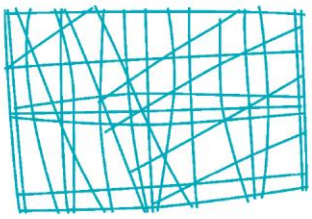

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SCHOLARLY COLLABORATION IN REGIONAL SCIENCE IN DEVELOPING COUNTRIES: THE CASE OF THE BRAZILIAN REAL NETWORK

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Scholarly Collaboration in Regional Science in Developing Countries: The Case of the Brazilian REAL Network[1]

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Abstract. The Regional Economics Applications Laboratory (REAL) celebrated its 25th anniversary in 2014. That was 25 years to the day since Philip Israilevich and Geoffrey JD Hewings started a cooperative venture between the Federal Reserve Bank at Chicago and the University of Illinois at Urbana-Champaign (UIUC). Since then, REAL has become one of the leading research centers of regional science worldwide. In this paper, we describe the scholarly network involving REAL's alumni working in academia in Brazil. We analyze the patterns of research collaboration among around 50 Brazilian researchers whose main activities are related to academic institutions in Brazil. The Brazilian REAL Network has shown to be an interesting case study that reflects the pattern of evolving collaboration networks in scientifically emerging economies. The expansion of the REAL scientific collaboration network in Brazil arises as a relevant mechanism for both the qualitative leap of national scientific production in regional science and for the dissemination of knowledge in peripheral regions of the country. Conducted under the leadership of Geoffrey JD Hewings, it has helped to further develop regional science in the country. We also present some of the developments in areas of research in regional science of particular interest to Brazil and other developing countries, taking stock of some of the network's contributions to the field.

1. Introduction

Regional science has developed and flourished in the developed world. However, as recognized by Chatterji (2014), it has much more potential applications to developing countries since those countries have stronger socioeconomic spatial diversity. Despite important developments of the field in countries such as Brazil, India, Indonesia, and, lately, China, its main journals have always been dominated by authors and themes from developed countries (Rey and Anselin, 2000; Suriñach *et al*., 2003; Royuela *et al*., 2006, 2008). More recently, nonetheless, institutional efforts are being directed to strengthen the presence of the field in the developing world (Pyke et al., 2007; Capello, 2013). Recognition of a broader international standing of regional science is especially important for its future development.

[1] The first version of this paper was presented at the Regional Economics Applications Laboratory 25th Anniversary Workshop, November 12, 2014, Washington D.C., USA. It has benefited from comments and suggestions from various participants of the meeting, to whom we are indebted. We are also grateful to Carlos R. Azzoni, Geoffrey JD Hewings, Alan Murray and Tomaz Ponce Dentinho for their suggestions on a previous version of the paper.

A great deal of attention has always been directed in this journal (Isserman, 1995, Rey and Anselin, 2000; Donaghy, 2014; Markusen, 2015) and in other scholarly journals of the field (Pyke et al., 2007) to reflections on the establishment, evolution and progress of regional science. More and more attention has been also directed lately to the identification of patterns of publication in the field (Rey and Anselin, 2000; Suriñach *et al*., 2003; Royuela *et al*., 2006, 2008). However, very little empirical evidence has been collected to inform the scientific community about successful experiences in broadening the presence of regional science in the developing world.[2] In this paper, we focus on the Brazilian case, describing recent developments of regional science in the country through the establishment of a network of scholars closely related to the Regional Economics Applications Laboratory (REAL), at the University of Illinois at Urbana-Champaign (UIUC). We claim that the growing presence of the discipline in Brazil, measured by the number of scientific publications by Brazilian scholars, is heavily influenced by proximity mechanisms embedded in the network.

From a broader perspective, the rapid growth of the world's scientific production is intimately associated with increased collaborative interaction among researchers, *i.e.*, the typical organizational unity of science changed from single individuals for the establishment of research groups in all areas of knowledge. Understanding and identifying operating patterns of scientific networks become increasingly important for the formulation of science and technology (S&T) policies. One of the biggest challenges faced by S&T policymakers in Brazil is the diffusion of scientific excellence from research centers in the Southeast to research centers in other less privileged regions (Cruz and Chaimovich, 2010). This challenge could be addressed more properly and efficiently by evaluating the perceptions that are inextricably linked to the establishment and operation of scientific collaboration in Brazil. Research collaboration is one of the main mechanisms for the dissemination of knowledge and is closely associated with a higher quality of scientific production.

The importance of geography in knowledge production, primarily its role in mediating interactions among Brazilian researchers in scientific collaborations, has been explored

[2] Chatterji (2014) reports on some of the experiences related to India he has shared with Walter Isard during the early days of regional science.

in Sidone *et al*. (2014). The authors provide evidence that geographic proximity plays an important role in determining inter-regional collaboration. While geographic proximity facilitates face-to-face interactions that enhance collaboration, other forms of proximity are also important.[3] For instance, while cognitive proximity is reflected in a shared knowledge base that is fundamental for interactive learning, organizational proximity helps fostering knowledge creation through organizational arrangements that reduce transaction costs. Institutional proximity allows actors of a network to share the same institutional framework, both formal (laws and rules) or informal (values, norms and cultural habits), potentially fostering collaboration. Social proximity, in turn, can be defined by the intensity in which two researchers have friendly relations with each other. The intensification of friendly relations can facilitate interaction by creating trust between researchers, which is essential in the continuity of complex research projects (Frenken *et al.* 2009). We show in this paper that the recent development of the field of regional science in Brazil has benefitted, to different degrees, from these different forms of proximity. We illustrate how these different facets of proximity successfully operated in the process of building a network of regional scientists in a developing country.

We use as our case study the transnational experience related to the Regional Economics Applications Laboratory (REAL), that celebrated in 2014 its 25th anniversary. That was 25 years to the day since Philip Israilevich and Geoffrey JD Hewings started a cooperative venture between the Federal Reserve Bank at Chicago and the University of Illinois at Urbana-Champaign (UIUC). Since then, REAL has become one of the leading research centers of regional science worldwide.[4]

REAL was created to operate as a science laboratory – with students and faculty together in one space, promoting interaction and collaboration on regional science research. This format has been very successful in terms of its intended outcome: to create a global network of researchers that generates high standard scholarly collaboration and social interactions. Throughout the five lustra of its existence, REAL has received over 500 scholars from more than 40 different countries.

[3] The usual definitions of the dimensions of proximity are presented by Boschma (2005).
[4] REAL-UIUC is listed as one of the *Main Regional Science Schools* at http://www.regionalscience.org.

> "Since its inception, REAL has provided at least two years (and usually more) support for 38 doctoral students from agricultural economics, economics, geography and urban and regional planning, welcomed 10 '*Bolsa Sandwich*' PhD students from Brazil who spent one year at REAL working on their doctoral dissertations and hosted over 100 international visitors (visiting students, visiting scholars and visiting professors) who stayed three months or more. Several experiences of foreign scholars coming informally to the University of Illinois at Urbana-Champaign demonstrated that a period of one or two semesters resulted in a major contribution to the thesis of these young researchers, as well as to their personal enhancement. At any one time, from 15 to 30 visitors and students will be in residence. Foreign visitors appreciate more especially the exposure to the challenges, issues and opportunities in another country because it provides them an important perspective that cannot be 'taught' effectively by distance learning. Residence in another country, coupled with engagement with other students and faculty involved in their work provide them with an invaluable learning opportunity. In addition, the mass of students and the profound respect of REAL's director for the various techniques of regional science allow foreign visitors to build quickly partnerships for their work and receive sound feedback." (http://www.real.uiuc.edu/)

In what follows, we describe the scholarly network involving REAL's alumni working in academia in Brazil. We analyze the patterns of research collaboration among around 50 Brazilian researchers whose main activities are related to academic institutions in Brazil. We first define, in section 2, the core of the network through the genealogy of Geoffrey JD Hewings' Brazilian PhD students. We then provide, in section 3, a brief description of the database on Brazilian REAL's alumni scientific production and collaboration. After that, we present the main characteristics of the endogenous and exogenous scientific collaboration networks involving those alumni. Concluding remarks follow in the last section, where we present some of the developments in areas of research in regional science of particular interest to Brazil and other developing countries, taking stock of some of the network's contributions to the field.

2. Genealogy: The Brazilian Branch

It is fair to say that the Brazilian branch of Geoffrey JD Hewings' academic tree is heavily rooted in the perennial influence of Professor Werner Baer in the shaping-up of economics graduate studies in Brazil. The partnership between the two scholars has been fundamental to the maintenance of a regular flow of Brazilian visitors to REAL.
As attested by Azzoni (2010), in the early years of institutional development of graduate studies in Brazil, "[Werner Baer] was instrumental in (…) choosing young professors to be trained abroad, arranging scholarships in the USA and influencing American universities to accept Brazilian students (…)" (p. 295). Since then, he has uninterruptedly generated a flow of Brazilian and Latin American scholars to graduate programs in the USA (especially at UIUC), accepting and sponsoring students from the region. According to Azzoni (op. cit., p. 295), "he must be responsible for at least 20% of all PhD degrees in economics in Brazil, at UIUC and other universities".

The constant and increasing flow of PhD students from Brazil and Latin America to the Department of Economics at UIUC in the late 1980s and early 1990s, together with the creation of REAL in 1989, provided the opportunity for a fruitful partnership between Werner Baer and Geoffrey JD Hewings. Still before REAL, academic interactions between Baer's students and Hewings created the roots of the Brazilian REAL network. Initial collaboration with Eduardo Martins, Joaquim Guilhoto, and Manuel Fonseca[5] in the second half of the 1980s triggered the network.

Brazilian scholars have a prominent role in Geoffrey JD Hewings' academic genealogy, accounting for 6 out of 48 of his all-time PhDs.[6] His first PhD student from Brazil, Eduardo Martins, defended his dissertation in 1993.[7] He was Hewings' 11th PhD student. Thereafter, he has advised five other Brazilian PhDs: Ricardo Gazel (number 14); Eduardo Haddad (21); André Magalhães (23); Mônica Haddad (28); and Carlos Eduardo Lobo e Silva (37).

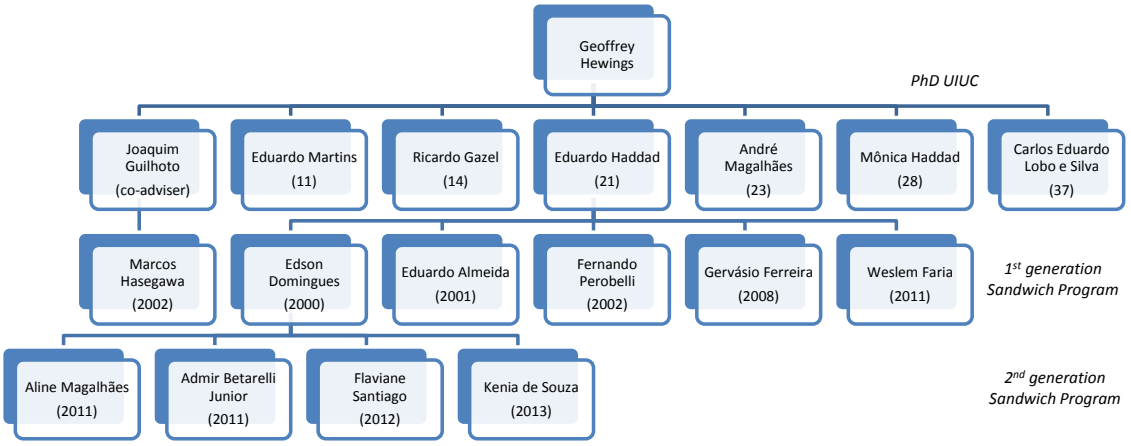
Multiplier Effect: The Sandwich Program

[5] See Hewings et al. (1989).
[6] As of October 2014.
[7] Before that, Geoffrey JD Hewings had co-advised, with Werner Baer, Joaquim Guilhoto's PhD dissertation, finished in 1986.

Over the years, Hewings' *academic sons* developed their careers, some of them in academia back in Brazil. As they became advisers of their own PhD students in their home institutions, stronger ties with REAL started to be created. Through a special program sponsored by the Brazilian government, the so-called *Sandwich Scholarship Program*, PhD students from Brazil would spend one year at REAL working on their doctoral dissertations. Since 2000, REAL has already welcomed ten of such "*Sandwich*" scholars from Brazil, who have already successfully defended their dissertations, with Geoffrey Hewings as their co-adviser.

It is interesting to notice that, after a group of first-generation participants in the program (Hewings' *academic grandchildren*), a group of second-generation students (*academic great-grandchildren*) already appeared (Figure 1).

Figure 1. Academic Genealogy of Geoffrey Hewings' Brazilian Ph.D. Students



Obs. There are four "Sandwich Scholars" currently pursuing their PhD degrees, three of them advised by Edson Domingues – Luiz Carlos Ribeiro (2014), Glaucia Possas da Motta (2015), and Debora Freire (2015) – and one advised by Raul Silveira-Neto (visiting scholar in 2013-2014) – Alvaro Furtado Coelho Junior.

3. Brazilian REAL Scientific Collaboration Database

The data used in our analysis were extracted from information available in the Lattes curricula vitae (CV), a part of the CNPq Lattes Platform, which consists in an

information system, deployed and maintained by the Brazilian government for managing information related to researchers, institutions and research activities across the country (CNPq, 2014).[8] The public availability of CV information and research groups via web and the utilization of such information by universities stimulate the correct insertion and veracity of published data, which became the national standard system to the registry of scientific community academic and professional activities. Therefore, the establishment of a real incentive mechanism to fill and correct update of information provided credibility and international recognition to the Lattes system, a successful model to be internationally followed (Lane, 2010).

The CVs are publicly available on the Lattes Platform web portal (CNPq, 2014), though, despite the immediate access to individual information, the portal does not enable systematic access to the entire database. Thus, the effort in gathering information is the main obstacle to the analysis of a large amount of data, making it necessary to automate this process.

We have used the *scriptLattes* (Mena-Chalco and Cesar-Jr, 2009) to extract automatically the information from 48 REAL's alumni registered in the platform (see Table A.1 in the Annex).[9] For our purposes, *scriptLattes* was also used to establish links between pairs of researchers, checking whether there was a shared scientific production between them publicized in their CVs. The procedure is based on a search of similarities from the direct comparison between the titles of publications registered in the CVs.[10] More precisely, the coauthorship identification and counting were performed from information contained in only two specific fields of the CV: *papers published in peer-*

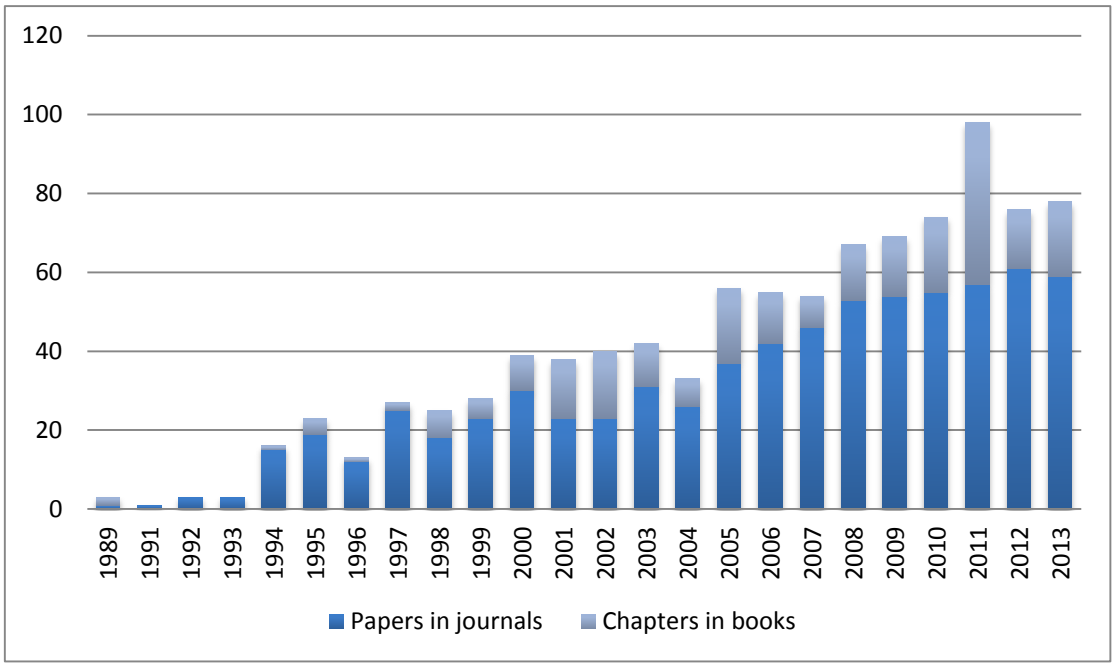
[8] The Lattes Platform consists of a comprehensive system of curriculum information of researchers, teachers, students and professionals from all knowledge areas and has crucial importance in planning, management and operation of the federal funding agencies, the foundations of science support, universities and research institutions, mainly to provide reliable information for the analysis of researchers merit and competence, evaluation of postgraduate programs and analysis of claims for funding (CNPq, 2014).

[9] The report was generated using the scriptLattes V.8.10, developed at NUVEM/UFABC and CCSL-IME/USP by Jesús P. Mena-Chalco and Roberto M. Cesar-Jr. The complete report can be accessed at http://professor.ufabc.edu.br/~jesus.mena/REAL-1989-2013/.

[10] In the social network analysis, each researcher is represented by a node and the detection of coauthorships relations among them is represented by a connection between nodes (edge).

reviewed journals, and *chapters of published books* (Figure 2), amounting to the analysis of 1,061 distinct academic outputs published between 1989 and 2013.[11]

Figure 2. Number of Papers in Peer-Reviewed Journals and Chapters in Books by Brazilian REAL's Alumni, 1989-2013



After the coauthorship identification, the links among researchers were accounted by means of the full-counting process, in which each unit of analysis (authors) receives one unit of collaboration for its participation in publications (Scherngell and Barber, 2011). This procedure generated the database to create the endogenous collaboration network.

We have then extended the database by including the collaborations with other REAL researchers that are not registered in the Lattes Platform. Thus, an extended endogenous collaboration network was created.

Finally, we have run the scriptLattes to look at the collaborations involving the REAL's alumni with all their coauthors – those registered in the Lattes Platform –, generating the exogenous collaboration network. In what follows, we characterize the three networks derived from the database.

[11] Compared to the total number of publications (7,351,957) contained in all the CVs in the Lattes Platform (1,131,912), the "location quotient" of publications by scholars pertaining to the REAL network is 3.4, suggesting a much higher productivity than the average Brazilian scholar.

4. Networks

Barabási *et al*. (2002) consider collaboration networks as prototypes of evolving networks. In their view, the coauthorship network continuously expands by the addition of new authors to the database, as well as the addition of new internal links representing papers coauthored by authors that were already part of the database. Thus, we can define a coauthorship or collaboration network which is a reflection of the professional links between the researchers.[12] In this network, the nodes are the researchers, and two researchers are linked if they wrote a paper together. We consider three different sets of researchers: (i) we start by considering only REAL's alumni working in research activities in Brazil (endogenous network); (ii) we then include other REAL affiliates elsewhere (extended endogenous network); and (iii) we finally expand the endogenous network by considering all coauthors of REAL's Brazilian alumni registered in the Lattes Platform (exogenous network).

4.1. Endogenous Collaboration Network

We have identified 51 Brazilian REAL's alumni, 48 of them are registered in the Lattes Platform. Over time, the number of new REAL members from Brazil increased from 6, in the period 1989-1998, to 11 in 1999-2003 and in 2004-2008, reaching 23 in 2009-2014 (Figure 3). The increasing number of Brazilian researchers associated with REAL is reflected in the temporal evolution of the endogenous network, as the network grows through the addition of new nodes (researchers) and new edges (coauthorship). Figure 4 depicts the non-cumulative network edges in different periods. REAL's alumni are represented in blue color; REAL researchers not registered in the Lattes Platform are represented in red color.[13] It is clear that the network became denser over the years, signaling a process of increasing interaction among its members. Notice that collaboration among Brazilian researchers did not take off until 1999, ten years after the

[12] Among the mechanisms responsible for the articulation of social relations among the scientific community, the network of coauthorships is particularly important since it provides indicators of knowledge flows among researchers. However, coauthorship is only one facet of the collaboration process, since there are numerous cases in which collaboration does not result in coauthored publications (Katz and Martin, 1997). Although coauthorship is a rather imperfect or partial indicator of research collaboration between individuals, we will use both terms interchangeably throughout the text.

[13] The focus is on the time at which the links have been added to the network. It reveals only part of the network dynamics, since we have depicted the total nodes as of 2014.

creation of the Lab. In the first years, collaborations involving international REAL researchers were fundamental for the kick-off of the network, suggesting that the process of the establishment of a scientific network requires a long period of maturation.

Figure 3. Number of Brazilian Scholars at REAL, by Period of Initial Affiliation

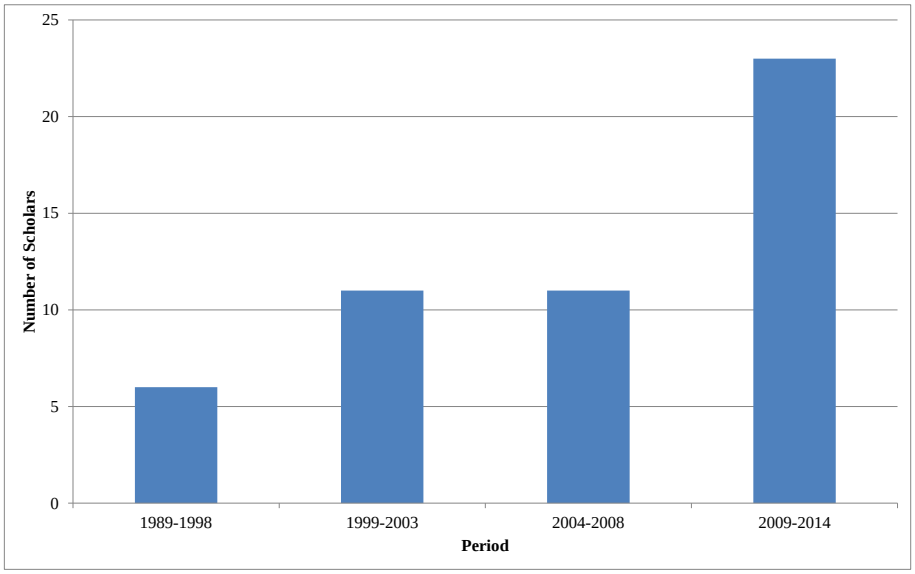


Figure 4. Evolution of the Endogenous Network, Non-Cumulative Links by Period

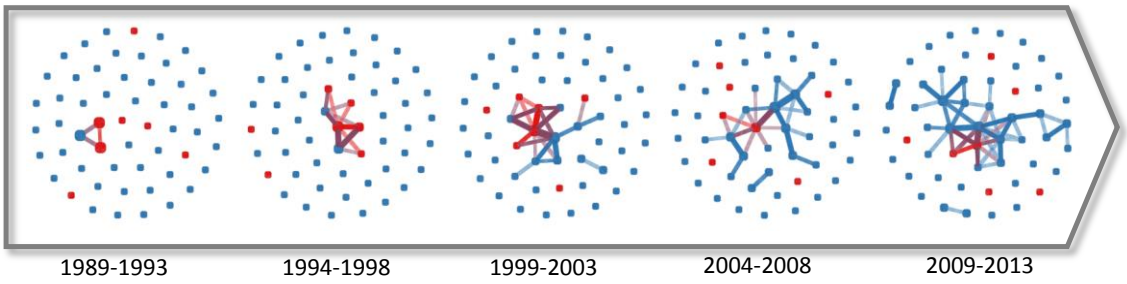


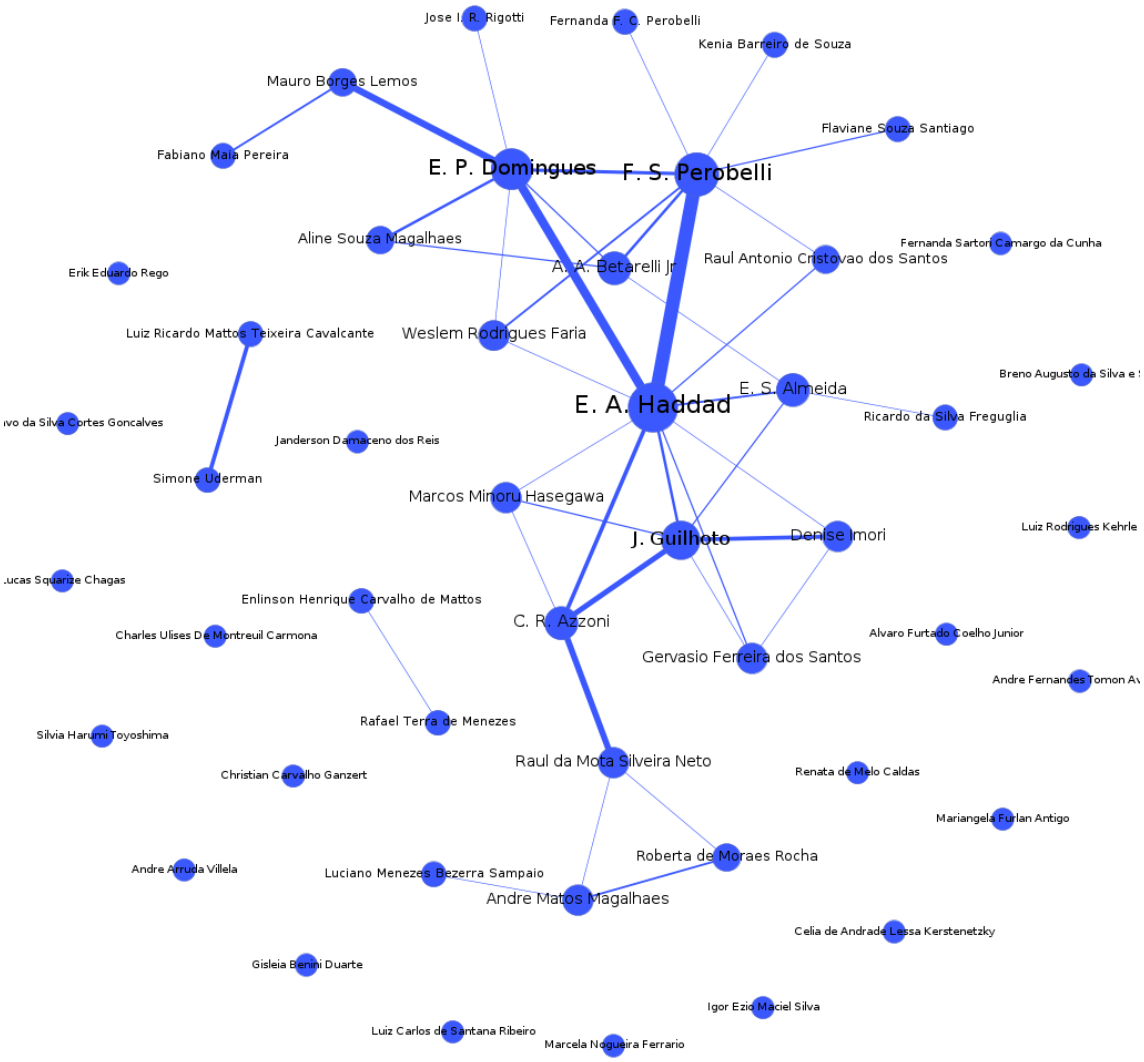
Figure 5 reveals the structure of the endogenous network over the period 1989-2013. Nodes are sized based on the *authorRank*[14] (Liu *et al*., 2005) considering the number of endogenous collaborations produced; edges are sized based on the number of collaborations between authors. Coauthorship among REAL's alumni involves 27 out of the 48 members of the network. While there are two isolated links (Cavalcante-Uderman and Mattos-Menezes), the remaining 23 researchers form an integrated network. The two main clusters are associated with the nodes Domingues-Haddad-Perobelli and Azzoni-Guilhoto-Haddad. The former is closely related to social proximity – Haddad was the adviser of both Domingues and Perobelli (see Figure 1); the latter is related to geographic and organizational proximities – the three scholars are based in the same department at the University of Sao Paulo. The intersection of the two clusters is heavily influenced by institutional proximity, as the five researchers are

[14] The *authorRank* (a weighted version of the *PageRank*) is an indicator of the impact/prestige of an individual author in weighted coauthorship network.

associated, to different degrees, to the activities of the University of São Paulo Regional and Urban Economics Lab (NEREUS), and the Institute of Economic Research Foundation (FIPE).

This case study provides a clear example of the possibility of interaction among different dimensions of proximity over time. Initial geographic proximity at REAL has favored the development of a larger cognitive and social proximity that allowed researchers to continue to work effectively even when they moved to other institutions in their home country. Thus, while geographic proximity is necessary in many forms of scientific interactions, it is expected that it will become less important in cases in which researchers build stronger social networks.

Figure 5. Endogenous Collaboration – Papers in Peer-Reviewed Journals and Chapters in Books, 1989-2013

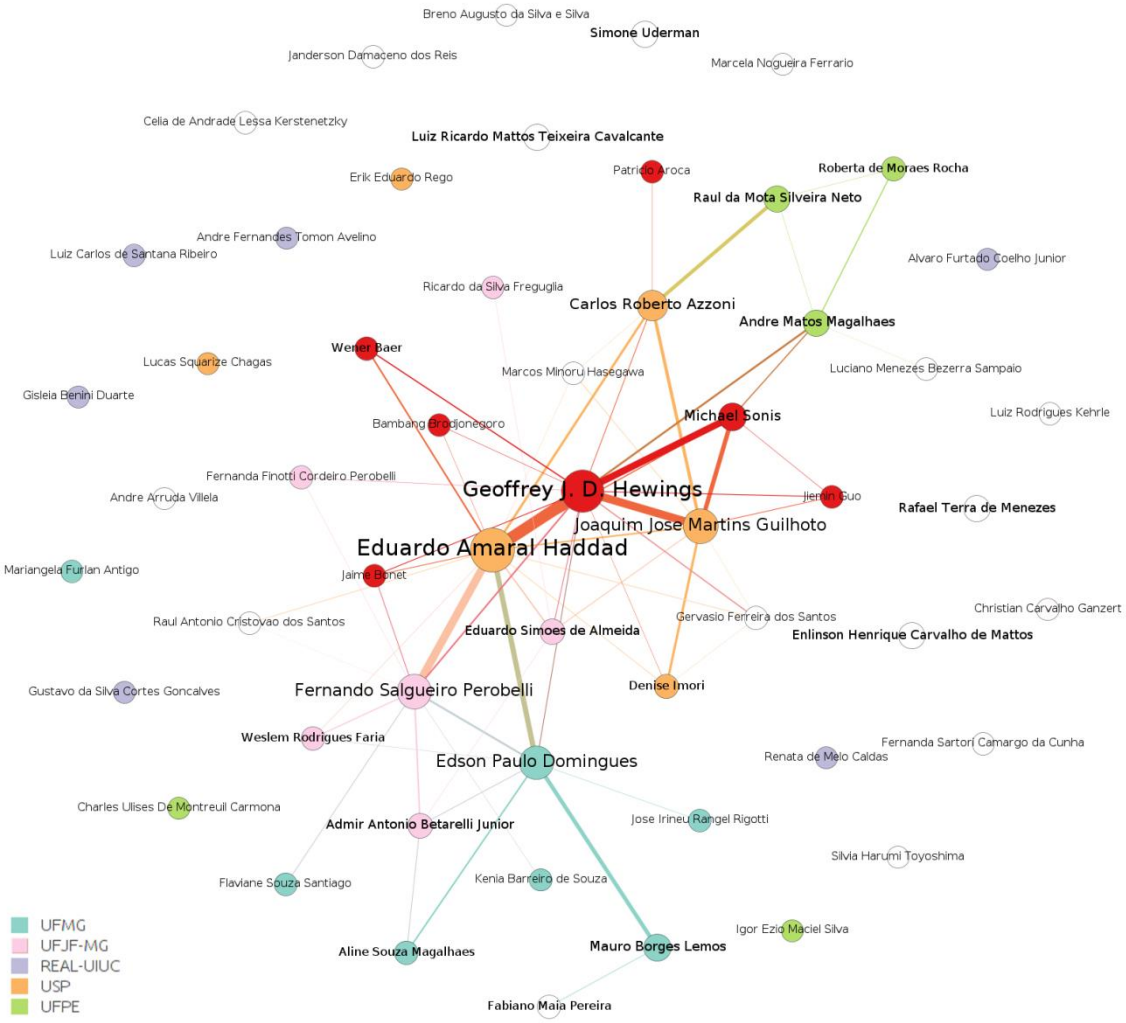


4.2. Extended Endogenous Collaboration Network

Figure 6 presents the extended endogenous collaboration networks among REAL`s researchers. New "additions" to the network – REAL researchers outside Brazil – are represented in red nodes. The central role played by Geoffrey JD Hewings is evident. It is also noteworthy the collaboration among the nodes Guilhoto-Hewings-Sonis, which brings us back to the early years of REAL.

We have also highlighted REAL's alumni using different colors to identify their current institutional affiliation. In addition to scholars currently at REAL, usually at the early stages of their academic careers, four institutions were considered: USP – where NEREUS and FIPE are hosted, UFMG and UFJF, both in the state of Minas Gerais, and UFPE (located in Brazil's Northeast). With Geoffrey JD Hewings at the center of the network, there is an immediate first-order collaboration cluster, identified with researchers at NEREUS (Azzoni-Guilhoto-Haddad), responsible for subsequent strong interactions with three second-order clusters – UFMG and UFJF, that also collaborate between themselves, and UFPE. It seems that the Brazilian REAL network has evolved following hierarchical steps, from initial localized international collaboration involving researchers from a center of national excellence (i.e. USP), followed by a gradual expansion of domestic collaboration networks that relied on social, geographical, organizational and institutional proximities.

Figure 6. Extended Endogenous Collaboration – Papers in Peer-Reviewed Journals and Chapters in Books, 1989-2013



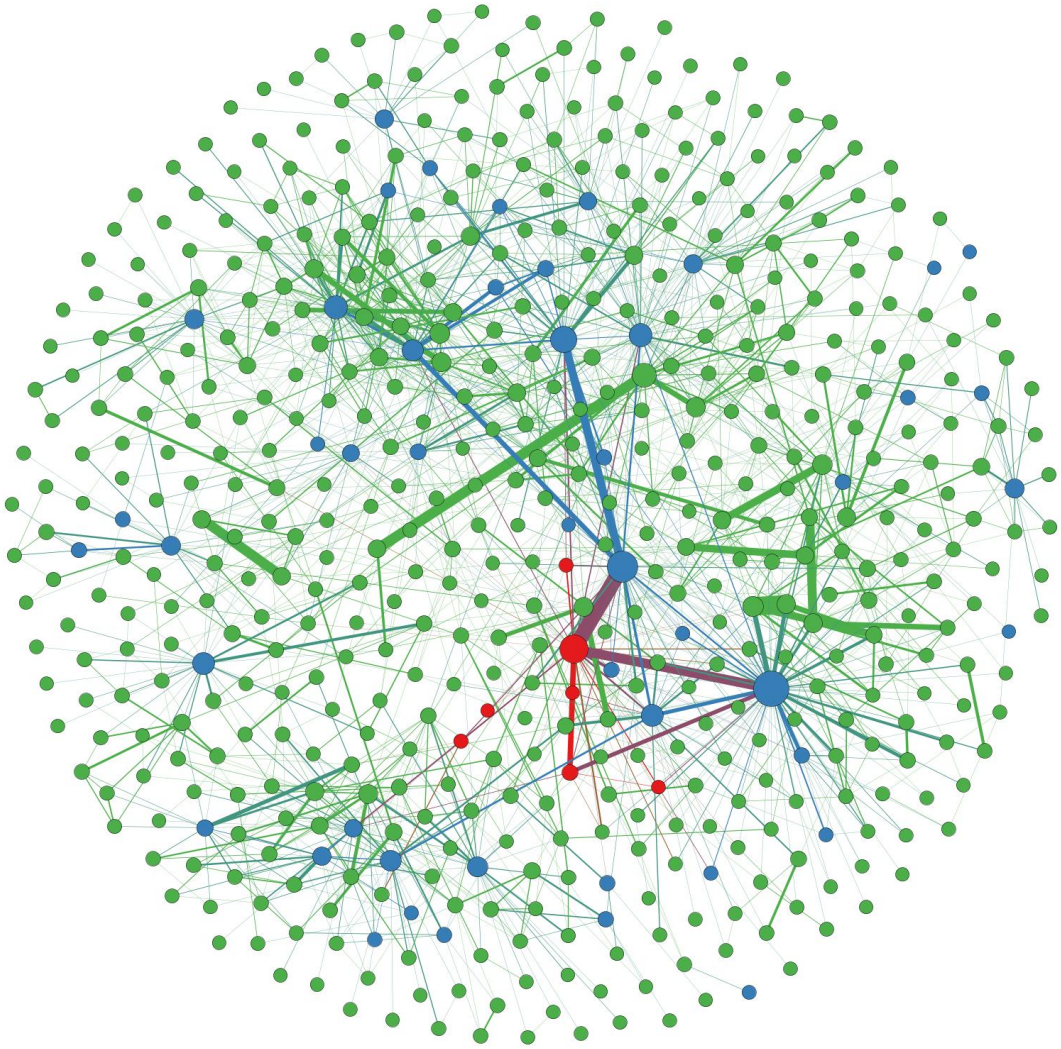
4.3. Exogenous Collaboration Network

We have identified, in the Lattes Platform, 501 collaborators with REAL's alumni in Brazil. Figure 7 shows the coauthor network generated from their publications. Nodes are sized based on the *authorRank* measure (impact in collaboration) and colored to highlight whether the researcher is a REAL's Brazilian alumnus (blue), another REAL researcher (red) or a collaborator (green). Similarly, edges are sized and colored based on the number of collaborations between authors. A brief inspection reveals the important role played by Geoffrey JD Hewings (larger red node) and a group of REAL scholars in the whole network, suggested by the prominence of larger blue nodes. It is important to note that the average number of collaborators per REAL member is 15.94.
We can also redesign the network in order to identify its main clusters more clearly. Belter (2012) mentions that a visual representation, or "map", of the entire network can be created once the network is constructed. In laying out the map, each node is positioned between other nodes to which it is connected by edges. This means that the absolute position of a node on the map is not meaningful, but its relative position is. Nodes that are more closely related are placed near each other, while nodes that are less related are placed farther away. In Figure 8, three main clusters emerge: (i) a cluster identified with three strong nodes (Domingues-Haddad-Perobelli) that includes Hewings' academic grandchildren and great-grandchildren from Haddad's heritage – located at the center of the network; (ii) a cluster identified with the nodes Azzoni-Guilhoto, with the prominence of Guilhoto's node clustering many external collaborators – center-right part of the network; (iii) a cluster involving 10 different alumni, most of them based in institutions located in the Northeast of Brazil, whose main link with the core network is given by interactions with Azzoni's node – bottom-right of the network.

Finally, we can examine the geographical aspects of the Brazilian REAL network. We adopted the same procedure as in Sidone *et al*. (2014). We considered the Brazilian municipalities as our geographical unit of analysis. However, instead of locating the coauthors from their addresses informed in the publications (or with the aid of complementary databases), we used the direct information about the professional

addresses of researchers reported in each CV.[15] Figure 9 shows the map with the collaboration flows for the complete period (1989-2013), revealing a relatively widespread geographical coverage, despite the polarization from the Southeast.

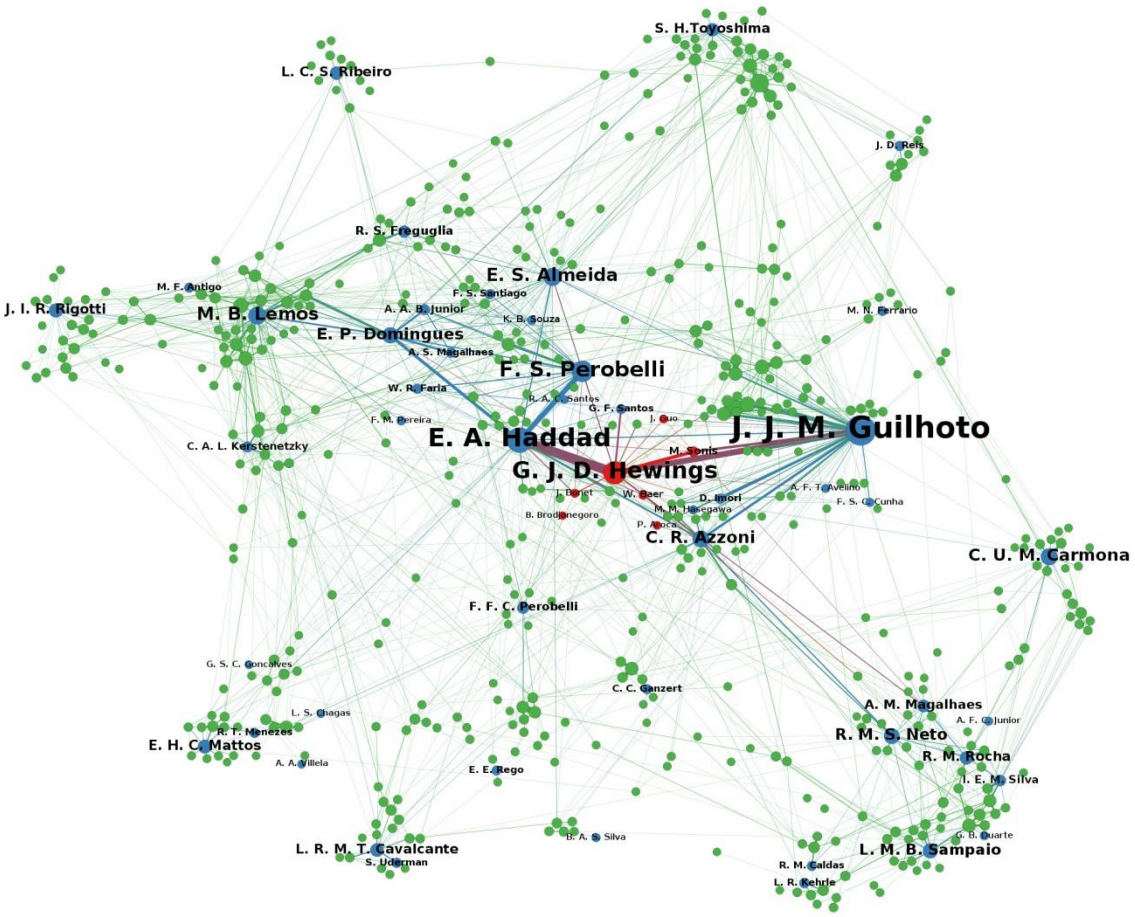
Figure 7. Exogenous Collaboration – Papers in Peer-Reviewed Journals and Chapters in Books, 1989-2013



Obs. Blue nodes refer to Brazilian REAL's alumni; red nodes refer to REAL researchers outside Brazil; green nodes refer to external collaborators.

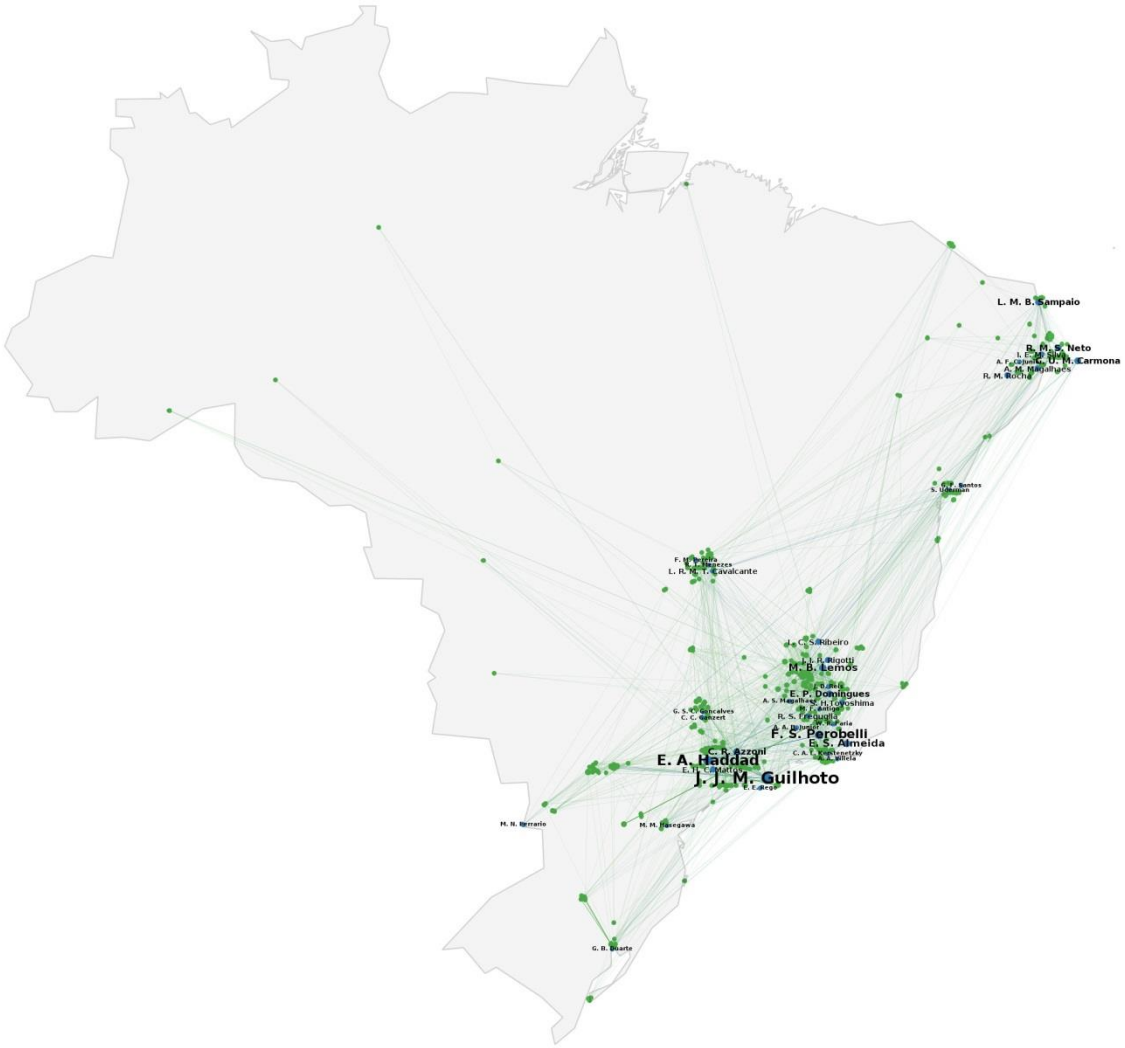
[15] Researchers whose locations were not reported in their CVs were excluded from the sample.

Figure 8. Clusters in the Exogenous Collaboration Network, Papers in Peer-Reviewed Journals and Chapters in Books, 1989-2013



Obs. Blue nodes refer to Brazilian REAL's alumni; red nodes refer to REAL researchers outside Brazil; green nodes refer to external collaborators.

Figure 9. Geographical Distribution of Exogenous Collaboration, 1989-2013



Obs. Blue nodes refer to Brazilian REAL's alumni; green nodes refer to external collaborators – it includes all types of publication.

5. Accomplishments and the Road Ahead

In scientifically emerging economies with large territorial extensions, such as the case of Brazil, it is expected that, parallel to an increase in international scientific collaboration, an expansion of domestic collaboration networks from nodes located in centers of national excellence emerges. It is a different situation from that of the smaller or less developed European countries for which international collaborations are practically unavoidable and respond, in some cases, by more than 90% of the scientific output. In those economies, the accelerated growth production is directly associated with the intensification of domestic collaborative efforts (Royal Society, 2011). Because the size of their country allows some scale advantages related to the existence of specialized research institutes, national researchers have more opportunities to collaborate with local partners (Glänzel and Schubert 2005; Chinchilla-Rodríguez *et al*. 2010).

The "Brazilian REAL Network" has shown to be an interesting case study that reflects this pattern of evolving collaboration networks in regional science in scientifically emerging economies. The expansion of the REAL scientific collaboration network in Brazil arises as a relevant mechanism for both the qualitative leap of national scientific production in regional science and for the dissemination of knowledge in peripheral regions of the country. Conducted under the leadership of Geoffrey JD Hewings, it has helped to further develop regional science in the country, triggering a second cycle of academic development of the field in Brazil.[16]

Initial links in the network were more strongly related to international collaboration involving Geoffrey JD Hewings, Michael Sonis and Werner Baer, from the "foreign" side, and Joaquim Guilhoto and Eduardo Haddad from the "domestic side". By the time the network was already established, its own dynamics generated a pattern of hierarchical integration in which NEREUS, a REAL-like lab founded by REAL alumni at the University of São Paulo, served as the key institutional node in Brazil to foster the spread of the network across the country.

[16] The first cycle of academic development of regional science in Brazil has its roots in the creation of the Center for Development and Regional Planning at the Federal University of Minas Gerais – CEDEPLAR-UFMG in 1968, led by the pioneers Fernando Antônio Roquete Reis, Élcio Costa Couto, Álvaro Fontes Santiago and Paulo Roberto Haddad.

But what have we learned so far? A partial qualitative assessment of the publication patterns associated with the network may elucidate part of the sense of the scientific embedded in the research outcomes.[17] As many developing countries, Brazil is characterized by strong regional inequalities. Many studies have looked at the evolution of regional inequality in Brazil with special attention to spatial effects. Given the country's territorial size and public availability of regional-level databases, Brazil became a laboratory for testing several of the facets of the Solow model in a subnational context (Azzoni, 2001; Azzoni and Servo, 2002; Azzoni and Silveira-Neto, 2005; Cravo and Resende, 2013; Ferreira, 2000; Laurini *et al*., 2005; Lima and Resende, 2007; Magalhaes *et al*., 2005; Mossi *et al*., 2003). The existence of a persistent regional dualism, in which spatial spillovers are very important, is one of the most robust results of these studies. Geography has been shown to play an important role also in the drivers of regional growth. Regional efficiency of manufacturing sectors, for instance, independent of their technology-intensity, is heavily affected by neighborhood effects (Schettini *et al*., 2011). Spatial spillovers are also important in determining regional innovative capacity and technology diffusion in Brazil (Gonçalves and Almeida, 2009). Demography influences the economic environment either through income inequality across individuals or through the possible influence of demographic characteristics on economic growth, with important effects on the process of convergence across Brazilian regions (Menezes *et al*., 2012). The existing uneven spatial distribution of demographic indicators that are deemed important to understand the current and future levels of welfare of a region (e.g. infant mortality) may, however, be improved by investments in health infrastructure, with more likely impacts in the long-run (Barufi *et al*., 2012).

Since the late 1980s until recently, the agreed agenda for Brazil included the competitive integration of the country in the global trade network, with additional domestic concerns focused on sustainable stabilization and social cohesion. This implied the attraction of foreign investments and a responsible (balanced) budget policy for all levels of government, reinforced by the promulgation of the "Lei de Responsabilidade Fiscal" (Fiscal Responsibility Law) in 2000. The latter restricted regional policies based primarily on re-distributional expenditures, as was the case in the 1970s (Haddad, 1999). The research undertaken in the last two decades by regional

[17] Despite the much higher number of publications in Brazilian journals, we will concentrate our discussion in results published in international scholarly journals.

scientists in Brazil refer to this context of policies in such areas as macroeconomic stabilization, economic opening with respect to both trade and investment, and the expansion of market forces within the domestic economy, common to many developing countries that embraced the "Washington Consensus".

Studies have shown that the interplay of market forces in the Brazilian economy tends to favor the more developed regions of the country. Regional repercussions of trade liberalization policies, including the creation of Mercosur, were very likely to increase regional inequality in the country (Guilhoto and Fonseca, 1998; Haddad *et al*., 2002, 2005). The future of Mercosur, in turn, brings challenges for Brazilian regional economies as specific rules for the free trade area (FTA) seem to overcome the usual effects of relative competitiveness associated with movements in relative prices (Vieira *et al*., 2014).

Regional governments in Brazil continued to adopt tax incentive programs to attract private investments to their jurisdictions. The case of the automobile industry deserved special attention of regional scientists. New investments were attracted in the late 1990s and early 2000s by policies implemented by the Brazilian government, which has played an active role in negotiations with foreign investors in the country. During this period, state governments have engaged in strong competition for the incoming capital through fiscal incentives. It has been documented that the regional dualism in Brazil is also associated with a strong productive dependence of the less developed regions on the more developed regions (Guilhoto *et al*., 2002). This poses a very real danger that the benefits of new inward investments are not fully internalized by the states that seek to instigate them. In this regard, from a regional perspective, it is important that effective strategies are devised which minimize this risk (Amann *et al*., 2007; Perobelli *et al*., 2007). Moreover, investments in the poorer regions, which tend to be more beneficial to the improvement of regional imbalances in the country, do not generate the same level of national growth as investments in the more developed, denser areas that benefit from agglomeration economies (Haddad and Hewings, 1999). Specialized structures of production are also important features of regional economies, even in more developed states, that help understanding the local impacts of regional tax incentives (Porsse *et al*., 2007).

Even though fiscal incentives continued to play a role in attracting capital to the regions, for private investors the search is dominated by attention to maximal financial returns with little concern for regional equity; location is defined on a purely economic basis. A stream of research has looked at the implication of investors' rationale to location of investments in Brazil. While Silva and Hewings (2012) attempted to understand, from a theoretical perspective, the role played by the internal organization of the firms, other authors addressed important empirical features of the Brazilian economy, common to many developing countries, such as financial constraints and volatility of the business cycle (Kalatzis *et al*., 2008, 2011). The results reveal that, in the Brazilian case, there are significant differences across regions in the importance of investment determinants, bringing relevant insights for the design of regional policies in the country (Azzoni and Kalatzis, 2008).

With the improvement of the perception on Brazil's economic prospects by the international community, after the consolidation of the stabilization program implemented in the mid-1990s, the country's efforts to attract major international events – which also included strong commitments of public resources – have paid off. After hosting the 2007 Pan American Games in Rio, Brazilian bids for both the 2014 FIFA World Cup and the 2016 Olympic Games have succeeded. This generated reflections on the role played by major sport events on regional development (Haddad and Haddad, 2010). Among the various aspects related to this debate, tourism has always been a topic of special interest in regional science. The potential increase of flows of domestic and international tourists to the host-cities required in-depth studies to assess the impacts of the sector on the regional economies. Insofar as the tourism sector is a relevant part of the economic base of a region, income injections are frequently associated with international and domestic tourist expenditures in the local economy. Although there is a relative consensus on the positive income effects associated with expenditures by foreign visitors, the analysis carried out for the Brazilian economy has shown that the total impact of domestic tourist expenditure could be approximated by a zero-sum game at the national level but not necessarily at the regional level. Most important, domestic tourism seems to play a non-distortionary role to improve regional inequality in Brazil (Haddad *et al*., 2013).

One important area of regional science research in Brazil relates to the development of large-scale integrated modeling systems for impact analysis. By inserting a core CGE in a broader modeling framework, Brazilian scholars have been able to suppress some of the shortcomings of isolated models. Applications for transportation policies have dealt with market imperfections in the Brazilian spatial economy, by introducing non-constant returns and non-iceberg transportation costs in an interregional CGE model integrated with a GIS transportation network model (Haddad and Hewings, 2005). In the case of Brazil, as well as in many developing countries, where transportation costs are high and accessibility low compared to European or North American standards, handling market imperfections becomes imperative as does the need to address internal spatial issues from the perspective of Brazil's increasing involvement with external markets. Projects of spatially connective infrastructure have been assessed using this methodology providing insightful results on the various trade-offs that emerge. Haddad *et al*. (2011) make it clear for policies of domestic integration in the country showing that, given different policy options, decision-makers face non-trivial choices: different projects perform differently in different dimensions, usually presenting outcomes with different hierarchies related to multi-dimensional policy goals. This is also true for other types of infrastructure investment. For instance, the choice of ports for government investment would have, potentially, significant implications on the hinterlands serving those ports as well as on other areas that may be able to access them once the investments have been completed, with very strong regional development policy implications (Haddad *et al*., 2010)

Despite still fettered to the reins of the perfectly competitive modeling paradigm, Almeida *et al*. (2010) add to the previous results revealing that, methodological differences aside, the evidence about the nature of the relationship between the provision of transport infrastructure and regional equity is controversial due to a fundamental characteristic associated with this issue. In other words, even with the same theory or model, method, and its specification, one may continue to obtain different results about this relationship. This outcome arises because this relationship crucially depends on where the transport infrastructure is located. In addition to methodological considerations, there seems to exist authentic spatial reasons that might yield controversial results. Indeed, transport infrastructure is strongly region-dependent. The spatial structure of the provision of transport infrastructure matters in this question,

playing a fundamental role in determining its effects on the economic system, as shown in a model developed for the State of Minas Gerais, Brazil.

Large-scale integrated modeling systems have also been developed for regional impact analysis of energy policies in Brazil (Santos *et al*., 2013). Simulations of the long-run regional impacts of electric power tariff policy in Brazil showed that the heterogeneity of energy-intensity and the differentials of energy substitution drive the spatial impacts of changes in electric power prices. On the other hand, the recent trend of spatial dispersion of electric power prices might contribute to a decrease in the long-run economic growth and to an increase in the regional inequalities in Brazil.

Since the 1990s, the energy sector in Brazil has been the subject of a variety of reform initiatives that are changing the market structure and the energy price levels. These reforms were also triggered by the implementation of neoliberal policies in the Brazilian economy. Energy policy in the country has stimulated energy diversification to increase the inter-fuel substitution. Some studies have attempted to understand the new patterns of sectoral and regional consumption of energy that emerged in the country (Perobelli and Oliveira, 2013; Carvalho *et al*., 2013). Emphasis on renewable energy has implications for food security in the country, since biofuels production in Brazil rely heavily on processing sugarcane. There is an ongoing debate on the risks associated with diverting farmland or crops for biofuels production to the detriment of the food supply. The expansion of sugarcane growing in Brazil, spurred particularly by increased demand for ethanol, has triggered the need to evaluate the economic, social, and environmental impacts of this process, both on the country as a whole and on the growing regions. Despite some evidence that the presence of sugarcane growing in these areas is not relevant to determine their social conditions (Chagas *et al*., 2012), positive demand shocks upon the sugarcane agro-industry does produce a greater income impact upon the less developed region of the country (North) compared to the Center-South (Costa *et al*., 2006; Martínez *et al*., 2013).

In the context of the fiscal adjustment process of the 1990s, the role of the central government in stimulating directly productive activities has been replaced by strategies of socio-economic inclusion. Seemingly non-spatial government policies in the form of spatially blind social programs played an important role in the recent decline in regional

income inequality in Brazil (Silveira-Neto and Azzoni, 2011, 2012). However, regional inequality continues to be very high in Brazil, and this issue will continue to be in the research agenda for many years to come. Important components of income and, especially, wealth inequality are still unknown in the Brazilian case. The distribution of property rights and rents on natural resources in Brazil need to be better understood (Goeschl and Igliori, 2006). Furthermore, a more complete picture of income and wealth distribution is still needed. As it has been shown by Piketty (2014), there can now be no doubt that the phenomenon of inequality is not dominantly about the inadequacy of the skills of lagging workers. Understanding the process of wealth accumulation across regions may change drastically our prescriptions of regional policies.

There are many other important challenges for regional economies in the developing world that will also shape the future research agenda in the field. "Local" and "global" phenomena can illustrate two promising research areas to be further developed in Brazil.

Brazil, as many development countries, experienced a rapid process of urban expansion around the CBD of its main cities that was not followed by the implementation of adequate infrastructure, causing important urban problems (Haddad and Nedović-Budić, 2006; Menezes *et al*., 2013; Silveira-Neto *et al*., 2015). Recent experimentation with integrated modeling of metropolitan systems in Brazil has proved relevant for assessing the consequences of apparently local phenomena related to the city of São Paulo: floods (Haddad and Teixeira, 2015) and local transportation infrastructure (Haddad *et al*., 2015). The key message is that one needs to consider interactions both inside and outside a prime metropolitan system to recognize the role it plays in an integrated inter-regional system. The lack of redundancy in the economic infrastructure of developing countries, i.e. the inability to have alternatives to solve problems of logistics, communications or energy in the advent of unexpected events, poses interesting research questions for regional scientists in Brazil.

As an example of a global phenomenon, ongoing global climate change will have potential consequences for the competitiveness of regions in the future. Resource-oriented activities, such as agriculture, mining, timber, etc., and the related processing

industries, deal with different restrictions as compared to footloose activities. The immediate impact of climate change will very likely be more intense in activities more dependent on nature. However, the repercussions of these effects will be felt also in other sectors, thus affecting the compositions of regional income, of household consumption, with influence on the tertiary sector of the main cities in the region, and finally reaching the industrial sectors supplying the regional demand. Thus, it is expected that the initial stimuli from natural resource-based industries will eventually result in major changes in the economy of the region as a whole (Azzoni and Haddad, 2012). In Brazil, the most vulnerable regions to climate change are the traditionally less developed areas of the country: the Amazon and the Northeast (Barbieiri *et al*., 2010). This is a challenging interdisciplinary research area, bringing various challenges for regional scientists in the country. It could provide opportunities in the form of increased integration between institutions, more accurate data through information sharing and interdisciplinary approaches, and a greater understanding of the potential impacts of climate change in Brazil to ensure the most effective response by the relevant political, economic and social sectors.

In sum, research topics developed by scholars involved in the Brazilian REAL network mainly address concerns with the analysis of regional problems in Brazil using the tool kits in regional science (Figure 10). There is, nonetheless, increasing collaboration with scholars in other parts of the developing world (Haddad *et al*., 2009, 2011, 2014, Haddad, 2014; Perobelli *et al*., 2010). The Brazilian experience has been proved relevant to be shared with other countries that face similar problems. Brazilians seem to have embraced the field seriously – by applying and amending the available tools to analyzing concrete problems of the Brazilian economy –, since, according to the founder of regional science, it "concerns the careful and patient study of social problems with regional or spatial dimensions, employing diverse combinations of analytical and empirical research" (Isard, 1975, p. 2).

Figure 10. Word Cloud based on Titles of Papers in International Peer-Reviewed Journals Published by REAL Brazilian Scholars

Obs. This image was generated by *wordle.net*.

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Annex

Table A.1. List of Brazilian REAL's Alumni Registered in the Lattes Platform

	Nome	*First year at REAL*		*Nome*	*First year at REAL*
1	Joaquim Jose Martins Guilhoto	1989	25	Mariangela Furlan Antigo	2008
2	Eduardo Amaral Haddad	1993	26	Erik Eduardo Rego	2009
3	André Matos Magalhães	1997	27	Fernanda Sartori Camargo da Cunha	2009
4	Edson Paulo Domingues	2000	28	Janderson Damaceno dos Reis	2009
5	Eduardo Simoes de Almeida	2001	29	Luciano Menezes Bezerra Sampaio	2009
6	Carlos Roberto Azzoni	2002	30	Marcela Nogueira Ferrario	2009
7	Fernanda Finotti Cordeiro Perobelli	2002	31	Rafael Terra de Menezes	2010
8	Fernando Salgueiro Perobelli	2002	32	Enlinson Henrique Carvalho de Mattos	2011
9	Marcos Minoru Hasegawa	2002	33	Admir Antonio Betarelli Junior	2011
10	Mauro Borges Lemos	2002	34	Aline Souza Magalhaes	2011
11	Jose Irineu Rangel Rigotti	2003	35	Breno Augusto da Silva e Silva	2011
12	Luiz Ricardo Mattos Teixeira Cavalcante	2003	36	Christian Carvalho Ganzert	2011
13	Luiz Rodrigues Kehrle	2003	37	Weslem Rodrigues Faria	2011
14	Simone Uderman	2003	38	Flaviane Souza Santiago	2012
15	Silvia Harumi Toyoshima	2005	39	Gisleia Benini Duarte	2013
16	Charles Ulises De Montreuil Carmona	2006	40	Gustavo da Silva Cortes Goncalves	2013
17	Ricardo da Silva Freguglia	2006	41	Igor Ezio Maciel Silva	2013
18	Roberta de Moraes Rocha	2006	42	Kenia Barreiro de Souza	2013
19	Andre Arruda Villela	2007	43	Lucas Squarize Chagas	2013
20	Celia de Andrade Lessa Kerstenetzky	2007	44	Raul da Mota Silveira Neto	2013
21	Raul Antonio Cristovao dos Santos	2007	45	Renata de Melo Caldas	2013
22	Denise Imori	2008	46	Alvaro Furtado Coelho Junior	2014
23	Fabiano Maia Pereira	2008	47	Andre Fernandes Tomon Avelino	2014
24	Gervasio Ferreira dos Santos	2008	48	Luiz Carlos de Santana Ribeiro	2014

Obs. There are three of the first Brazilian scholars at REAL that are not registered in the Lattes Platform and/or do not work in research institutions in Brazil: Eduardo Borges Matins (1989); Ricardo Gazel (1991); Mônica Amaral Haddad (1997).