RETURN MOBILITY OF SCIENTISTS AND KNOWLEDGE CIRCULATION: AN EXPLORATORY APPROACH TO SCIENTISTS ATTITUDES AND PERSPECTIVES

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ABSTRACT:

This paper addresses the mobility of scientists and its implications for countries with weaker scientific and technological systems. It focuses on the "return dilemma" and, using the Portuguese case as empirical setting, discusses the conditions for return, the diaspora option and the role of policies in minimising the impacts of unbalanced flows. We propose a method to identify and locate key expatriate scientists (a basic problem in mobility research) and conduct an exploratory application of that methodology in a specific field, in order to collect some information on scientists' trajectories as well as gaining some preliminary insights on their attitudes towards the home country.

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1 - INTRODUCTION

The mobility flows of scientists between countries/regions with different levels of scientific development has recently begun to receive greater attention in the context of debates about highly skilled migration. While the mobility of scientists and the associated knowledge exchange are elements of the contemporary process of knowledge circulation (Ackers, 2005) and although the relationship between human and knowledge flows can be more complex than is often assumed in the "brain drain" discourse (Meyer, 2001), the imbalanced outflow of scientists is detrimental for countries not able to retain their skilled human resources (Mahroum, 2005). Growing concerns regarding the impact of these processes on countries with weaker scientific and technological (S&T) systems, brought to the policy forefront the question of return mobility (Casey et al, 2001). In addition, the emergence of the "brain circulation" paradigm in migration research (Johnson and Regets, 1998) and debates on the role of transnational knowledge communities (Williams et al, 2004), called the attention to the fact that return is not always the most productive option and that expatriate scientists can still contribute with their knowledge and networks to the development of the home country (Meyer, 2001).

Despite the growing importance assumed by scientific mobility, namely in the European context, our understanding of mobility flows, in particular of return mobility, is deficient. Data about the level of mobility and mobility paths is scarce and difficult to obtain and our knowledge of scientists motivations and strategies, namely their attitudes towards the home country and their perspectives concerning career and return mobility, remains limited. A more in-depth understanding of these issues is indispensable to identify the key problems and to devise adequate policies.

The case of Portugal provides a good illustration of the above problems. Despite an extensive investment in the advanced training of human resources in foreign centres of excellence, there is little knowledge about the mobility flows associated with this training effort, especially in recent years, when the Portuguese system appears to be reaching a limit concerning the capacity to absorb such resources. The absence of accurate information on the mobility flows and trajectories, as well as on the attitudes and perspectives of those scientists who moved abroad to developed academic or professional activities, remains an obstacle to an informed debate on these questions.

The research presented in this paper is a preliminary contribution to attend to some of these issues. A method is developed to address some methodological problems of empirical research

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in scientific mobility. It permits to delimit a sample of "scientifically productive" expatriate scientists in specific fields, to locate these scientists and to trace their professional trajectories, thus making possible to collect information on their mobility behaviour and perspectives. This methodology is then experimentally applied to the Portuguese case. Despite the limited scope and the exploratory nature of the empirical research, the results obtained provide some early insights into the behaviour of the younger generation of "scientifically productive scientists" in a field with a strong international mobility pattern (biotechnology), which, given the characteristics of the scientists and the nature of the field, can be relevant for policy makers.

2 – SCIENTISTS MOBILITY: BRAIN DRAIN VS. BRAIN CIRCULATION

International mobility has long been an important element in European scientific careers (Musselin, 2004), being reinforced in recent years by targeted European policies. Scientific mobility is a at the core of the creation of an European Research Area (ERA), being regarded as a key element in the development of a strong research and innovation competence (CEC, 2000). However some concerns have been raised regarding the impact of such mobility on countries with weaker S&T systems (Ackers, 2005; Balázs et al, 2004), with some documents calling the attention to the risk of "brain drain" and suggesting mechanisms to prevent it (CEC, 2001, 2005).

2.1 – Mobility flows and knowledge transfer

These concerns mirror a wider debate on the detrimental effects of the unidirectional migration of highly skilled professionals from less to more developed countries, a phenomenon that has been generally described as brain drain (Salt, 1997). Behind this concept is the assumption that the flow of skilled individuals is associated to the transfer of knowledge embodied in these individuals, from the home to the host country and that there is, therefore, a net loss on the part of the former. More recent research has acknowledged the greater complexity of the scientific mobility phenomenon, which may take a greater diversity of forms than was assumed by this linear approach, in terms of the timing and direction of the flows, their knowledge contents and also concerning the presence of some compensation mechanisms (Ackers, 2005; Meyer, 2001).

The concept of "brain circulation" (Johnson and Regets, 1998) was introduced to encompass this broader perspective. According to this approach, skilled individuals, rather than enacting a one time move to a specific country where they settle down (as in the traditional migration

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approach), circulate between different locations, including the home country, acquire new knowledge and further develop their competences, integrate transnational knowledge networks and through these processes contribute to knowledge creation and diffusion along the various nodes of their networks (Coe and Bunnell, 2003). Furthermore, it is increasingly recognised that knowledge exchange may not necessarily require the physical presence of the individual scientist and can take place at distance, providing that there is "epistemic proximity" between the scientific communities (Steinmueller, 2000). From the standpoint of the country of origin, the central elements of the brain circulation approach are the possibility of return (temporary or definitive), or else, the building of expatriate networks that can be mobilised to support its development (Gaillard and Gaillard, 1998; Williams et al, 2004).

However, if the concept of brain circulation introduced important new elements in the debate, it cannot conceal the fact that such circulation is far from being balanced. Indeed, in the case of scientists, the growing competition for skilled human resources has increased the mobility flows - of people and knowledge - towards the more developed countries and regions (Mahroum, 2005). In the specific case of the European Union, the removal of obstacles to intra-European mobility has created conditions for an effective outflow from southern and eastern countries into a small group of northern countries (Ackers, 2005), a phenomenon still scarcely studied.

Authors addressing the motivations behind mobility (e.g. Ackers, 2005; Casey et al, 2001; DTI, 2002) concluded that scientists move more for career related reasons, than for purely economic motives. They move in search of environments where they can find scientific excellence, funding opportunities, meritocratic recruitment and career advance systems, independence and autonomy of work and where science is respected. Nevertheless salary differentials and contractual security also have an impact in mobility decisions. In fields where early career mobility is expected, foreign experience can also be a passport to obtain a position at home. The relative importance of those motives is likely to vary over the scientists' life course. Considering the nature of scientists' motivations, it is possible to conclude that, in a context characterised by a growing globalisation of science and by the emergence of international centres of excellence that function as attractors to the most promising ones, mobility is likely to remain a feature of the system.

2.2 - Return mobility

However, the concept of brain circulation is also associated with the idea of returning home of individuals endowed with enhanced skills and networks (Williams et al, 2004). In the case of

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scientists, for whom temporary mobility to centres of excellence have become almost a requirement (Musselin, 2004), what remains at stake is the ability of European countries with weaker S&T systems to attract back their nationals. Even if the wish to return is a strong feeling amongst the generality of migrants (Ackers, 2005), the actual materialisation of such aspiration may be thwarted – or at least postponed - by professional and personal factors (Gill, 2005; Rizvi, 2005).

While the return of scientists is often discussed in association with the capacity of local research organisations to absorb them, returning scientists may nevertheless play other roles, as was highlighted by recent research on transnational entrepreneurship (Saxenian and Hsu, 2001; Williams et al, 2004). In the case of Portugal, Fontes (2005) has shown that the majority of new biotechnology firms were created by entrepreneurs who had been abroad and that the knowledge acquired and the networks developed during these periods had been instrumental for firms' subsequent development. These pioneering efforts were found to pave the way for further attempts and also to start creating new jobs for qualified human resources.

Despite the extensive literature debating the possibility and conditions of "reverse brain drain", generally focusing on developing countries (Johnson, 2002; Kapur and McHale, 2005; Mahroum, 2005; OECD, 2001), there is still limited research on the actual return process and on the factors influencing it, namely in the case of scientists (Gill, 2005).

First of all there are obvious difficulties in measuring return flows in statistical terms (Gill, 2005; Balázs et al, 2004). However, it can also be argued that, quantitative data only, may not uncover the most relevant questions. For instance it does not enable to trace and weight the relevance of the variety of moves between home and abroad enacted by scientists along their career (King, 2002) or distinguish phenomena of negative selection (Kapur and McHale, 2005). Above all, it will not permit to assess the motivations behind these moves, or the knowledge circulation processes they entail. Therefore, in parallel to efforts to improve the measurement of mobility flows, more qualitative research is necessary to achieve a better understanding of the determinants of return decisions (Ackers, 2005).

Empirical research on return mobility in the European context was conducted by Gill (2005) addressing Italian expatriate scientists and by Casey et al (2001) addressing scientists in IT and biotechnology who returned successfully to the home country. Their research reveals that most scientists desire to return and that such desire is grounded in personal and cultural reasons. They often express the wish to contribute to their country scientific development and regret not being

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able to pursue that endeavour. With respect to the factors that influence return decisions, those related with availability and quality of employment opportunities and with the ease of re-entry in the home labour market emerge as critical, possibly also because they generate the principal obstacles. In the case of the former, limited career opportunities, lack of conditions to maintain the same level of scientific activity, absence of employment alternatives that take advantage of skills and knowledge acquired, high salary differentials, emerge as the main barriers. For the latter, barriers include those conditions that reduce the ability to identify and apply successfully to posts at home: lower familiarity with the academic system and procedures; lack of connections with scientific communities at home; CVs that are not competitive enough. Scientists may also experience cultural difficulties in (re)adapting to a different system. This type of problems led to recommendations about a careful planning of outward moves and preparation of return strategies (Casey et al, 2001).

Other relevant factors are length of stay and career stage (Ackers, 2005). The longer the stay the more complex the decision to return (particularly for scientists with family ties) and the re-entry processes. Similarly, by mid-career scientists may be less inclined to move, unless particularly favourable conditions are offered. Mobility at young ages (undergraduate level) was also found to be associated with greater level of non-return and, upon return, to foster greater openness to further mobility (Balázs et al, 2004). Ackers (2005) also points out the fact that personal lives impact on return decisions and can even supersede professional concerns.

Several countries have been devising return-oriented policies that either attempt to force return, through “control” policies, or encourage it, through return incentives. But the success of these mechanisms is always limited, if they are not associated with policies that focus on the development of the country’s science base and the promotion of technological innovation, making return attractive (Davenport, 2004).

2. 3. The role of international networks: diasporas and beyond

The concept of brain circulation also encompasses the view that sometimes return will not be possible, or may not the best option, not only from the standpoint of the individual, but also from that of the country – since individuals separated from the context where they are scientifically productive, may not be as valuable (Meyer, 2001). In fact, the return of the scientists may not lead to an equivalent transfer of knowledge, if it occurs in a context where they are forced to work in conditions that reduce their effectiveness or even to abandon research

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(Ackers, 2005). It is argued that, in these cases, it may be more effective to try to capitalise on the presence of country nationals in foreign centres of excellence, motivating them to link with the home country and thus creating conditions for the exchange of knowledge between expatriates and the local scientific communities (Gaillard and Gaillard, 1998; Meyer, 2001).

This perspective is supported by evidence that expatriate scientists have often organised themselves in more or less loose networks, both for mutual support and to maintain contact with and/or provide some contribution to their home country, in what has been labelled "*scientific diaspora*". Although diasporas differ in nature, size and scope, policy theorists and governments are increasingly regarding these networks as a policy asset (Barré et al, 2003). The effectiveness of the "diaspora option" has yet to be evaluated (Gamlen, 2005), but this approach represents a shift in countries' perception of their scientific resources (Davenport, 2004).

However, the rationale behind the notion of diaspora networks as channels in processes of knowledge transfer, can equally be applied to the case of scientists who return home but retain their network connections. In fact, it is frequent that returning scientists maintain close relationships with their previous host institution(s) and profit from a variety of professional and personal networks, developed over their career abroad (Williams et al, 2004). They are also likely to engage in short-term mobility, which permit them to access more tacit type of knowledge and help nurture the relationships (Fontes, 2005). It can be argued that this may enable them to remain part of the transnational scientific community in their field and continue developing high quality research, providing that there is a minimum of conditions in the home country.

As in the case of return mobility, the role of these international networks in knowledge generation and transfer and their impact upon the home country have scarcely been studied for Europe. However, it is possible that exit, return and expatriate behaviours assume specific features in the European context. The specificity of the organisation of the scientific profession may also differentiate scientists from other skilled migrants (Ackers, 2005). It is therefore relevant to gain a better understanding of the way these processes take place among scientists, in the European context.

We will subsequently address the Portuguese case, discussing the conditions that favour foreign mobility and those that may constrain return, with particular emphasis on the case of young scientists. As Gill (2005) points out, some aspects of scientific mobility are likely to be similar

across countries, but it is nevertheless important to contextualise the analysis within the specific socio-political environment.

3 - MOBILITY FLOWS AND POLICIES IN PORTUGAL

3.1 - Foreign training and return flows

The Portuguese government has been making an extensive investment in the advanced training of young scientists in foreign centres of excellence, especially from the 1990s onwards (FCT, 2003). Between 1990 and 2002 a total of 8759 PhD grants were awarded, 57.3% of which abroad or including a period abroad (mixed grants). Although the number of grants *exclusively* abroad has decreased, associated with the improvement of the national science base, in the period 2000-2002 they were still 32% of the total. Life sciences[1] is one of the areas where this investment was higher: 2537 grants (29% of the total awarded), of which 51.3% abroad or mixed. In addition, 528 post-doctoral grants abroad were awarded between 1994 and 2002, 45.3% of which in the life sciences[2].

However, there is limited knowledge about the mobility flows associated with this foreign training effort, especially for more recent years. Indeed, while successive governments stress the need to maintain the investment on advanced training and diffuse data about achievements at that level, the actual use of these resources is rarely addressed in the political discourse and, correspondingly, data on this matter is scarce.

One first step to understand the implications of mobility would be to find out to what extent young people trained abroad are returning. The data available is very limited and concerns exclusively scientists who received a PhD grant from the National Research Council. Four surveys were conducted by the Observatory for Science and Higher Education (OCES), inquiring PhD grant-holders one year past the end of the grant (i.e. those ended in 1999, 2000 and 2001 and also between 1990 and 1998). A total of 3558 grant holders were inquired about their subsequent career development, but only a very short summary of the results has been disclosed (Gonçalves et al, 2006) and the full data is not accessible. According to that summary, 15% of the 3122 respondents were still abroad one year past the end of the grant. But while we

[1] Life sciences include: Biological Sciences, Health Sciences, Agrarian and Veterinary Sciences, Biochemical Engineering.
[2] Data from the Ministry of Science, Technology and Higher Education: <http://www.gpeari.mctes.pt>.

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know that 47.4% of the respondents did their PhD abroad and 9.1% had a mixed grant, the data published does not enable us to assess their relative weight in the non-returning group.

These results have been used to support the notion that "the majority returns home", thus creating a context where it is admissible to ignore the potential for brain drain. However that notion is not necessarily correct. First of all, although government grants are the bulk of PhD funding, other mechanisms are used by young scientists - some of them targeting the most promising ones - from European mobility schemes to private funding systems[3]. Also, these results do not encompass the recipients of post-doctoral grants. So, these numbers alone can be misleading.

On the other hand, the data available has several limitations. It is not possible to separate the answers from grant holders who did their graduate studies in Portugal from those who did them abroad. It is not possible either to assess whether certain scientific fields register a relatively higher rate of non-returns. The information is collected one year after the end of the grant, but in the absence of follow-ups, it is impossible to evaluate whether there were further changes in this very volatile period and namely whether some returnees felt compelled to go abroad again. Purely quantitative data has also the shortcoming of not permitting to weigh up the relative quality of those who return, against those who do not. Finally, there is no data regarding young scientists who completed their PhDs after 2001.

The latter aspect is critical, because more recent data might reveal a changing pattern. In fact, while in earlier years doctorate holders faced an expanding S&T system and thus stood a good chance to take a post at universities or public research organisations, the situation appears to have changed in the late 1990s/early 2000s, when the system seems to have reached a saturation point (Fontes et al, 2005). Anecdotal evidence concerning the growing employment difficulties faced by young scientists, suggests that the conditions are less favourable for recent PhDs' cohorts, particularly those who return from abroad without a link to an university or research organisation. The absence of more recent data does not enable to confirm this view. However, according to a recent World Bank report (Özden and Schiff, 2006), Portugal is one of the European countries more affected by graduate migration, with 19.1% of its graduates working abroad. This tendency is likely to be replicated in the case of post-graduates.

[3] Particularly important, in the life sciences, are the grants awarded by the Gulbenkian Foundation and the activities in the context of its international PhD Programme.

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In summary, three issues appear to be relevant in a discussion of potential brain drain:

1. Evolution of return flows: Did the return rate change through time and, in particular, which is the situation of those who left for graduate/postgraduate training in the late 1990s /early 2000s? Whether and to what extent did scientists who have returned, choose to leave again later?
2. Differences between scientific fields: Is the rate of non-return higher in some fields, e.g. where the science-base or the job market is less developed at country level?
3. Quality vs. quantity: Are quality factors, associated with the training/career path and performance, affecting the return pattern, implying that there are differences between those who are more successful and have more opportunities abroad and those who are less successful and thus are more likely to return ?

None of these issues can be addressed with the data currently available, so it is critical to obtain additional information.

3.2 – Return and diaspora policies

The lack of accurate information and the optimistic approach towards return flows has also impact at the level of policies, both those aiming at attracting back the scientists and those targeting the diaspora. With respect to the former, the first government mechanism explicitly oriented to encourage the return of Portuguese scientists was introduced in 2005, but it addressed only senior scientists[4]. At the institutional level, entry into the academic/research careers or access to temporary positions is based on CV evaluation and the system does not formally discriminates against (or favour) expatriates, although access to information and ability to comply with the requirements may be more difficult for them. But academic careers tend to blocked and thus young scientists are often left with a succession of temporary appointments, sometimes in very precarious conditions and facing high uncertainty relatively to the next position (Araújo, 2007). At this level, some new opportunities are currently being created by a new government programme that aims at offering 1000 new five year contracts (instead of the usual post-doctoral grants) for PhD holders, in public or private organisations with a record of scientific excellence, financed or co-financed by public funds (http://www. fct.mctes.pt). But it remains to be seen whether the labour market will have the capacity to fully absorb them when

[4] The requirements were: to have published 100 papers in ISI referenced journals or to have published 50 papers and supervised 10 PhDs. This mechanism was criticised on the grounds that the advantages offered were not enough to attract senior scientists established abroad, while the requirements precluded it to be used by even the most promising young scientists.

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the funded programme is over. Finally, adequate employment in industry is rarely a viable alternative, particularly in the case of life sciences, given the specialisation of Portuguese industry and the still limited incidence of entrepreneurial initiatives in the field (Fontes, 2005).

With respect to the attempt to mobilise scientists who remain abroad, explicit "diaspora policies" are absent. However, it is a relatively common practice to ask reputed scientists established abroad to be part of evaluation or advisory committees or to invite them to specific events. On the other hand, in certain fields, the Portuguese scientific community is highly internationalised (Pereira, 2002) and it is not uncommon that local teams are part of scientific networks integrating Portuguese expatriates. But the only visible "expatriate network" type of initiatives have emerged from the scientists themselves, who have created a variety of fora, such as the "International Forum of Portuguese Researchers" (http://www.fiip.org/) or the "Portuguese American Post-Graduate Society" (http://www. papsnet.org/).

It is therefore evident that the mobility flows of Portuguese scientists are more extensive and complex than can be captured through PhD data. Moreover, it is to be expected that, as in other countries with similar levels of scientific development, a high outward mobility associated with unsatisfactory conditions for young scientists, leads to a growing rate of non-return. However, the assessment of the situation and perspectives of scientists who engaged in temporary or permanent migration is paved with methodological difficulties. In order to address this issue it will be therefore necessary to start tackling the problem of identification and location of the relevant object of analysis.

4 - LOCATING EXPATRIATE SCIENTISTS: A METHODOLOGY

4.1 Methodological problems of research on scientific mobility

Most authors addressing the outward and return mobility of scientists draw attention to data difficulties: identifying the population, locating the expatriate scientists, measuring return flows. To complicate matters, scientific mobility is an increasingly complex phenomenon: scientists tend to engage in different forms of more or less temporary mobility and to circulate between different countries, including their own. This type of mobility is particularly difficult to measure and can only be traced through the analysis of the trajectories of individual scientists (Dietz et al, 2000). Additionally, some authors argue that, in what concerns the role of scientific mobility on knowledge circulation, quality can be more relevant than quantity and therefore the focus

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should be put on the most productive scientists, rather than on the whole population (Ackers, 2005; Laudel, 2003; Moguérou, 2006). In fact, the decisions of the former concerning departure, return or collaborative relationships, are the ones that can have greater impact on the sending country. However, while this issue is discussed in theoretical terms, there is the still unsolved problem of identifying the "productive" mobile scientists.

The above considerations call the attention to the fact that there are serious methodological problems in mobility research that are far from being solved. First of all, those concerning the delimitation of the "population", from which a representative sample can be obtained. Then, those related with identifying and locating the individual scientists who are the object of analysis, especially when those scientists are expatriate. Therefore, the majority of empirical studies use "convenience samples": e.g. scientists in specific organisations and/or countries; scientists who were part of national or European programmes, promoting outward or return mobility. The snowball effect is often used, through which scientists direct the researchers to colleagues. Given the absence of more precise methods/data, these approaches permit to gain some insights into the problem.

"Quality" of the scientists is a less frequently addressed issue, despite its theoretical relevance. Two of the most commonly used measures of productivity in science are publications and patents (Bozeman et al, 2001; Verbeek et al, 2002), with the former being the most used (Bonaccorsi and Daraio, 2003; Levin and Stephan, 1991). However, the latter has increasingly become an important indicator (e.g. Azagra-Caro et al, 2003; Breschi et al, 2007; Carayol and Matt, 2006; Meyer, 2003), which can be associated with the multidimensional nature of contemporary research and the blurring boundaries between public and private science in some fields (Nagpaul and Roy, 2003; Owen-Smith and Powell, 2003). The striking growth of university patenting (Mowery et al, 2001) and the involvement of academic scientists as inventors in patents, whether these are filled by research organisations or by firms (Balconi et al, 2004) accentuate their importance.

A recent study on scientific mobility used publications as the methodology for identifying the most productive scientists in specific fields, in order to find out in which countries they were located (Laudel, 2003). But while this method was adequate for the purpose of that study – since publications permit to identify the country where the scientist works - it is less useful for locating scientists *originating* from a particular country, since they do not provide the authors'

nationality. To our knowledge, patents, which provide information on location and nationality, have not been used for that purpose[5].

Considering all these problems, we have tried to devise a methodology that, having in mind the (still) unsurpassable difficulty of identifying the population, simultaneously attempted to be more rigorous in the definition of a sample, took into consideration the issue of "quality" and created the conditions for tracing the trajectories of scientists.

4.2 – Research approach

The methodology adopted started from the assumption that patents could be used as proxy of "scientific quality" in science-based fields. As pointed out above, patents are a measure of productivity in science, their use being particularly appropriate in fields characterised by strong direct links between science and inventions, such as the life sciences (Narin et al, 1997). In these fields, patents are likely to correspond to scientific discoveries and therefore point towards scientists conducting leading-edge research (Stephan and Everhart, 1998; Zucker et al, 1998). This is corroborated by research that points to a strong relationship between patenting and publication activities at the level of individual scientists (Gittelman and Kogut, 2003; Van Looy et al, 2006). Indeed life sciences, particularly biotechnology, are among the fields where the number of academic patents has increased substantially in recent years (Hicks et al, 2001; Owen-Smith and Powell, 2003).

Thus, scientists who were inventors in biotechnology patents were considered to provide an appropriate sample of scientifically productive scientists in an advanced field. Two additional reasons justify the choice of *biotechnology* as the target field: the importance assumed by international mobility in the scientific domains that compose biotechnology (Casey et al, 2001), which are equally the target of an important proportion of the Portuguese investment in advanced training abroad; the possibility of achieving a non-ambiguous identification of "biotechnology patents" (which does not happen in other science-based fields), given the work conducted by the OECD in precisely defining the respective IPC codes (OECD, 2005). Finally, the focus on patent inventors has two additional advantages. First, it permits to identify scientists from different types of organisations, including firms, which are rarely addressed in

[5] With a different purpose, Stephan and Levin (2001) used scientists with most cited patents as one of the criteria to select key scientists, in their study of the contributions of foreign-born scientists to US science. In a different context – interorganisational mobility of engineers - the identity of patent inventors and their mobility/patenting activity in different organisations was used by Agrawal et al (2006) to analyse knowledge spillovers and (through citations) the importance of social ties.

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studies of scientific mobility. Second, it designates scientists who acquired skills that can be particularly relevant for a country with a very low patent performance, as is the case of Portugal (Moutinho et al, 2007).

The above considerations supported the precise definition of a sample of expatriate "productive scientists", who are the unit of analysis in this research: Portuguese scientists who are inventors in biotechnology patents filled by foreign organisations, and who resided abroad at the time of the patent filling. The sampling process permits to satisfy a number of criteria: scientists have Portuguese nationality; are scientifically productive as defined by being a patent inventor; work in the biotechnology field, as defined by the OECD classification of patents; are located in organisations abroad, as defined by the nationality of the applicant and the inventor country of residence.

4.3 Methodology

The methodology adopted for the analysis involved: a) identification of biotechnology patents filed by foreign organisations, with Portuguese nationals as inventors, and selection of those scientist/inventors who resided abroad; b) search for current location and contacts of the selected scientists; c) search for more complete biographical information on these scientists, based on secondary data, with a view to start tracing their career trajectories; d) questionnaire survey to the scientists, with a view to complement biographical data and to elicit some preliminary information concerning their attitude towards the home country.

4.3.1- Identification and location of scientists

The OECD (2005) classification of biotechnology patents was used as the basis for patent selection. It covers the following International Patent Classification codes:

A01H 1/00; A01H 4/00; A61K 38/00 ; A61K 39/00; A61K 48/00; C02F 3/34; C07G 11/00; C07G 13/00; C07G 15/00; C07K 4/00; C07K 14/00; C07K 16/00; C07K 17/00; C07K 19/00; C12M; C12N; C12P; C12Q; C12S; G01N 27/327; G01N 33/53; G01N 33/54; G01N 33/55; G01N 33/57; G01N 33/68; G01N 33/74; G01N 33/76; G01N 33/78; G01N 33/88; G01N 33/92.

PCT patent applications, that is "international applications" filed under the system established by the Patent Cooperation Treaty - a multilateral agreement that provides for the filling of one patent application, with effects in the signatory states - were used. The search for patent applications was thus conducted in the database provided by the World Intellectual Property Organization (WIPO). The option for PCT patent applications requires some explanation. Given the exploratory nature of this research, we resorted exclusively to free access patent databases. Considering our objectives, it was necessary that the bibliographic information format and search facilities of the database permitted to: a) search for inventor nationality, independently of applicant nationality; b) separate the nationality and the residence of the inventor. Of the free databases (Espacenet for EP patent applications; USPO for US ones and WIPO/Intellectual Property Digital Library for PCT ones) only the WIPO database provided the required bibliographic information, associated with a reasonable coverage: from January 1997 onwards[6].

The search in the PCT database, for the period January 1997 to July 2005, led to the identification of 126 biotechnology patent applications with Portuguese nationals as inventors. From those, were selected the 97 patents whose applicants were exclusively foreign (organisations or individuals) and whose Portuguese inventors were abroad at the time of the patent application[7]. Those 97 patents involved a total of 59 Portuguese inventors, who were therefore our sample. The fact that ¾ of the biotechnology patent applications with Portuguese as inventors involved scientists who are abroad provides a first indication of the expatriate condition of a substantial part of the "productive scientists" in the field, when this measure of productivity is considered.

An Internet search was conducted in order to find the current location and obtain the contacts of these inventors. This was a very laborious process, since not only several scientists did not belong to the actual organisation that had filled the patent[8], but it was also found that only a few of them were still in the same organisation. However, this search also permitted to start

[6] While operational motives weighted strongly in our choice, PCT applications were also considered an acceptable source of patent information, considering the growing use of the "international route", namely by research organisations, due to the advantages afforded by the PCT system (Dernis and Khan, 2004). Although no "international patent" is granted – granting patents remains the responsibility of patent offices of the countries/regions where protection still needs to be sought subsequently – and although it is possible that the PCT procedure is more frequently used by applicants who are less certain of the potential of their invention and wish to gain time or additional information (Dernis and Khan, 2004; WIPO, 2005), the PCT application already reflects a steady intention to patent, which is adequate for our purposes. The use of PCT patent applications precluded the introduction of an additional measure of "patent quality" that could improve the selection – e.g. "most cited patents". However, the small number of patents that ended-up being identified would have excluded an additional filtering option.

[7] The patents excluded comprise 7 cases where all applicants were foreign but the inventors were in Portugal, 7 cases of co-application between foreign and Portuguese organisations and 15 where all applicants were Portuguese.

[8] This was namely the case of several patents filled by firms, but whose inventors were academic scientists from research organisations, that were not applicants. This finding confirms a practice that has been documented by recent research as recurrent in Europe (Balconi et al, 2004).

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collecting information about their career path. In the few cases in which it was not possible to find the scientists' whereabouts at the time of the search (mid-2005), we contacted ex-supervisors or laboratory/team leaders at their last known location, or co-authors in recent papers. All but one did answer and provide the required information, for which we remain particularly grateful.

At the end of this process it was concluded that:

- 41 scientists were abroad, although not necessarily in the same country. Of these, 35 were in research organisations, 5 in firms and 1 in a governmental organisation.
- 12 had returned to Portugal. Of these, 11 were in research organisations and 1 in a governmental organisation.
- 4 had Portuguese nationality but were born abroad and had never been to Portugal, so they were removed from the sample.
- In 2 cases it was impossible to confirm the scientists' current location (although they were still presumably abroad).

It is worth noting that 16 out of 41 scientists who were expatriate were not found in any of the National Research Council public databases that list doctoral grants or PhDs holders. This suggests that a still non-negligible segment of the expatriate population may be ignored by official records.

4.3.2 – Data collection on scientists

To complement the information obtained during the location process, a comprehensive search was conducted on each scientist, still based in the Internet and drawing on a variety of secondary sources. This permitted to follow-up the scientists' path along different organisations and countries and to collect a variety of biographical information about their academic and professional activity. Although this data can only be considered to be fully accurate for those scientists whose detailed CV was obtained, this exercise already provided relevant information about their mobility path. However, assuming that there were gaps and possibly some inaccuracies in the data thus collected, we sought to confirm and complement it through direct inquiry. In addition, we were also interested in obtaining some behavioural information that could only be elicited through direct contact with the individual scientists.

Thus a questionnaire was devised to obtain information at four levels: a) current situation of the scientists and previous path; b) position towards the home country: attitude regarding a potential

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return (for those abroad); or reasons for return and future perspectives (for those who had returned); c) personal networks: type of links maintained with the home country (for those abroad) or with foreign organisations (for those who had returned); d) presence of connections between the foreign organisation(s) where they were/ had been and Portuguese ones and their nature. The questionnaire was short, in order to guarantee a good response rate. However, the respondents were encouraged to make additional comments as well as to send their CVs.

Questionnaires were sent by e-mail to 51 out of the 53 scientists whose whereabouts were known[9], in the period between October and December 2005. A total of 37 answers were received, of which 29 from scientists abroad, corresponding to a total response rate of 72.5% (74.4% from those abroad). The high response rate reflects the importance attributed to this theme by the respondents, several of whom added comments in the return mail and manifested interest in being informed about the research and its results.

It should be pointed out that this is only a first stage on the collection of information, both from secondary sources and through direct inquiry. In fact, data collection is underway or planned on additional issues, which we expect to provide a more precise picture of some aspects of the professional/scientific trajectory of these scientists and some indications regarding their scientific networks, as well as some explanatory evidence regarding their mobility behaviour, in line with recent methodological advances in the analysis of scientific careers (Ackers, 2004; Bozeman and Mangematin, 2004; Rizvi, 2005).

Figure 1 presents a schematic overview of methodology devised in this study. It was found to be effective in identifying and locating the expatriate scientist/inventors, in tracing their paths and thus obtaining some data on their situation and trajectory and in eliciting some preliminary information about their attitudes toward the home country.

[9] In the remaining two cases (both outside research), it was impossible to obtain a personal e-mail and all the other attempts of contact were unsuccessful.

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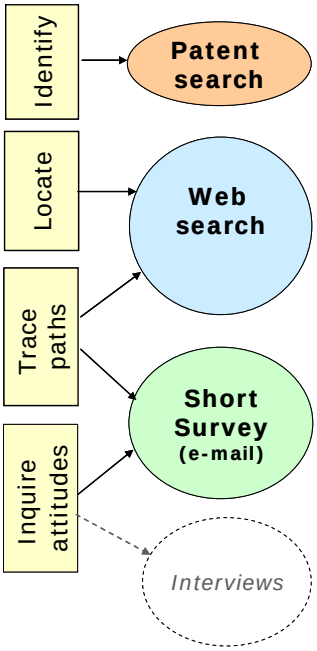
Figure 1 – Methodological approach to identification, location, data collection on expatriate scientists



5 - SITUATION AND PERSPECTIVES OF EXPATRIATE SCIENTISTS

This section presents some results from the preliminary data collection and analysis. It includes a generic overview of mobility paths, for the whole sample of 53 scientists/ inventors and a more detailed analysis of the situation, return perspectives and type of links maintained, for the 37 scientists who answered to the questionnaire.

5. 1 – Generic overview of scientists' mobility path

Tables 1 and 2 present very summarised information about the current situation (country, organisation and position) and foreign career moves (countries and positions) of the scientists/inventors, drawing on data obtained from the Internet search, confirmed or complemented with questionnaire data, when available. Although only the latter can be regarded as exhaustive, Tables 1 and 2 offer a general overview of the mobility profile of the whole sample.

Table 1 - Scientists abroad: summarised mobility data

Current situation (2005)			Career path		Links	Age
Country	Organis.	Position	Countries	Path details: country (position)	PT	
Internet search and questionnaire data						
FR	RC	PhD Stud	FR	PT(d)<>FR(d)	N	1975
UK	Univ.	PhD Stud	UK	UK(d) -> *expect to return 2006*	N	1974
US	Univ.	PhD Stud	US	US(d)	Y	1974
BE	Univ.	Post-doc	BE	BE(m)+ BE(d)+BE(p)	N	1972
CH	RC	Post-doc	FR, US, CH	PT(d)<> F(d)+US(v) -> CH(p)	N	1972
FR	RC	Post-doc	UK, FR	UK(d)+FR(p)	N	1975
FR	RC	Post-doc	FR, UK	FR(d)-> UK(p)	Y	1972
NL	Univ.	Post-doc	NL	NL(m)+NL(d)+NL(f)+NL(p)	Y	1967
SE	Univ.	Post-doc	SE, US	SE(d)<>US(d) -> SE(p)	Y	1972
SP	RC	Post-doc	UK, DE, SP	UK(d)+DE(fp)+DE(p)->SP(p)	Y	1974
UK	Univ.	Post-doc	FR, UK	FR(g)+FR(d) - > UK(p)	N	1969
UK	RC	Post-doc	UK	UK(d)+UK(p)+UK(s?)	N	1975
UK	U. Hosp	Post-doc	UK, CA	UK(g)+UK(d)+CA(p)	Y	1979
US	Univ.	Post-doc	FR, PT, US	FR(d)+FR(p)+FR(f)->PT()->US(p)	N	1973
US	Univ.	Post-doc	US	US(d)+US(p)	Y	1971
US	Univ.	Post-doc+Entrepr	US	PT(d)<>US(d)+US(e)+US(p)+PT(e)	Y	1976
SE	Univ.	Post-doc+Entrepr	SE	SE(d) <>PT(e)+SE(p)	Y	1976
CA	Univ.	Staff+Entrepr	UK, CA	UK(g)+UK(d)+UK(p)+UK(s)+UK(e)->CA(s)	Y	1964
FR	RC	Staff	UK, PT, FR	UK(d)->PT(s)->FR(s)	Y	1949
FR	RC	Staff	FR, NL, FR	FR(g+m)+FR(d)+FR(p)+NL(p)->FR(s)	Y	1963
FR	RC	Staff	US, FR	US(d) -> FR(p)+FR(s)	Y	1971
FR	Univ.	Staff	FR, NL, FR	FR(d)+FR(p)+NL(p)-> FR(s)	Y	1972
SE	Univ.	Staff	SE	SE(d)+SE(p)+SE(s)	Y	1963
SP	RC	Staff	US, SP	US(m)+US(d) -> SP(p)+SP(s)	Y	1969
UK	RC	Staff	UK	UK(d)+UK(p)+UK(f)+UK(s)	N	1970
UK	Univ.	Staff	NL, UK	NL(d)+UK(s)	N	1970
UK	Univ.	Staff	US, UK	US(p)-> UK(p)+UK(s)	Y	1960
US	Firm	Staff	US	US(p)+US(fp)+US(f)	N	1962
US	Firm	Staff	US	US(d)+US(f)	Y	1971
Internet search only						
UK	Univ	Post-doc	UK	UK(d)+UK(p) -> *returned 2006*	Y	1973
UK	Univ	Post-doc	UK	UK(d)+UK(p)		
US	RC	Post-doc	US	PT(d)<->US(d)+US(p)		1972
DK	Firm	Entrepr	UK, DK	UK(d)+DK(e)		1970
CA	U. Hosp	Staff	CA	CA(d)+CA(p)+CA(s)	Y	
DE	Gov	Staff	DE	DE(p) -> DE (s)		
DK	Univ	Staff	DK	?+DK(s)	Y	
US	Firm	Staff	CA,US	CA(p)+US(f)		
US	Univ	Staff	UK, US	UK(d)->US(s)		1976
US	Hosp	Staff	US,DK, US	US(d)+DK(p)+US(p)+US(s)	Y	1962
US	Univ	Staff	US	UK(d)+US(s)		1965
US	U. Hosp	Staff	US	US(d)+US(s)		

Legend

Organisations**:** Univ – University; RC – research centre; U. Hosp – University Hospital; Gov – Government Body

Path details (position): d-doctoral student; m-master stud; g – graduate stud; p-post-doctoral fellow; v-visiting fellow; s–member of staff at university or research centre; f-employed in firm; fp-post-doc in firm; e-entrepreneur; PT(d)<> UK(d) – PhD "shared" between a Portuguese and a foreign university.

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Table 2 - Scientists returned: summarised mobility data

Current situation (2005)			Career path		Links	Age
Country	Organis.	Position	Countries	Path details: country (position)	abroad	
Internet search and questionnaire data						
PT 2005	-	Unemployed	DK, US, PT	DK(m)+DK(d)+US(p) -> PT	Y	1968
PT 2002	RC	Post-doc	UK, US, PT	UK(m)+UK(d)+US(p)->PT(p) -> *2006 UK*	Y	1969
PT	Univ.	Staff	UK, AU, PT	UK(d)+UK(p)->AU(p) -> P(s)	Y	1971
PT 2005	U. Hosp	Staff (1)	US, PT	US(p) -> PT(s) <-> US(v)	Y	1970
PT 2002	RC	Staff	BE, US, PT	BE(g)+BE(d)+US(p)+US(s)-> PT(s)	Y	1968
PT 2001	Gov	Staff (1)	UK, PT	UK(d)+PT(s)->UK(p)- > PT(s)	Y	1957
PT 2003	Univ	Staff	DK, PT	PT(d)<>DK(d) -> PT(s)	Y	1965
PT	U. Hosp	Staff (1)	FR, PT	FR(m)+PT(d)<>FR(d)+FR(p) -> PT(s)	Y	1965
Internet search only						
PT	Univ	Post-doc ?	US, PT	US(d)+? -> PT(p?)		1963
PT 1999	Univ	Staff	US, FR, PT	US(d)+US(p)+FR(p)-> PT(s)		1965
PT 2005	RC	Staff	DE, US, PT	PT(d)+US(p)->PT(s)	Y	1973
PT 1999	Univ	Staff	UK, PT	UK(d) + UK(p) -> PT(s)	Y	1965

Legend: see Table 1

(1) Returned to previous job (leave of absence);

This data permits to highlight a few aspects. First of all, a high mobility, between countries and also between organisations (particularly among younger scientists) and the preponderance of the UK, US and France as destinations, with a few other European countries (Sweden, Belgium, Denmark, Netherlands, Spain) and Canada registering smaller number of presences, as well as the intense circulation between Europe and the US. It also uncovers the existence of various generations of expatriate scientists: from those older and apparently established to those who have recently completed their PhDs and occupy post-doctoral positions; and the presence of a small group of scientists working in firms or involved in entrepreneurial activities. Finally, it draws attention to the fact that fact that most scientists (even those who end-up returning) remain abroad after the PhD, even when it was "shared" between a foreign and a Portuguese organisation, which could facilitate return and to the frequent presence of some type of link with the home country. Some of these aspects will be subsequently addressed in more detail, on the basis of the survey data.

5.2 – Questionnaire survey: attitudes towards the home country

The large majority of expatriate scientists who answered to the questionnaire are young, below 35 (72.4%), although there is also a group who are above 40 (20.7%). The distribution in terms of career position is consistent with age: about half of the respondents hold post-doctoral

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positions while only 3 are still completing their PhD; a smaller group hold more stable mid-career posts (26.7%) and there is a few senior scientists (13.8%) (Figures 2 and 3). The results regarding age and position are not unexpected, due to the nature of scientific mobility - scientists are likely to move abroad in the early stages of their career - and given the change in mobility conditions: early cohorts had better conditions to return. Practically all the respondents are employed in research organisations. Only 2 work in firms, although 4 others have been involved in the creation of spin-off firms (2 of them in Portugal), while retaining their research posts. Among the few respondents (8) who have returned to Portugal, the majority is in the 31-40 age group and most of them hold research posts.

Figure 2 – Distribution by age group

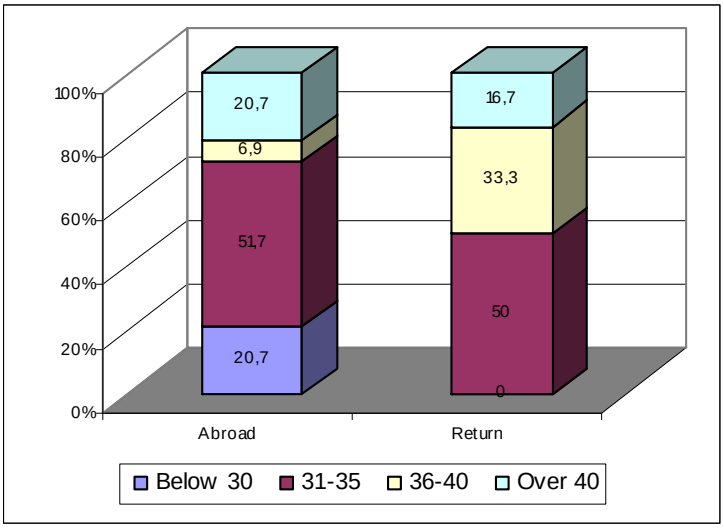
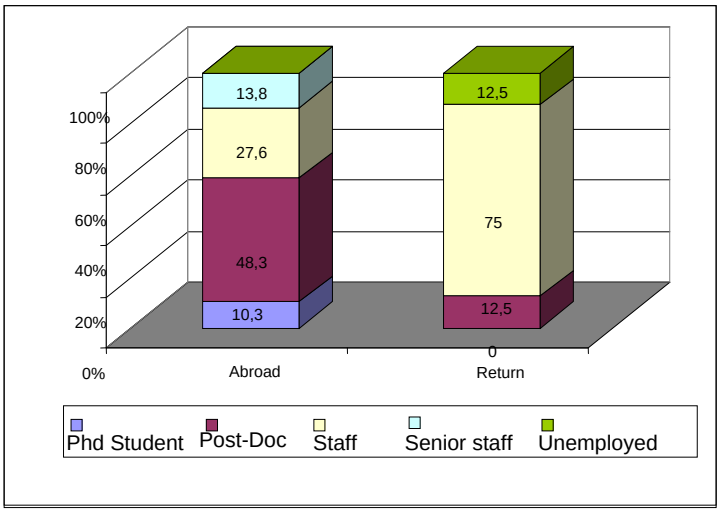
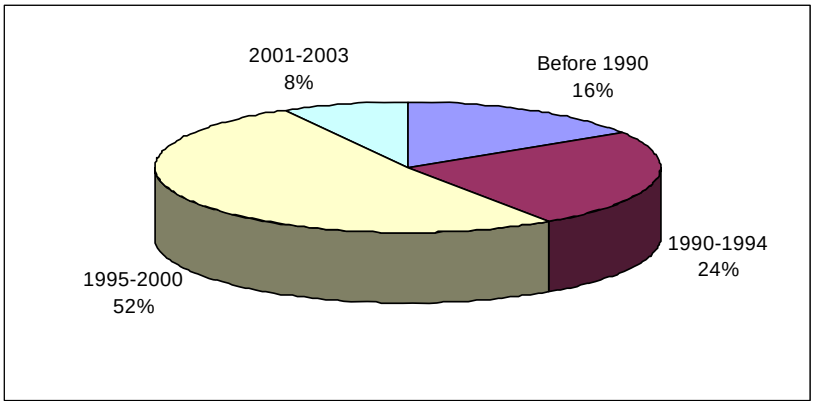


Figure 3 – Distribution by career position



Additionally, data about the period when respondents went abroad for the first time, shows that the majority belong to relatively recent cohorts: about 60% went in the second half of the 1990s or in the 2000s, 24.3% went in the first half of the 1990s and only a few (16.2%) went before 1990 (Figure 4). Most went to do a PhD (59.5%), although about 1/3 went earlier in their training process. Only a small minority went directly to post-doctoral research. However, not only the pre-doctoral movers pursued with their doctoral studies abroad, but also the majority of those who completed a PhD, moved subsequently to post-doctoral positions. Among those who returned to Portugal, the majority did their doctoral studies abroad and all of them occupied at least one post-doctoral position before returning.

Figure 4 – Date of first move abroad



The data also confirms the high level of mobility: 62,5% moved at least once and 40,5% more than once between organisations; 51,7% moved at least once and 13,5% more than once between countries (excluding Portugal) (Tables 3 and 4). As would be expected, the most frequent moves occur in the post-doctoral stage: scientists will often move away from their organisation (and less frequently country) after the PhD, to occupy a post-doctoral position elsewhere, or will occupy a sequence of post-doctoral positions in different organisations, which will be, in many cases, in a different country. These results are consistent with the mobility behaviour of post-docs, traced by Musselin (2004). Interestingly, while the US was the preferred destination for the first move, closely followed by the UK and France, European countries become relatively more important as subsequent locations, including some not envisaged earlier (e.g. Spain) (Table 5).

Table 3 - Number of moves between countries

Number of moves	Currently abroad		Returned to PT	
	Nº	%	Nº	%
0	14	48,3	4	50,0
1	11	37,9	3	37,5
2	4	13,8	0	0,0
3	0	0,0	1	12,5
Total	29	100,0	8	100,0

Table 4 - Number of moves between organisations (same or different country)

Number of moves	Currently abroad		Returned to PT	
	Nº	%	Nº	%
0	7	24,1	3	37,5
1	9	31,0	3	37,5
2	8	27,6	1	12,5
3	3	10,3	1	12,5
4	1	3,4	0	0,0
5	1	3,4	0	0,0
Total	29	100	8	

Table 5 - Relative importance of mobility countries through time

	Currently Abroad				Returned to PT			
	Current country		First country		Last country before return		First country	
	Nº	%	Nº	%	Nº	%	Nº	%
UK	**7**	**24,1**	**7**	**24,1**	1	12,5	**2**	**25**
FR	**6**	**20,7**	**7**	**24,1**	1	12,5	-	-
US	**6**	**20,7**	**9**	**31,1**	**4**	**50,0**	**3**	**37,5**
SE	**3**	**10,3**	3	10,3	-	-	-	-
CA	**2**	**6,9**	-	-	--	-	-	-
SP	**2**	**6,9**	-	-	-	-	1	12,5
BE	1	3,4	1	3,4	-	-	1	12,5
CH	1	3,4	-	-	-	-	-	-
NL	1	3,4	2	6,9	-	-	-	-
AU	-	-	-	-	1	12,5	-	-
DN	-	-	-	-	1	12,5	1	12,5
Total	29	100,0	29	100	8	100,0	8	100

5.2.1 - Return perspectives

The data shows that for most scientists (about 2/3) the return to Portugal does not appear to be an option, at least in the near future. This conclusion is not just based on the low return rate observed in this group – which could be influenced by the career stage of a substantial proportion of the respondents - but also on the return perspectives of those who remain abroad (Table 6). Only 3 of the respondents decisively express the intention to return, although two of them consider necessary to improve their CV beforehand. The most frequent situation is that of scientists who would envisage the possibility of returning, but do not see it as a realistic or viable alternative (72.4%). In this group we have nevertheless two different attitudes: those who express a stronger wish to return and regret the absence of employment compatible with their qualifications (37.9%) and those who would only be willing to return if a particularly good opportunity did emerge (34.5%). Finally 17.2% of the respondents are established and have no intention of returning.

Table 6 – Scientists abroad: attitude towards return

Perspectives of return for scientists who are abroad	Nº	%	
Is going to return as soon as the current activity is completed	1	3,4	10,3
Is going to return but first wants to gain further experience / CV	2	6,9	
Would like to return, but does not see adequate employment perspectives	11	37,9	72,4
Will only return if there is a good opportunity in Portugal	10	34,5	
Is not going to return	5	17,2	17,2
Total	29	100,0	100,0

The attitude towards return is associated with age and stability of position, as would be expected (Ackers, 2005): the older and more senior the scientists are, the lower the inclination to return or the higher the requirements. However, there is still a high number of post-docs who state that they would only return if a good opportunity emerged, and a number of scientists in (non-senior) stable positions, who mention that they would definitively like to return, but see no prospects at home.

The results obtained concerning the questions asked to the 8 scientists who have already returned (Table 7) can provide some additional insights on return conditions, although the small number of cases does not allow drawing any conclusions. First of all, it is relevant to notice that three had a stable position to return to. Among those who had not, only two out of five mention to have returned to a position with which they explicitly declare to be satisfied. When asked

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about future perspectives, five out of the eight respondents express the willingness to remain in Portugal, while three put the possibility of leaving again, one of them having, in the meanwhile, effectively moved abroad. Similarly, two of the scientists currently expatriated also mentioned to have returned to the country and then left again later, for lack of opportunities. These results can partly substantiate the reticence of those, of the same generation, who remain abroad.

Table 7 – Returned scientists: attitude towards return

Motives for returning for scientists who are in Portugal	Nº	%	
Always planned to return because had a position in PT	3	37.5	62.5
Always planned to return for personal reasons but did not have a position in PT	2	25.0	
Decided to return but does not see good employment perspectives	1	12.5	25.0
Decided to return and is satisfied with the employment obtained	1	12.5	
Only returned because there was a good opportunity in Portugal	1	12.5	12.5
Total	8	100.0	100.0
Future perspectives for scientists who are in Portugal	Nº	%	
Intend to stay	5	62.5	62.5
Is willing to leave again given the absence of a compatible job	1	12.5	37.5
Will leave again if a good opportunity arises abroad	2	25.0	
Total	8	100.0	100.0

One possible conclusion is that, as was already pointed out by researchers elsewhere (Casey et al, 2001), the desire to return is a strong feeling among expatriate scientists, often associated with the idea that they could contribute to the country's development. But this feeling tends to be moderated by the awareness of the lack of conditions for this return to take place in satisfactory conditions. Although the condensed nature of the questionnaire did not allow prodding more deeply into this issue, some comments offered by the respondents provide further insights.

The willingness to return exists, but pragmatism dominates:

Since I am completing my PhD I have searched for the opportunities available in Portugal […] but unfortunately I found nothing. Comparing to offers I got abroad (where I intend to remain), I realise that Portuguese institutions have a lower scientific level (at least in my field), do not have strong teams (one cannot work alone) and that the salaries are incommensurably lower. Unless decisive measures are taken to make it attractive for scientists to return to Portugal, many of us will continue working abroad. I would really like to return (and I am sure I will one

day…) because I believe I could contribute to the research in my field, but the opportunities have to be there [PhD student in the US].

And scepticism prevails, often fuelled by the negative "role models" of those who returned to frustrating situations:

I have little hope that opportunities for researchers emerge or are promoted in Portugal […] My scepticism has been confirmed by the news I receive from colleagues who decided to return to try their chance. The vast majority has stagnated in professional terms, due to the lack of opportunities and of stable jobs. I imagine that this is the image that nowadays reaches the Portuguese scientists who are abroad. Without a minimum of guarantees it will be impossible to return, since many of us have a family life that we don't want to jeopardize. [Young post-doc currently in Spain]

But this situation is indeed a reason for deep regret:

My return to Portugal [when the PhD is completed] will be strictly for personal reasons, otherwise I would not return now. It is more difficult to obtain grants and there is much less choice of institutions […].For those who would like to work in a pharmaceutical or biotechnology company, the opportunities are practically inexistent. Portugal is "my home", but I find it very sad that so much emphasis is put on training PhDs abroad, without having in mind that there will never be employment for all of them, if they decide to return home [PhD student in the UK].

We are Portuguese only by birth, in fact we are "world scientists". Indeed, we only become Portuguese scientists when it comes to the statistics... Portugal could use better its resources! [Young post-doc currently in the US].

These remarks are more frequent among the younger generation. Indeed, they echo comments by young expatriate scientists, from a wider variety of fields that can be found in media articles on this theme. Older scientists, already established, are in a different position. Although a couple of them mention early attempts to return that were unsuccessful, they appear to have found their way to provide some contribution to the home country, by developing closer links with Portuguese organisations or researchers. This question will be addressed below.

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5.2.2 - Links with the home country

The vast majority of respondents who are abroad (75.9%) have some type of link with the home country. As would be expected, the most frequent are occasional or personal contacts, but a substantial number also keep closer scientific relationships involving exchange of students or researchers, co-supervision of post-graduate students, joint projects and joint publications (Table 8). The fact that two of the respondents were involved, although at a distance, in the start-up of a biotechnology company in Portugal, to which they brought knowledge and contacts, introduces a further type of contribution that can be particularly relevant, as revealed by research on the role of foreign backgrounds on the activity of new biotechnology firms (Fontes, 2005).

Table 8 - Type of links maintained

	Scientists Abroad with the home country		**Returned Scientists** with previous host countries	
	Nº	%	Nº	%
Have links	22	75,9	8	100,0
Type of links	Nº	%	Nº	%
Exchange of students / scientists	9	31,0	3	37,5
Joint-projects	7	24,1	5	62,5
Joint publication	7	24,1	7	87,5
Co-supervision of PhDs	6	20,7	1	12,5
Activities as expert / evaluator	5	17,2	2	25,0
Advisory committee of organisations	4	13,8	0	0,0
Occasional organisation of courses/seminars	14	48,3	2	25,0
Personal relationships	12	41,4	7	87,5

A closer examination shows that a few scientists, particularly the most senior, are involved in a wide range of activities. Indeed, some activities - exchange of people, co-supervision, acting in advisory committees and occasional events - are associated with seniority. On the other hand, joint-projects and publications are performed by a greater variety of respondents, involving also a higher proportion of younger scientists. Besides, some among those who are established abroad and have no such links, mention the interest to develop them in the future:

I would like to participate in activities in Portugal (e.g. courses, seminars, advisory committees) where I could share my experience and help young scientists or students, either in areas of my scientific expertise, or with regard to the differences between an academic career and a career

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in the pharmaceutical and biotechnology industry [Researcher in a biotechnology company in the US].

It is also relevant to point out that all the scientists who returned (Table 8) keep links with their previous host organisation(s) or colleagues, which is consistent with the literature on returnee networks (Melin, 2004). Most frequently these links assume the form of personal relationships, research collaboration (joint-projects) or joint publication, but there are also some instances of exchange of people. The relevance of networks gained through foreign experiences can be further illustrated by the case of those scientists who, while being *located in Portuguese organisations*, were inventors in patents filled by foreign organisations or in patents co-filled by Portuguese and foreign organisations (see Footnote 7). Although the scientists involved in the 14 cases identified were not part of the sample, their background was nevertheless investigated and it was found in all cases of co-application and all but one case of foreign applications, that there was at least one inventor (often older/senior) who had an international experience at an earlier period. This result is quite significant in a context where academic patenting is still very infrequent. It suggests that both exposure to foreign research environments and continuity of relationships with them can bring about changes in the behaviour of the research communities these scientists reintegrate (or build up) in returning. Additionally, it was concluded that some of them kept extensive international networks and maintained collaboration through time, of which (co)patenting was only one expression, which confirms the role of returning scientists in accessing and integrating international scientific communities.

The extensive range of links possessed by some of the respondents who remain abroad suggests the presence of scientific networks of the diaspora type. Since one additional effect of these networks is to serve as channels to further mobility (Ackers, 2005), we asked them whether there were other Portuguese scientists in their current organisation, to which about half answered positively. Additionally, we asked all scientists if they were aware of a "tradition" of mobility of Portuguese nationals to any of the foreign organisations they had moved through (and of what type). 70.3% answered positively and some of them described longstanding connections that varied from simple hosting of graduate students to cases of extensive networking.

These results confirm that the presence of Portuguese scientists in foreign organisations of excellence is an important source of mobility incentives. But this is not just a one-way process and those who remain abroad may also act as nodes in important networks, along which take

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place a variety of activities (Gaillard and Gaillard, 1998). This role is illustrated by the comments of some senior scientists, who not only describe their activities, but also express enthusiasm for their involvement in those actions and gratification for the outcomes. It is also confirmed by the comments of younger scientists who recognize that the "tradition of receiving Portuguese nationals" is grounded in the presence of Portuguese senior researchers, who keep contacts with organisations in the home country. Additional evidence of diaspora networking can be obtained from the several cases of membership, or even organising responsibilities, in international associations of Portuguese scientists.

6 - CONCLUSIONS

This paper addressed the growing mobility of scientists and its implications for countries with weaker S&T systems and thus less able to retain their best scientists. Portugal is an example of sending country that may be experiencing problems to attract back and retain its most promising talents, particularly in some fields. However, contrary to other countries, this question is seldom addressed at policy level. Indeed, there appears to be a clear dissociation between the extensive anecdotal evidence on the situation of expatriate or returning young scientists and the political discourse that minimizes or ignores the problem. The absence of data on return mobility and particularly the lack of knowledge about the situation and career perspectives of those who move abroad, precludes a more informed discussion about this subject.

The objective of this paper was to provide some contribution to that debate. Our goal was not necessarily to address the whole population of expatriate scientists (that would always be very difficult to delimit), but rather to consider the situation and perspectives of particularly qualified scientists. This approach was grounded on the argument that the quality of scientists who do (or do not) return, may be the most critical question for the sending country. It supported the definition of a sample of "scientifically productive scientists", based on their position as patent inventors in a science–based field. A methodology was thus devised to identify and locate the scientist/inventors, that enabled us: to trace and contact the 53 Portuguese expatriate scientists who were inventors in biotechnology patents; to obtain some data on their situation and trajectory; and to elicit some preliminary information about their attitudes toward the home country, whether they remained abroad or had already returned to Portugal.

First of all, it should be noticed that this search enabled us to conclude that ¾ of the biotechnology PCT patent applications with Portuguese as inventors involved only expatriate

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scientists. It was found that most of these scientists are still abroad and that, at least among those who answered to our survey, the vast majority intends to remain there, so far. However, for most of them, this decision is based less on the unwillingness to return, than on the awareness of the difficulties to be expected at home. Thus a substantial number, especially among the younger generation, express the desire to return and to "make some contribution", but only if more favourable conditions are found at home. Their behaviour reflects some pragmatism, but their comments often express sadness or frustration with the impossibility of returning in reasonable conditions and with the waste of resources their situation epitomizes, given the high investment made on them.

Obviously there are differences between the most recent cohorts (who went abroad in the mid/late 90s) and the earlier ones, who are mostly composed of senior scientists. But the latter, while not intending to return, express a similar desire to "make some contribution", which is often materialised in an extensive range of links to the home country. Indeed, relationships with Portuguese institutions or researchers are common practice: in the case of younger scientists they tend to assume the form of co-publications or joint-projects, in the case of older ones they also include supervision and advisory functions. The results obtained and the comments offered by the scientists provide some evidence of "diaspora" behaviours, both in terms of knowledge transfer/ exchange and in terms of channelling effects.

Although these results are still preliminary and may not be generalised to the whole population - neither that was our objective – they are nevertheless pertinent for policy makers. In fact, what our results suggest is that a reluctance to return may be the prevailing attitude among those scientists who have more opportunities to remain abroad and who will suffer greater personal loss in career terms if, upon returning, were unable to find adequate research conditions. That is, those whose contribution could also be more valuable to the home country.

In this, our results somewhat contrast with the (only partial) results disclosed for a larger, but more "undifferentiated" sample, that base official positions. However, even if these results depart from an idealised political approach, they are not really unexpected. They reflect the situation that is likely to be typical of a small European country in an intermediate stage of development, with a relatively weak S&T and the associated difficulties in fully absorbing its highly qualified human resources, especially when confronted with the attraction of international centres of scientific excellence. Indeed, they share some similarities with results from recent research on Italy or Spain (Gill, 2005; Morano-Foadi, 2005; Cruz and Sanz, 2005), although they also present some specificities when compared with results from other

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"intermediate countries" often addressed by mobility research: e.g. Asian or South-American countries (Kapur and McHale 2005; Charum, 2001; Zweig, 2008) or even Central and East European countries (Stretnova, 2003; Gill, 2003). But basically, these results suggest that the question of mobility and return, particularly of the most promising scientists, needs to be addressed, at policy level, with much greater attention than it has received so far.

The results obtained are particularly illustrative of the generation that ended-up being more neatly captured by this research - in their early 30s, having moved abroad late 1990s/early 2000s - although they also provide some hints on the behaviour of an older generation, who settled abroad a few years back. It can be argued that this younger generation is relevant, since those scientists have reached the stage when decisions are taken concerning future career development. Therefore, their views and their perspectives are pertinent, if policies are to be devised to encourage their return before professional stability, personal factors or even sheer disenchantment make them less receptive to such initiatives. In addition, the interest – sometimes, indeed, the enthusiasm – expressed by several scientists in senior positions, regarding their potential contribution to the country's scientific development, suggests that there may be conditions for further use of the scientific diaspora by national S&T policies.

These results are based on a small sample and on a relatively simple questionnaire. They provided some interesting insights, but these need to be further developed. Subsequent research will both expand the analysis, applying this methodology to other science-based fields[10], and deepen the analysis through more in-depth qualitative research, to which the respondents were fully receptive. Indeed, the great interest expressed by the scientists inquired is a clear indication of the relevance of the problem.

[10] This could include scientists in other fields where patents are an adequate measure of productivity, even if a precise patent/field delimitation may be more controversial. An extension to all Portuguese scientists who were inventors in patents filled by foreign organisations, should be addressed with greater care, given the differences between fields regarding the nature of patents (Levin et al, 1987).

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