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The impact of long term scientific mobility on the creation of persistent knowledge networks

Margarida Fontes
LNEG / UMOSE and DINAMIA'CET-IUL
margarida.fontes@lneg.pt

Pedro Videira
Instituto Universitário de Lisboa (ISCTE-IUL) & DINÂMIA'CET-IUL
p_videira@yahoo.com

Teresa Calapez
Instituto Universitário de Lisboa (ISCTE-IUL) & UNIDE - IUL
teresa.calapez@iscte.pt

Abstract

International scientific mobility is a strategic element in the science policies of several countries, being often equated with the development of extensive knowledge networks that can be mobilised by the scientists (and their organisations) upon their return. The objective of this paper is to understand whether and in which conditions mobility leads to the development of knowledge links that are long lasting and effectively play a key role in scientists' activities. In conceptual terms, the influence of mobility is explained through the opportunities it provides for temporary co-location in one organisation, and thus for the creation of social, cognitive and organisational proximity between scientists, which are critical for knowledge transmission and which can persist after the individuals draw apart. This conceptual framework supports an empirical analysis of the impact of two types of long term mobility - for training and professional purposes - on the creation of "persistent knowledge networks", in the case of Portuguese scientists. The results show that mobile scientists are more likely to have foreign organisations in their core knowledge network. Even more importantly, they reveal a high incidence of organisations that were part of the scientists' trajectory in these networks, providing some confirmation to the effects of co-location. However, these effects are not always present: the research also identifies some factors – related with personal characteristics, career situation, scientific field, time, geographical distance, motivations to move - that increase the likelihood of network persistence, which differ for the two types of mobility.

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1. Introduction

International mobility, for training or professional purposes, has become an intrinsic element of the scientific career. Research organisations value it in their recruitment and promotion policies and often encourage it among their staff and graduate students (Araújo, 2007). Scientists not only perceive mobility as critical for the construction of their human and social capital (Bozeman et al., 2001) but are also increasingly aware of its signalling role in the scientific labour market. While these effects are particularly evident in some scientific fields – e.g. life sciences - where there is an "expectation of mobility" and in early career stages (Musselin, 2004; Morano-Foadi, 2005; Ackers, 2005), international mobility has grown significantly throughout the whole system (Reiner, 2010; OECD, 2008; Veugelers, 2010).

European policies, namely through the creation of the European Research Area, have fuelled this "mobility requirement", linking it with excellence and competitiveness (Ackers 2008; OECD, 2008). The relevance attributed to mobility in European policies is also patent at country level, particularly in the case of countries with weaker scientific systems. Some of these countries have regarded international mobility as strategic and have devised policies whose goal was to use mobility as an instrument for the country's scientific development (Jonkers and Tijssen, 2008). Policies which encouraged the most talented scientists to conduct doctoral studies or post doctoral research in foreign centres of excellence were expected to enable access to advanced knowledge in fields that were absent or underdeveloped in the home country (Veugelers, 2010). In addition, mobility was also expected to provide scientists with opportunities to become part of international scientific networks (Ackers, 2005; Jöns, 2007; Mahroum, 2000; Williams et al., 2004). These networks could be mobilised upon their return, benefiting both the individuals and the organisations that employed them. The success of these strategies was obviously associated with the return of the mobile scientists. Thus, more recently, the awareness that a substantial number of expatriate scientists remained abroad, led those countries to introduce additional policies to foster their return (Davenport, 2004; Laudel, 2005; Zweig and Fung, 2004), or, when this was not viable, to attempt to benefit from their expertise through the promotion of "diaspora networks" (Kuznetsov, 2006; Meyer, 2001).

Debates on the results of these strategies have usually centred on whether scientists return or on the conditions they face when willing to return to the home country (Gill, 2005;

Giannoccolo, 2006; Fontes, 2007), or on whether scientists who do not return can be mobilised to contribute from a distance (Davenport, 2003; Gamlen, 2005; Laudel, 2005). However, less attention has been put on the networks of those scientists who return (Jonkers and Tijssen, 2008). As a result, we still know very little about the role played by mobility on the creation of international relationships that effectively act as vehicles for knowledge access and exchange across country borders.

The objective of this paper is exactly to contribute to fill this gap, by investigating whether international scientific mobility – particularly more long term mobility associated with advanced training or research positions - has an impact on knowledge network formation. Additionally, we investigate whether relationships established during extended periods of co-location play a relevant role in the subsequent knowledge exchange activities of the scientists. This research is expected to contribute to a better understanding of the role played by scientific mobility in transnational knowledge exchange activities.

2. Analytical Framework

In order to address this question we need, first of all, to consider the rationale behind the *expectation of network building* that is associated with international mobility of scientists. For this purpose, we need to bring to the discussion the relationship between mobility, proximity and knowledge flows, which will provide the theoretical framework for our approach. This approach will draw largely on two main streams of research: i) the literature on the spatial diffusion of knowledge that discusses the role played by different types proximity in knowledge transmission processes and the importance of co-location for the development of those types of proximity; ii) the brain circulation literature that discusses the importance of international mobility of scientists in the creation of transnational knowledge networks and the importance that those networks can assume for peripheral national scientific systems.

2.1 Mobility, proximity and knowledge networks

It can be argued that mobility is relevant for the creation of knowledge networks because it provides opportunities for co-location – i.e. physical proximity - between individuals through more or less extended periods of time. Physical proximity is generally accepted to be critical for knowledge exchange (Feldman, 1999), particularly when the knowledge being transmitted

has a strong tacit component, as is the case with new scientific discoveries (Zucker et al., 2002); or when knowledge is highly complex, in which case even codification may not guarantee complete comprehension and reproduction (Dasgupta & David, 1994).

However, physical proximity is not a sufficient condition for knowledge transmission. Its importance lies also in the fact that the periods of co-location between individuals create conditions for the development of *other types of proximity* – social, cognitive, organisational (Boschma, 2005) – that are essential for effective knowledge transmission (Breschi and Lissoni, 2001). Social proximity is related with the presence of social ties between actors, which derive from sharing the same origin or affiliation. Social proximity is important because it gives rise to social attributes such as trust and ease of communication (Coleman, 1988) facilitating exchanges between individuals and namely enabling entry into more exclusive knowledge communities. Cognitive proximity is associated with the sharing of a common knowledge base. In fact an effective comprehension and absorption of the knowledge being transmitted, requires that the receiver's cognitive structure does not differ significantly from the sender's (Cohen and Levinthal, 1990). The conjugation of high levels of social and cognitive proximity may lead to the formation of an 'epistemic community', with shared meanings, language and communication codes, which in turn creates conditions for the knowledge produced to be at least partly articulated and transmitted at a distance between its members (Breschi and Lissoni, 2001). Finally, organisational proximity is associated with relationships that take place on an organisational basis and enables an understanding of the rules, hierarchies and codes of behaviour that prevail in a given organisation (Boschma, 2005). This understanding, which facilitates interactions between organisation members, can also make it easier for ex-members to establish cooperation.

Since these forms of proximity tend to be more difficult to develop when there is no physical proximity, they are often the result from the frequent face to face interaction and experience sharing enabled by co-location (Torre and Rallet, 2005). However, while it is accepted that co-location is critical for the development of relationships characterised by these types of proximity, the links endowed with them can persist after the individuals draw apart and base subsequent knowledge exchanges at a distance. In fact the capacity to benefit from and further develop this type of relationship does not necessarily require continued physical proximity – although it may benefit from new instances of temporary co-location to nurture the relationship and avoid decay (Saxenian and Hsu 2001; Williams et al. 2004).

Going back to our discussion on the expectation of knowledge network building associated with international scientific mobility, it becomes evident that these effects can indeed be generated. However, it is not just because scientists move to a foreign organisation, but because the physical proximity it entails may support the development of this type of relationship and favour their persistence after the scientist leaves. Whether this effectively happens, the intensity and contents of the links developed and the likelihood that they are subsequently mobilised will depend on a number of other factors, partly related with the scientist and partly related with the host context and the returning one. However, it can be argued that longer term mobility may have the greatest impact, leading to the establishment of stronger and more longstanding relationships and thus potentially more important ones.

2.2. The impact of mobility on knowledge networks / knowledge flows

Previous empirical research on the impact of mobility on knowledge networks and associated knowledge flows can provide some additional insights into this discussion. Two streams of research appear to be relevant. Research on the influence of labour mobility on knowledge flows for the case of mobility between firms, has produced relevant theoretical and empirical insights. It has namely confirmed the importance of co-location periods in the same organization in the creation of social and cognitive relationships that persist after the move. Research for the case of scientific mobility has initially focused on the creation of scientific diaspora networks and only recently has started providing some empirical evidence on the relevance of mobility for the development of knowledge networks between returning scientists and the countries of their previous stay. The contributions of these two streams of research will be more extensively discussed below.

Several authors have investigated the influence of employee mobility on knowledge flows in the case of firms (Almeida and Kogut, 1999; Oettl and Agrawal, 2008; Rosenkopf and Almeida, 2003; Song et al., 2003). Basically the assumption is that movers will maintain relationships with at least some of their previous colleagues and that these relationships will serve as conduits for continued knowledge exchanges between them. The impact of these exchanges may extend to the colleagues in the new organisation and therefore, when the move is between countries, it can be argued that mobility may also lead to knowledge flows between countries (Oettl and Agrawal, 2008). Empirical analyses, based on patent citations, have confirmed the persistence of knowledge flows (back and forth) after the move. In other

words, the social and cognitive relationships built by these individuals during their co-location in one organisation persist after their move and add to the individual personal networks. At least some of these relationships are subsequently mobilised in the new context for their knowledge activities. Thus the creation and mobilisation of these networks is key for the development of knowledge flows between people and their organisations/countries.

Research on the relationship between international mobility of scientists and knowledge flows has emerged largely as a response to the "brain drain" debate. In fact, more recent approaches depart from the idea that international mobility of scientists from less to more developed scientific contexts was a unidirectional zero sum game, in which the sending country was fully deprived from their scientific talent. These approaches have defined scientific mobility as a complex, multi-dimensional and multi-directional phenomenon (Ackers, 2005), in which expatriate scientists can still contribute for the development of their national scientific system through what was described as "scientific diaspora networks" (Meyer, 2001). That is, transnational networks that link them with scientists from their home country and that may enable the latter to connect to and conduct a variety of knowledge exchanges with more advanced scientific environments (Davenport, 2003; Kuznetsov, 2006). Following this rationale, early research on knowledge flows associated with international scientific mobility focused on diaspora networks.

More recently researchers have started to turn their attention to the case of returning scientists. The role of returning expatriates as connectors to sources of competences and resources located in the countries where they previously worked or studied had already been discussed by some authors (Saxenian and Hsu, 2001; Williams et al., 2004). However, only two studies have been conducted that focus specifically on the influence of international scientific mobility on the creation of knowledge networks, which persist after the scientist returns to the country of origin or moves to a new country. One of them addresses a large sample of scientists from a series of Asia-Pacific countries and investigates the impact of their mobility across countries - for doctoral training or for post-doctoral activities – on the building of research networks and transnational collaborations with those countries (Turpin et al., 2008). The other addresses foreign scientists who visited Germany in the context of the Humboldt research fellowships and investigates the subsequent process of collaboration and transnational mobility, having Germany as destination, which resulted from it (Jöns, 2009).

Both studies have found evidence of the relevance of mobility for the development of networks *at country level*, showing that scientists tend to establish knowledge relationships with the countries where they previously stayed. However, since the unit of analysis is the country, it is not possible to disentangle the conditions in which the relationship was established, i.e. whether it derived from the permanence in the same organisation, or was driven by other circumstances.

2.3 Limitations in current research

The research described above provides important insights into the relation between mobility and knowledge networks as conducts for knowledge flows, but has limitations regarding the effective assessment of the importance of co-location for knowledge network creation.

Studies on mobility between firms encompass mobility between organisations and thus address the proximity issue, but use proxies for the presence of networks (based on patent or publication data), whose adherence to reality can be discussed. The frequent equation of knowledge networks with co-publication or co-citation networks is based on the assumption that the most *important* knowledge networks are those that end-up producing an ISI referenced publication. While this is partly true, this approach also runs the risk of excluding a significant number of relevant exchanges and amplifying occasional contacts. This issue has been subject to some debate, with some authors pointing out the limitations of publications as an expression of collaboration. These include namely major differences between fields in terms of (co)publication practices and time lag problems given that outputs may only be produced in the future (Katz and Martin, 1997; Jöns, 2007). In addition, looking at the relevance of networks from the standpoint of returning scientists may also require us to take into account other effects that are not necessarily reflected in direct collaborations that produce outputs (Melin and Persson, 1996), such as the mediator role of more senior scientists towards other groups/networks; the access to sources of funding; and the opportunities for additional mobility for the scientists or their teams. Thus, we think that it is important to achieve a more precise identification of the key *networks that are effectively built and mobilised* by the returning scientists.

Studies on scientific mobility also tend to use publications, even though a few authors have started to collect primary data about the actual networks. However since these studies focus

on countries and not on organisations we have no real evidence about the mechanisms behind the development of those networks. In fact, the permanence in a given country can offer different types of opportunities. On the one hand, scientists integrate one (or more) organisation for a certain period of time. As pointed out above, this creates conditions for the development of social, cognitive and organisational proximity between the members of the organisation, favouring the establishment of strong relationships that may persist after their move. On the other hand, permanence in a country increases the knowledge of the prevailing cultural and institutional behaviour, facilitating further contacts and provides opportunities for interactions with scientists from nearby organisations (which might have not taken place if they were geographically distant) and whose contacts may also be mobilised later on.

While both types of circumstances may increase the likelihood of maintaining relationships with that particular country, it is our contention that the former are potentially likely to produce more relevant and persistent knowledge relationships. As we have seen above, co-location may generate relationships that are closer in social terms and thus have higher trust content, which can be critical for the exchange of new or tacit knowledge. The nature of the "proximities" generated can also contribute to facilitate continued knowledge exchanges allowing the relationship to withstand the effects of time and geographical distance. Thus, it is important to move one step further and address the processes behind the *establishment of networks with specific organisations* by returning scientists.

3. Methodology

3.1 Research Approach

The object of the research is to analyse the impact of long term international mobility on the development and persistence of knowledge networks with foreign organisations.

More specifically we want to understand whether and in which circumstances co-location in a given organisation - and thus the opportunity for the development of social, cognitive and organisational proximity it brings about - leads to the creation of knowledge links that are long lasting and play an important role on the scientists' activities – what we have labelled "persistent knowledge networks".

Thus our research questions are as follows:

- Does long term mobility effectively influence the composition of scientists' knowledge networks, namely through the presence of foreign organizations in their networks?
- Are the relationships obtained through co-location in specific organisations persistent and important enough to become part of the scientists' core knowledge networks?
- Which factors increase the likelihood of network persistence among mobile scientists?

Long term mobility is defined as outward mobility that lasts at least one year and includes both mobility for the PhD and professional mobility taking place after the PhD, the latter encompassing postdoctoral fellowships or actual job positions, as well as a variety of long term temporary stays by scientists who have their main position elsewhere. These two types of mobility are addressed separately since the objectives and the circumstances surrounding each are likely to be different and therefore their potential impact on network formation may also be different.

Persistent networks are defined as relationships that are built by scientists as a result of their training or professional mobility through different organisations and not only endure after the scientists' departure, but are perceived by them as their most important knowledge networks.

In order to address our research questions we started by investigating whether there were foreign organisations in the scientists trajectory (including the PhD and the post-PhD period) and, if that was the case, whether those organisations were among those perceived by the scientists as being part of their five most important knowledge relationships. The presence of a match was assumed to provide an indication that a long term stay in that organisation might have influenced its subsequent inclusion in the scientist core network. In other words, that the relationships built were persistent. Subsequently, we attempted to understand which types of factors are likely to explain the occurrence of persistence within mobile groups.

3.2. Empirical Setting

The empirical setting for the analysis were scientists, holding a PhD, who are currently members of a set of Portuguese "core" research centres - the Pluriannual Funding R&D Units and the Associated Laboratories – in three main fields: Health Sciences, Information Technologies and Sociology.

The choice of this setting was based on the role played by these centres in the Portuguese scientific arena. On the one hand, the fact that they are subject to a periodical assessment exercise, which provides a classification and determines an amount of base funding to be received annually, endows them with a minimum quality certification. On the other hand, their university location but relatively autonomous status, imply that these centres join together a wide range of researchers: a) university staff, who are not employed by the centre but conduct there the essential of their research; b) post-doctoral and other researchers contracted by the centre (including the greatest concentration of foreign scientists in the country) and, in some cases, c) individuals employed by other organisations (public or private) who find in the centre the setting for their research activities. Since these centres are currently the main locus of research in Portugal and offer a heterogeneous population, they were considered to be particularly adequate for our purposes.

The choice of these three broad scientific fields[1] was based on the assumption that they represent substantially diverse research environments, with different modes of organisation in terms of knowledge production and exchange and, namely, with different approaches to mobility (Ackers, 2005; Jöns, 2007), which are relevant to contrast and compare.

Finally, the decision to restrict the analysis to PhD holders can be explained by the fact that this group is regarded as the most likely to have a role on the advancement and diffusion of scientific and technological knowledge (Auriol et al., 2007), being crucial for knowledge-based economic growth, as well for the education and research training of new generations of young scientists. The choice of the PhD as reference period relates to the fact that the PhD is frequently the moment when long term international mobility first occurs (OECD, 2002).

Given the characteristics of the centres selected, the scientists studied fall into three categories: a) non-mobile scientists (i.e. Portuguese scientists who had no long term mobility as defined in this research); b) mobile scientists who returned to the home country (i.e. Portuguese scientists who are currently in Portugal after one or more mobility events); c)

[1] The assignment of individual centres to each field is done by the Research Council. However, many centres are clearly multidisciplinary and therefore composed of scientists from a greater variety of disciplines. Thus, "Sociology" centres often encompass scientists who specialise in a range of social sciences and humanities disciplines; "Health Sciences", in a combination of natural and exact sciences; and ICT in some engineering and technology fields and in a set of exact sciences

scientists who are currently mobile (i.e. foreign scientists working in Portugal or Portuguese scientists who belong to these organisations but are currently abroad).

3.3 Data collection

The data was collected through a questionnaire sent individually, through e-mail, to all PhD holders from the Centres (R&D Units and Associated Laboratories) in the three fields selected, whose e-mail contacts could be obtained. The questionnaires inquired about: a) the PhD and the professional trajectory after the PhD; b) motivations for mobility or non-mobility decisions and future mobility intentions; c) core knowledge network (the 5 most important research collaborations); d) nature of international knowledge collaborations; e) personal and professional situation. The respondents were also asked to supply a detailed CV.

The questionnaires were mailed at two different periods during 2009 and 2010, involving a total of 86 Centres: 43% from Health Sciences, 35% from IT and 22% from Sociology. The centres were heterogeneous in size, ranging from very small Units with less than 10 doctorates to large Associated Laboratories with over 100. Their quality assessment varied, ranging from Fair to Excellent, the majority being classified as Good or Very Good.

A total of 2647 questionnaires was sent and although it is not possible to state precisely how many were effectively addressed to doctorates (due to incomplete information in the case of some centres[2]) we estimate these to be at least ¾. We received 469 answers, which corresponds to a response rate of 18%. However, 48 were from non-doctorates and thus had to be discarded and 68 were not usable, since they did not provide information on the networks or on trajectories. Thus, we were left with 353 cases, 33% from health sciences, 28% from IT and 39% from sociology centres. The sample included 24 foreign scientists currently in Portugal, which corresponds to 11% of the foreign scientists who could be roughly identified (based on the name) among the group inquired. Only a subset of the respondents sent a detailed CV. Internet searches enabled us to find CVs for the remaining – excluding those who had opted for remaining anonymous[3] – although the on-line CVs varied in quality, some providing very limited information, which is frequently a problem when

[2] The information available for some centres did not distinguish PhD holders from other researchers. In these cases the questionnaire was sent to all members of the centre with a clear indication of the target audience.
[3] The questionnaire asked for the name of the scientist to allow for cross checking with CV and other information, but there was the option of remaining anonymous, chosen by only 9% of the respondents.

using CVs as data source (Dietz and al., 2000). The non anonymity and the availability of CV data were particularly important because they enabled us to complete the frequently missing data about the professional trajectory and the training record.

3.4 Description of sample

The group of scientists being studied is relatively balanced in terms of gender: 54% are men and 46% are women. In terms of age distribution there is a predominance of the 35-44 age group (47%), which corresponds to the early to mid career stage. The youngest (less than 34) and oldest (more than 54) groups are the least represented (respectively 16% and 11%). This is confirmed by career data: 58% occupy the typical post-PhD formal career positions, including both tenure positions and contract (3 to 5 years) positions, which are increasingly prevalent among the younger group. About 20% occupy "grant holder" or other highly precarious positions and only 23% occupy the top career positions.

In terms of scientific fields, we opted for considering the scientists' PhD field as an approximation to their area of expertise, classifying it according to the UNIDO Fields of Science (FOS). Scientists with backgrounds in social sciences (not exclusively sociology) correspond to 32% of the sample, to which can be added a smaller group (7%) from humanities. Scientists from engineering and technologies correspond to 22.4% and those from exact and natural sciences to 27%, while medical and health sciences are relatively less represented (11.6%). These results confirmed the multidisciplinary nature of several centres, leading us to abandon the centre-based classification and to group the scientists inquired in two main groups: social sciences and humanities on the one hand (40% of the sample); exact/natural sciences and engineering on the other hand (60%).

Finally, 36% of the respondents are exclusively researchers (about 1/3 of whom are grant holders), 62% combine teaching and research and a residual 3% combine research with other activities. A small group of scientists is currently "abroad" (11.7%). This includes temporary stays as visiting researchers, post-doctoral fellowships or temporary positions, as well as a few cases of (usually more senior) scientists who have stable positions in foreign organisations, but keep a close link to Portuguese organisations, through the affiliation to one of the research centres included in our analysis. It also includes the 17 foreign scientists who have not adopted Portuguese nationality, for whom Portugal is "abroad".

4. Empirical results

4.1 International mobility and foreign networks

In order to assess the influence of long-term mobility on network building, we have started by looking into the mobility trajectories of the scientists inquired. Data on mobility derives mainly from the questionnaire, even though the CVs supplied by the respondents or obtained on-line complemented the missing or incomplete data. Table 1 shows that almost half of the sample (42.8%) had engaged in some type of long term mobility. PhD mobility and post-PhD professional mobility involved the same number of scientists (16.4% each). However, only 10% of the sample had both types of mobility. It is also relevant to mention that among the 92 scientists who had post-PhD professional mobility, 78.3% went abroad in the 3 years immediately after the PhD, while 44.6% did it in later periods.

Table 1 – Incidence of long term international mobility

Long term mobility	Cases	%	
Only for PhD	57	16.4	
Only professional	57	16.4	42.8
Both	35	10.1	
No mobility	199		57.2
Total	348		100.0

Only 25% of the respondents had more than one long term stay abroad. The main destinations were European countries. The vast majority of PhDs were conducted in Europe (73%) with US second at a great distance (17.4%). European countries still prevailed in subsequent mobility (64%), but the US had a more important position (33%) and a small group of scientists had stayed in both locations. Other locations had a very marginal weight. This is consistent with other studies on Portuguese scientists (Delicado, 2010) and reflects the relevance of organisations from the US and a set of more advanced European countries as mobility destinations for scientists from more peripheral economies (Veugelers, 2010).

Data on international networks was obtained from the questionnaire, which asked scientists to list, by order of importance, up to five organisations where were their most important research contacts were located. While we acknowledge that these organisations will often be

only a sub-set of the total network, we assume that they are likely to be its "core" and therefore, encompass their key knowledge exchanges. The organisations thus obtained – either national or foreign – were defined as the scientists' "core network" (Net5).

From this group we selected the foreign organisations and analysed their relative importance in the scientist's "core network". Table 2 shows the result of this exercise, revealing a relatively internationalised group: about 2/3 have at least one foreign organisation in the core network and for about one half the most important organisation in the network is foreign. The average number of foreign organisations in the core network is 2.6.

Table 2 – Foreign organisations in "core network"

Foreign organisations in Net5	**Cases**	**%**
Have ***at least one*** foreign organisation in core network	271	76.8%
The ***most important*** organisation is foreign	188	53.3%
More than half of core network is abroad	135	38,30%
All the core network is abroad	28	7.9%
		N=353

A first step in the assessment of the influence of long-term mobility on international network building is to find out whether there is some relationship between the presence of foreign organisations in the core network and long term international mobility. Table 3 shows the distribution for having at least one foreign organisation in the core network, categorised by having or not PhD mobility. Table 4 shows the same distribution, categorised by having or not Professional mobility. In both cases there is evidence of a statistically significant relationship between the network and the mobility variables[4], suggesting that scientists with previous long term mobility are relatively more likely to have foreign organisations among their main knowledge contacts. These results are consistent with previous research that has identified a relationship between international mobility and network building (Turpin et al., 2008; Jöns, 2009).

Table 3 – Relationship between PhD mobility and foreign networks

	PhD Mobility		Total
	Yes	No	
Foreign organisation(s) in NET 5	91.3%	71.8%	76.9%
No foreign organisation(s) in NET 5	8.7%	28.2%	23.1%
Total	100.0%	100.0%	100.0%

[4] Fisher's exact tests on the 2x2 contingency tables: PhD mobility vs. Foreign Organisation in Net 5, $p<0.001$; Professional mobility vs. Foreign Organisation in Net 5, $p<0.001$.

Table 4 - Relationship between long term professional mobility and foreign networks

	Professional Mobility		Total
	Yes	No	
Foreign organisation(s) in NET 5	92.9%	71.4%	77.5%
No foreign organisation(s) in NET 5	7.1%	28.6%	22.5%
Total	100.0%	100.0%	100.0%

However, the data also show that although long-term mobility appears to increase the propensity to establish international knowledge networks, international networking is a relatively generalised phenomenon, even among non mobile scientists. In fact, if we consider the group of scientists who had neither PhD mobility nor professional mobility we still find that 66% have foreign organisations in their core networks. The main difference between the mobile and the non mobile scientists lies in the fact that the former are relatively more likley to rank a foreign organisation as the most important research contact[5].

Thus, in order to fully understand the actual impact of mobility we need to work out the mechanisms that were behind the formation of the networks among the mobile scientists. Following our argument that physical proximity between scientists in a given organisation, can be one such mechanism, we are particularly interested in assessing how important were co-location effects in the formation of these networks.

4.2 Looking for persistent networks

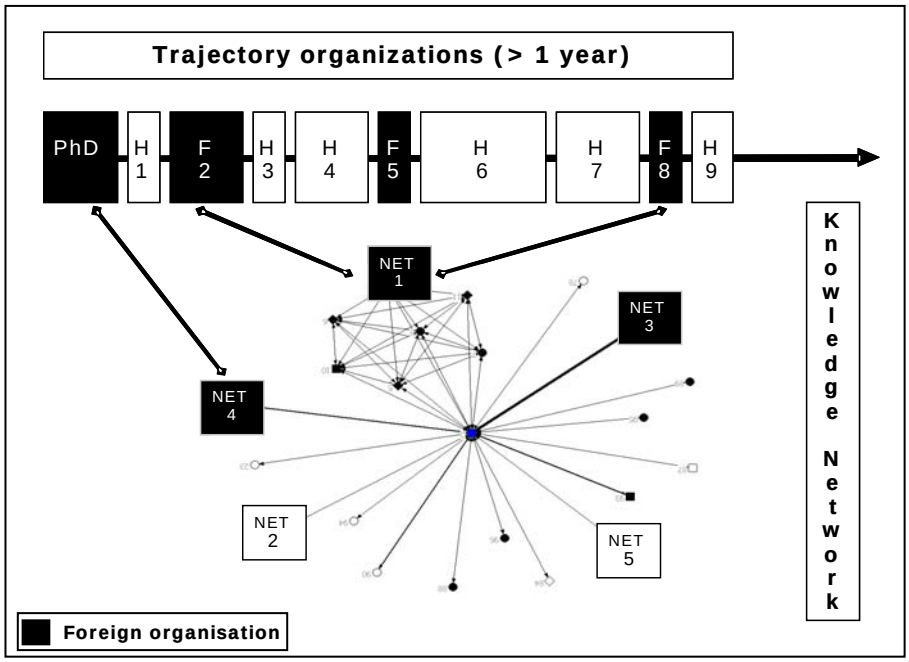
In order to assess the role played by previous co-location, we have looked specifically to the case of mobile scientists who had at least one foreign organisation in their core knowledge network, to find out whether relationships deriving from their long term stays in foreign organisations were lasting enough and important enough to be part of that network. In fact we are looking for what we previously defined as persistent knowledge networks: close relations built by scientists along their training or professional mobility trajectories that not only endure after their departure but are regarded as their most important knowledge relations.

For this purpose we examined each scientist's trajectory in order to identify: i) the organisations where they conducted the PhD; ii) all the organisations outside the home country where they had long term stays. These organisations were then checked against the

[5] Fisher exact test on the 2x2 contingency table: PhD mobility vs. Foreign Organisation Ranked 1st in Net 5, $p<0.01$

foreign organisations he or she had included in the core network, in order to identify eventual matches. Figure 1 exemplifies the process with one case where two matches were found, one being the PhD organisation, the other being an organisation where the scientist had a post-doctoral position after the PhD and to which she returned years later, as visiting professor.

Figure 1 – Identifying persistent knowledge networks



This method has the disadvantage of being highly time consuming, requiring extensive manual check of the information. However, despite this shortcoming, we believe that our approach was instrumental in identifying instances of long-term co-location that are likely to be associated with the development of persistent knowledge relationships.

Table 5 shows a first result of this exercise, indicating the incidence of network persistence in this group of scientists. It is possible to conclude that the proportion of mobile scientists who have the PhD organisation or another organisation that was part of their international trajectory in the core network is high, around 60% (slightly less for the case of the PhD). This can be regarded as indication of effective importance of scientists' permanence in these organisations in the subsequent development of relevant knowledge relationships.

Table 5 - Incidence of network persistence

	Cases	Weight on mobile group (%)	Total mobile group
Foreign organisation of *PhD* is in core network	52	57.8	N=92
At least one foreign organisation from *Professional Trajectory* is in core network	54	60.0	N=90
At least one foreign organisation from *Trajectory - PhD or Professional -* is in core network	93	62.8	N=148

Some additional information can be obtained from a closer observation of the structure of the persistent relationships identified in this sample. First of all, when we consider all scientists who had foreign organisations from their trajectory in the core network, we observe that in the majority of cases there is only one such organisation, even if the scientist had several long term stays in different organisations. Only 18 scientists have two different organisations and none has more than two. However, the trajectory organisation is frequently listed first in terms of importance (60% of cases).

Only a small group of scientists have simultaneously the organisation of the PhD and one organisation of the professional trajectory in the network (13 cases). Moreover, in half of these cases, we are effectively speaking of the same organisation, which means that these scientists returned to the PhD organisation for a long term stay - usually less than 3 years after the PhD, which points to a post-doctoral position – and that this organisation persisted as one of their key networks. In addition, it is interesting to notice that when the professional trajectory organisation was not the same of the PhD, they were usually in the same country, suggesting that the stay in the PhD organisation might have had some influence on the development of other relationships with a persistent character. Repeated long term stays in organisations of the professional trajectory included in the core network, were rare.

These results suggest that the impact of long term stays tends to be focused in one organisation, which remains an important knowledge relationship through time. They also suggest that for the majority of scientists the impact of PhD and post-PhD mobility might be different. This finding, associated with the limited overlap between PhD and professional long term mobility, confirms the need to address their effects separately.

4.3. Explaining differences in network persistence

In the previous section it was found that a substantial number of scientists who had long term international mobility also had at least one organisation from their mobility trajectory in the core network. However that was not always the case. Thus, as a final step in this research, we are interested in identifying the factors that explain these differences in network building behaviour among mobile scientists. That is, we are interested in understanding which factors are likely to increase the probability of network persistence.

4.3.1 Data and variables

For this purpose we have built two models: one for the persistence of the PhD organisation and one for the persistence of organisation(s) of the professional trajectory. In the first model we use as dependent variable a categorical variable that distinguishes between scientists who have the PhD organisations in the core network and those who have not. In the second model we use as dependent variable a categorical variable that distinguishes between scientists who have at least one of the organisations of the professional trajectory (where stays were longer than one year) in the core network and those who have not.

The independent variables in both models measure some factors that according to the literature can influence networking behaviour and/or knowledge production activities and thus are expected to have some impact on network persistence. These include: personal characteristics such as age and gender; career situation; scientific field; time passed since mobility; geographical location. In the case of the professional organisation we have also included measures of previous mobility and motivation to move. The variables used in both models are described in greater detail below.

Age allows accounting for the potentially different behaviour of younger and older scientists regarding mobility and networking (Musselin, 2004; Horta, 2009) but it also permits to consider different generations and thus different periods in the country scientific system and the changes that took place at that level regarding the motives to go abroad and the conditions in which mobility and return took place (Delicado, 2010; Fontes, 2007). Age was found to be highly correlated with time passed since the PhD (R=0.8). Therefore, age is included as independent variable in Model 2, while in Model 1 only the time variable is used.

Career situation and more specifically the degree of job stability, was expected to influencing the nature and strength of the relationships that scientists (with and without a stable job in the home country) establish with the organisations from their trajectory (Musselin, 2004; Armbruster, 2008). In Model 1 job stability is measured as being a grant-holder as compared with having some type of contract. In Model 2 it is measured as having a longer term contract (>3 years) as compared with having a short term contract or being a grant-holder[6].

The introduction of time is related with the idea that it may bring about the decay of links (Burt, 2000). Thus, the longer since mobility took place, the more likely the relationships established with scientists from the host organisation to have become non-existent or less relevant. In Model 1, we measure the passing of time as time since the date of completion of the PhD. In Model 2, since scientists may have several professional trajectory organisations we used time since last long term stay abroad as proxy.

The inclusion of geographical location is based on the assumption that periodic face to face contacts (even if short-term) may be important to nurture relationships and counteract decay of links (McEvily and Zaheer, 1999; Saxenian and Hsu, 2001), thus facilitating network persistence. In both models it is measured as location in Europe (as opposed to outside Europe) of the PhD organisation (model 1) and of professional trajectory organisation (model 2). This choice was based on the presumption that European level collaboration policies might have an added impact on networking strategies (Smeby and Trondal, 2005).

Differences between scientific fields in terms of mobility (Canibano et al., 2008) and in terms of the presence of collaborative networks and nature of the relationships established (Jöns, 2009; Wagner, 2005), have been described in the literature. Differences are particularly evident between exact and natural sciences (where collaborations tend to assume the form of co-publications and scientific consulting); and social sciences and humanities (where co-publications are less dominant). This suggests that networks in these areas are established according to different criteria and that networking activities follow different paths (Larivière et al., 2006). Thus scientific field is included in both models as being in the social sciences (as opposed to being in exact/natural sciences or engineering).

[6] The different measures reflect the differences in the populations at the time of the mobility event being analysed: post-PhD mobility is more likely to take place among scientists who already have some type of contractual position (even temporary), thus stability is more clearly expressed in terms of contract duration.

Gender differences in terms of mobility and networking behaviour have been mentioned in the literature (Ackers, 2004; Bozeman and Corley, 2004) and therefore this variable is also considered in both models.

Previous PhD mobility is included as independent variable in Model 2. Previous research has shown that early mobility initiatives increase the propensity to move again (King and Ruiz-Gellices, 2003; Melin, 2005). Thus scientists who had a first mobility experience during the PhD may be more likely to remain mobile and thus establish closer relationship with the host foreign organisation - which in the limit might be the same as the PhD's.

Finally the motives that led scientists to move can also influence their subsequent networking behaviour. In fact, it can be argued that scientists propensity to maintain a relationship with the foreign organisation where they stayed at some point in their career, may be related with the type of effect they were searching when they moved there for the first time.

Motivation to move is a multidimensional concept - which can encompass scientific, professional/career, economic and personal motives (Ackers, 2005; Auriol, 2007; Casey et al., 2001; Delicado, 2010) – that we tried to capture using Likert-type items and applying dimensional reduction techniques. Since 3-point items were used (not important at all; somewhat important; very important) which can hardly be seen as interval, we applied Categorical Principal Component Analysis (PCA) which can accommodate mixed type variables (Linting et al, 2007). Applying Categorical PCA conducted to the identification of three dimensions: move to access a better scientific environment, move to fulfil career or economic expectations and move for personal reasons. The first one is theoretically expected to have some explanatory power regarding presence of the previous host organization in the core network (see Appendix 1) and highly correlated with the following items: better conditions to conduct research; prestige of the host institution; access to international scientific networks; field of research absent or underdeveloped at home. The respective variable "Move in order to access a better scientific environment, compensating for scientific deficiencies in the home context" was included in Model 2.

Tables 6 and 7 summarise the variables used in each model.

Table 6 - Variables in Model 1: Foreign PhD organisation in core network

Dimension	Variable	Description	Type	Values
	Dependent			
Persistence	OrgPhD in Net5	Foreign PhD organisation in core network	Dummy	1 if organisation is in network; 0 otherwise
	Independent			
Time / Age	Time since PhD	Time since completion of PhD (in 2010) [Time correlated with Age: 0,792; s<0,001]	Continuous	Mean: 11.1 SD: 9.3 Min: 0 Max: 45
Gender	Gender	Gender is Female (vs. Male)	Dummy	1 if Female; 0 otherwise
Field	Social Sciences	Scientific field of PhD is Social Sciences (vs. Exact/ Natural & Engineering)	Dummy	1 if Social Sciences; 0 otherwise
Geography	PhD Europe	PhD in Europe (vs. other locations)	Dummy	1 if PhD in Europe; 0 otherwise
Career	Grant holder	Grant holder (vs. contract)	Dummy	1 if grant-holder; 0 otherwise

Table 7 - Variables in Model 2: Foreign professional trajectory organisation in core network

Dimension	Variable	Description	Type	Values
	Dependent			
Persistence	OrgProf in Net5	Foreign organisation from professional trajectory in core network	Dummy	1 if At least one organisation is in Net5; 0 otherwise
	Independent			
Age	Age	Age (in 2010)	Continuous	Mean: 41.5 SD: 9.4 Min: 28 Max: 71
Time	Time since last stay	Number of years since last abroad over 6 months (in 2010)	Continuous	Mean: 3.8 SD: 6.3 Min: 0 Max: 29
Gender	Gender	Gender Female (vs. Male)	Dummy	1 if Female; 0 otherwise
Field	Social Sciences	Scientific field of PhD Social Sciences (vs. (Exact & Engineering)	Dummy	1 if Social Sciences; 0 otherwise
Career	Longer term contract	Long term contract (vs. short contract or grant)	Dummy	1 if contract over 3 years; 0 otherwise
Geography	Location Europe	Location of trajectory organisation(s) in Europe (vs. other locations)	Dummy	1 if included / was exclusively in Europe; 0 otherwise
Previous mobility	PhD Mobility	PhD Abroad	Dummy	1 if PhD abroad; 0 otherwise
Motivations to move	Motivation to move	Motivations associated with access to a better scientific environment	Continuous	Mean: 0 SD: 0.93 Min: -2.9 Max: 1.3

4.3.2 Regression results

The two models were run using logistic regression, due to the dichotomous nature of the dependent variables[7]. Tables 8 and 9 show the regression results for each model and Table 10 summarises and compares these results. Both models were found to provide a good fit to the data (see Appendix 2).

In the case of Model 1, Table 8 shows that being a grant holder and having conducted the PhD in an organisation located in Europe increase the odds of having the foreign PhD organisation in the core network, while having conducted the PhD less recently and being female decrease these odds. The scientific field was not found to have explanatory power.

Table 8 - Regression results of Model 1
"Having the foreign PhD organisation in core network"

Independent variables	Exp(B)	Sig.
Time since PhD	**0.887**	**0.001**
Grant holder	**7.566**	**0.076**
Gender (Female)	**0.233**	**0.009**
PhD Europe	**3.038**	**0.062**
Social Sciences	0.663	0.445
Constant	3.797	0.061
Pseudo-R^2 Nagelkerke	0.428	
Valid N	91	
Omnibus Test of Model Coefficients	$\chi^2_{MODEL(5)} = 35.065$ *p<0.001*	

In the case of Model 2, Table 9 shows that having had professional mobility to organisations located in Europe and having as motivation to move the desire to gain access to a better scientific environment increase the odds of having a foreign organisation of professional trajectory in core network, while being in social sciences decrease these odds. In this case neither personal factors such as age and gender, nor the professional situation, nor time were found to have explanatory power.

[7] The presence of multicollinearity was checked for in two ways: i) by inspection of the correlation matrix and ii) running the corresponding multiple regression models and requesting the collinearity diagnostics. There was no evidence of strong linear relationships between independent variables, and the variance inflation factor (VIF) never exceeded 2, far below the recommended threshold of 10.

Table 9 - Regression results of Model 2
"Having a foreign organisation of professional trajectory in core network"

Independent variables	Exp(B)	Sig.
Social Sciences	**0.221**	**0.015**
Location Europe	**5.130**	**0.007**
Motivation to move	**1.756**	**0.096**
Gender: Female	2.311	0.184
Age	0.943	0.140
Longer term contract	1.657	0.444
Time since last stay	0.968	0.546
PhD Mobility	1.959	0.294
Constant	5.761	0.260
Pseudo-R^2 Nagelkerke	0.398	
Valid N	82	
Omnibus Test of Model Coefficients	$\chi^2_{MODEL(8)}$= 28.366 $p<0.001$	

Table 10 compares the factors that were found to increase or decrease the likelihood of having the two types of trajectory organisations in the core knowledge network. These factors can contribute to explain network persistence among mobile scientists.

Table 10 – Factors explaining network persistence:
Comparison between PhD and Professional organisations

Dimensions	PhD organisation more likely to be in core network	Professional organisation more likely to be in Net5
Age	Less time passed since PhD *Correlated with Age, thus pointing to:* Younger scientists	*No significant effect of* Age
Time/decay of links		*No significant effect of* Time since last long term stay
Career features	Grant-holder (vs. Contract)	*No significant effect of* Contract over 3 years (vs. grant-holder or short contract)
Gender	Among men	No significant effect of Gender
Geography	Location of PhD organisation is in Europe	Stays include or are exclusively in organisation located in Europe
Scientific Field	*No significant effect* of Field being Social Sciences	Exact sciences or Engineering (vs. Social sciences)
Motivations to move		Motivations to move associated with scientific environment
Other mobility		No significant effect of Previous PhD mobility

Age and time effects are only present for the PhD. Scientists who did the PhD more recently – who are also the younger ones – are more likely have the PhD organisation in the core

network. This may reflect behavioural differences between generations, with younger generations building more decisively international networks from the PhD stage. It can also reflect the decay of links over time. However, a decay effect was not found for the professional organisation, which may be related with the variable used, which is likely to be a weak proxy. This calls for more qualitative data about subsequent contacts with trajectory organisations and consideration of short term stays (Ackers, 2008).

The result obtained for the career variable - which is only significant for the PhD case – corroborates the age/time effect. Scientists who are grant-holders are more likely to have the PhD organisation in the core network. This suggests that scientists with less stable positions tend to profit more from the relationships established to strengthen their international networks, which may be critical for their career development (Musselin, 2004). However, career situation lacks explanatory power for the professional organisations, suggesting differences in the nature of the links established with PhD and with professional organisations during the mobility period.

Gender effects are only present in the case of the PhD organisation: being a man increases the odds of having this organisation in the core network. Conversely, the type of scientific field only has a significant impact on the case of the professional organisation. In this case, scientists in exact/natural sciences and engineering are more likely than social scientists to have the trajectory organisation in the network. The fact that scientific field has no impact on the persistence of relationships established during the PhD – a period when the main objective of mobility is to acquire knowledge/competences - but has impact on the persistence of those established during post-PhD mobility – whose objectives may be more focused - suggests again that the nature of the links established during these moves may be different. Indeed, the fact that persistence of the PhD organisation is transversal to all fields suggests that the links established during the PhD have a broader nature.

The only dimension transversal to both types of mobility is geography. Network persistence is always more likely when mobility took place to European organisations, confirming the idea that greater geographical proximity and the opportunities it provides for periodical face to face contacts (even short-time) can counteract the decay of links. This result may also be influenced by European programmes, which offer opportunities for reinforcing existing connections (Hoekman et al., 2010).

Finally, scientists whose motives to engage on professional mobility were associated with the search for a good scientific environment – more specifically a prestigious organisation where they could find better research conditions, including integration in knowledge networks - were more likely to have at least one of the foreign organisations in the network, thus attempting to continue benefiting from these effects after their return.

It can be concluded that while co-location in a given organisation provides the opportunity for establishing close relationships between scientists, these are not automatically turned into knowledge networks that persist through space and time and assume an important role in the scientists' subsequent activity. The development of these persistent networks appears to be more likely in some conditions and for certain types of scientists as shown above. The effects of mobility also differ according to the period in which it takes place, with PhD mobility emerging as different from mobility that occurs later in the scientist's career.

5. Conclusions

This research addressed the impact of long term international mobility on knowledge network building and network persistence. Starting from the expectation of network building - and therefore of an increase in knowledge exchanges between scientists – often associated with scientific mobility policies, our objective was to try to understand the rationale behind this connection and to assess whether and in which conditions it effectively took place.

This paper proposes a new conceptual framework, combining contributions from the literature on proximity, knowledge transmission and network building, with recent research on mobility and knowledge circulation, in order to explain the potential relevance of long-term mobility for knowledge network building. According to this framework, mobility provides opportunities for temporary physical proximity between scientists, thus creating conditions for the development of other types of proximity - social, cognitive, organisational - that are critical for knowledge transmission. Links characterised by these types of proximity can persist after the individuals move apart and thus can be subsequently mobilised for knowledge exchange purposes, becoming part of the scientist's knowledge network.

Exploratory research on the case of Portuguese scientists was conducted in order to empirically investigate whether international mobility and the opportunity for co-location in a

foreign organisation during extended periods of time - the PhD and post-PhD stays over one year - effectively produces these effects, increasing the scientists' capacity to develop relevant knowledge networks, upon their return.

The research was based on a questionnaire survey that targeted scientists (mobile and non-mobile) from research centres in three main fields: health sciences, information technologies and sociology. The empirical analysis revealed a highly internationalised group, but concluded that international networks were relatively more frequent in the case of mobile scientists. More importantly, it found a high incidence of foreign organisations that had been part of the mobile scientists' PhD and post-PhD professional trajectory in their core knowledge networks. This denotes the *persistence and relevance* of the links established, thus providing some confirmation of the influence of previous co-location on the composition of scientists' knowledge networks.

From a policy standpoint, these results, although still exploratory, confirm, to some extent, the "network expectation" frequently associated with mobility. The fact that mobile scientists are more likely to build international knowledge networks and the fact that these networks frequently involve at least one of the organisations from their mobility trajectory appear to provide some support to the idea that policies promoting mobility can have a positive impact on the knowledge networking behaviour of those scientists who decide to return (even if that return is not guaranteed (Fontes, 2007; Gill, 2005)). However, an excessive reliance on the effects of mobility – and therefore of mobility oriented policies - should be moderated by the following considerations.

First, while long-term mobility effectively appears to favour the establishment of persistent knowledge networks with trajectory organisations, these effects are not always present. Thus, it is important to understand the factors that are likely to influence the persistence of the relationships established by scientists during international mobility. This research offered some insights into the factors at work in the case of PhD and post-PhD professional mobility, also finding that there were substantial differences between these two types of mobility. Thus, age, time and career effects influenced persistence of PhD organisations, whereas scientific field and type of motivation to move influenced persistence of the professional organisation. The results suggest both differences between generations and differences in the nature and scope of the knowledge relationships established during the PhD as compared

with subsequent ones. The only transversal factor was geographical proximity (i.e. location in Europe vs. location outside Europe) suggesting that greater opportunities to face to face contacts may be important in sustaining relationships, while European-level cooperation policies eventually facilitate the continuity and/or strengthening of those links.

Second, an appreciation of the core knowledge networks of the whole sample shows that international networking appears to be a rather widespread phenomenon, even in the absence of long term mobility. Thus, while mobility is undoubtedly an important mechanism behind network building, other mechanisms are at work. An investigation of these mechanisms is beyond the scope of this paper, but other research suggests that some types of shorter-term mobility (Canibano, 2008) and integration in the networks of more internationalised scientists may be among them (Araújo, 2007). Regarding the latter, Araujo (2007) found that the younger generation of Portuguese scientists often benefitted from the networks built by senior scientists, who went abroad in earlier periods and, upon their return, contributed to develop and internationalise their field. Although more qualitative research is necessary to understand whether the nature of the networks resulting from these different types of interactions is effectively similar, this suggests that the routes to international knowledge networking expand as the scientific system matures and that policies need to adjust to the new conditions.

Overall, the results of this research add to our understanding of the mechanisms that are behind the association between scientific mobility and network formation. The understanding of the conditions in which mobility is more likely to lead to network building and the differences found in terms of the effects of PhD and professional mobility are also relevant from a policy standpoint. In fact, they invite some reflection on the implications of this diversity for the design of policies, namely pointing to the possibility of differentiating mobility-oriented policies according to target groups. These results will subsequently be explored in more depth, through on-going qualitative research, based on interviews and also by integrating in the analysis information about shorter-term mobility events.

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Appendix 1 - Categorical Principal Components Analysis

Motivation to move in the case of post-PhD mobility was addressed using 10 Likert-type items, which intended to capture the relevance of three types of variables: a) scientific conditions: prestige of the host institution; conditions to conduct research; possibility to work in a field underdeveloped or absent in the home country; access to international scientific networks; b) career/economic expectations: job stability; financial conditions; opportunities for career progression; c) personal motives: personal fulfilment as a scientist; dissatisfaction with home country; previous relationships with scientists from the host institution.

Each item was valued on a three-point scale (not important at all; somewhat important; very important). Consequently, ordinary Principal Components Analysis (PCA) should not be applied. Instead, we used Categorical PCA (CATPCA, Meulman et al., 2004; Linting et al., 2007), which relies on an alternating least squares scheme (Tenenhaus and Young, 1985). In Categorical PCA both a quantification of the original variables and a decomposition of the multidimensional space are achieved. In this context, quantification is a transformation of the original values that simultaneously satisfy the measurement level of each variable (ordinal, for the case being) and best represent the relationship between variables given the current space decomposition. CATPCA was thus conducted on these 10 items and a three-dimensional structure was requested. The resulting loading matrix was rotated (VARIMAX rotation) in order to simplify interpretation (Table 11). A global fit measure of the solution retained, as calculated in Meulman et al. (2004), is 0.918 (maximum is 1).

Table 11 – Motivations to move: Rotated loadings matrix

		Dimension (a)		
		1	2	3
Move to access a better scientific environment, compensating for home context deficiencies	Better conditions to conduct research	0.767		
	Prestige of the host institution	0.717		
	Access to international scientific networks	0.677		
	Field of research absent or underdeveloped at home	0.598		
Move in order to achieve a better professional status	Better financial conditions		0.787	
	Stable job		0.785	
	Expectations in terms of career progression		0.594	
Move for personal motives	Personal fulfilment as a scientist			0.763
	Dissatisfaction with home country context			0.791
	Previous relationships with host institution scientists			0.535

(a) Loadings below 0.3 were omitted

Having in mind the objective of this analysis, we considered that the first rotated dimension that we labelled “Move in order to access a better scientific environment, compensating for scientific deficiencies in the home context” was likely to have some explanatory power regarding presence of the previous host organization in the core network. Thus this dimension was included in Model 2.

Appendix 2 – Logistic regression: model fit

Both models provide a good fit to the data. Firstly, the chi-squared goodness-of-fit test for the change in the –2Loglikelihood value - which tests the null hypothesis that all logistic regression coefficients, except the constant, are zero - revealed to be statistically significant. This provides support for acceptance of the models as significant logistic regressions. Secondly, the overall rate of correct classification is very satisfactory: around 78% for both models. Moreover, observed sensitivity (i.e. percentage of correctly classified cases within scientists who do have i) Model 1: the PhD organization in NET5; ii) Model 2: at least one foreign professional organization in NET5) is high (around 90%, for Model 1 and around 86% for Model 2). Thirdly, the Hosmer-Lemeshow goodness of fit statistic) was requested and its significance was found to be relatively large, as desirable (Hosmer and Lemeshow 2000): Model 1: $\chi^2_{(8)} = 3.8$, sig = 0.877; Model 2: $\chi^2_{(8)} = 12.7$, sig = 0.124