# The Invisible College of The Economics of Innovation and Technological Change

By *BART VERSPAGEN & **CLAUDIA WERKER
*Ecis, Eindhoven University of Technology.*
*E-mail: b.verspagen@tm.tue.nl; **E-mail: c.werker@tm.tue.nl

## ABSTRACT

The research area of the economics of innovation and technological change (EITC) has flourished over the past decades. While it was a relatively marginal field of economics in the 1950s and 1960s, the field has now grown to become a major part of economic analysis. Because many of the early scholars in the field were rather critical about the standard tools of (neoclassical) economics, EITC has become a research area in which a curious mix of mainstream methodology and alternative approaches co-exists and co-evolves. The paper reports on a survey that was conducted among scholars in the field. We construct networks of scholars, based on weak or strong linkages. Strong linkages are defined as relations between co-workers, weak linkages as relations between people that meet in the circuit of conferences, workshops, etc., or just read each other's work. We also explore how network linkages are related to opinions on the field, e.g., which are the important journals or important centers of activity.

*Keywords:* networks of scientists, economics of innovation and technological change, science dynamics, invisible colleges.

## El colegio invisible de la economía de la innovación y del cambio tecnológico

### RESUMEN

Durante los últimos años se ha desarrollado con fuerza la Economía de la Innovación y del Cambio Climático (EICT). En los años cincuenta y sesenta era un campo marginal de la investigación económica, pero desde entonces se ha transformado en un componente importante del análisis económico. Los primeros investigadores que trabajaron en este campo fueron muy críticos en relación con los instrumentos y métodos habituales de la economía (neoclásica), y con posterioridad la EICT se ha elaborado en base a una mezcla curiosa de actividades investigadoras que cubren enfoques de la corriente central junto con propuestas alternativas. Este artículo está basado en los resultados de una encuesta dirigida a investigadores de la EICT. En el artículo se elaboran redes de investigadores, en base a relaciones fuertes o débiles. Las relaciones fuertes se definen entre investigadores que colaboran permanentemente (co-autores), mientras que las relaciones débiles se establecen por la vía de encuentros en conferencias, sesiones de trabajo, etc., o simplemente en base a lectores comunes. También se explica en este artículo la relación entre estas redes y las opiniones que se forman en el anexo, como por ejemplo sobre las revistas o centros de actividad más importantes.

*Palabras clave:* redes científicas, economía de la innovación y cambio tecnológico, dinámica de la ciencia, colegios invisibles.

## 1. INTRODUCTION

In the introductory chapter to a handbook on 'Economics of Technology', Granstrand (1994, p. 1) argues that "technology has historically penetrated the economy far more than it has penetrated economics". This might be due to a lack of interest or a lack of appropriate tools within the research community dealing with this issue. Research communities deal with certain aspects of reality in order to understand them better, but often their research is rooted in a single so-called scientific paradigm, i.e., it is based on a limited but shared set of assumptions and tools (Kuhn, 1962). However, if research based on this set of assumptions and tools does not explain reality sufficiently, a scientific revolution might take place and a new paradigm might emerge. Usually both paradigms then co-exists at least for a while. During this period researchers of the two different paradigms cooperate and compete.

Some would argue that the analysis of technological change and innovation poses a paradigmatic challenge to the economic mainstream, and that indeed this has led to a situation of competing paradigms in the research field on "economics of innovation and technological change". An informal narrative of the development of this research area (the same one as surveyed by Granstrand, 1994) thus includes two major paradigms. The first, with pioneering authors such as Griliches, Kamien, Mansfield, Scherer, Schmookler and Stoneman, emerged out of mainstream neoclassical economics, and essentially tried to apply this body of theory to technology and innovation. A second stream in the literature is more critical about the neoclassical principles, and would argue that the application of concepts such as full rationality and marginalism obscures our understanding of the major issues related to technology and the economy. Prominent authors in this corner are Dosi, Freeman, Pavitt and Soete (all from the so-called SPRU school), and Nelson and Winter (in the U.S.).[1] This second stream, which emerged in the beginning of the 1980s and especially flourished in Europe, is obviously more diverse in method and themes than the first one. The term 'Evolutionary Economics' has been suggested as a broad label for this collection of approaches (e.g., Dosi, 2000), and is now used by an increasing number of scholars, not all of whom, by the way, share a common understanding of what makes evolutionary economics different from 'normal economics'.

The aim of this paper is to map the intellectual relationships within the scientific community working in the Invisible College (a term that we will explain further below) of the "Economics of Innovation and Technological Change". The paper presents the basic outcomes of our survey only, and leaves further analytical work (using additional databases) for future papers. A major theme of the research is to investigate whether one can actually observe the two separate streams as suggested

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1. It is interesting to note that especially authors working from a historical angle seem to be able to bridge these two streams, e.g., the work of David and Rosenberg.

in the above informal narrative, and to assess their interaction. By looking into the relationships within the Invisible College we hope to get more insights into how relationships between researchers emerge and how they affect the way researchers look on research input and output -in particular in a situation where paradigmatic differences seem to exist. In Section 2 below, we explain which approaches were used to describe and explain the relationships between researchers and research communities, possibly with competing paradigms. Section 3 presents the methodological aspects of the survey.

In Section 4, we present the main empirical results obtained so far. Here (Section 4.1) we first illustrate the paradigmatic split of researchers that our database allows us to make, and analyze how this split affects opinions on the importance of journals and centers of activity (Section 4.1). Second, in Section 4.2, we want to show which kinds of relationships researchers maintain to do their research, ranging from rather close relationships like those between PhD students and supervisors as well as between co-workers, to relationships based on being influenced by someone else's work without even having met this person. In this context, it is shown how such relationships of different kinds connect researchers in this invisible college, and how these relationships are related to possible paradigmatic differences between research communities. In particular, we want to investigate how these paradigmatic differences are related to the distinction between core and periphery in the Invisible College. Finally, in Section 4.3 we ask the question how relationships between researchers as well as differences in paradigm determine the level of agreement on the importance of journals and centers of activity of researchers. A final section will summarize the argument and draw some conclusions.

## 2. PARADIGMS AND INVISIBLE COLLEGES

Our method of analysis follows in the footsteps of Crane (1972). In her treatment of a research community as an 'invisible college' (a term earlier used by Robert Merton), she viewed intellectual relations in the 'college' primarily as social relations between researchers. The term invisible college is used to signal that the group of researchers that is being studied works together closely. This cooperation depends not only on the strong relations that exist between people actually working together in a single organization, but also on cooperation between people who are distant in geographical space. Crane's interest was in explaining the development of a new field of research, for which she argued that it crucially depends on a number of pioneering scientists, and the circles of co-workers and students they create around them. We are more interested in looking into an existing field of research, i.e. "Economics of Innovation and Technological Change" and to see how parallel paradigms compete and cooperate, thereby also investigating different kinds of relationships between researchers.

Research emerges from a need to explain something in reality that is not well understood. It is usually conducted within scientific communities that evolve in time. As long as a community bases its research on "... one or more past scientific achievements, achievements that some particular scientific community acknowledges for a time as supplying the foundation for its further practice" (Kuhn, 1962, p. 10), research is carried out within one scientific paradigm. This means that this scientific paradigm deals with that rather small part of the world that can be explained based on a set of assumptions (cf. Kuhn, 1962). There is such a strong belief in the explanatory power of the paradigm that new phenomena are usually ignored. Moreover, as students learn from researchers who had learned and based their research on the same paradigm, there is rarely disagreement about the set of received beliefs the paradigm is based on.

Often the emergence of a new paradigm is caused by the fact that large parts of reality are not in line with the results the paradigm predicts, i.e. that many anomalies are not explained by the paradigm. However, according to Kuhn this might not be sufficient for a paradigmatic change, because paradigms are extremely resistant to change. Max Planck made this point even more strongly in his famous remark "Truth never triumphs, only its enemies die".[2] In his opinion, scientific revolutions only take place because the promoters of the old paradigm die, making place for a new paradigm. Kuhn (1962), however, states that if an old paradigm is not able to incorporate severe anomalies or to label them as being only manageable by future generations with appropriate tools, a new paradigm might emerge that competes with the old. This means that when a scientific revolution takes place, the competing scientific communities have to exist in parallel - at least for a while, not the least because researchers of the new scientific community are to a large extent trained in the old scientific community. In the end, we may either see a dominance of the new paradigm, or a fusion between the old and new paradigms, implying at least a major change in the established wisdom.

As already stressed in the introduction above, some would argue that at the beginning of the 1980s a new paradigm –labeled "evolutionary economics" – emerged, whereas the research area was before mainly dominated by economists in the neoclassical tradition. In line with the Kuhnian tradition of Scientific Revolutions, we would expect a clash of opinions between the mainstream and evolutionary streams, but we may also expect convergence between them once ideas are cross-fertilized. Hence, some observers have asserted that the boundaries between the two streams are becoming increasingly fuzzy. Mainstream economists, evolutionary economists and other 'heterodox' economists meet at conferences, publish in similar journals and discuss the same issues. In a number of cases, similar methodologies are used

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2. Our own translation of the original sentence: "Die Wahrheit triumphiert nie, ihre Gegner sterben nur aus."

between the different groups, and similar conclusions are reached. For example, Arnold Heertje (1983) argued:

> "neo-Schumpeterians [i.e., the evolutionary tradition] have been productive in their criticism of the neoclassical scheme on the basis of an evolutionary approach, but the questions they have raised have been addressed more or less successfully by many scholars, who have close links with the neoclassical tradition (…) I would not be surprised to see the present Schumpeterian mood to be part of mainstream economics before the end of this century" (p. 273-275).

Being already at the beginning of this new century, we set out to investigate to what extent evolutionary economics is tied in with more mainstream approaches. Therefore, we start from the assumption that is based on the informal narrative that the research field "economics of innovation and technological change" is in a period of paradigmatic change. Like Kuhn (1962) suggested, the scientific community changes considerably in such a period of competing paradigms. The researchers in such a scientific community have to compete and cooperate with other researchers belonging to the old, new or even other paradigms. Little is known how relationships between researchers in a scientific community with competing paradigms look like. With the help of a survey conducted amongst researchers in this field we try to shed more light on this.

The survey is based on a number of recent (and not so recent) trends in the (sociological) study of science as a process. These new theoretical as well as methodological approaches aim at identifying relationships between researchers. First of all, there is a large literature on bibliometric work, i.e. indicators mapping citations between researchers by using large databases like for example the Social Science Citation Index (SSCI) (cf. e.g. Leydesdorff, 2002 or Gupta et al., 2002). The bibliometric approach is also used in the context of less methodological and more theorizing approaches like the "social network" and the "social capital approach". The "social network" approach is rather broad and investigates the individual and social structure of research networks (cf. e.g. Moody, 2001 or Wasserman and Faust, 1994). The "social capital" approach can be seen as a part of the "social network" approach but with a stronger focus. This focus is on explaining what is going on in networks by looking into the social structure of networks and how investments in this social structure might pay off by getting access to important knowledge (cf. e.g. Burt, 2001, Lin et al., 2001, and Lin, 1999). Both the "social network" and the "social capital" approach are based on the famous distinction between strong and weak ties that was suggested by Granovetter (1972).

To our knowledge the research field "Economics of Innovation and Technological Change" has been mostly analyzed with the help of bibliometrical analysis (cf. e.g.

Granstrand, 1994 or Dachs et al, 2001). We add to this our study based on a survey on relationships, norms and beliefs in the hope that it will help to illuminate new aspects of scientific interaction in the field of the economics of technological change.


## 3. THE SURVEY

To get closer insights into the composition of the broad and diverse group of economists working in the Invisible College of "Innovation and Technological Change", and in particular to find out how the above mentioned paradigms are related, like Crane (1972), we conducted a survey that was done in the research community.[3] The survey takes a distinctly different approach than the bibliometric analyses mentioned above and comes closer to the "social network" and the "social capital" approaches. The survey was conducted among scholars in the field of the economics of innovation and technological change and/or evolutionary economics, and was aimed at mapping the intellectual relations between people active in the field, in a way that has become popular in the field of social network analysis (e.g., Wasserman and Faust, 1994) and social capital (e.g., Lin, 1999).[4] In particular, we interpret the invisible college that we are analyzing as a social network in which both strong and weak ties (Granovetter, 1973) play a role. Following Crane (1972), strong ties (e.g., between PhD student and supervisor, or between co-authors) may be important for the formation of intensive knowledge networks in which the main ideas of a new field are created. Weak ties (e.g., inspiration through the written literature) may be more important for the diffusion of these ideas to a wider research community.

Our survey was set up specifically to identify weak and strong ties. Respondents were asked to list people who had influenced them (see also Table 1). Six categories of people were asked for: the respondent's PhD supervisor, his/her PhD students, his/her co-workers (defined as people working in the same institution), his/her co-authors (outside the respondent's main institution), his/her network contacts (defined as people who the respondent meets regularly at conferences, workshops, etc.) and, finally, his/her sources of inspiration (important scholars whose work the respondent knows, but whom he/she has never met, an important category of this are scholars from the past who are no longer active).

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3. For a full version of the questionnaire see Appendix C, in the electronic version in www.revista-eea.net. http://www.revista-eea.net/coleccion/documentos/21305.pdf

4. The research project on 'The Invisible College' was started at Ecis, Eindhoven University of Technology in the Netherlands in November 2002.

**Table 1: Relationships between researchers and the quality of their ties**

| relationships | inspiration | network | co-authors | co-workers | PhD students | PhD supervisor |
|---|---|---|---|---|---|---|
| Maximum number | 5 | 5 | 5 | 5 | 5 | 1 |
| ties between researchers becoming stronger | | | | | | |

Respondents were asked to list at most five people in each category, with the exception of the PhD supervisor, which could only be one name. Names could be based on the entire career of an individual, not only the state of affairs at the time of the survey. If more than five people qualified for a category, only the five most important persons (in terms of the quality of their contribution) were asked for. The categories were presented in the order mentioned in the text above, where our interpretation is that earlier categories imply stronger links. Our instructions said that if a person qualifies for one category, (s)he could no longer be filled in a later category, even if (s)he was not listed because (s)he was not among the five most important people in the category. In this way, we wanted to force people to report on a broad range of contacts in the continuum of strong links to weak links.[5]

The survey was sent to all people who appeared in the reference list of a recent overview paper of the field (Dosi, Orsenigo and Sylos Labini, 2002). We chose this paper because it is recent, was done by experts in the field and because it refers to work done by researchers from all kinds of backgrounds. As explained above, these people were asked to give the names of researchers with whom they have the aforementioned relationships. We asked for the email addresses of the people listed, but indicated this was optional, i.e. we still wanted to have a name when the email address was unknown or the respondent did not want to give it. For names that were reported without an email address, we did a search for the email address on the Internet. Everybody mentioned in the responses was also sent an invitation to fill in the survey (this corresponds to the name generator mechanism in Lin, 1999). The survey was kept running in this fashion, and the results reported in this paper correspond to the database at 3 March 2003. At this point, there were 2492 names in our database, of which we had sent out invitations to fill in the survey to 1597 persons (we don't have an email address for the remaining persons). 580 responses were obtained (36% of

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5. In general, the respondents understood these instructions, and listed different people under different categories. However, there were also a number of respondents who did not follow the instructions, and listed a single name in more than one category. We cleaned the database for this, and deleted all occurrences of people after the first time. Although this solves the immediate inconsistencies, it does not solve for the fact that the people for whom we deleted names did not have the opportunity to supply new names, and hence these people will generally have less 'weak links' to other people in the database.

the invited people, 23% of the total).[6] The results reported in this paper are based on the database consisting of these 580 respondents, plus 118 additional persons. The majority of the 118 persons consist of deceased scholars who contributed to the area.[7]

## 4. MAPPING THE INVISIBLE COLLEGE

### 4.1. Paradigms in the Invisible College?

At the beginning of the survey, we asked people to answer yes/no to the questions "Do you consider yourself to be an evolutionary economist?"[8] and "Do you consider 'the economics of innovation and technological change' to be a field to which you have contributed or plan to contribute in the near future?". If the answer to both questions was No, the respondent was instructed to submit the survey with only a limited number of questions (regarding affiliation and PhD degree, including supervisor). We consider these respondents as 'outsiders' to the invisible college we are investigating, although they obviously did have an impact on the field. Thus, we define the boundaries of the college on the basis of this question. The 'outsiders' are included in the analysis below (unless otherwise stated), but they were not able to generate new names on the list of respondents[9] (and thus they can only be listed, and not list other people).

Table 2 reports on the answers to the two main introductory questions. Almost three quarters of the respondents (72.1%) reports to have an interest in the economics of innovation and technological change. Since the survey was specifically aimed at this field, this high percentage is not surprising. One third of the respondents (33.8%) consider themselves as evolutionary economists. About one quarter of the respondents (24.1) falls in the 'outsider' category that we defined above.

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6. By excluding the people who did not (yet) respond to the survey, we miss an important part of the research community in the field. However, because these people did not respond, they will, on average, have much less (compared to actual respondents) links to other people in the database, simply because they could not list, but only could be listed. This is why we decided to exclude these people from the database. The consequence is that our database does not give a complete mapping of the invisible college. However, with the response rate of 36%/23%, we still have a good sample of the field, and there seems to be no indication of a particular non-response bias. Thus we may consider a map of the invisible college based on our database as a reasonable approximation of the actual research community.
7. A few (less than 10) of the 118 persons concerns persons who indicated they did not want to participate in the survey.
8 We did not provide a definition of 'evolutionary economics', and left it to the respondent him/herself to define the concept appropriately.
9. The only exception are their PhD supervisors, to whom we also send questionnaires.

**Table 2: Interest in technology/innovation vs. evolutionary economics**

|  |  | *Interested in innovation and technological change* | | | |
|---|---|---|---|---|---|
|  |  | *Missing* | *No* | *Yes* | *Total* |
| Evolutionary economist | Missing | 5 (0.9%) |  | 9 (1.6%) | 14 (2.4%) |
|  | No | 2 (0.3%) | 140 (24.1%) | 228 (39.3%) | 370 (63.8%) |
|  | Yes |  | 15 (2.6%) | 181 (31.2%) | 196 (33.8%) |
|  | Total | 7 (1.2%) | 155 (26.7%) | 418 (72.1%) | 580 (100%) |

In the third column, we see that within the broad research community on the economics of innovation and technology, the group of economists that considers themselves as evolutionary economists make up 43%. This is in fact a rather large minority. Although our sample of economists not particularly interested in technology (in the second column) is rather small (and biased), it is clear that evolutionary economists are well represented in the economics and 'technology field'. On the basis of the history of the field (briefly outlined in the introduction above), this is not surprising.

To get an idea how research on "economics of innovation and technological change" is distributed spatially over the world and how it is linked, we asked the respondents about the institutes related to this kind of research. Therefore, the following question was asked: "In case you regularly (on average at least once every two years) visit other institutes (in your own country or abroad) supporting the research areas 'the economics of innovation and technological change' and/or 'evolutionary economics', please list the names of the institutes (universities, research centers, etc,) and countries in which they are based (most important first)." Each respondent could list at most five different institutions in the answer to this question.[10] Figure 1 reports the number of times an institution was mentioned.[11]

For an insider in the field, there will be little surprises in terms of the names that appear on the list of most-often mentioned institutes. What is interesting to note, however, is that the institutes mentioned most often all seem to carry an evolutionary

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10. All answers to the question were pooled together, without taking account at which rank an institution was listed. The figure only lists institutes mentioned more than 4 times. Where only place names are mentioned, this refers to the university with the same name. In determining which units to choose as an institution, some arbitrary judgment had to be made. The procedures used to standardize the affiliations are described in the Appendix A. The most obvious case where our arbitrary procedure for defining what an institution is, is the Manchester area: We have three different institutes from Manchester in the list.

11. The results in Figure 1 should not be taken as an indicator of quality of research. It seems reasonable to assume that the institutes on the list generally perform high-quality research, but this may also hold for institutes not featured on the list.

**Figure 1: Regularly visited institutes**
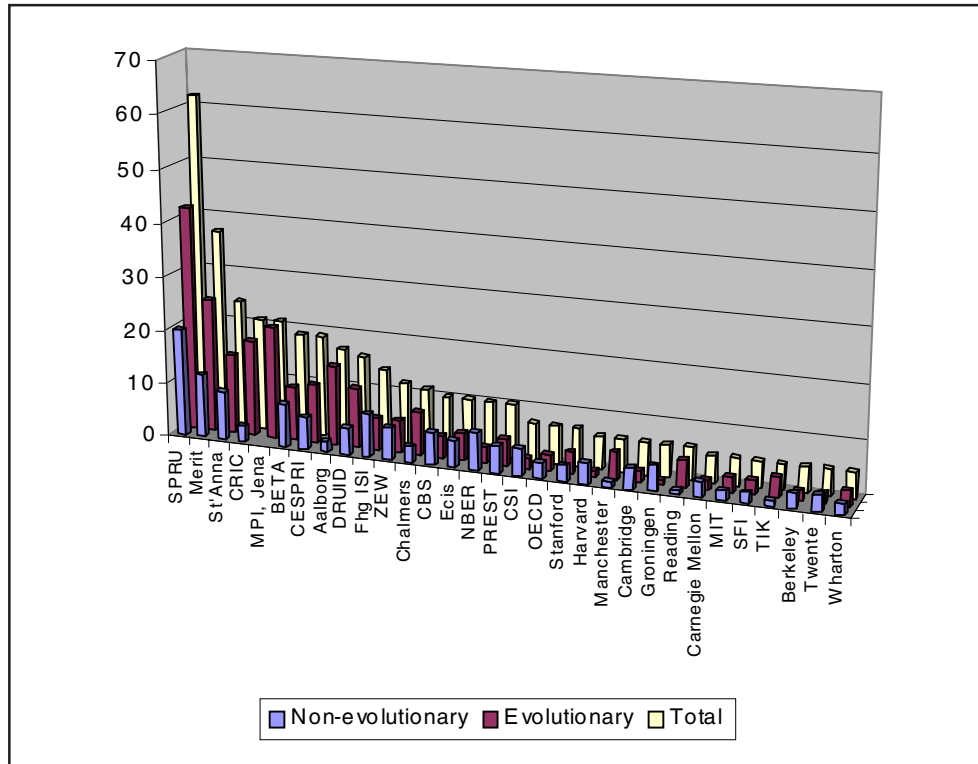


signature. The first nine institutes are all more often mentioned by evolutionary scholars, although this group is a minority (see Table 2). For the non-evolutionary scholars, the tendency seems to be to spread the answers to this question over more institutes. However, the dividing line between evolutionary and non-evolutionary scholars is not very strong: all except one are mentioned by both categories of scholars. The Max Planck Institute in Jena was only mentioned by evolutionary economists; the University of Aalborg and the institutes in Manchester are also mentioned relatively more often by evolutionary scholars.

To get an idea where the research results in the invisible college are diffused and noticed best, we asked the respondents about their perception of the most important journals in the field. The first question was phrased as follows but leave in the: "Which academic journals do you consider CURRENTLY to be the best outlet for work on 'evolutionary economics' or 'the economics of innovation and technological change' (most important first)?". The question allowed up to five possible answers. It seems to be likely that with the development of a research field also the journals in which one can find research results change in time. We therefore asked the same question for the period before 1985. This date was chosen, because there seems to be some

*Figure 2: Journals most often mentioned as best outlet for work before 1985*
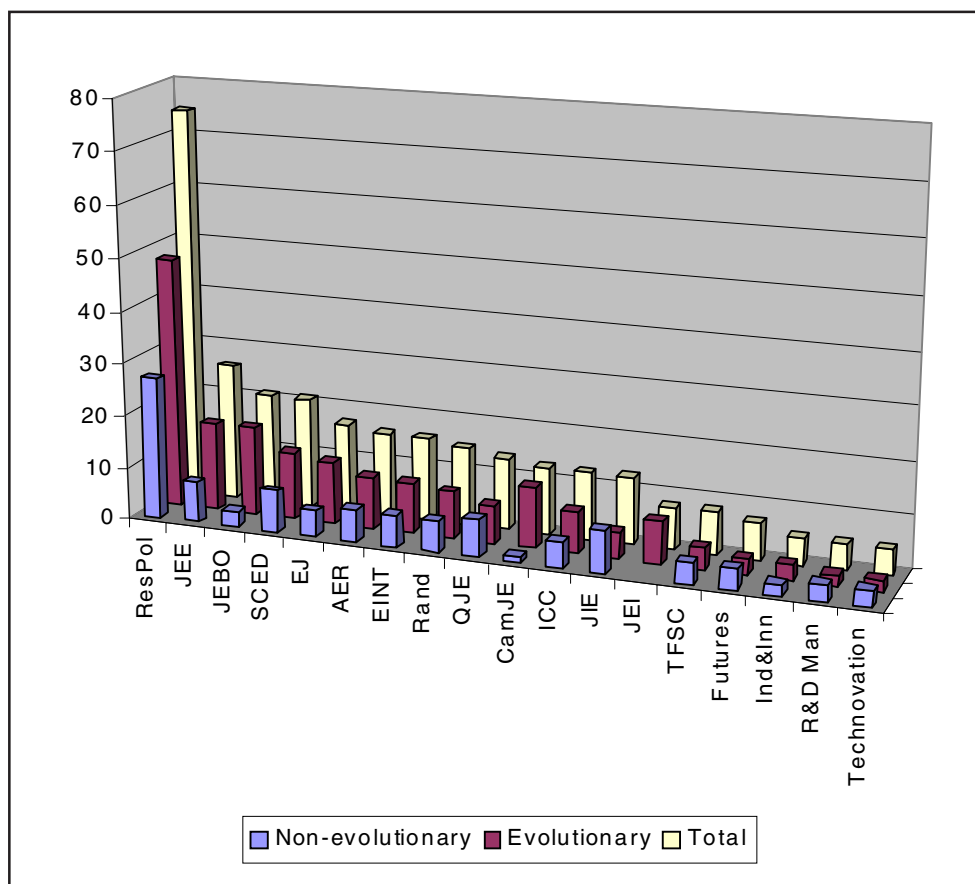


agreement that evolutionary economics emerged in the first half of the 1980s as a competing paradigm for the stream routed in "neoclassical economics". The question was posed as follows: "Which academic journals did you consider to be the best outlet for work on 'evolutionary economics' or 'the economics of innovation and technological change' (most important first) BEFORE 1985? (If you feel too young to have an informed opinion, please leave open this question)".

Considerable changes have taken place over the last two decades, in particular that specialized journals in the field have become much more important for diffusing research results.[12] The first thing that is obvious is the same tendency that was observed above for evolutionary scholars to be more outspoken. The non-evolutionary scholars

12. We collect the answers to these questions in the same way as was done before for the case of institutions. Figure 2 lists the results for the period before 1985 that were mentioned more than 4 times. For the journal abbreviation index see Appendix B.

**Figure 3: Journals most often mentioned as best current outlet for work**
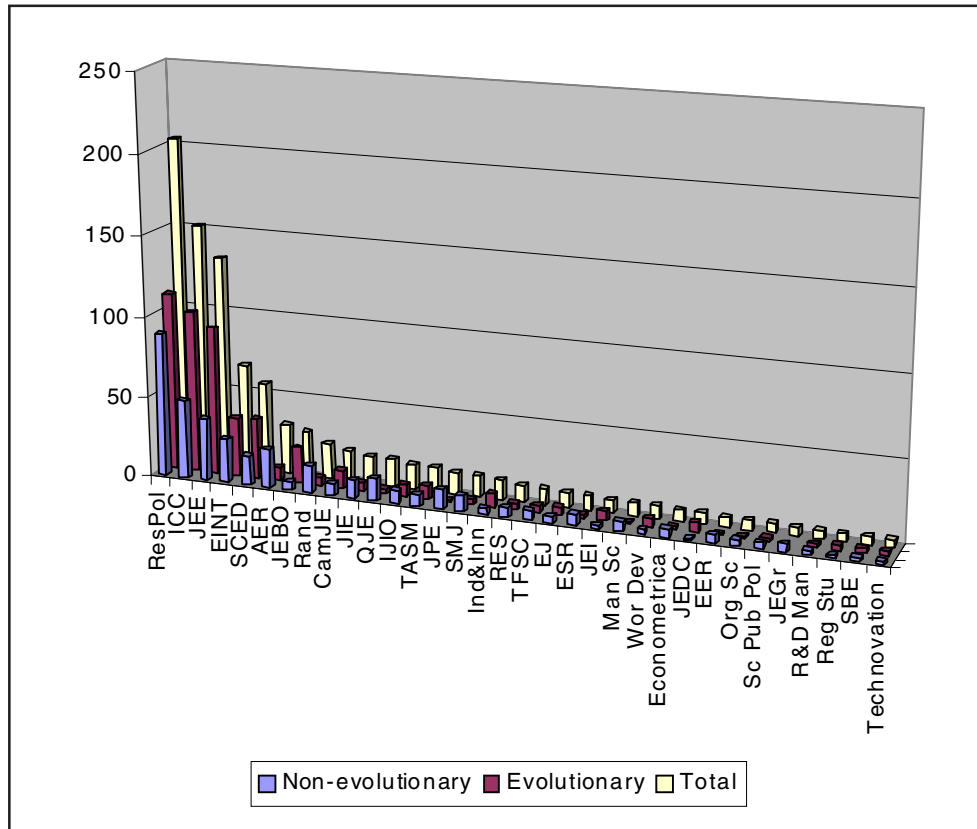


spread their answers over a larger range of journals, leading to the result that no journal scores particularly high within the group of non-evolutionary scholars. Research Policy (ResPol) is somewhat of an exception as a journal that clearly stands out within the non-evolutionary group. In fact, Research Policy stands out in the total group of respondents as the single most important journal before 1985.

Other journals listed often are a mix of new journals (Journal of Evolutionary Economics, JEE; Structural Change and Economic Dynamics, SCED; Economics of Innovation and New Technology, EINT; Industrial and Corporate Change, ICC), established top-journals in economics, which cover a wide perspective that is certainly much broader than just the topics addressed by our group of respondents (these include American Economic Review, AER; Economic Journal, EJ; Quarterly Journal of Economics, QJE; Cambridge Journal of Economics, CamJE; Rand Journal[13]), as well as journals that are clearly not pure economics journals but do focus on innovation

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13. We include its predecessor The Bell Journal under this heading.

and technology (Technological Forecasting and Social Change, TFSC; Futures; Technovation).

The set of journals found for the question for the period after 1985 is larger (Figure 3). Research Policy is still at the top of the list, with a large lead over the runners-up. The next four positions in the list are taken by the four new journals mentioned above. It thus appears these journals have quickly found a niche in the field of innovation and technological change. They are now also recognized by non-evolutionary scholars in the field, although evolutionary scholars are their largest support group. Taking into account this top-5 of journals in the field, the tendency for non-evolutionary scholars to be less outspoken than evolutionary scholars seems to disappear somewhat. Most of the other journals from Figure 2 are again present here, and some new journals appear (most notably International Journal of Industrial Organization, IJIO; Technology Analysis and Strategic Management, TASM; Journal of Political Economy, JPE and Strategic Management Journal, SMJ). The journal Futures disappears.

## 4.2. Paradigms and the Nature of the Relationships Between Researchers in the Invisible College

The lists of people in the responses to the questionnaire were used to build a network matrix. This matrix has the individuals in our group of 698 (see above) persons in the rows and columns. When a link between two people exists, i.e., they have mentioned each other in the survey, we add a 1 in the matrix cell, otherwise there is a 0. Although this matrix is in principle non-symmetric (person A may mention person B, but not vice versa), we will often make the matrix symmetric by taking the maximum of the cells (i,j) and (j,i). In other words, we assume that a network link between two people exists even if only one of them reports the links.

In this way, we can build various matrices, depending on which type of links (on the scale strong to weak ties) we take into account. In this paper, we will only work with *cumulative* links, as in Table 3. In the last column of this table, we have results for a network based on only links between PhD supervisor and PhD student. The second-last column includes all links in the previous (last) column, plus links between co-workers (colleagues in the same institution). The third-last column is based on a network including all links in the previous columns, plus links between co-authors (outside the respondent's own institution), etc., until in the first column we have a network based on all types of links between respondents.

Table 3 reports some rough measures for some of the characteristics of the network. The first one, largest connected component, starts from the concept of a network component, which is defined as a subset of the network in which every network member 'can be reached' from every other network member by successive links between people. To see how this works, imagine a network respondent was asked to

transmit a red piece of paper to all the people she listed in our survey, plus the people who listed her. The receivers of the piece of paper are asked to do the same. The 'largest' component in Table 4 measures the number of people who would have received a red piece of paper after it has diffused completely.

In case of the complete database (top part of the table), we use all people in the group of 698. In the case of 'only declared evolutionary scholars', we delete from the network everybody who did not answer 'yes' to the question 'Do you consider yourself to be an evolutionary economist'. When we move left-to-right in the table, network links in a specific category of ties (weak or strong) are deleted. Naturally, this makes it harder to 'reach' other people in the network, and hence the size of the largest component decreases. In fact, what happens is that the network breaks up in a number of smaller components. We report only the size of the largest of these. This largest component is in all cases significantly larger than the next-largest component, even in the rightmost column.

**Table 3. Network properties of the Invisible College at various network 'layers'**

|  | All relations | Excl. "Inspiration" | Excl. "Network" | Excl. "Co-authors" | Excl. Co-workers |
|---|---|---|---|---|---|
| Complete database (n=698) | | | | | |
| Largest connected component* | 673 (100.0) | 604 (89.7) | 518 (77.0) | 322 (47.8) | 63 (9.4) |
| Network density** | 0.0053 (0.0726) | 0.0035 (0.0592) | 0.0025 (0.0496) | 0.0017 (0.0415) | 0.0007 (0.0262) |
| Clustering coefficient*** | 0.171 (0.077) | 0.207 (0.113) | 0.188 (0.127) | 0.194 (0.152) | 0.062 (0.030) |
| Only declared evolutionary scholars (n=196) | | | | | |
| Largest connected component* | 179 (100.0) | 166 (92.7) | 144 (80.4) | 109 (60.9) | 28 (15.6) |
| Network density** | 0.0199 (0.1395) | 0.0150 (0.1215) | 0.0100 (0.0993) | 0.0070 (0.0836) | 0.0023 (0.0482) |
| Clustering coefficient*** | 0.259 (0.100) | 0.249 (0.129) | 0.237 (0.156) | 0.296 (0.194) | 0.059 (0.033) |

*\* Between brackets is the size of the component as a percentage of the size of the component in the first column. The last line indicates the size of the largest component in the evolutionary network as a percentage of that in the total network.*
*\*\* Between brackets is the standard deviation.*
*\*\*\* Without brackets: unweighted average over network; between brackets: average weighted by degree.*

For the complete database, the largest drop in the number of respondents still in the largest component happens when we delete co-authors (outside the own institution) links (a drop from 77.0% to 47.8%) and when we delete co-workers links (47.8% to 9.4%). The size of the largest component at these levels is still rather large: of the 673

people in the largest component based on all links, about half are linked to each other, albeit often indirectly, through a co-worker relation. This shows that both strong and weak ties play an important role in holding together the invisible college.

Looking at the largest component for the subgroup of evolutionary scholars, what is most notable is that strong ties are relatively more important than weak ties, as compared to the network as a whole. At the level of PhD supervisor/student relations, 15% of the largest component based on all ties is still held together, which is almost twice as much as for the total network. At the level of co-workers, the difference is still striking: 60.9% of the evolutionary group is held together by relations of this type, vs. 47.8% for the network as whole. We may thus conclude that compared to the rest of the invisible college we are analyzing, the evolutionary subgroup is a (large) minority of which the members have invested heavily in strong links between them.

The next measure, network density, gives the total number of links in the network as a fraction of all potential links. We see here that the network is rather sparse: less than 1% of all potential links is actually present for the whole group. Density falls monotonically when the network becomes smaller as the number of different relations taken into consideration becomes smaller. For the evolutionary group, network density is higher in every column, indicating a network that is more closely tied than the College as a whole.

The final indicator measures clustering, or the overlap in local environments. At the level of single network member, clustering is defined as the density of the network consisting of those network members to whom she is directly linked. The overall network clustering coefficient is obtained by averaging this over all network members, either non-weighted or weighted by degree. We observe a clustering coefficient for the total network that oscillates with different network layers, although for the smallest network (only PhD relations), it is very low. For the subgroup of evolutionary scholars, it is again always higher than for the total network, indicating the more clustered nature of this part of the network.

In order to visualize the network structure more clearly, we plot the total network in its 5 layers and discuss the structure. In the pictures below, each of the colored dots represents a network member, lines between dots represent reported links. Most lines are not visible because of cluttering in the picture. The total of 698 members is an upper limit to the number of colored dots, because we omit isolated (non-connected) members. The different colors represent different types of network members, according to the answer to the two first questions (Yes/No Evolutionary and Yes/No Worked on technology). The network layout was obtained using a Gower metric scaling method in UCINET 6.0. The input data is the binary matrix of relations described before. This method aims to plot those network members close together who have intense relations, either directly, or through other network members. However, the method is impressionistic, and at the level of individual network members, positions may be subject to significant stress (mismatch between true distances and distances in the 2-dimensional plane).

**Figure 4. Structure for the Invisible College based on all types of relations**
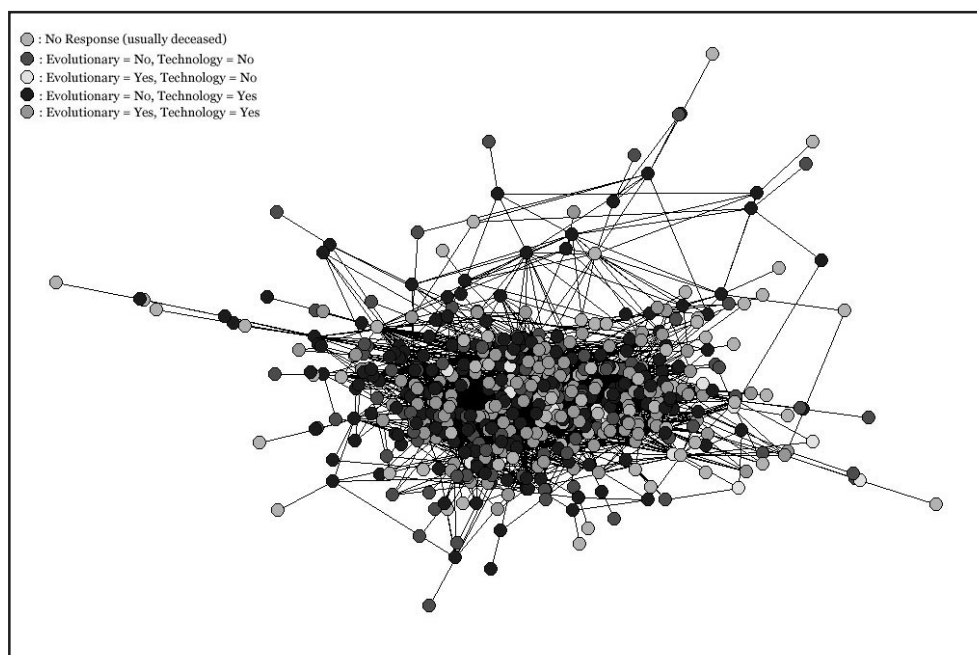*(colours visualized in <u>http://www.revista-eea.net/coleccion/documentos/21305.pdf</u> )*



Figure 4 gives the structure for all relations. Network members who did not respond themselves but where only mentioned by others,[14] and network members who indicated they did not belong to the Invisible College (and hence did not list any links to others) have a tendency to appear more at the periphery of the figure. This is, of course, perfectly understandable, because by the very nature of their response, these network members are less well-connected than the other network members.

The core of the network is thus made up of a large group of people, both evolutionary and not, as well as a smaller number of 'outsiders' or deceased scholars. Looking at the differences between evolutionary and non-evolutionary scholars, we see that the number of non-evolutionary scholars at the periphery is somewhat larger, or, in other words, that evolutionary scholars have a tendency to be closer to the core. This is obviously connected to the previously observed tendency that evolutionary scholars form a more dense and clustered network. Within the core, there seems to be a weak separation between evolutionary scholars (who appear more frequently on the right) and non-evolutionary scholars (who appear more frequently on the left).

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14. Remember that this includes mostly scholars who were no longer alive at the time of the survey, but also some who indicated they did not want to participate.

This is also related to the result that evolutionary scholars not interested in technology (yellow dots) appear more frequently on the right, at least those of this subgroup that are not in the core.

***Figure 5. Structure for the Invisible College based on all types of relations except "inspiration"***
***(colours visualized in http://www.revista-eea.net/coleccion/documentos/21305.pdf )***
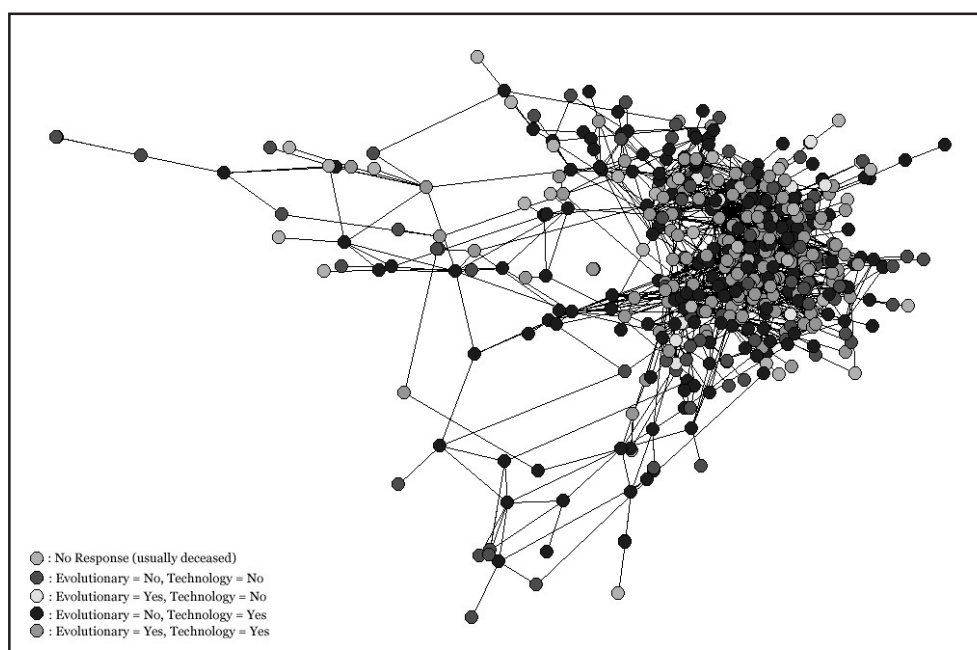


Omitting the highest layer of relations, i.e., relations just based on inspiration without personal relationships, changes the picture quite a bit (Figure 5). What remains is a dense core or network members consisting of evolutionary and non-evolutionary scholars, but also, perhaps surprisingly so, a large number of 'outsiders'. The frequency of deceased scholars is now much less, because many of the relationships with these network members obviously are of a non-personal nature. What is different from the previous picture though, is that the core now carries a trail of more peripheral scholars on only one side. There is clearly a front- and back end to the Invisible College here, suggesting that it is a specific part of the core that is responsible for communication with the 'outside world'. In the 'peripheral trail itself, there is a clear separation between lines with relatively many similarly colored dots.

Now we look at the network structure based on the previous layers minus relations of the network type, thereby skipping all weak ties. The network depicted in Figure 6 is based on PhD supervisor relationships as well on relationships between co-workers

and external co-authors. These relationships require interaction over a longer period of time. Therefore, it is reasonable to assume that all relationships in this and the following figures represent strong ties. The core and peripheral trails of Figure 5 are still visible in Figure 6, although chains of peripheral network members emerge at more sides of the core than just the 'back' as in Figure 5. Due to the lesser amount of relationships, the graph now becomes less densely populated with links, something that is especially noticeable in the peripheral parts of the network. In this periphery, we now observe mainly chain-formed relationships, and triangular relationships are sparse. Still, dots of similar color cluster together outside the core. Inside the core, there are now less 'outsiders', and a separation between evolutionary (bottom) and non-evolutionary (top) core members is emerging.

***Figure 6: Network structure for the Invisible College based on all previous types of relations except "network"***
*(colours visualized in <u>http://www.revista-eea.net/coleccion/documentos/21305.pdf</u> )*
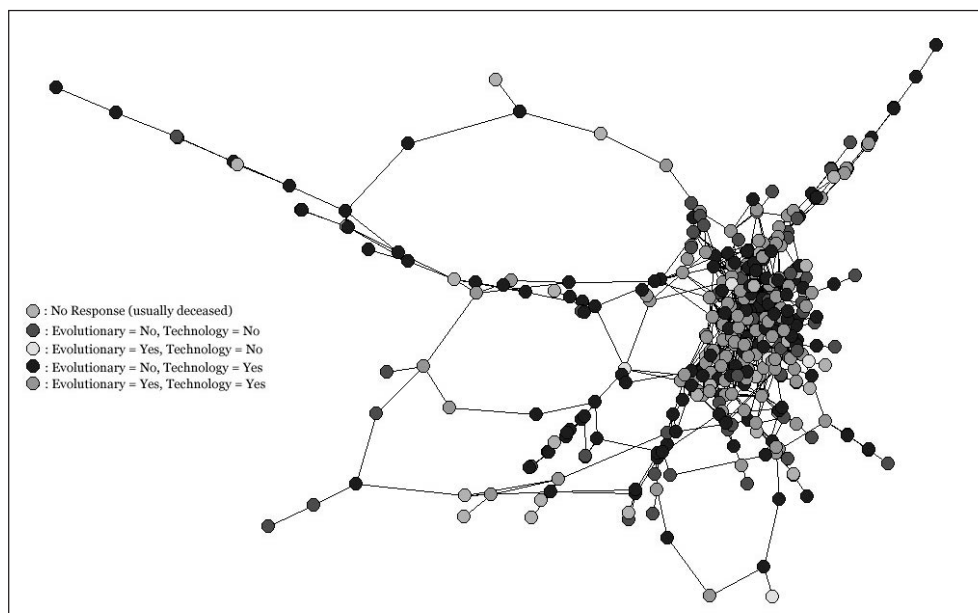


Figure 7 deletes the next network layer, i.e., external co-author relationships. Thus, we now have a network based solely on relationships between people who have worked in the same institute at some point in their career. Despite this restrictive criterion, the network is still quite large. The picture looks quite different, but much of the difference is due to an approximate 90º counter-clockwise rotation, something that may result arbitrarily in the plotting procedure but does not have much 'real' meaning. In addition to this, the most obvious changes are twofold. First, we now have many peripheral

trails emerging from the core, but these hardly interact at all. All the peripheral trails are now non-interacting chains, with only a very few exceptions. Second, the proportion of 'outsiders' in the core is now very low. Thus, while 'outsiders' play an important role in the core of the Invisible College, they mainly do so by inspiration, networking and co-authoring, but not in terms of actually being employed together with the core members of the College.

*Figure 7: Network structure for the Invisible College based on all previous relations except «external co-authors»*
*(colours visualized in http://www.revista-eea.net/coleccion/documentos/21305.pdf )*



    ○ : No Response (usually deceased)
    ● : Evolutionary = No, Technology = No
    ○ : Evolutionary = Yes, Technology = No
    ● : Evolutionary = No, Technology = Yes
    ● : Evolutionary = Yes, Technology = Yes

For the sake of completeness, we document in Figure 8 the last layer of the network, which consists only of relations based on PhD student-supervisor relationships. This is a fairly small network, which consists of two chains of members (one long, one shorter). In the longer chain, one can clearly discern an evolutionary half (right) and a non-evolutionary half (left), although the separation is obviously not complete.

### 4.3. Identities in the Invisible College

The descriptive material thus far clearly suggests that within the group of respondents to our survey, there is a clear core group of researchers that interacts strongly with each other, as well as a suggestion of a divide between evolutionary and non-evolutionary scholars (the latter becomes visible in the way these two groups

***Figure 8. Network structure for the Invisible College based on all types of relations
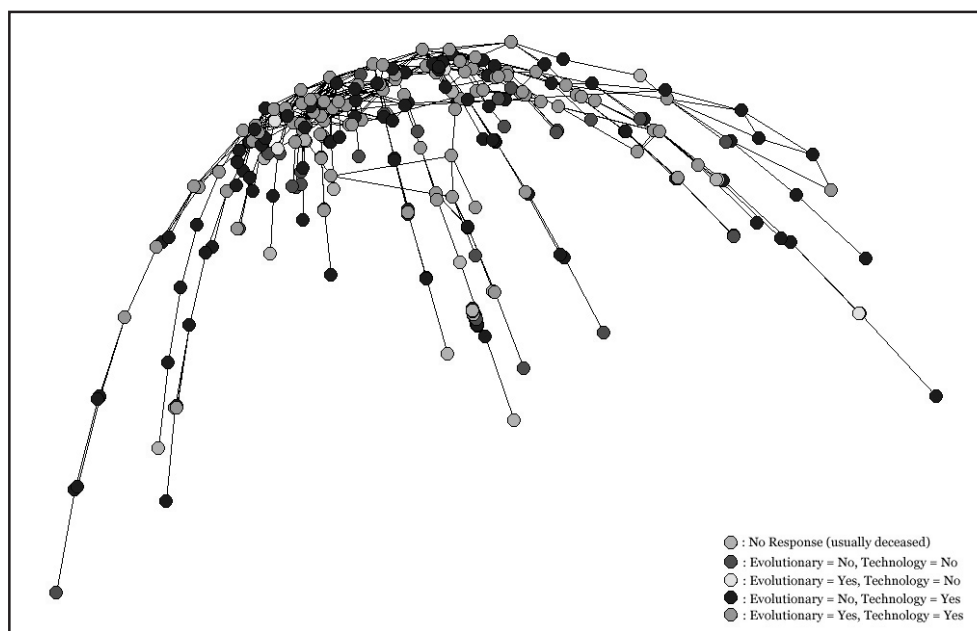except "co-workers"***
***(colours visualized in http://www.revista-eea.net/coleccion/documentos/21305.pdf )***
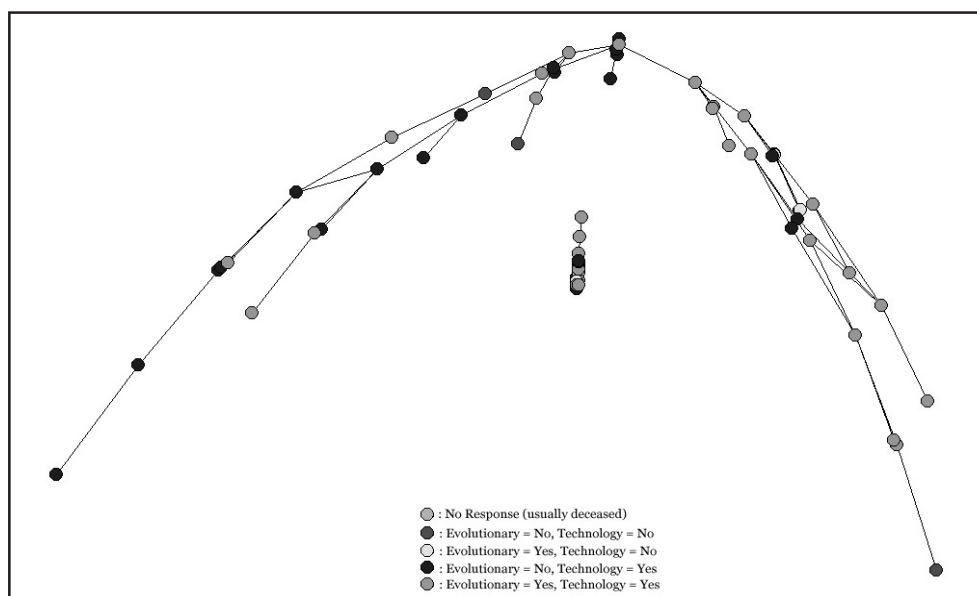


look at certain issues). In this section we undertake a more formal statistical analysis to investigate how these two factors (relationships between researchers and shared evolutionary/non-evolutionary background) impact on the opinions they form and share about the field of study.

The respondents' judgment about journals and centers of activity (see Section 4.1) can serve as a basis to assess the degree of common understanding - in particular concerning where to publish and where to look for ideas developed within the invisible college. Therefore, we investigate whether network connections or the identification as a (non-)evolutionary economist plays any role in this context. To this end, we use the answers to the three questions that we have already analyzed, i.e. the opinions on journals ('old' and 'new') and centers of activities important to visit. We will use the answers to these three questions to construct a bilateral measure of shared opinion between any two scholars in our network (limited, of course, to those who answered the relevant questions).

We express the agreement of two respondents on the answer to each of the three questions as the number of answers they both listed.[15] This yields an integer number

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15. For example, in the question about journals, they could both list Research Policy and have no other common journals. This would yield a score of 1.

in the interval [0.0.5]. These numbers can be expressed in a square symmetric matrix, of which we exclude the diagonal from the analysis. The matrix is used in a statistical analysis using the so-called QAP regression technique (Krackhardt, 1988). In this technique, the above constructed agreement variable is the dependent variable. A number of other variables are entered in the regression as predictors of the agreement variable.[16] First, we use the survey data on ties (weak or strong) between people as one independent variable (see Section 3, Table 1). This data consists of the same binary matrices that were used to construct the network plots above. Five different regressions will be documented, one for each of the five different network layers (weak to strong ties). Two additional explanatory variables are dummy variables based on the distinction between evolutionary and non-evolutionary respondents. One dummy equals 1 if both respondents report to be evolutionary economists, and another one equals 1 if both respondents report to be non-evolutionary economists. Because we do not have any answers on the agreement questions for respondents who filled in "No" to our two initial questions, we have to exclude these respondents from the analysis. This leaves us 433 respondents that can be included in the QAP regressions.

Based on informal theorizing, we expect that all independent variables have a positive sign. For the network relationship variables, this is based on the expectation that more frequent interaction between people will increase the likelihood that they share opinions. More specifically, we expect that stronger ties have a higher impact (larger coefficient). We also expect that researchers belonging to the same paradigm (i.e., the dummy variables) will more likely agree on the importance of journals, and hence that both dummy variables will have a positive sign.

The results for shared opinions about current academic journals are in Table 4. All three explanatory variables are highly significant as indicated by the p-values. The network variables all have positive signs, as expected: ties between two respondents increase the likelihood of agreement in opinions. However, there are no very systematic differences between weak or strong ties. The highest coefficient is found for all ties included except "frame of reference". This result makes sense: the frame of reference category of people is defined as people whom the respondent does not know (very well) personally, so a link of this nature is unlikely to have an impact on shared opinions.

The dummy variable that indicates that both people are evolutionary economists has a positive sign, as expected. This indicates that evolutionary scholars tend to share opinions about journals. The sign for the other dummy variable is negative, however, which is against expectations. This seems to indicate that the group of non-evolutionary scholars in the survey is indeed a rather heterogeneous group, in which

16. QAP regression differs from OLS in the calculation of the standard errors of the estimated coefficients, which have to be obtained through simulation based on permutations of rows and columns in the dependent variable matrix. We perform 2000 permutations in each regression.

opinions differ more than within the homogenous group of evolutionary economists. The result could also be due to the fact that there are only a few specialized journals that serve the evolutionary community, while there is a larger set of journals to choose from if one is not committed to evolutionary analysis. Finally, it is notable that both the network variables and the "evolutionary Yes dummy" have high explanatory power as compared with the mean value of the dependent variable.

Table 5 reports the same regressions for shared opinions on the importance of academic journals before 1985. The mean of the dependent variable is much lower than for current journals, as many respondents do not list any journals for the period before 1985. This is reflected in the lower value of the intercept. Still, all variables are significant. The signs of the coefficients and the other patterns are the same as in Table 4. The network variables again have a positive impact, with the highest coefficient resulting for all ties expect the "frame of reference" category. Again, two evolutionary respondents agree to a relatively large extent, while to non-evolutionary respondents tend to disagree more.

**Table 4. QAP regressions, dependent variable shared opinion on current important journals**

|            | (1)            | (2)            | (3)            | (4)            | (5)            |
|------------|----------------|----------------|----------------|----------------|----------------|
| Intercept  | 0.564          | 0.565          | 0.567          | 0.567          | 0.569          |
| All ties   | 0.768 (0.000)  |                |                |                |                |
| Ex Refr    |                | 0.849 (0.000)  |                |                |                |
| Ex Netw    |                |                | 0.803 (0.000)  |                |                |
| Ex Coaut   |                |                |                | 0.829 (0.000)  |                |
| Ex Cowo    |                |                |                |                | 0.808 (0.000)  |
| ShEvol Y   | 0.580 (0.000)  | 0.582 (0.000)  | 0.584 (0.000)  | 0.586 (0.000)  | 0.588 (0.000)  |
| ShEvol N   | -0.234 (0.000) | -0.235 (0.000) | -0.235 (0.000) | -0.234 (0.000) | -0.234 (0.000) |
| R2         | 0.106          | 0.106          | 0.103          | 0.102          | 0.100          |

p-values in brackets; mean of dependent variable = 0.62.

**Table 5: QAP regressions, dependent var. shared opinion on important journals before 1985**

|            | (1)            | (2)            | (3)            | (4)            | (5)            |
|------------|----------------|----------------|----------------|----------------|----------------|
| Intercept  | 0.020          | 0.020          | 0.020          | 0.020          | 0.021          |
| All ties   | 0.081 (0.000)  |                |                |                |                |
| Ex Refr    |                | 0.088 (0.000)  |                |                |                |
| Ex Netw    |                |                | 0.068 (0.000)  |                |                |
| Ex Coaut   |                |                |                | 0.071 (0.000)  |                |
| Ex Cowo    |                |                |                |                | 0.061 (0.000)  |
| ShEvol Y   | 0.029 (0.000)  | 0.030 (0.001)  | 0.030 (0.000)  | 0.030 (0.000)  | 0.030 (0.000)  |
| ShEvol N   | -0.011 (0.005) | -0.011 (0.006) | -0.011 (0.006) | -0.011 (0.004) | -0.011 (0.004) |
| R2         | 0.010          | 0.010          | 0.009          | 0.008          | 0.008          |

p-values in brackets; mean of dependent variable = 0.02.

**Table 6. QAP regressions, dependent variable shared opinion on places often visited**

|  | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Intercept | 0.039 | 0.039 | 0.039 | 0.040 | 0.040 |
| All ties | 0.233 (0.000) |  |  |  |  |
| Ex Refr |  | 0.254 (0.000) |  |  |  |
| Ex Netw |  |  | 0.242 (0.000) |  |  |
| Ex Coaut |  |  |  | 0.228 (0.000) |  |
| Ex Cowo |  |  |  |  | 0.199 (0.000) |
| ShEvol Y | 0.064 (0.000) | 0.065 (0.000) | 0.066 (0.000) | 0.066 (0.000) | 0.067 (0.000) |
| ShEvol N | -0.020 (0.001) | -0.020 (0.000) | -0.021 (0.000) | -0.020 (0.002) | -0.020 (0.001) |
| R2 | 0.027 | 0.026 | 0.023 | 0.021 | 0.018 |

p-values in brackets; mean of dependent variable = 0.05.

Table 6 reports the results for the question about which places are often visited. The results are in line with the questions on academic journals. Network variables are all positive and significant, with the highest value again for the category of links that excludes the weakest links. Evolutionary economists tend to agree more, non-evolutionary economists less.

Concluding, the results indicate that the subset of evolutionary scholars in our database is a relatively homogenous group in terms of their opinions about important academic journals, or which places are important to visit often. This indicates that there is indeed such a thing as an 'identity' of the evolutionary community within the invisible college. The other researchers contributing to this invisible college do not seem to have such a clear identity, a finding that must be interpreted with some care (as will be done in the next, concluding, section).

## 6. CONCLUSIONS

In this paper, we have reported on a survey undertaken among economists working in the field of "economics of innovation and technological change" and/or "evolutionary economics". The main aim of the survey was to outline the intellectual relations that exist between scholars in the field. The paper was aimed at providing a first descriptive interpretation of the main results of the survey. Our main conclusion is that we observe a split between different streams in the research community under consideration, related to fundamental issues about the approach to use. More specifically, those scholars who label themselves as 'evolutionary economists' seem to emerge as a sub-community. The evolutionary group is characterized by several findings from the database.

First, the group of evolutionary economists has invested relatively strongly in strong ties between them. As compared to the non-evolutionary part of our respondents database, evolutionary economists span a relatively wide circle based on co-worker

relationships. Second, the evolutionary and non-evolutionary scholars emerge as somewhat separate clusters in the maps of the research community that we have drawn. The maps also show, however, that the separation is far from complete, or, in other words, that there is significant interaction between scholars from the two groups shows nicely that although scholars from two paradigms compete, they also cooperate and draw on the expertise from one another. By and large, however, the groups remain observable as separate entities.

Third, evolutionary scholars seem to share to a larger extent than non-evolutionary scholars the same opinions about important journals and centers of activity. Their 'votes' for what is important are concentrated on a smaller number of journals/places, and QAP regressions show that a shared evolutionary label increases the tendency to share opinions in this respect. Thus, evolutionary economics seems to be a useful label to identify a specific group of scholars in the field. In addition to a shared evolutionary view, whether or not two respondents reported links with each other also seems to matter for shared opinions (having links leads to a higher agreement in opinions). Although these specific results from the QAP regression are in accordance with our expectations, they have important implications. For example, in research assessment exercises used in various countries, the 'quality' of journals is still largely based on mainstream opinions. For evolutionary economists, who according to our results put their main trust in relatively new and specialized journals, this implies that the main journals they favour are undervalued.

As a caveat to these results, we should point out that the way in which we set up our survey may have biased the results in this respect. We distinguish the two groups in the community by means of the answer to the question 'Do you consider yourself to be an evolutionary economist?'. While our results show that a Yes to this question certainly identifies people in a certain sense, one cannot of course assume that a No does so to an equal extent. The No answer may have been given by a widely varying group of scholars, and we don't know whether this heterogeneous group may consist of relatively coherent subgroups. Had we asked the question differently (e.g., 'Do you consider yourself to be a neoclassical economist?'), we might have found similar results for the specific group targeted by this question (in the example, neoclassical economists).

Thus, at this stage, we can only take our results as a confirmation of evolutionary economics as a subgroup with an identity of its own, and not as evidence of the absence of an identity of non-evolutionary economists. Neither do our results tell us whether the evolutionary vs non-evolutionary divide is the most useful one that can be made. It is our aim to elaborate in the direction of obtaining more positive conclusions in this respect, both by investigating the network data in more detail (for example, by searching for so-called cohesive subgroups), and by collecting other data. Specifically, it is our aim to complement the data of the survey with bibliometric data. Further analytical work along these lines is envisaged in future papers.

## GRATITUDE

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## APPENDIX A: RULES TO STANDARDIZE AFFILIATIONS

Some general cases emerge. The first of these is when a research institute is part of a larger institution, such as a university. In this case, the classification used was based on what the majority of respondents filled in. This resulted in a number of research institutes being listed separately, while a number of other institutes were merged into the "mother institutions" (university). The most important research institutes that remained separately are the following ones:

- Merit, Maastricht University: the majority of respondents listed "Merit", possibly in combination with "Maastricht University" or "Maastricht". Almost never was "Maastricht University" mentioned without "Merit". The few cases (<5) in which this happened were classified as "Merit".
- CESPRI, Bocconi University. Most respondents mentioned "Bocconi University", without CESPRI, a minority mentioned also "CESPRI". We noticed, however, that a large number of the "Bocconi" respondents were indeed associated with CESPRI, and hence we label the entire category as CESPRI.
- DRUID. This Danish institute is a "join venture" between two universities: Aalborg University and the Copenhagen Business School. Many variants were found in this case. Most often people mentioned either one of the two "mother institutes". Some times this was done in combination with the word "DRUID". Also, sometimes just "DRUID" was mentioned. We decided to treat the two mother institutes and the joint venture as three separate units. Whenever one of the two mother institutes was mentioned, this was used, if only DRUID was mentioned, we used this.
- The Manchester institutes: CRIC, PREST, UMIST and their mother institute the University of Manchester, and the Manchester Metropolitan University. These occurred all five, in about equal numbers. This is why we treated them all separately.

**APPENDIX B:**
**LIST OF ABBREVIATIONS USED FOR JOURNALS**
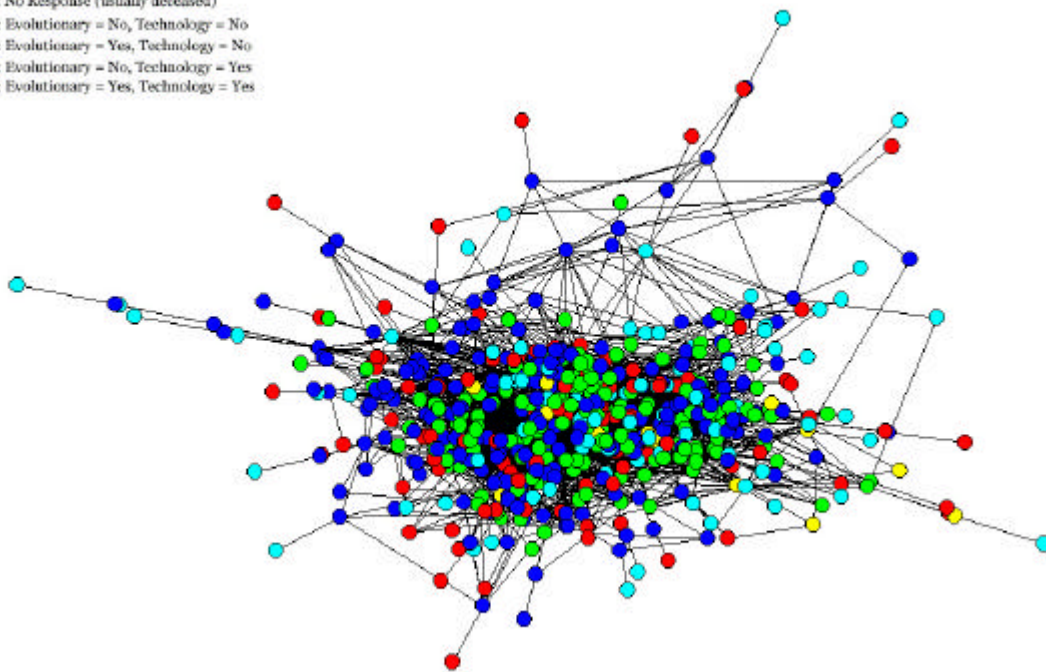**(FIGURE 2 AND FIGURE 3)**
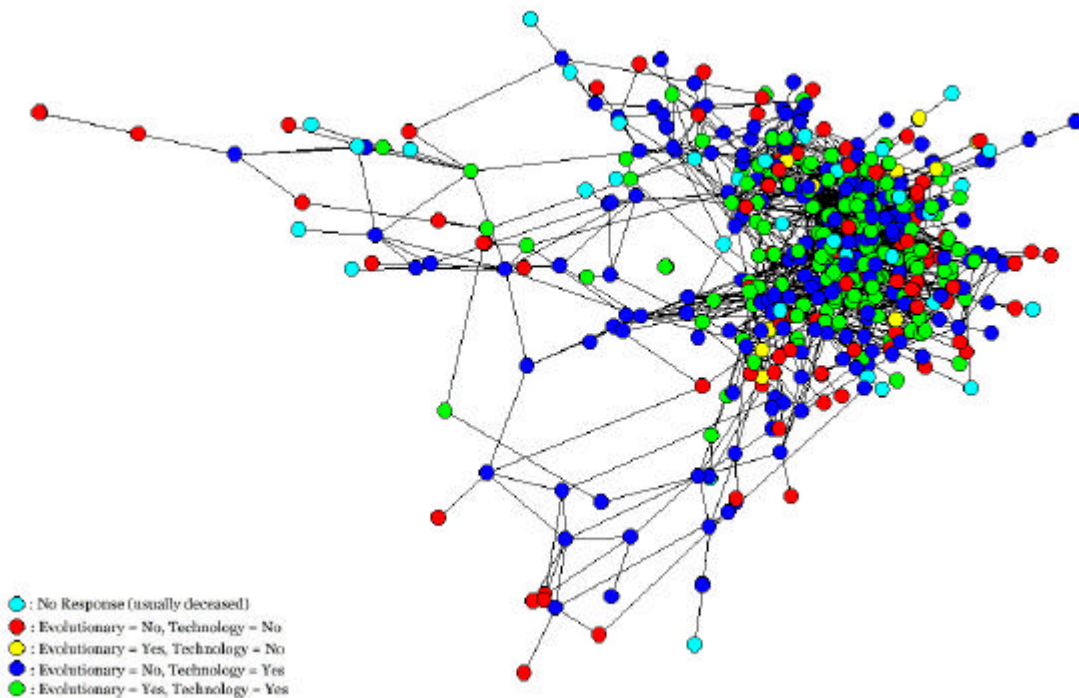
Abbreviation used  Full name:

| | |
|---|---|
| AER | American Economic Review |
| CamJE | Cambridge Journal of Economics |
| Econometrica | Econometrica |
| EER | European Economic Review |
| EINT | Economics of Innovation and New Technology |
| EJ | Economic Journal |
| ESR | Economic Systems Research |
| Futures | Futures |
| Ind&Inn | Industry and Innovation |
| ICC | Industrial and Corporate Change |
| IJIO | International Journal of Industrial Organization |
| Ind&Inn | Industry and Innovation |
| JEBO | Journal of Economic Behavior and Organization |
| JEDC | Journal of Economic Dynamics and Control |
| JEE | Journal of Evolutionary Economics |
| JEGr | Journal of Economic Growth |
| JEI | Journal of Economic Issues |
| JIE | Journal of Industrial Economics |
| JPE | Journal of Political Economy |
| Man Sc | Management Science |
| Org Sc | Organization Science |
| QJE | Quarterly Journal of Economics |
| R&D Man | R&D Management |
| Rand | Rand Journal |
| Reg Stu | Regional Studies |
| RES | Review of Economics and Statistics |
| ResPol | Research Policy |
| SBE | Small Business Economics |
| Sc Pub Pol | Science and Public Policy |
| SCED | Structural Change and Economic Dynamics |
| SMJ | Strategic Management Journal |
| TASM | Technology Analysis and Strategic Management |
| Technovation | Technovation |
| TFSC | Technological Forecasting and Social Change |
| Wor Dev | World Development |

# Figures in colors



**Legend:**
- : No Response (usually deceased)
- : Evolutionary = No, Technology = No
- : Evolutionary = Yes, Technology = No
- : Evolutionary = No, Technology = Yes
- : Evolutionary = Yes, Technology = Yes

**Figure 4. Structure for the Invisible College based on all types of relations**



**Legend:**
- : No Response (usually deceased)
- : Evolutionary = No, Technology = No
- : Evolutionary = Yes, Technology = No
- : Evolutionary = No, Technology = Yes
- : Evolutionary = Yes, Technology = Yes

**Figure 5. Structure for the Invisible College based on all types of relations except "inspiration"**
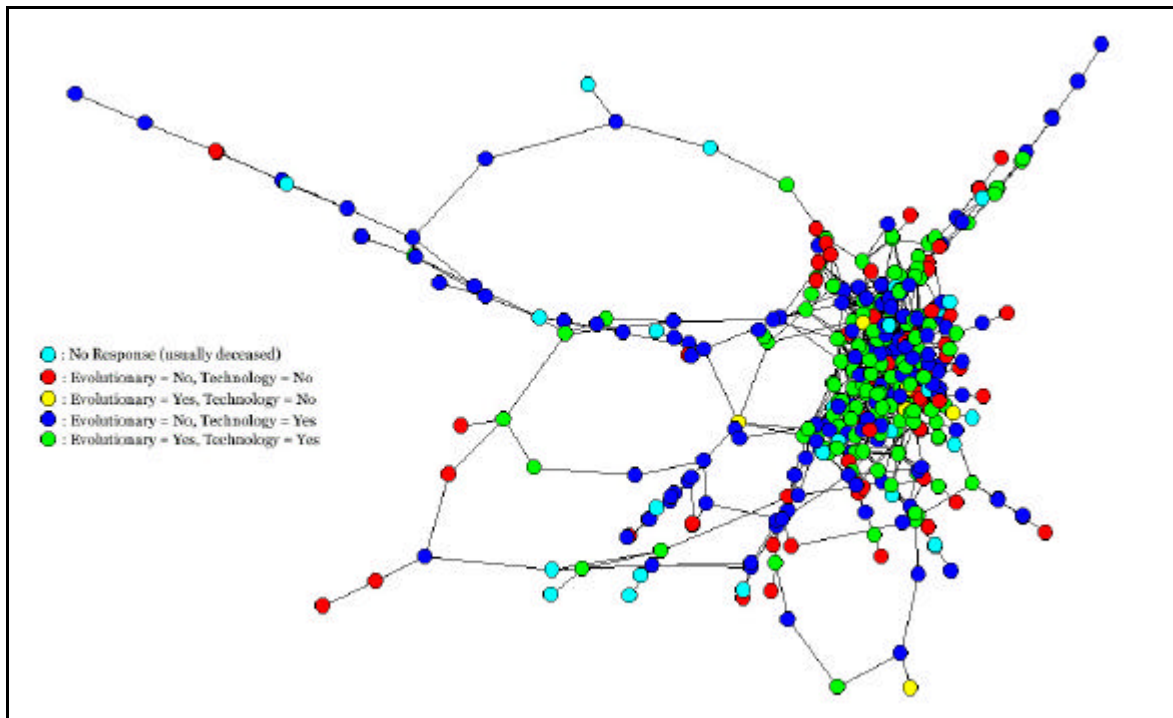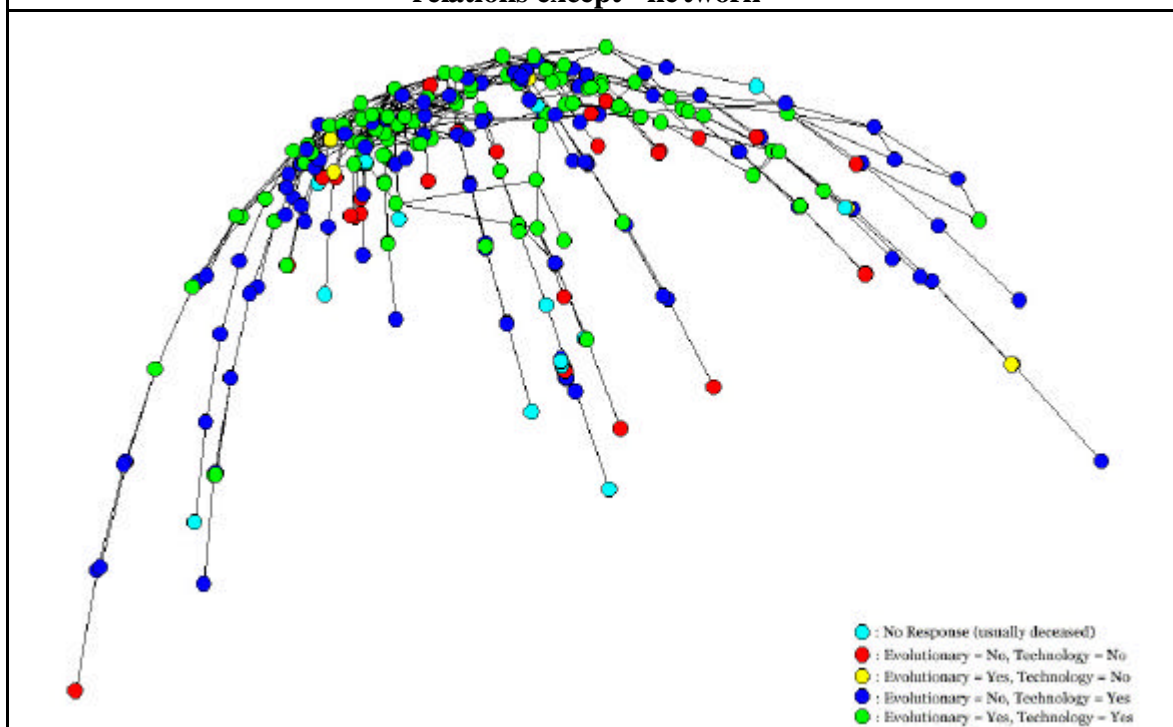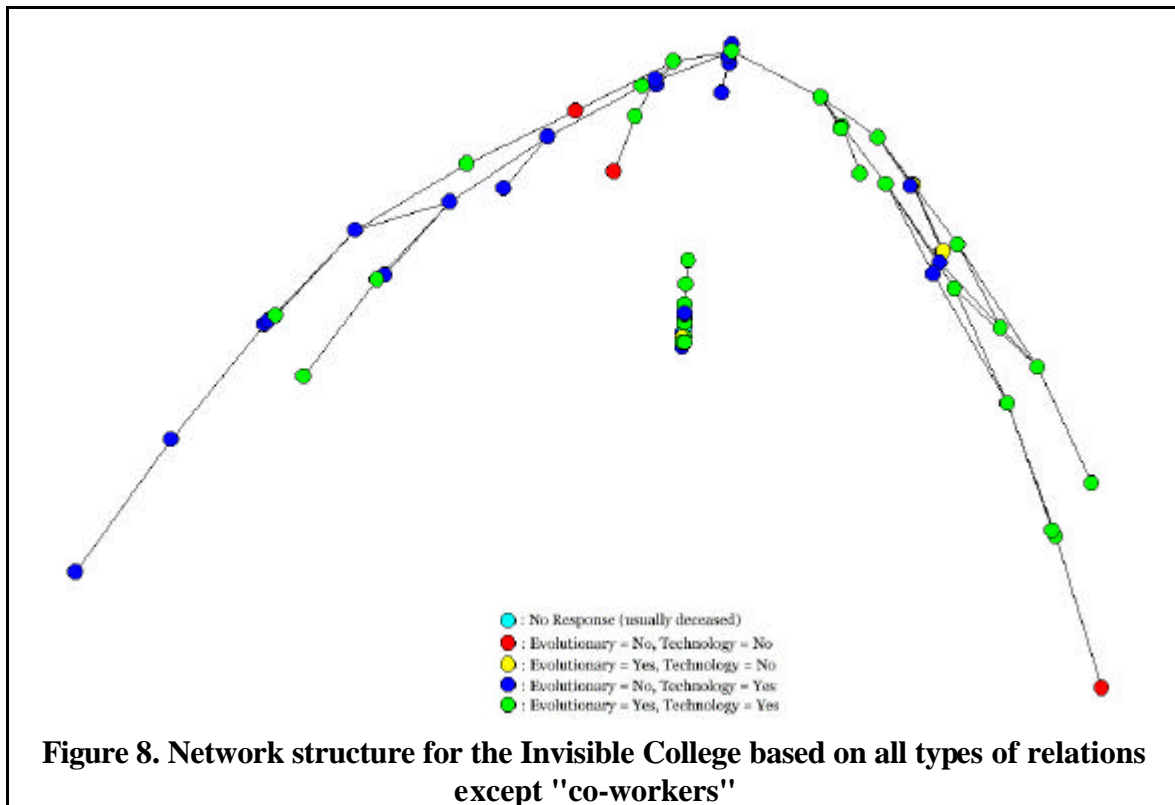
**Figure 6: Network structure for the Invisible College based on all previous types of relations except "network"**



**Figure 7: Network structure for the Invisible College based on all previous relations except "external co-authors"**

**Figure 8. Network structure for the Invisible College based on all types of relations except "co-workers"**

**Appendix C:** Survey questionnaire (Word version, the large majority of results was obtained through an identical online web survey)

## 1. YOUR BACKGROUND

We would like to know a few details about your academic background.

**1a. Which country do you consider to be your native country from a SCIENTIFIC point of view (e.g., if you are Italian by nationality, but pursued your entire scientific career in the UK, fill in "United Kingdom" here)?**

**Country:**

**1b. What is your current (main) affiliation?**

**Affiliation:**

**Country:**

**1c. In case you hold a PhD Degree, at which academic institution did you get it, who was your (main) supervisor, what is his/her current email address, and when did you obtain the degree (year)? In case you hold more than one PhD degree, please list the one most relevant to 'the economics of innovation and technological change' or 'evolutionary economics'.**

**Institute:**

**Supervisor:**

**Email:**

**Year:**

**1d. In case you are currently prepearing a PhD Dissertation, at which academic institution do you plan to receive the PhD degree, who is your (main) supervisor, and what is his/her current email address?**

**Institute:**

**Supervisor:**

**Email:**

**Year:**

**1e. Do you consider yourself to be an evolutionary economist?**

**Answer: Yes/ No   (Please delete the option that does not apply)**

**1f. Do you consider 'the economics of innovation and technological change' to be a field to which you have contributed or plan to contribute in the near future?**

**Answer: Yes/ No   (Please delete the option that does not apply)**

**If you answered 'No' to both of the previous questions, you may now save the file and submit your results without answering the remaining questions. It is important for our research that you submit your results! You may submit your results by sending the saved file as an attachment to b.verspagen@tm.tue.nl. Thank you for your cooperation!**

## 2. YOUR NETWORK

**The following questions will ask for names of people. We would like to give you a few general directions for answering these questions:**

· **Our questions refer to EXCLUSIVE groups of people. This means, for example, that a person who would qualify as a possible answer to the first question below, is not a valid answer for any of the following questions. This even holds if you decided not to fill in the name of this person in the first question, because the person did not rank among the five most important people in the category. Also, never fill in your PhD supervisor as listed in Question 1.**

· **Only consider those people relevant to YOUR work on "the economics of innovation and technological change" and/or "evolutionary economics", although the people you list may themselves not specialize in these areas.**

· **Always use the quality of the input of a person as a measure rather than the quantity.**

· **List most important people in a category highest, least important people last.**

· **A few directions for formatting the names. Please do not use any academic titles, so write "J. Lennon" rather than "Prof. J. Lennon" or "dr. J. Lennon". Also, please write names in the order FIRST NAME - LAST NAME, e.g., "M. Jagger", rather than "Jagger, M.". Finally, please give us as much detail as you reasonably can, i.e., provide full first names (if you know them) rather than initials (e.g., "Elvis Presley" rather than E. Presley"), and also provide middle initials if you know them (e.g., "Elvis A. Presley" rather than "Elvis Presley").**

· **The questions will ask for current email addresses of the people you list. If you do not have these available, please leave this field empty, but complete the rest of the answer.**

· **If there are less than five people who qualify the description given in the question, simply leave the appropriate number of rows empty.**

### 2a. YOUR PhD STUDENTS

**In case you ever supervised PhD students, we would like to know who you consider to be the most influential of these. Please list up to five PhD students from those who have completed their dissertation.**

|   | name | Email address |
|---|------|---------------|
| 1 |      |               |
| 2 |      |               |
| 3 |      |               |
| 4 |      |               |
| 5 |      |               |

### 2b. YOUR CO-WORKERS

**We would like to know who you consider to be the most important co-workers with whom you have worked over your entire career. We define a co-worker as a person employed in the same organization as yourself, and who is/was a source of inspriration in the form of formal and informal discussions, exchange of ideas, commenting on papers, etc.**

|   | name | Email address |
|---|------|---------------|
| 1 |      |               |
| 2 |      |               |
| 3 |      |               |
| 4 |      |               |
| 5 |      |               |

## 2c. YOUR CO-AUTHORS

We would like to know who you consider to be the most important co-authors (working outside your own organization at the time of the joint work) whom you have worked with over your entire career. Please include also work outside scholarly journals, such as reports for contract research, etc., in your definition of a co-author.

|   | name | Email address |
|---|------|---------------|
| 1 |      |               |
| 2 |      |               |
| 3 |      |               |
| 4 |      |               |
| 5 |      |               |

## 2d. YOUR NETWORK

We would like to know who you consider to be the most important people in your network. Define your network as people you are in regular contact with, by face-to-face contact, meeting at conferences, paper correspondence, email, etc.

|   | name | Email address |
|---|------|---------------|
| 1 |      |               |
| 2 |      |               |
| 3 |      |               |
| 4 |      |               |
| 5 |      |               |

## 2e. YOUR FRAME OF REFERENCE

We would like to know who you consider to be the most important people in your frame of reference. We define the frame of reference as those people who have inspired your own work, but do not fit in the above categories. A good example of this could be a classic author who lived before your time (e.g., Adam Smith), but this category can also include living people, for example those authors you reference in your own work, but you have never been in contact with.

|   | name | Email address |
|---|------|---------------|
| 1 |      |               |
| 2 |      |               |
| 3 |      |               |
| 4 |      |               |
| 5 |      |               |

## 2f. INSTITUTIONAL SETTING

In case you regularly (on average at least once every two years) visit other institutes (in your own country or abroad) supporting the research areas 'the economics of innovation and technological change' and /or 'evolutionary economics', please list the names of the institutes (universities, research centres, etc,) and countries in which they are based (most important first).

|   | Institute | country |
|---|-----------|---------|
| 1 |           |         |
| 2 |           |         |
| 3 |           |         |
| 4 |           |         |
| 5 |           |         |

## 3. RESEARCH INFRASTRUCTURE

Please indicate the level of support for research in the area 'the economics of innovation and technological change' and /or 'evolutionary economics' you have experienced from the following institutions (1=no support, 5=strong support). Indicate your answer by putting a 'x' under the appropriate level of support.

1. Your own institution (university, research institute, etc.)

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
|   |   |   |   |   |

2. 2. National and/or regional research funding agencies in the country you work in

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
|   |   |   |   |   |

3. 3. European research funding agencies (please answer this only if you are employed in Europe)

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
|   |   |   |   |   |

## 4. JOURNALS

Which academic journals do you consider CURRENTLY to be the best outlet for work on 'evolutionary economics' or 'the economics of innovation and technological change' (most important first)?

|   | Journal |
|---|---------|
| 1 |         |
| 2 |         |
| 3 |         |
| 4 |         |
| 5 |         |

Which academic journals did you consider to be the best outlet for work on 'evolutionary economics' or 'the economics of innovation and technological change' (most important first) BEFORE 1985? (If you feel too young to have an informed opinion, please leave open this question)

|   | Journal |
|---|---------|
| 1 |         |
| 2 |         |
| 3 |         |
| 4 |         |
| 5 |         |

This is the end of the survey. Please save the file and submit your results by sending the saved file as an attachment to b.verspagen@tm.tue.nl. Thank you for your cooperation!