin partly because they are qualified enough to assess investment opportunities and partly because they possess contacts to facilitate this process. The return option is considered as a logical outcome of a "calculated strategy", where migrants accumulate savings and develop skills abroad to be used later in their home countries. Returning migrants consequently represent a flow of financial and human resources. However, within the effects of emigration on domestic economies, there is no a consensus in the literature of migration on the role that returnees play in their homeland, and particularly if they are more likely to be consumers or investors. In this context in China, Zhao (2002) states that because the majority of returnees are in their primary productive age by an average of 35.6 years, they are expected to be mainly producers rather than consumers. Although mean age of returnees can change by countries, it is possible to take into account this result especially as it concerns a large developing country, China, a reference country in the field of return option**.** As for Puri and Rizema (1999) and Lowell and de la Garza (2000), incentives are created by the countries of origin to encourage their nationals to spend their financial resources on investments source of employment; a general trend in most countries of the South such as the countries of Latin America. At this level, for example, when returnees intend to establish micro-enterprises, customs duty may be reduced on imported equipment and machinery.

-Examples of Southern Countries.

The brain drain is often seen as a scourge for developing countries such as India and China, but recent analysis suggests the opposite. In fact, brain drain can bring about a key advantage for these countries through the return option, especially in a global competitive environment. Indeed, returnees would play a significant role in the development of innovative capacities in these countries by bridging knowledge gaps in key areas of R&D. India and China have been treated as places of low-cost production for multinational firms, but over the years the situation has changed: Engineers and scientists educated and trained in the United States or Europe have speeded up the technological upgrade of their regional economies and this is a reverse gain of brain drain.

What is worth being noted, countries which have worked best with the return option are not only the major developing countries such as India and China, but also the newly industrialised countries (NIC) of Asia like Singapore, South Korea and Taiwan (Charum & Meyer, 1999). These countries today have very advanced Sciences and Technologies (S&T) sectors as well as qualified population which has many opportunities to continue innovation and production.

The empirical literature, consequently, has underlined the importance of the role of the return option in the improvement of competence levels. Such option has enhanced the technology transfer and capital accumulation, particularly in successfully economies of the East and South Asia since the 1990's (Saxenian et al., 2002). The return option discourse has also extended beyond Asia to involve other parts of the developing world. Ireland is a clear example to show the role of the returnees in its economic miracle: From 1993 to 2001, the Irish economy has grown at a staggering annual pace of 8.4%, that to say three times the pace of the rest of the European Union (EU). In addition, McCormick and Wahba (2002) showed that a qualified immigrant who returns to his country of origin, Egypt, can establish a new company making use of new advanced technologies. Indeed, qualified immigrants make use of what they have already learned abroad and this itself is a form of knowledge transfer. More recently, according to McCormick and Wahba (2003) and Wahba (2007), immigrants returning to Egypt tend to have higher levels of human capital than non-immigrants. They are more entrepreneurial given that their working experience abroad is quite long. Finally, according to Logan (2009), in the case of reverse brain drain from North to South, any African country gets the qualifications of the

expert back in. The returnees in their country of origin will be able to use their skills for the national development efforts.

It is true that countries in the South need returnees with the objective to bring technology and therefore economic development, but these countries of origin are required to develop an adequate scientific, technological and business environment which provides income opportunities for qualified returning nationals. This is evident through a set of policies or incentives initiated by the governments of countries of origin in order to encourage the return of migrants and of highly skilled permanent diaspora members. These policies are formulated to directly attract returnees, mainly through providing a package of incentives (Note 3), or to accomplish the same objective indirectly by taking legal measures to encourage the return such as providing a dual citizenship and flexible residence rights. Concerning the results of these repatriation policies, Cervantes and Guellec (2002) state: "the harsh reality is that only a handful of countries have been successful in luring their talented émigrés back home" The "little dragons" of South East Asia are the champions of brain gain. At this level, South Korea and Taiwan have made the most effective return policies (Note 4). These two countries, along with Malaysia, then followed by India and China, have adopted nearly the same policy. In all these cases, they undertake voluntarist and incitative policies that are committed to preserve the autonomy of researchers as well as their membership in the international scientific community. However, there were several cases of failure, like the least developed countries in Africa, insofar as they have not provided a scientific, technological and business environment favorable to a definitive return of their nationals in the North. As a consequence, these countries have shown more interest in short-term visits by trained professionals. These visits may involve teachers and professors giving courses, engineers providing specific inputs in their fields of expertise, etc. These repatriation policies, however, are not only and exclusively the domain of governments. Here, it is appropriate to note, first of all, the role of international organizations such as the International Organization for Migration (IOM) which implemented, in 2002, programs related to return of talents back home in Africa. It worked on the program of return and reintegration of qualified African Nationals. Later on, it introduced the Migration for Development in Africa (MIDA) program, with the main objective of "mobilizing, and promoting the utilization of highly qualified, qualified and skilled personnel in the development of African countries through voluntary programs" (Note 5). The IOM has also launched similar programs in Latin America namely the program of return and reintegration for qualified Latin American nationals, and more recently in Afghanistan with the program of return of qualified Afghans. In collaboration with the countries of origin governments, the IOM often identifies suitable candidates, finds them jobs, finances their return and helps them to reintegrate. Other measures are taken to attract potential returnees and new incentives have been suggested such as tax exemptions, financial assistance with relocation expenses, a start-up capital to launch a business, and even citizenship rights for spouses and children could be introduced. On the other hand, developed countries in Europe and North America, as countries of destination, have established effective migration policies to encourage highly skilled immigrants coming from any Southern developing country not to settle down permanently in the country of destination, but also to move or commute between two modes: living in the host country and returning to the country of origin. What is almost agreed upon is that immigration is a continuous substitution of older human capital by younger generations and that is why they prefer to keep a younger age profile of immigrants, particularly in order to neutralize their ageing own structures of population. France, for example, has provided loans to immigrants from Mali and Senegal to set up businesses in their country of origin. However, the small size of programs, lack of experience in business development and the weak economic conditions at home have reduced the effectiveness of such programs.

*2.2 Diaspora Option, Technology Transfer and Economic Growth*

Whether emigrants are permanent or temporary loss of short to medium terms, their links to their source countries can bring significant benefits. This link causes a return of knowledge and technology. Rauch (2003) claimed that the diaspora "should be especially adept at transferring technology" because they "avoid language and cultural barriers to knowledge diffusion". Based on that, the ultimate objective of the diaspora option is to create channels through which expatriates can contribute effectively and productively to the development of their country of origin, irrespective of being temporary or permanent physical return. At this level, not only do diaspora communities send financial resources home, remittances, to help reduce poverty and support economic growth, but they also serve as an important source of international trade and FDI for their country. On another level, many communities living abroad have established associations and partnerships to tackle social and economic problems in their country of origin. More precisely, the diaspora option suggests that thanks to expatriates the country can get access to their individual knowledge as well as to the socio-professional networks in which they are inserted abroad. So, emigrants and diasporas communities can use their financial and

intellectual resources to help reduce poverty, contribute to private sector development and improve overall competitiveness in their country of origin. In that way, they are somehow making major contributions to technological progress. Taking into consideration these positive impacts, many national governments have looked for ways to further engage the emigrants and diaspora communities in the development agenda.

2.2.1 Remittances

Saravia and Miranda (2004) suggested some innovative mechanisms to recover and invest a portion of remittances sent home by migrants working abroad to promote the creation of a knowledge-based industry in developing countries, through knowledge and technology transfer. How is that?

Remittances can promote technology diffusion by reducing the credit constraints of receiving households and by encouraging investment and entrepreneurship (Puri & Rizema, 1999; World Bank, 2006; Fajnzylber & López, 2007; Woodruff & Zenteno, 2007). In addition, remittance flows have also contributed to the extension of banking services (often by using innovative technologies), including microfinance, to previously unserved, often rural sectors. This has improved household and firm access to financial services (Note 6), and their ability to purchase and invest in technology. Lastly, remittances have also helped domestic banks to foster links with banks in high-income countries. In turn, such links have fostered technology transfers as banks in high-income countries have helped local partners to upgrade their systems to comply with the anti-money-laundering, antiterrorism and know-your-customer regulations in developed countries.

While mobilizing financial resources through individual or collective remittances is part of the diaspora-development link, it can be argued that the mobilization of knowledge and skills of these expatriate professionals can play an even more effective role, facilitating economic development in their countries of origin. Remittances, therefore, encourage opportunities in R&D in the home country, having positive effects not only on productivity and competitiveness of firms, but also improving their profitability and their potential for future expansion.

2.2.2 Links with International Trade and FDI

What is commonly recognized is the crucial role that emigrants and diaspora communities can play in transferring technology, and consequently in facilitating trade and foreign investment in their country of origin. In this framework, on the one hand, Gould (1994), Lloyd (1996), Head and Ries (1998), Saxenian (1999), Vertovec (1999) and Stalker (2000) have found a statistically significant relationship between emigration and trade: emigrants may boost trade with their country of origin. In addition, according to Rauch and Trindade (2002), 60% of the increase in bilateral trade in differentiated products within the Southeast Asia may be attributed to ethnic Chinese networks. Also, a research has been conducted by the Organisation for economic cooperation and development (OECD) on immigrants in three key host nations and their source countries has found a long run increase in exports and imports with each other in the 1980's. More precisely, the research finds that transnational communities stimulate trade (imports) of their country of origin. More again, a literature exists on the consequences of a growing diaspora on the promotion of international trade. That is supported by a Canadian study which has come out with the same findings. It has shown that the 1980's witnessed an increase of 10% in the number of emigrants from a given country which was associated with a 1% increase of exports to this country and 3% of imports from this country. Head and Ries (1998) have studied the links between Canadian trade and other 136 countries while taking into account the origins of immigrants of these countries in Canada. Both authors found that skilled emigrants have a greater impact on Canadian trade than refugees possibly do. Indeed, their evaluations suggest a very great effect. The doubled number of skilled immigrants from East Asia to Canada has increased imports of East Asia from Canada by almost 75% (Note 7).

On the other hand, other researchers like Bugamelli and Marconi (2006) have tried to identify the mechanism behind the technology transfer enhancing growth. Their preliminary exercises have shown that the positive effect of skilled emigrations is related to FDI flows, which are widely recognized as an important channel for technology transfer. The importance of this result is that it consolidates a recent proof of Kluger and Rapoport (2005) concerning the positive effects of skilled emigration on FDI flows. For Wei (2004), in the year 2000, China received 41 billion dollars as FDI of which almost half were brought by its diaspora abroad. In addition, highly skilled diaspora of India has contributed heavily not only to the growth of the information technology (IT) sector (Note 8) but also to the attraction of FDI in this country of origin. At this level, the flow of external FDI of the United States of America (USA) into other countries is highly correlated with the number of emigrants coming from these countries themselves (Javorcik et al., 2006).

2.2.3 Diaspora Networks

A lot of developing countries have a large number of highly skilled and educated professionals living abroad. Some see this fact as a negative result of the brain drain, but others see knowledge and skills of these professionals as a potential economic factor. They might be even more important than the mobilization of any financial resources. It has already been seen that externalities of diaspora-development link imply a certain level of knowledge transfer due to remittances and links with international trade and FDI. Another essential part of these mechanisms is diaspora networks. They have been established to favor regular contacts, opportunities for businesses and knowledge transfers with researchers, scientists and entrepreneurs in the country of origin. More precisely, for those who remain abroad, the "diaspora option" relies mainly on the creation of networks which can be a benefit for the country of origin, especially when it facilitates technology transfer.

In fact, the Internet has played a key role in this area. Most diaspora networks have a discussion forum or a newsletter, either a paper or an electronic version. These have been practical to encourage communication between network members and inform them on the latest developments at home. Consequently, mechanisms for technology transfer include efforts to mobilize digital diaspora through web-based portals, which allow professional diasporas and their counterparts at home to share knowledge between them. In all, Brown (2000) has identified at least 41 e-based diaspora networks for 30 different countries. They were founded during the 1990's and they are classified into five categories:

- Student /scholarly networks;
- Local associations of skilled expatriates;
- Expert pool assistance;
- Developing intellectual/scientific diaspora networks; and
- The Transfer Of Knowledge Through Expatriate Nationals (TOKTEN) program of the United Nations Development Program (UNDP): it was introduced in 1977 with the objective to provide knowledge, expertise and experience of expatriates to their country of origin. Indeed, the program helps to make highly skilled expatriates return back home for short visits. These visits are usually ranging from three weeks to three months in which skilled expatriates take part in various developmental projects or undertake teaching assignments at local universities.

On the other hand, network members can engage in various activities namely conferences, seminars, workshops, etc. In addition, particular networks such as the Tunisian scientific consortium have specific periodicals in which the articles and books written by network members are published. The latter diffuse the research results and information and facilitate dialogue and discussion between network members themselves as well as with their counterparts at home. Also, the exchanges between network members and the national community may be in other types of scientific meetings, electronic data interchange or training sessions. The limitation is that no tangible results are there to evaluate them statistically. That is why it is difficult to determine the success of diaspora networks in terms of their impact on the development of country of origin. However, this does not mean that these exchanges are not significant at all.

-Major Examples of Diaspora Networks.

Several initiatives have been taken in recent years by many countries to identify, mobilize, organize and connect again their expatriate researchers with the national scientific community at home. Here are some examples are worth being mentioned. The "Red Caldas" network of expatriate researchers was established in Colombia in 1991 with the help of the government and has become one of the most advanced and promising examples of networks. This network today was one of the most developed as a "diaspora option" concerning brain gain. It was one of the first diaspora networks which have succeeded to promote collaborative research between domestic scientists and Colombian researchers abroad. That has been fulfilled through training and providing broader research opportunities (Note 9). At this level, training sessions in Bogota are presented by French and Franco-Colombian researchers. Other examples of diasporas networks are the brain drain Project in Serbia and the South African expatriate professionals Network. The latter is best known as a diaspora network which makes qualified persons living abroad connected to local experts and projects. The qualified persons are usually interested in contributing to economic and social development of South Africa. South African expatriate professionals Network is an active network with over 2.000 members in 57 countries. These members are well-equipped with expertise in hundreds of specialties and in different professional sectors. It should be noted that the project is supported by the South African national research and development Foundation.

The fact that many countries have simultaneously established diaspora networks, with comparable characteristics

and structures, would indicate that the "diaspora option" is a significant strategy. Another fact is that none of these networks has been dissolved and that they still exist today. It is true a few of them are not so dynamic in terms of activities and projects, but the objective of their creation has not disappeared and they still receive some form of support. In most cases, diaspora networks have reached their initial goal of mobilizing of highly qualified expatriate human resources to varying levels of success. However, some diaspora networks have failed, mainly because they were so ambitious, particularly in the case where the political and institutional environment in the country of origin was not favorable.

In a nutshell, scientific diasporas represent a new approach of the brain drain. For developing countries, these diasporas constitute a huge potential of additional resources. In addition, they are strong potential resources for effective and beneficial cooperation between these developing countries as countries of origin of these diasporas and highly industrialized countries as host countries: on the one hand, the host country has nothing to lose as long as scientists and engineers are still working within its borders; on the other hand, the country of origin benefits from additional capacity provided by expatriates. So, there is a clear potential for individuals to act in diaspora as agents of development. Being involved in their homelands, diasporas can play a crucial role as "agents of change" to inject new ideas and resources to stimulate progress in rather stagnant economies. The involvement of these emigrant and diasporas communities in the development process would be the same objective like any other development agenda: to promote a long-term and sustained economic growth. However, these benefits of the "diaspora option" differ among developing countries themselves. Indeed, the benefits of reverse flows of capital, of trade with countries of origin and of technology transfer, such as identified in the cases of India and Philippines, are low in the least developed African countries. Such benefits depend on economic conditions and on development level of productive capacities in countries of origin.

## 3. Econometric Estimation in Tunisia

### *3.1 Overview of the Follow-Up Study Model*

First of all, our empirical study is centered on developing countries which belong to different continents. This has drawn attention to difficulties of collecting data on skilled immigrants of developing countries staying abroad, mainly in developed countries of the North that are technologically very advanced. As a consequence, our choice was limited to our country, Tunisia. Another good reason for our choice is to search for a technology diffusion vector to Tunisia, especially due to the ineffectiveness of commonly recognized technology transfer channels namely international trade, intra-industry trade and FDI. The objective here at this stage is to view whether Tunisia, as a developing Southern country, can benefit from its highly qualified diaspora, in the framework of both the "return option" and the "diaspora option". At the absence of data on Tunisian skills abroad where there is a distinction between those that return and those who remain in the host country, the choice will be related to these skills on the assumption that both options are possible without distinguishing between them. The Office of Tunisians Abroad (OTA) has provided us with data on the Tunisian competences abroad, by region. Our focus is on the technology transfer from the technologically advanced North to Tunisia, namely from Europe (Note 10) and North America (Note 11). As for Asia, especially Japan, there has been a lack of data on expenditure on R&D in Japan for a certain number of years, added to the unimportant number of Tunisian skills in this country. It is worth being noted that data about gross domestic expenditures on R&D are provided by the OECD, and that data about Gross domestic product (GDP) of Tunisia are provided by the Central Bank of Tunisia (CBT).

In our previous studies, we relied on the three models listed below to explore a possible impact of imports, intra-industry trade and FDI on the total factor productivity (TFP) growth and therefore on the Tunisian economic growth via a technology transfer from the North. At this level, the economy sector taken into account is the manufacturing sector divided into six branches because this is the sector through which most of the technology transfer is done. The estimation method used was the panel data method, taking into account the six branches of the manufacturing sector as six individuals constituting the panel (i = 6). The three models, respectively for each technology transfer channel, are as follows:

$$\begin{cases} \text{Ln TFP}_{i,t} = \alpha_{i0} + \alpha_{i1}\ \text{Ln S}_{j,t} + \alpha_{i3}\ \text{M}_{ji,t}\ \text{Ln S}_{j,t} + \alpha_{i4}\ \text{Ln E}_{i,t} + \mu_{i,t} \\ \text{Ln TFP}_{i,t} = \alpha'_{i0} + \alpha'_{i1}\ \text{Ln S}_{j,t} + \alpha'_{i3}\ \text{B}_{i,t}\ \text{Ln S}_{j,t} + \alpha'_{i4}\ \text{Ln E}_{i,t} + \mu'_{i,t} \\ \text{Ln TFP}_{i,t} = \alpha''_{i0} + \alpha''_{i1}\ \text{Ln S}_{j,t} + \alpha''_{i3}\ \text{FDI}_{ji,t}\ \text{Ln S}_{j,t} + \alpha''_{i4}\ \text{Ln E}_{i,t} + \mu''_{i,t} \end{cases}$$

In response to our problematic, brain gain, represented by the Tunisian skills in the North, will be studied to see

if it may be a substitute for international trade, intra-industry trade and FDI as a technology transfer channel from North to Tunisia, and therefore to show its potential impact on the Tunisian economy growth. Compared to previous models, and since Tunisian skills are not characteristic of a particular field such as the manufacturing sector in addition to the difficulties of collecting data on TFP by skill, the dependent variable will be the GDP as an indicator of economic growth. Also, since a large number of Tunisian skills are fleeing the country, the third explanatory variable ($E_{i,t}$), part of the post graduate level in the manufacturing industries in Tunisia, will be deleted. Thus, the follow-up study model is the following:

$$Ln\ GDP_t = \alpha_0 + \alpha_1\ Ln\ S_{j,t} + \alpha_2\ C_{j,t}*Ln\ S_{j,t} + \mu_t \quad (1)$$

With: j and t = Respective indices of the North (E = Europe, A = America) and of annual periods;

GDP = Gross Domestic Product (at constant prices, base 1990) of Tunisia;

$S_j$ = R&D capital stock of the North;

$C_j$ = Number of Tunisian competences in the North (return option + diaspora option).

The estimation of this model showed that it is generally statistically significant at the 5% risk (Note 12). However, the coefficients associated with different explanatory variables Ln $S_{j,t}$ and $C_{j,t}$*Ln $S_{j,t}$, respectively 0.054 and 0.374, are not statistically significant (at 5%) (Note 13), showing the absence of effect of foreign R&D on economic growth in general, and via the Tunisian skills in the North in particular. In the hope of improving the results found, our choice was to make a change to this model by eliminating the variable "Ln $S_{j,t}$". In this case, the model as well as the results are statistically significant (at 5%) (Note 14). The new model is then as follows:

$$Ln\ GDP_t = \alpha_0 + \alpha_1\ C_{j,t}*Ln\ S_{j,t} + \mu_t \quad (2)$$

*3.2 Estimation Method: OLS Method*

The chosen study period will cover the 2000 decade. The choice of this period can be explained firstly by the lack of data on domestic expenditure on R&D for many northern countries in our sample for the year 2011 and secondly by the lack of data on the number of Tunisian skills abroad before 2000. Indeed, the ground had been prepared before 2000, and more precisely in the 1990's, that lead to the result of obtaining data on the Tunisian skills abroad starting from 2000. In fact, when we cast a glance at history, we can see that the need to establish a relationship or a better system of relations with the Tunisian elites located abroad became an urgent need as early as 1994, that's why some attempts were taken in this direction. For example, the Ministry of International Cooperation and Foreign Investment organized, in 1994, a meeting with a number of Tunisian executives and experts working in international organizations. In the next year, a second meeting was organized by the Ministry of Higher Education, with the assistance of OTA. It succeeded to bring together Tunisian teachers and researchers residing in France. The major criticism to those attempts was that they were limited to some categories of our skills abroad in a few host countries. To cope with that, in 1996, the OTA decided to organize periodical meetings which could bring together the different Tunisian skills abroad, whatever their specialty or their host country. The product of all these efforts was collecting data by OTA on Tunisian skills abroad since 2000. Moreover, data on the number of Tunisian skills abroad are provided by OTA in a discontinuous manner, within the framework of investigations conducted since 2000 on average every three to four years. At this level, data are available in the years 2000, 2003, 2007 and 2010 that is 4 observations. What is worth being noted in this context is that the chosen study period was exactly the period just preceding the Tunisian revolution, which took place in early 2011. Consequently, we can say our research has been based on a precise and clear time period to achieve its objectives.

The estimation of the study model used by Ordinary least squares (OLS) did not lead to statistically significant results to the extent the number of observations is only 4, which is a very small number. Therefore, and in order to have statistically significant results, the estimation by OLS with the technique of bootstrapping (Sampling with replacement) seems to be the most appropriate method.

The estimation of used study model will be done in three steps:

- The first estimation will treat the overall effect of Tunisian skills in the North on the Tunisian economy growth, to check if Tunisia can benefit from its diaspora abroad;

- The second estimation will study the "region effect", by distinguishing between the two regions: Europe "E" and America "A". Our goal at this level is to see if there are any regional disparities in the effects of Tunisian skills abroad on the national economy. In this case, the model (2) will be divided into two ways (Note 15):

- A model for the region of Europe:

$$Ln\ GDP_t = \alpha_0' + \alpha_1' C_{E,t} * Ln\ S_{E,t} + \mu_t' \quad (3)$$

- Another model for the region of North America:

$$Ln\ GDP_t = \alpha_0'' + \alpha_1'' C_{A,t} * Ln\ S_{A,t} + \mu_t'' \quad (4)$$

- The third and last estimation will analyze the "competence effect", taking into account the Tunisian skills abroad according to the following order: Teachers and researchers (TR), engineers and architects (EA), doctors and chemicals (DC), computer scientists (CS), lawyers (L) and other skilled executives (OSE). This estimation will make it possible to determine the category (or the categories) of competences of the Tunisian diaspora in the North who can influence its (or their) country of origin most.

*3.3 Estimation of the Used Study Model: Results and Interpretations*

The estimation results of the used study model are given while considering both the "return option" and the "diaspora option" without any distinction between them. It is true Tunisian skilled expatriates have intentions to continue their residence abroad with a particular interest in their international current experience (Note 16), yet they can be motivated by the return to Tunisia for many reasons such as career development, stimulating working environment, family factors, good pay and a position of responsibility.

The first estimation (Note 17) leads to the following result:

$$Ln\ GDP_t = 9.331016 + 9.53*10^{-6}\ C_{j,t} * Ln\ S_{j,t}$$
$$(0.000) \qquad (0.001)$$

The test has shown a positive and statistically significant effect (at 5%) of the R&D of Europe and North America on Tunisian GDP. It is achieved via the Tunisian skills in these two northern regions, which can be a technological diffusion vector to Tunisia and at the same time a substitute for international trade, intra-industry trade and FDI as conventional technology transfer channels.

As for the second estimation (Note 18), it leads to the following two results, respectively for Europe and America:

$$Ln\ GDP_t = 9.379923 + 0.0000133\ C_{E,t} * Ln\ S_{E,t}$$
$$(0.000) \qquad (0.000)$$
$$Ln\ GDP_t = 9.200395 + 0.0000401\ C_{A,t} * Ln\ S_{A,t}$$
$$(0.000) \qquad (0.660)$$

The two previous results have shown that only Tunisian skills in Europe have a positive and statistically significant effect (at 5%) on the national economy, probably because they are more numerous. Indeed, according to Zaoui (2009), a former President of the Network of Tunisian graduates of the elite schools, in a survey conducted in 2009, the Tunisian immigrant community is estimated at 1.060.000 people, 55% of them in France and 28% in other European countries and all in all about 110.000 people are considered skilled. The Tunisian competences living abroad are very attached to their origins and identity; therefore they play a crucial role in the development and promotion of research in Tunisia thanks to the addition of their knowledge, expertise as well as their experience. The intake of these skills for Tunisia is reflected in being technology transfer vectors and therefore as carriers of innovative projects. In addition, the Tunisian community abroad was behind the framing of a national policy in leadership on the principle that the Tunisians abroad are an integral part of the national community, which allows them to claim rights in their country of origin. In return, they are supposed to participate more and more in economic development efforts.

Concerning the third estimation (Note 19), it leads, for each of the six categories of skills realized according to the order previously indicated (Note 20), to the six following results:

$$Ln\ GDP_t = 9.437023 + 0.0000477\ TR_{E,t} * Ln\ S_{E,t}$$
$$(0.000) \qquad (0.000)$$
$$Ln\ GDP_t = 9.568348 + 0.000037\ EA_{E,t} * Ln\ S_{E,t}$$
$$(0.000) \qquad (0.069)$$
$$Ln\ GDP_t = 9.258544 + 0.0000962\ DC_{E,t} * Ln\ S_{E,t}$$
$$(0.000) \qquad (0.072)$$

$$Ln\ GDP_t = 9.582188 + 0.0001304\ CS_{E,t} * Ln\ S_{E,t}$$
$$(0.000) \qquad (0.144)$$
$$Ln\ GDP_t = 9.411263 + 0.0010238\ L_{E,t} * Ln\ S_{E,t}$$
$$(0.000) \qquad (0.762)$$
$$Ln\ GDP_t = 8.890375 + 0.0000952\ OSE_{E,t} * Ln\ S_{E,t}$$
$$(0.000) \qquad (0.007)$$

First of all, our choice was focused on the Tunisian skills settled in Europe because as it was shown in the previous estimation, it is at the level of this region that the effects on the Tunisian economy growth are positive and statistically significant (at 5%). Then, the results have indicated that only teachers & researchers and other skilled executives, more numerous, contribute to the Tunisian economy growth, with statistically significant coefficients (at 5%) and positive respectively of 0.0000477 and 0.0000952.

Taking into account these different estimations, we can say that they are teachers & researchers and other skilled executives settled in the region of Europe that were able to influence positively on the Tunisian economy as technology transfer channels from Europe to Tunisia, within the framework of both the return option as well as the diaspora option. However, it is necessary to mention the little contribution of these two categories of skills living in Europe in the Tunisian economy.

Consequently, the raised question is: "Why all categories of Tunisian skills abroad are not concerned about the technology transfer and its positive impact on the Tunisian economy growth, given for example that the contribution is limited to two expatriate categories in Europe?" To answer this, we should have a look at the general environment prevailing in Tunisia before the revolution: it was certainly characterized by a political and social stability, a favorable climate for investment, which attracted certain categories of Tunisian skills settled abroad, such as teachers & researchers in Europe, within the framework of both the return option as well as the diaspora option. However, at the same time, such an environment was characterized also by corruption, lack of transparency and absence of a genuine competition because the relatives of the former regime plundered the country and had upper hand in all sectors of the economy which consequently jeopardized any possibility of the existence of a real competitive environment. These factors were really unfavorable for investment which left much of Tunisian skills in Europe (engineers and architects, doctors and chemicals, computer scientists and lawyers) and all categories of skills in North America withdrawn and not involved in the development of the Tunisian economy. Their contribution, as a result, was restricted to the development of their host country, without any effect on the Tunisian economy (Note 21).

## 4. Conclusion

We can say that the last results are compatible with the literature review, arguing for the importance of brain gain, including both return option and diaspora option, as a substitute for international trade, intra-industry trade and FDI to not only technology transfer from the North (Europe) to Tunisia but also to be a driving force for economic growth. Although the "competence effect" suggests that only few or none of the skills categories are involved in efforts to develop the national economy, respectively for Europe and America, it does not deny the possibility to improve the last findings when all categories of Tunisian skills abroad could become agents of development, with a very important contribution. This can be realized in the context of a complementary research work in the future, especially with the new climate set in Tunisia since the Tunisian revolution on January 14, 2011, date of the Tunisian revolution. The new climate after the revolution, in the medium and above all the long term, would support a highly probable return of Tunisian skills to their country of origin and the involvement of the Tunisian diaspora in technology transfer to Tunisia, to the extent that would prevail all economic and political key success factors. These factors would include security, political stability, transparency, lack of corruption as well as the existence of a real competitive environment, all of these within the framework of a new democratic environment.

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**Notes**

Note 1. See, for example, Samet (2011b), whose work is a summary of all the studies which have been made about this topic.

Note 2. See, for example, Samet and Chaabane (2010), and Samet (2011a).

Note 3. In terms of the reverse brain drain model, it is the supply of material and non-material incentives, lead coordinating body, research institutes, science parks, as well as networks and a database to connect expatriates to their local employers and colleagues. In addition to the returnees with human capital, Southern governments have also shown interest in attracting returnees with financial capital (business model).

Note 4. Chang (1992), Yoon (1992).

Note 5. Wickramasekera (2002), pp.11-12.

Note 6. Gupta et al. (2007).

Note 7. For a literature review in the context of East Asian migration of skilled workers, see also Lucas (2001a).

Note 8. Kapur and McHale (2005 b), Pandey et al. (2006).

Note 9. Chaparro et al. (2006).

Note 10. France, Italy, Germany, Belgium, Netherlands, Austria, Spain, Poland, Finland, Sweden, Switzerland, Portugal, United Kingdom, Czech Republic, Slovakia, Turkey and Denmark.

Note 11. United States and Canada.

Note 12. See appendix A, where Prob > chi 2 = 0.0002 < 0.05.

Note 13. See appendix A.

Note 14. See appendix B.

Note 15. The division of the model into two is explained by the fact of avoiding mixed effect.

Note 16. The reasons for no return to Tunisia are usually explained by a lack of opportunities, inadequate working conditions, financial conditions and quality of life.

Note 17. See appendix B.

Note 18. See appendix C.

Note 19. See appendix D.

Note 20. The division of the model into six is also explained by the fact of avoiding mixed effect.

Note 21. See appendix C for America and appendix D for Europe.

**Appendix A.**

| Linear regression | | |
|---|---|---|
| Number of obs | = | 4 |
| Replications | = | 1000 |
| Wald chi2(2) | = | 16.76 |
| Prob > chi2 | = | 0.0002 |
| R-squared | = | 0.9999 |
| Adj R-squared | = | 0.9998 |
| Root MSE | = | 0.0027 |

| | Observed | Bootstrap | | Normal-based | | |
|---|---|---|---|---|---|---|
| $LGDP_t$ | Coef. | Std. Err. | z | P>z | [95% Conf. | Interval] |
| $LS_{jt}$ | 0.6068621 | 0.3144159 | 1.93 | 0.054 | -0.00938 | 1.223106 |
| $C_{jt}LS_{jt}$ | $3.95e^{-06}$ | $4.44e^{-06}$ | 0.89 | 0.374 | $-4.76e^{-06}$ | .0000126 |
| cons | 0.6244289 | 4.469182 | 0.14 | 0.889 | -8.13501 | 9.383865 |

**Appendix B.**

| Linear regression | | |
|---|---|---|
| Number of obs | = | 4 |
| Replications | = | 1000 |
| Wald chi2(1) | = | 10.24 |
| Prob > chi2 | = | 0.0014 |
| R-squared | = | 0.9839 |
| Adj R-squared | = | 0.9758 |
| Root MSE | = | 0.0314 |

| | Observed | Bootstrap | | Normal-based | | |
|---|---|---|---|---|---|---|
| $LGDP_t$ | Coef. | Std. Err. | z | P>z | [95% Conf. | Interval] |
| $C_{jt}LS_{jt}$ | $9.53e^{-06}$ | $2.98e^{-06}$ | 3.20 | $3.69e^{-06}$ | 0.001 | .0000154 |
| cons | 9.331016 | 0.2457416 | 37.97 | 0 | 8.849371 | 9.812661 |

**Appendix C.**

| Linear regression | | |
|---|---|---|
| Number of obs | = | 4 |
| Replications | = | 1000 |
| Wald chi2(1) | = | 20.56 |
| Prob > chi2 | = | 0 |
| R-squared | = | 0.9892 |
| Adj R-squared | = | 0.9838 |
| Root MSE | = | 0.0257 |

| | Observed | Bootstrap | | Normal-based | | |
|---|---|---|---|---|---|---|
| $LGDP_t$ | Coef. | Std. Err. | z | P>z | [95% Conf. | Interval] |
| $C_{Et}LS_{Et}$ | 0000133 | $2.94e^{-06}$ | 4.53 | 0.000 | $7.56e^{-06}$ | .0000191 |
| cons | 9.379923 | 0.158611 | 59.14 | 0 | 9.069051 | 9.690794 |

| Linear regression | | |
|---|---|---|
| Number of obs | = | 4 |
| Replications | = | 1000 |
| Wald chi2(1) | = | 0.19 |
| Prob > chi2 | = | 0.6603 |
| R-squared | = | 0.9471 |

| | | |
|---|---|---|
| Adj R-squared | = | 0.9207 |
| Root MSE | = | 0.0569 |

| | Observed | Bootstrap | | | Normal-based | |
|---|---|---|---|---|---|---|
| $LGDP_t$ | Coef. | Std. Err. | z | P>z | [95% Conf. | Interval] |
| $C_{At}LS_{At}$ | 0.0000401 | 0.0000911 | 0.44 | 0.660 | -0.00014 | 0.000219 |
| cons | 9.200395 | 2.125538 | 4.33 | 0.000 | 5.034418 | 13.36637 |

## Appendix D.

| Linear regression | | |
|---|---|---|
| Number of obs | = | 4 |
| Replications | = | 1000 |
| Wald chi2(1) | = | 57.77 |
| Prob > chi2 | = | 0 |
| R-squared | = | 0.9986 |
| Adj R-squared | = | 0.998 |
| Root MSE | = | 0.0091 |

| | Observed | Bootstrap | | | Normal-based | |
|---|---|---|---|---|---|---|
| $LGDP_t$ | Coef. | Std. Err. | z | P>z | [95% Conf. | Interval] |
| $TR_{Et}LS_{Et}$ | .0000477 | $6.28e^{-06}$ | 7.60 | 0.000 | .0000354 | .00006 |
| cons | 9.437023 | 0.0823832 | 114.55 | 0.000 | 9.275555 | 9.598491 |

| Linear regression | | |
|---|---|---|
| Number of obs | = | 4 |
| Replications | = | 1000 |
| Wald chi2(1) | = | 3.31 |
| Prob > chi2 | = | 0.069 |
| R-squared | = | 0.9574 |
| Adj R-squared | = | 0.9361 |
| Root MSE | = | 0.051 |

| | Observed | Bootstrap | | | Normal-based | |
|---|---|---|---|---|---|---|
| $LGDP_t$ | Coef. | Std. Err. | z | P>z | [95% Conf. | Interval] |
| $EA_{Et}LS_{Et}$ | 0.000037 | 0.0000203 | 1.82 | 0.069 | $-2.87e^{-06}$ | .0000769 |
| cons | 9.568348 | 0.2853691 | 33.53 | 0.000 | 9.009035 | 10.12766 |

| Linear regression | | |
|---|---|---|
| Number of obs | = | 4 |
| Replications | = | 1000 |
| Wald chi2(1) | = | 3.24 |
| Prob > chi2 | = | 0.0721 |
| R-squared | = | 0.9725 |
| Adj R-squared | = | 0.9588 |
| Root MSE | = | 0.041 |

| | Observed | Bootstrap | | | Normal-based | |
|---|---|---|---|---|---|---|
| $LGDP_t$ | Coef. | Std. Err. | z | P>z | [95% Conf. | Interval] |
| $DC_{Et}LS_{Et}$ | 0.0000962 | 0.0000535 | 1.8 | 0.072 | $-8.63e^{-06}$ | 0.000201 |
| cons | 9.258544 | 0.4866116 | 19.03 | 0.000 | 8.304803 | 10.21229 |

| Linear regression | | |
|---|---|---|
| Number of obs | = | 4 |
| Replications | = | 1000 |
| Wald chi2(1) | = | 2.13 |
| Prob > chi2 | = | 0.1441 |
| R-squared | = | 0.9586 |
| Adj R-squared | = | 0.9379 |
| Root MSE | = | 0.0504 |

| | Observed | Bootstrap | | | Normal-based | |
|---|---|---|---|---|---|---|
| $LGDP_t$ | Coef. | Std. Err. | z | P>z | [95% Conf. | Interval] |
| $CS_{Et}LS_{Et}$ | 0.0001304 | 0.0000893 | 1.46 | 0.144 | -.0000445 | 0.000305 |
| cons | 9.582188 | 0.1825672 | 52.49 | 0.000 | 9.224362 | 9.940013 |

| Linear regression | | |
|---|---|---|
| Number of obs | = | 4 |
| Replications | = | 1000 |
| Wald chi2(1) | = | 0.09 |
| Prob > chi2 | = | 0.7621 |
| R-squared | = | 0.4014 |
| Adj R-squared | = | 0.102 |
| Root MSE | = | 0.1914 |

| | Observed | Bootstrap | | | Normal-based | |
|---|---|---|---|---|---|---|
| $LGDP_t$ | Coef. | Std. Err. | z | P>z | [95% Conf. | Interval] |
| $L_{Et}LS_{Et}$ | 0.0010238 | 0.0033819 | 0.3 | 0.762 | -0.0056045 | 0.007652 |
| cons | 9.411263 | 1.561532 | 6.03 | 0.000 | 6.350717 | 12.47181 |

| Linear regression | | |
|---|---|---|
| Number of obs | = | 4 |
| Replications | = | 1000 |
| Wald chi2(1) | = | 7.18 |
| Prob > chi2 | = | 0.0074 |
| R-squared | = | 0.9145 |
| Adj R-squared | = | 0.8717 |
| Root MSE | = | 0.0723 |

| | Observed | Bootstrap | | | Normal-based | |
|---|---|---|---|---|---|---|
| $LGDP_t$ | Coef. | Std. Err. | z | P>z | [95% Conf. | Interval] |
| $OSE_{Et}LS_{Et}$ | 0.0000952 | 0.0000355 | 2.68 | 0.007 | 0.0000256 | 0.0001647 |
| cons | 8.890375 | 0.430651 | 20.64 | 0.000 | 8.046314 | 9.734435 |