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Scientific Migration and National Innovation System: First Steps to Converge the Fields

Maria Karaulova

PhD Candidate,
Manchester Institute of Innovation Research,
University of Manchester

C/ Albasanz 26-28, 3D
28037 Madrid. SPAIN
http://www.ipp.csic.es

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Maria Karaulova[a]

[a]PhD Candidate, Manchester Institute of Innovation Research, University of Manchester

Introduction

Devising policy mix for migration is a challenge many countries have to face in the contemporary world. Especially with the migration of scientists and highly skilled persons, the knowledge about mobility patterns is crucial for policy. (MORE report 2010; Jones 2012) This proves to be methodologically difficult do explore, and theoretical problems exist as well. The problem is discussed in several domains of knowledge by several disciplines, the debate not intersecting. Thus there are cases when prominent scientists who contribute to the development of science and technology systems of their receiving countries greatly, creating jobs and facilitating commercialisation[1], have to face problems moving to and settling in various receiving countries.

The disparities in debates occur in migration studies that focus centrally on individual mobility and the migration flows, and in innovation studies, where the mobility is acknowledged, but is generally viewed as only one of many system factors in innovation processes. This divide creates loopholes in theory and research, as well as in policy, in relation to scientific practice and scientific employment. The current paper attempts to make first steps in bridging gaps in terminologies and methodologies of migration studies and innovation studies.

This paper introduces the two fields of knowledge, and examines how they can be brought together, what methodological difficulties appear, and how the factor of scientific mobility can be incorporated into the system of innovation model, followed up by some implications for further research.

[1] Such is the story of founding National Graphene Institute in Manchester: http://www.bbc.co.uk/news/uk-england-manchester-21015371

Definitions and where innovation studies come to help migration studies.

In this paper migration is used interchangeably with mobility and, following Moed et al (2013) is used as a neutral term, indicating the event of a researcher moving from one country to another. (p.931) There is a large set of literature dealing with mobility and migration of scientists and other skilled persons, varying from enclave and diasporas studies to cosmopolitanism. Migration may be temporary or permanent, as well as with the embodied knowledge transfer: sectoral, cross-regional, or cross-national. A classic way to investigate scientific mobility patterns is the centre-periphery model and the 'brain drain' (in recent version – brain circulation – see Saxenian [2001]) model. These vary in complexity, from simple descriptions of flows from developing to developed countries (Gaillard and Gaillard 2003) to more sophisticated multi-layered hierarchical system analyses with different centres attracting different types of highly skilled migrants. For example, students from former colonies arrive to study in France and then settle there, whereas the increasing numbers of the highly skilled French leave to seek opportunities in the United States (see Meyer et al. 2001). Many of such studies usually do not consider secondary or tertiary movements of the highly skilled persons, and group the countries that are put on the same level in the hierarchy without considering national specificities. Another route that can be taken by someone who wants to explore scientific mobility is a bibliometric study method. It allows tracing patterns of publication activities and movements of scientists from and to various countries. (Moed et al. 2013; Basu 2013) These suggest the division of scientific mobility into several types, each of which is covered to a different extent in existing national innovation system models.

Table 1. Four types of scientific migration studies.

Level	Aspect	Example
Country	Mobility	Researchers migrating from one country to another
Economic Sector	S&T Interface	Researchers moving from academics to industry
Subject field	Multi-disciplinarity	Authors moving from one subject field to another
Group, institution	School formation	Where did the PhD students of prof. X go to?

Table 1 presents the classification of types of scientific migration, as proposed by Aisati et al (2012). Among the four types of migration, one – economic sector – is well-studied in

innovation studies. This type of scientific mobility is examined as a direct embodied knowledge transfer (Zellner 2003), scientific entrepreneurship (Saxenian 2006; Muller and Sternberg 2010), university spillovers (Powers and McDougall 2005), formation of entrepreneurial universities (Guerrero and Urbano 2009) and innovation hubs (Youtie and Shapira 2008), and other various knowledge transfer processes that examine processes of commercialisation that follows scientific discovery.

In this paper I claim that innovation studies can contribute to another type of scientific migration studies, which is the mobility on the country level. Classic definition of innovations is that they are "new and improved products and processes, new organisational forms, the application of existing technology to new fields, the discovery of new resources, and the opening of new markets". (Niosi et al. 1993) The vast majority of innovation studies now examine these phenomena as elements of the system. This usually requires artificially induced 'closure' of the system in order reach the necessary level of isolation that the model demands. The degree of such closure varies as well. A suitable definition for the purposes of this paper is provided by J.S.Metcalfe (1995): "A national system of innovation is that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provide the framework within which governments form and implement policies to influence the innovation process." (p.38) This definition is loose enough to allow to include various institutions into the process of innovation, and all steps of knowledge lifecycle, from creation to transfer and implementation. It allows to incorporate science and technology system (and associated mobility patterns), but still adheres to classic perspectives on innovation process.

It may seem quite difficult to involve innovation systems as a theory that may help to explain the migratory processes. Some of studies of this sort, for example, do not take any external factors into account (Lundvall 2002**;** Edquist 2010), and others only consider a limited number, usually in connection with globalisation processes (Smits et al., 2010; Shapira et al, 2011). Migration and mobility is usually not included, and if it is, is understood in quite simplistic 'attracting the talent' ways. (Boschma 2005 is a good regional system of innovation example) However, the systems approach, whereas having limited capability of tracking individual movement and processes of change, has the explaining potential that the migration studies lack. It is majorly due to national policy, national (or regional) environment, and other factors of national character that prompt scientists and highly skilled

migrants to stay, or to move on. Therefore, converging the national innovation system approach with some of the migration approaches opens the way to mutually enrich both fields and attain new conceptualisations of scientific mobility.

Converging the Fields

Several classical studies that discuss national innovation system approach admit that there are particular problems with situating international links and flows within it. Scientific mobility directly contributes to scientific knowledge production, which, in its turn, is an important source of innovation. Mobility flows can be incorporated into the national system of innovation approach by invoking arguments of knowledge transfer and extrapolating it to the inter-systems relations, not to in-system science and technology and commercialisation sector. Also, mobility can be incorporated into the NIS in the capacity building section, and skills training one as well. It remains to be tested whether high levels of scientific mobility and immigration flows have positive effect on national innovation systems. As noted by Metcalfe (1995), national innovation systems (surely, just like national science and technology systems) become stable due to 'elements of shared language and culture which bind the system together' (p.38)

There are studies that combine innovation systems approach with network analysis and other similar methodologies. It is admitted even in the very evolutionary economy inspired studies that network, learning and sharing of knowledge play a big role in the innovation process. (Lundvall 2007) Networks bring various institutions and organisations together in the system, and facilitate knowledge sharing and production. Network analysis is widely applied in migration studies, It may probably be placed on the same level as notions of community, identity and diasporas. This might become another point of convergence, as migration studies literature often applies network analysis, identifies 'strong' and 'weak' ties (Granovetter 1985). Scientific mobility, its patterns and structure can be regarded as an important part of an institutional infrastructure of a national innovation system. Carlsson and Stankiewicz (1991) note that institutional infrastructure has an important function to "support, stimulate and regulate the process of innovation and diffusion of technology". Targeting scientific mobility as a network-organised infrastructural movements from one location (national, regional innovation system) to other locations while maintaining (or nor) professional and

personal links, and implications for science and technology systems knowledge production, sharing and diffusion, may be put in the spotlight by converging the disciplines in this way.

The role of the state is perceived as very important in both innovation studies and migration studies approaches. Theories that admit the importance of regulation and policy have potential for hosting debates featuring both perspectives. Therefore, the two approaches can be converged by including policy analysis and invoking the importance of state regulation of scientific mobility and innovative activities. At the moment there are certain discrepancies in where the two disciplines place their policy arguments. Innovation studies mainly look at efforts of national policy to attract R&D-intensive companies and tend to neglect individual movements, which become a prerogative of migration studies policy advice. Scientists and highly skilled migrants here become one of the immigrating groups of persons, along with low-skilled migrants, refugees and other persons. Policy mix in most countries is diversified and is designed to attract more highly demanded groups of potential migrants and create barriers to the others, but there is a certain bias in such a distribution of policy analysis. Migration of scientists and other mobile persons is an important factor on the labour market that affects national innovation system functioning, but labour markets, just as other markets, are becoming increasingly globalised. Yet there is currently no clear view of which parts of labour legislation fit with what parts of innovation policies. (Jones 2012) Therefore, innovation studies scholars should get involved into debate about international scientific mobility and its impacts on innovation systems, engaging into debates with migration studies scholars.

Difficulties with converging

There are several methodological problems that may occur when bringing migration studies and innovation studies together. Science and scientific knowledge production (which are main implications for scientific mobility) occupy only marginal place in innovation studies, even when in the models that expand to include the variety of actors and institutions into the innovation process, for a number of reasons.

First, it might be suggested that mobility and migration do not constitute significant part of innovation studies, because the majority of studies in the field concentrate on the firm as a unit of analysis, and on a resource-based view on the firm. Firms, although experiencing

workforce turnover that includes migrants and ex-academics, rarely move to another countries or even another region within the country. The process here is the location of commercial activities abroad, whereas the office usually stays in the place where it was founded. Therefore, innovation studies, although they now include multiple actors into the innovation process, rarely study mobility of systemic elements. One possible exception of this is the 'innovation journeys' approach which focuses on the mobility of the technology and explores how innovation takes place in different countries with better receptive capacities. (Rip 2012)

The second problem stems from the origins of the innovation studies. Dating as back as to the works of J. Shumpeter (1942) who was aiming to conceptualise economic growth in a way that would include knowledge, technology and creativity, innovation studies stem from economic theory, and new theoretical concepts have long been conceptualised in terms of economic theory. Early publications on the national innovation system (Lundvall 1992) are also written in a narrative of institutional economics. First conceptualisations of the national innovation system, therefore, are unlikely to include societal processes and flows, such as mobility. Such steps have been made since the first publications on national innovation systems, mainly for the purposes of policy analysis and policy advice (see, for example, Edquist [2010] who makes suggestion about 'activities' in systems of innovation; also Chaminade and Edquist 2010; Bergek et al. 2010), but the model still stays quite robust to such amendments, most of which are not successful.

Third, it is problematic to track changes in the NIS approach in general. The approach aims for the closure of the system in order to examine a limited number of the systemic elements outlined beforehand. It is a very rigid and structured neo-positivist approach (Smits et al 2010), and processes occurring 'outside' the system are incorporated into it by being reduced to a limited number of parameters. The demand for this appeared with the rise of globalisation studies, and globalisation factor and influence on innovation system is in most cases described from the firm-based point of view, as international exploitation of nationally produced innovations, global generation of innovations, and global techno-scientific cooperation. (Smith 2010: 78). Scientific migration can be conceptualised as an external 'function' of the system, though, in case there is a need. K. Smith (2010) lists it as one of the indicators on globalisation (p.77), noting that it is highly relevant for national innovation systems, but cannot really be addressed because of the poor availability of the data.

In cases where it is required transnationalism, a subdiscipline of migration studies, can be brought into methodological framework. Transnationalism concerns itself with issues transcending national borders that can be of economic, political, or socio-cultural character and looks at established processes and patterns that significantly large groups of people express. (Portes et al. 2011) The emergent subfield of transnationalism provides many opportunities for investigation of processes occurring worldwide, but not in terms of highly abstract macro-indicators of globalisation process, but in terms of individuals and organisations. This approach is helpful in conceptualising migratory and other flows and exchanges between national innovation systems.

Finally, there is a discrepancy in the general level of analysis in innovation studies and migration studies. Institutional economics that underlies innovation system approach, and evolutionary economics that is currently widely used to complement it (Boschma 1999; Carlsson and Stankiewicz 1991) do not bed well with main approaches. Classic approaches to the former ones indeed used to mainly deal with migration flows and articulation between places of origin and places of migration. More recent studies, though, consider multi-cited approaches and temporary migration, as well as less isolated studies, promoting 'thick descriptions' and converging with anthropology in the method of participant observation. (Bretell 2000) There are ways to overcome this difficulty as well. For example, Anna Tsing's (2000) insight into globalisation theory provides the reader with toolkit to overcome traditional dichotomies between local, regional and global by invoking the argument of interconnectedness of globalisation processes. It is therefore possible to make the transition from the systemic to the level of the individual. Tsing also sees globalisation as a set of projects: "how particular projects become formulated, how they are tied and transformed in the process, and how they sometimes interrupt each other despite themselves". (Tsing, 2000: 334), which is helpful for integrating into the established modelling of functions of a national innovation system and expanding the established narrow view.

Integrating mobility factor into the NIS: first steps

National system of innovation model has many flaws, as has been noted, and is now rarely used on its own. Researchers tend to combine it with other theories and approaches to cover issues that the NIS approach would have failed to address on its own. Migration studies and

the focus on migration may be used in this relation as well, and the systemic approach of the NIS may address issues that migration studies rarely cover.

I suggest that the mobility factors for a national innovation system can be divided into two broad groups: the 'pull' factors and the 'hold' factors. The first group of factors indicates the level of attractiveness of innovation system to potential migrants. The second group helps to explicate the ability of the innovation system to retain the migrants within its borders. Most studies and policy analyses focus on the ways to attract scientists, engineers, and other highly skilled persons to the country (and situate them in a national innovation system), and often miss out the second group of factors. Scientists are 'modern nomads' and they are inherently mobile (Meyer et al 2001; Gaillard and Gaillard 2003), so there is no guarantee that once they move from their original country to another one, they'd stop and settle. Migratory processes may go on, and it is the internal 'hold' factors of the innovation system that determine the outcome. Some studies just indicate that there are inward and outward migration processes, without analysing why it is happening and what can be done. (Meyer et al. 2001; Moed et al. 2013)

'Pull' factors of a country may include the following:

- Immigration policy should perhaps be listed in the first place in this case. For instance, after George Bush signed the Soviet Scientists Immigration Act into law in 1992, it allowed scientists from the former Soviet Union to immigrate into the US without an offer for employment (Hart 1993 in Gurcak et al. 2001), and entailed a big wave of immigration of highly skilled labour force from Russia. This indicator is a pretty straightforward one.
- Research opportunities, such as availability of funding, grant systems, equipment and availability of resources is a crucial factor that determines the decision to leave. These indicators can be found in the world university rankings, such as the *Times Higher Education Supplement (THES)* World University Rankings and the Shanghai Jiao Tong Academic Ranking of World Universities. (Taylor and Braddock 2007) Public research organisations networks and the degree of inclusion of such organisation into global professional communities should be taken into an account as well. Of course, the level of available opportunities varies greatly according to the institution, but there is an overall level of national university excellence.

- Research Clusters and Community. Some migration studies suggest that firms tend to cluster in certain localities, often due to favourable conditions of some sort, and then because of the easiness to communicate and operate. (Cohen and Zysman 1987) These theories were further developed into the importance of sectoral clusters and conductive factors that then continue to attract new companies, such as centralisation of company headquarters in global cities (Sassen 2002). Florida (2003) makes one more step further and makes a suggestion about a capacity of cities and regional centres to attract talent (which he names a 'creative class'). It can be inferred that scientists also may make location decisions based on the extent of current concentrations in agglomerations or clusters.
- Reputation. Whitley (2000) describes public research systems as reputational organisations. Price (1980), Mabe and Amin (2002) and Persson et al. (2004) methodologically conceptualise an 'active researcher' as a researcher who published at least one paper in a year. Publishing is a key activity for an active scientist, and, according to Whitley, large amounts of publishing in high-impact journals create high reputations for persons and institutions they are doing research in, attracting funds and graduate students. I might add that other researchers might want to move to such institutions as well. The 'Ivy League' is a good example here. There is a practice of setting up new faculties and whole institutions around 'star scientists' as well. (Heinze et al. 2007)

'Hold factors' may include the following:

- Favourable Environment that includes not only very context specific issues such as immediate environment, but also career promotion availability and the number of foreign-born persons on managerial and senior positions, the level of national heterogeneity of the research collective, the degree of freedom in doing research against high level of subordination and others. All listed factors will need to be tested in due course of the study.
- Official languages spoken in the country. Moed (2013) ascertained that for both short-term and long-term scientific migration languages spoken in a country play significant role. Aisati et al. (2012) notes than the language factor matters more in scientific mobility than in collaboration.
- General policy for settling down matters as much as immigration policy. Cornelius and Espenshade (2001) provide a comparison between USA and Germany in this

> respect. The scholars note that immigrant scientists and engineers often move from one country to another with plans to settle down in mind, and often bring families with them. In the USA the H-1B visas (for temporary, highly-skilled workers) allow to apply for residency after several years, whereas German 'green card' holders are limited to a five-year stay and have no right to petition for permanent residency, notwithstanding other disincentives, such as high income taxes. All these discourage immigrating scientists from settling in the country. (pp. 11-12)

The above listed is a short and preliminary list of 'pull' and 'hold' factors, the validity of some of which can only be tested empirically. There are some theoretical tensions with devising these arguments regarding the national level of discussion as well. Both migration studies and innovation studies have variations where regional dimensions are explored, and many of those may vary from region to region of the same countries. Some of the factors listed above may vary if the scale of analysis is changed, sometimes to the point of each separate organisation. Further developments of the argument will have to be made in order to escape accusations of methodological nationalism (Glick Schiller 2010). Perhaps, practical investigation in further research may bring possible insights to solve the problem.

Further Research

The above described propositions will be tested on the sample of Russian scientific migrants that is yet to be identified by the means of bibliometric analysis. There have been multiple studies of scientific mobility and mobility of the highly skilled persons. Among developing countries the most well-studied are China (Muller and Sternberg, 2010; Tang and Shapira, 2011) and India (Khadria 1999; Basu 2009). There also are studies on the nature and structure of immigration into receiving countries, usually with contributions to debates about policy (Cornelius and Espenshade 2001; Gurcak et al. 2001). Due to various reasons Russians have been largely left out from such studies.

Russian scientific migration is very specific. I hypothesise that because mass migratory movements of Russians don't have big legacy (they only became possible right before and after the breakup of the Soviet Union), and because second-generation scientific population of Russian origin is virtually nonexistent, it is possible to identify and locate a sample of Russian scientists who are employed in public research organisations (universities and public

labs) and are doing research in nanotechnology. These people, provided that they left the country in the early years of the independence of the new Russia, in one of the early 'waves' of emigration (Graham and Dezhina, 2008), would have common background of professional practices, shared symbolic systems, memory patterns, learning experiences, tacit knowledge, and other cognitive path-dependencies. (Bower and Hilgard 1981; Anderson, Farrell and Sauers 1984; Zenger and Lawrence 1989)

Additionally, I will be focusing on the professional field of nanoscience. It is partly accounted for due to dynamics of the discipline. The speed of publishing articles in various disciplines varies as well. Aisati et al. (2012) mention the research field bias: "while in some fields active researchers do tend to publish at least one paper per year, in other fields they publish less." (p.44) The bias with sampling study objects can be avoided is I concentrate on one discipline. Additionally, nanotechnology provides a case of a still-emerging multidisciplinary field that converges research from several established disciplines, such as chemistry, physics, medicine. (Roco and Bainbridge 2002) Soviet and Russian fundamental science has been traditionally strong in quite a few of these disciplines (Klochikhin 2012), and research in nanotechnology (semiconductors, for example) has been carried out in Russia for an extended period of time without being named so. Therefore, focusing on nanotechnology will allow to capture bigger sample of Russian scientists outside Russia without getting the disciplinary bias.

Published bibliometric studies on Russian nanoscience developments mainly focus on the in-country publication development and only pay attention to the Russian-origin scientists abroad in case they collaborate with their colleagues from Russia. It is not definite, on the other hand, that scientists that leave the country maintain their professional network over years. Further research design involves a mixed methods approach and will be structured in three stages. After the pilot project data selection and bibliometric analysis will result in mapping Russian Nanoscience Diasporas abroad. Then a questionnaire will be designed to answer the research questions and will then be sent to the scientists sampled on the previous stage. Finally, several cases will be selected on the base of the questionnaire results and semi-structured in-depth Interviews will be conducted. The target locations for cases remain to be determined, but, following secondary studies (Terekhov 2012), may include public research organisations in the UK, Germany, The US, Netherlands, and possibly some other countries.

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