In: D. Torres-Salinas & H. Moed (eds.) *Scientometrics and Informetrics 2007*. Madrid: Cindoc-CSIS, 803-813

Mapping Review Networks: Exploring Research Community Roles and Contributions

Alesia Zuccala and Peter van den Besselaar

a.zuccala@rathenau.nl; p.vandenbesselaar@rathenau.nl
Netherlands Center for Science System Assessment, Rathenau Institute
Anna van Saksenlaan 51, 2509 CJ, Den Haag, The Netherlands

Abstract

In this paper we investigate the position of a review network within a research specialty; the network of scholars that who write reviews of their colleagues' work. This is one of the voluntary activities that researchers perform as a prerequisite for the functioning of the invisible college. We compare this network to other networks within the specialty, and this enables us to distinguish various roles: *stars*, *influentials, members, supporters* and *juniors*. As scholars are characterized by different role-configurations, the invisible college becomes stratified. We discuss the implications for the development of a referee factor and review factor, norms for refereeing and reviewing, and the development of systems-based research evaluations.

Keywords

Peer Review; Subject Specialties; Invisible Colleges; Mapping Knowledge Domains

Introduction

Scientific communication systems engage scientists in formal research-related activities, informal activities, and volunteer-based activities (e.g., Garvey & Griffith, 1968; Griffith, 1990). Scientometrics focuses predominantly on formal aspects of scientific communication; measurable outputs like journal impact factors (e.g. Glanzel & Moed, 2002) and citation networks (e.g., White, 2001; Small, 2005). Informal activities are elusive and studied less frequently, but have been emphasized in research on acknowledgements (e.g., Cronin, 1995) and in some metric evaluations of co-authorship and underlying processes of informal collaboration (e.g., Melin & Persson, 1996; Laudel, 2001; Newman, 2004). Volunteer activities can be defined in terms of services that scientists undertake to support a scientific communication system – i.e., to ensure that contributions are good for the system as a whole in addition to the career of the individual scientist. Such activities include refereeing papers for publication, organizing conferences, chairing award/grant committees, and writing reviews of newly published books and papers.

Research concerning scientific communication systems usually focuses on highly cited and co-cited papers in a research field, and scholars who are research stars; however, voluntary support work is also essential to the system. Without it, certain types of communities, namely invisible colleges, might not function effectively. An invisible college is a communication system of scholars comprised of approximately 80 to 100 individuals who are part of the social "in-group" of a subject specialty (Crane, 1972; Price, 1986). Invisible colleges normally grow when scientists from subject specialties share similar interests, interact with one another at select conferences, and communicate new knowledge both formally and informally. Over time, the social network of the invisible college can become more "visible" due to the published output of its scholars (e.g., White, Wellman & Nazer, 2004; Zuccala, 2006).

In this paper we present research results based on an explorative study concerning support work in science. Our primary focus is on the role of the *reviewer* – i.e., the scientist from an invisible college network who writes an evaluative summary of a colleague's book or research paper. The chosen specialty is an area in mathematics known as Singularity Theory. When a new paper is published in mathematics, a researcher may cite it in his own work, but prior to this, he may also be asked by a Mathematical Reviews editor to write a formal review. The function of the review is to give colleagues in the specialty (or broader field) a brief idea of its significance so that they can decide whether or not to read the original work. To be asked to review a particular paper means that a mathematician has acquired the respect of his peers: he has the reputation of being careful, reliable and knowledgeable in the specialized area to which the paper belongs (D. Trotman, personal communication, November 3, 2006). Given the importance of mathematical reviews, our research objective is to investigate who the reviewers are in Singularity Theory research, and what their role is vis-à-vis other types of roles within the invisible college network.

The Dialog MathSci® database of the American Mathematical Society (AMS) maintains a record of review contributions; thus have selected 85 prominent Singularity Theory authors for the purpose of constructing a review network. MathSci® covers international publication data from 1940 to the present. In addition to journal articles, "roughly 10,000 monographs, conference proceedings, theses and technical reports are reviewed annually" (MathSci® Bluesheet). Review work in mathematics is formal, but does not need to be extensive: a few lines to 600 words are written to explain main results in a paper. The AMS guide states that a review can sometimes be evaluative; however "negative critical remarks [are expected to be] objective, precise, documented and expressed in good taste." If the reviewer thinks that the item "duplicates earlier work, [he/she] must cite specific references" and if the reviewer also thinks "that the item is in error, the errors should be described precisely" (Mathematical Reviews Database, 2006).

Research Methods and Findings

Data for this study were collected using both the Dialog SciSearch® citation index and the MathSci®: index. Table 1, in the Appendix, indicates how we categorized the data before it was used for separate mapping procedures. First, we mapped the Singularities specialty based on the author cocitation procedure outlined in White and Griffith (1981), using Cosine as the similarity measure (Ahlgren et al., 2003; Leydesdorff, 2005). For a list of 85 authors, cocitation counts were retrieved from SciSearch® for the period 1974 to 2006 [i.e., 85(85-1)/2=3570 pairs]. Figure 1 shows the map produced using the SPSS-11 multidimensional scaling and cluster routine. With the SPSS cluster function we have identified and labelled three sub-fields of Singularities research (*A-Real and Complex Analytic Geometry*; *B-Topology of Complex Algebraic Singularities*; *C-Singularities of Differentiable Maps*) and the authors attributed to these sub-fields. SciSearch® was used again to retrieve directed citation counts between the 85 Singularity Theorists, for a NetDraw (Borgatti, 2002) mapping of a citation network (see Figure 3). The authors at the centre of the spring-embedded network have received the most citations from colleagues within the invisible college.

With MathSci® we retrieved information concerning each author's total publication count, and produced a ranked list of mathematicians who have written signed reviews. Figure 2, for example, shows the number of publications for MARIA A. S. RUAS, the year of her first publication and a ranked list of mathematicians who have reviewed her work. The names highlighted in the ranked list are authors from her invisible college/specialty network. With the MathSci® data concerning reviewers and reviewed authors, we created another NetDraw map, using a principle components layout, to illustrate the invisible college's directed review network (see Figure 4). Reviewers have a distinct role in a research community as research supporters. Again, we will examine who the main supporters are in Singularities research, and how they relate to other roles within the invisible college network.

In our first analysis, we examined the ranked (ascending) publication output for each author and compared it to their individual review contributions. Figure 5 shows that review contributions tend to be less frequent than publications, yet some authors have reviewed as many articles as they have published (e.g., HOUSTON, FUKUI, TROTMAN); while others have actually published less, and contributed more to the communication system as reviewers (e.g., STEVENS, CHILLINGWORTH, GIBLON). With the ranked reviewer data, we then examined how many reviews have been written by authors 'inside' the Singularity Theory specialty and how many have been written by 'outsiders' or colleagues from neighbouring subjects (see Figure 6). This particular research area seems to be open to external reviewing: approximately 86% of this community's published articles have been reviewed by authors from other specialties.

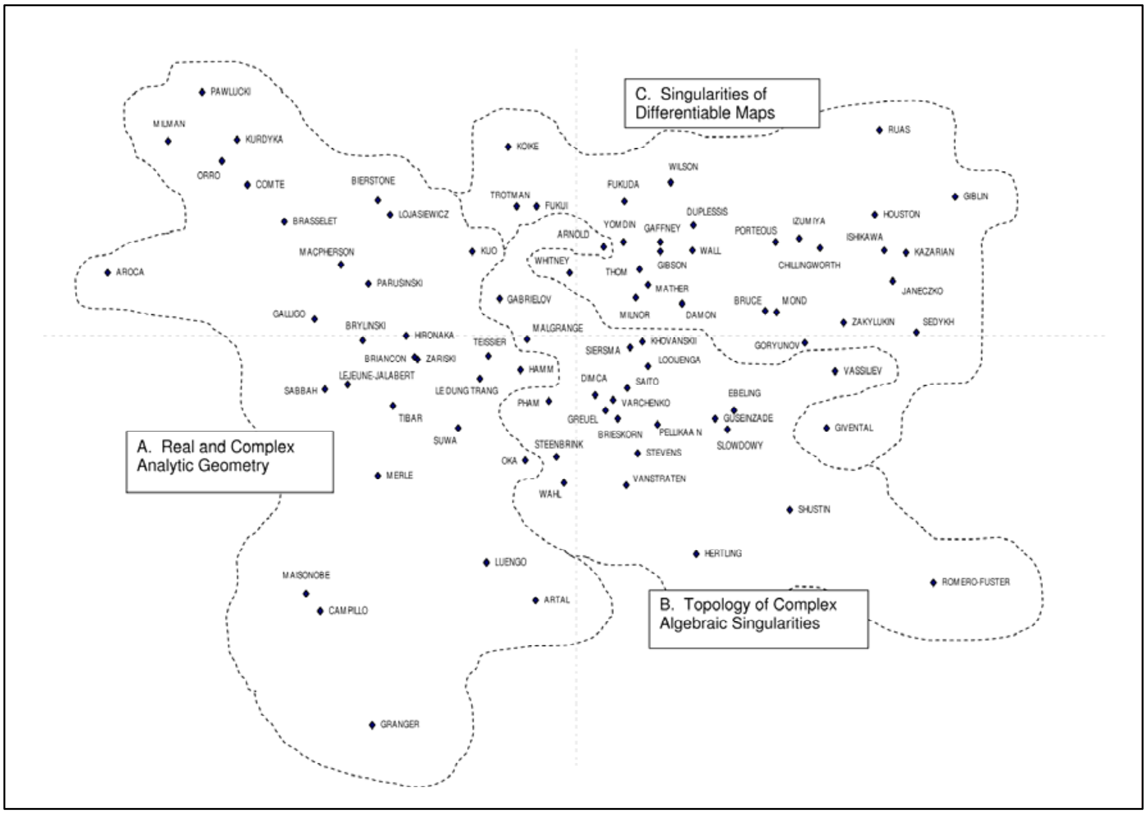

Figure 1. Cocitation map of 85 Singularity Theory authors (1974-2006), and research subfields (SciSearch®).

RUAS, MARIA A.S.? = 33 publications (First publication in 1986)

[Reviewers]

RANK No.	Items	Term
1	4	ANDRICA, DORIN
2	3	OUTERELO DOMINGUEZ, ENRIQUE
3	3	WILSON, LESLIE CHARLES
4	2	LI, YANG CHENG
5	2	TIBAR, MIHAI
6	1	BEEM, J. K.
7	1	CHILLINGWORTH, D. R. J.
8	1	FUKUI, TOSHIZUMI
9	1	GOMOZOV, EUGENI P.
10	1	HURLEY, DONAL
11	1	IBANEZ, SANTIAGO
12	1	JANECZKO, STANISLAW
13	1	JIANG, GUANGFENG
14	1	LEVINE, J. P.
15	1	NUNO-BALLESTEROS, JUAN J.
16	1	WEINER, JOEL L.

Figure 2. Number of publications for MARIA A. S. RUAS and ranked reviewers (MathSci®).

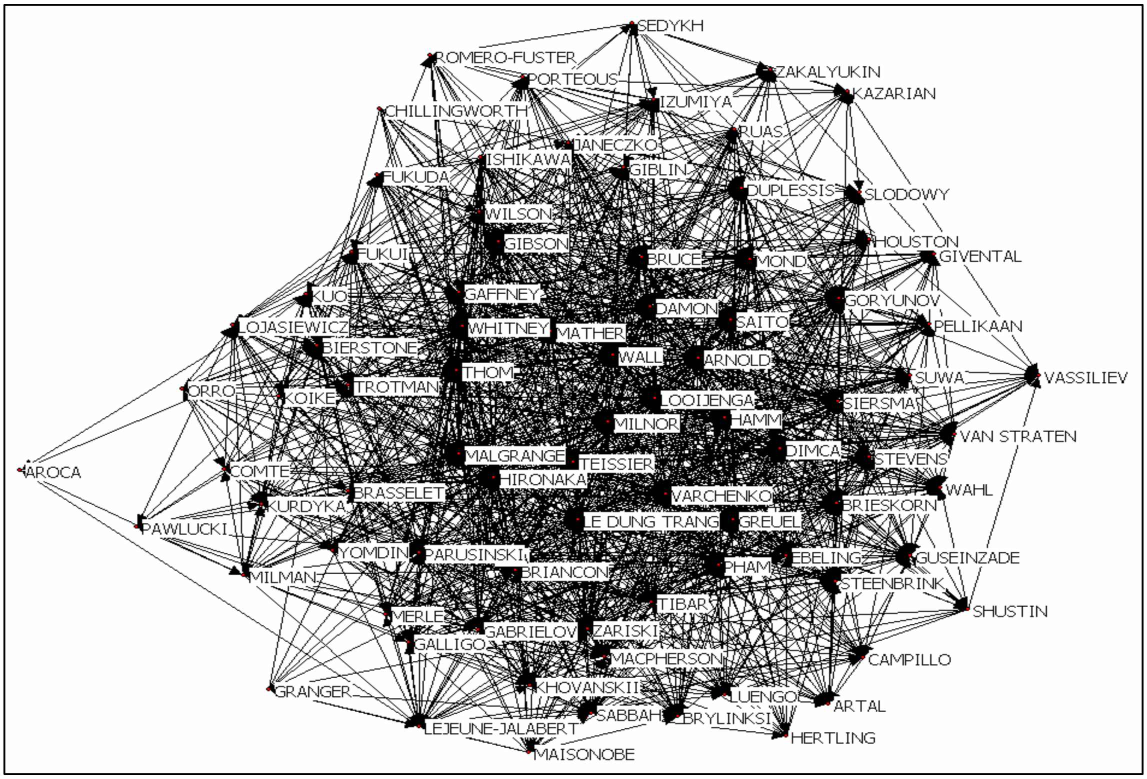

Figure 3. Directed citation network for 85 authors in Singularity Theory (1974-2006; SciSearch®).

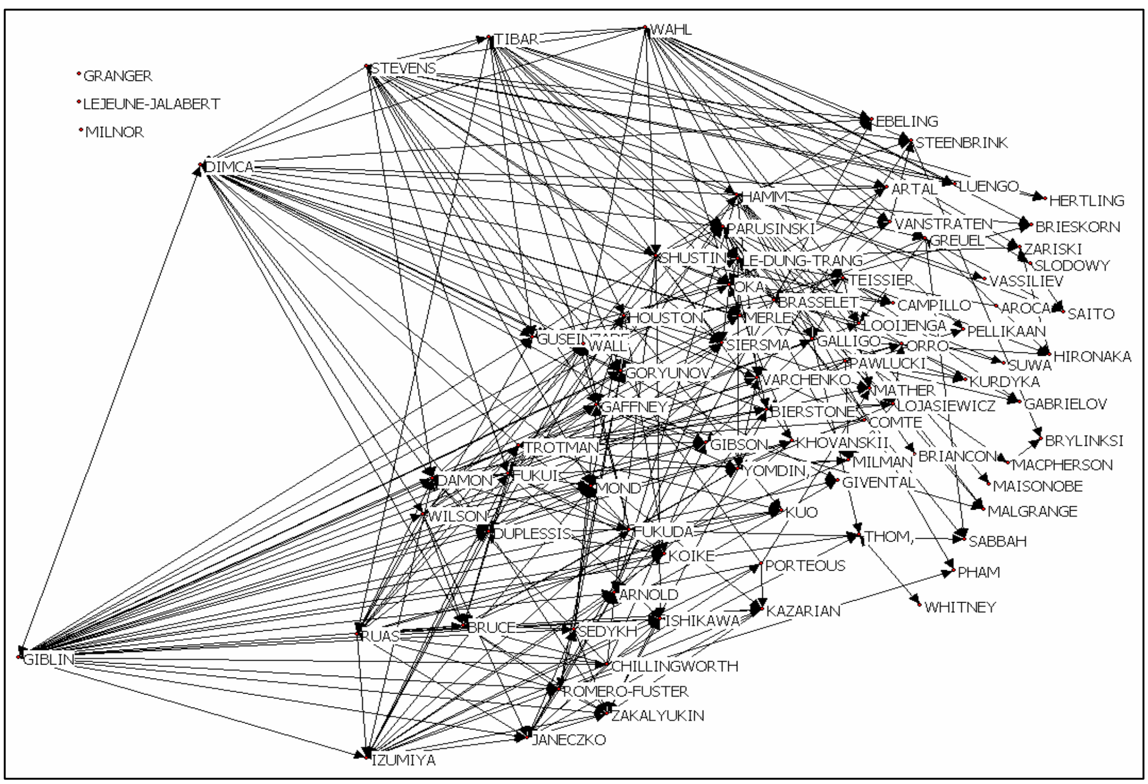

Figure 4. Directed review network for 85 authors in Singularity Theory (1970-2006; MathSci®).

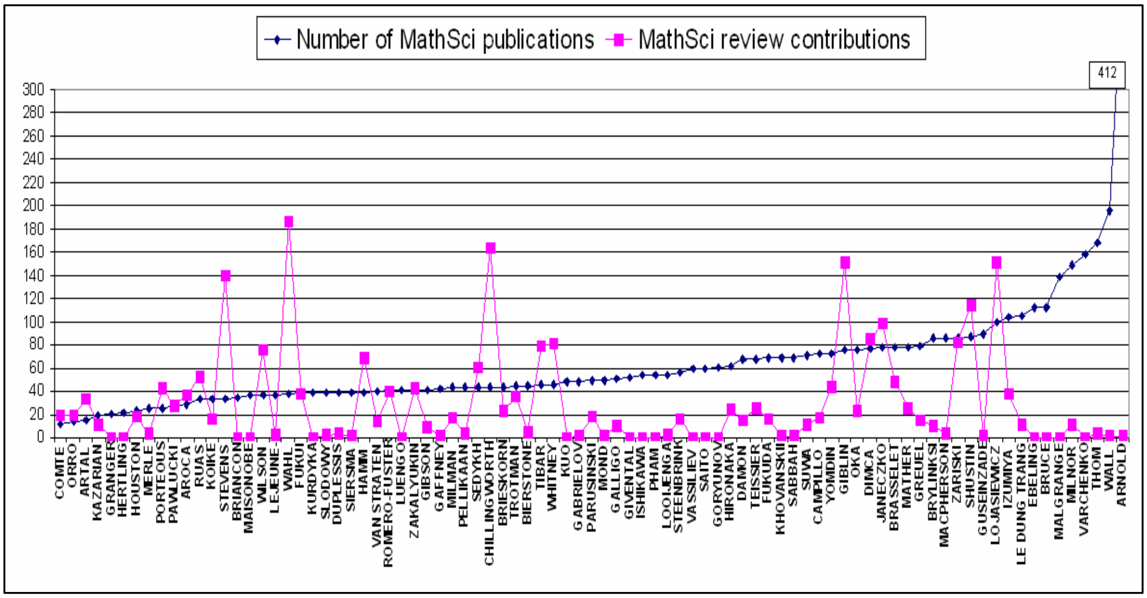

Figure 5. Publication counts for Singularity Theory authors compared to review contributions. Authors ranked by publication count (MathSci®).

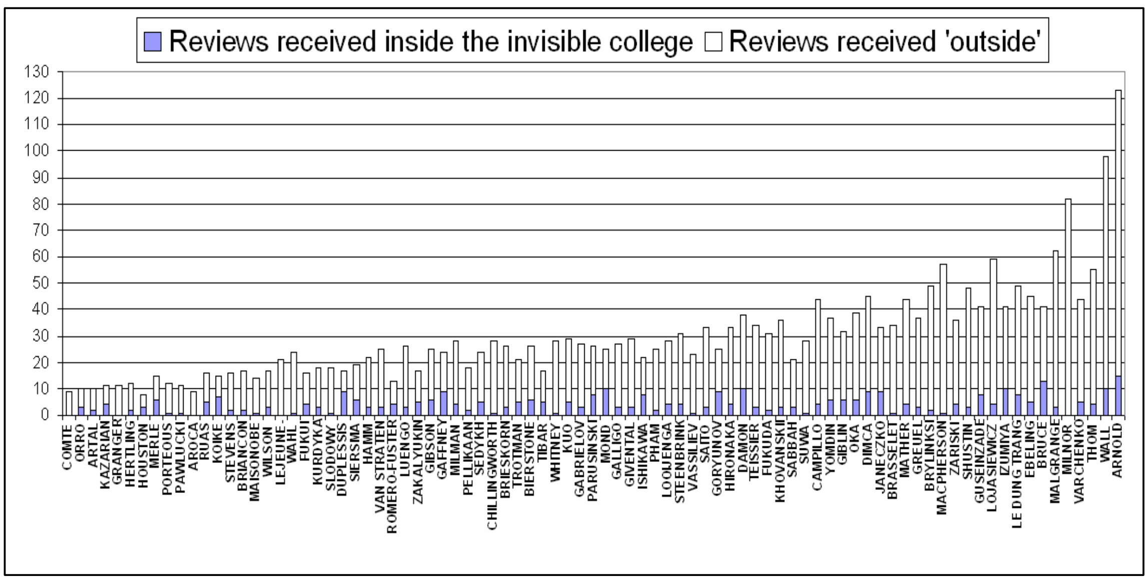

Figure 6. Reviews received by authors within Singularity Theory versus outside reviewers. Authors ranked by number of reviews received (MathSci®).

We also measured the relationship between the reviews that Singularity Theorists have written for colleagues within the invisible college, compared to reviews written for colleagues ‘outside’ the specialty and found a positive correlation (r=0.620). The scatterplot shown in Figure 7 shows that authors who review a lot of papers within their specialty area also tend to contribute frequently to the mathematics review system in general.

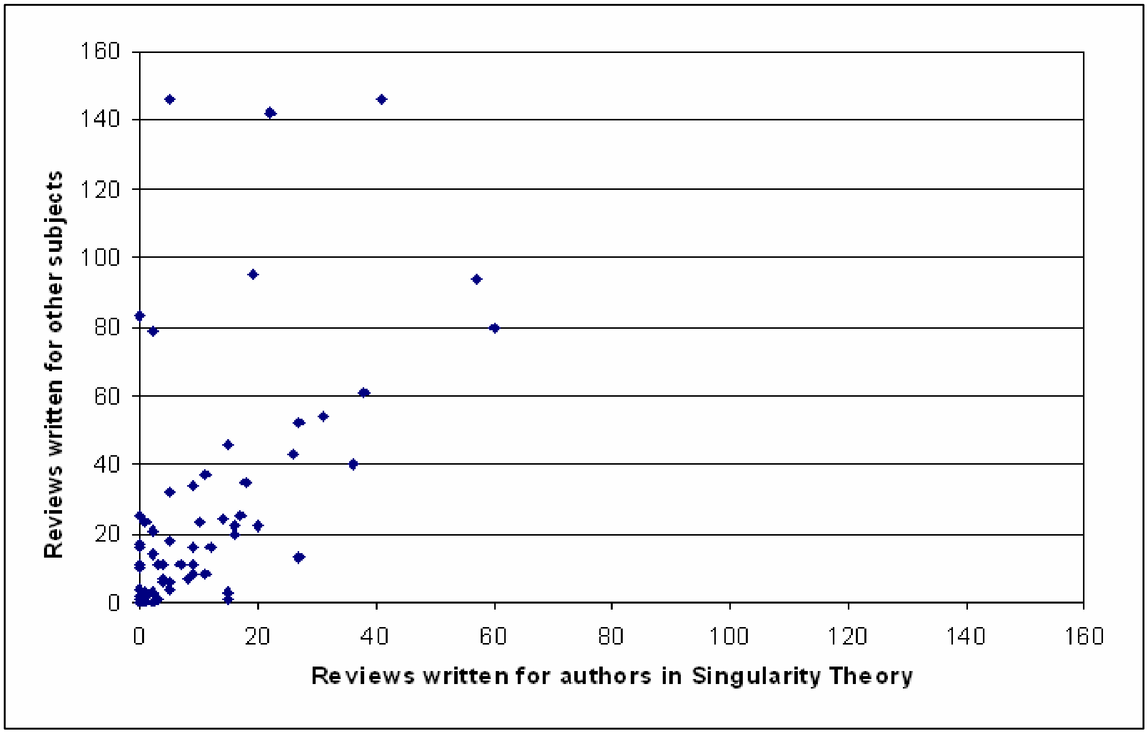

Figure 7. Reviews written for authors in Singularity Theory
compared to reviews written for other subjects (MathSci®).

To determine if authors who have reviewed each other's work were also likely to cite one other (Figures 3 and 4), we used the QAP (Quadradic Assignment Procedure) matrix correlation function in UCINET (Borgatti et al., 2002). This compares the observed correlation with the average correlation of 2500 random permutations. As the latter was zero with a standard error of 0.015, the observed Pearson correlation value of 0.147 was significant (<0.00). In other words, a positive correlation exists between writing a review of someone's work and citing the same scholar.

Conclusions and Research Implications

Based on our research findings, it is clear that mathematicians will undertake review work at different stages in their career: young researchers will write reviews (e.g., COMTE; ORRO) as well as seniors, with stronger publication profiles (e.g., GIBLIN; DIMCA). Figure 5 indicates also that there is a small group of well-published mathematicians who do not often carry out this type of support work (e.g., LOOIJENGA, PHAM, GORYUNOV), including an elite group clustered at the top of the publication rank (e.g., ARNOLD, WALL, MILNOR). Can we explain this review-versus-publication output imbalance? Yes, but there are perhaps more contributing factors than just one. In this study we cannot account for the motivation of an individual; therefore, if a mathematician is ambitious and wants to devote most of his time to research and publishing, he can refuse to write reviews or pass the work on to another colleague. Also, if the mathematician is academically strong – i.e., a recognized leader – he might not have time to write reviews because he is too busy mentoring Ph.D. students, chairing committees, organizing special seminars/workshops, lecturing and travelling to conferences. Junior researchers generally have more time to write reviews, and perhaps they agree to do this work to generate exposure or demonstrate to seniors where their abilities and interests lie. Senior mathematicians who write reviews might actually enjoy the process, or feel that it is a good way to keep in touch with what is happening in their research community. These mathematicians could have a reputation amongst editors for having a wide variety of interests and may also be very efficient review writers.

Review work in mathematics is not subject-specific or subject-centred. The review system tends to function in a way that is similar to the citation system: a mathematician may cite a research relevant paper of interest, just as he or she might review a paper of interest, regardless of the specialty area to which the paper belongs. Specialty areas of research grow because there is a core set of problems that mathematicians focus on at the outset, but cross-over interests with other subjects (permeable boundaries) are expected and allow researchers to build important connections. Singh (1998) reinforces this notion eloquently: "the value of mathematical bridges is enormous. They enable communities of mathematicians who have been living on separate islands…to explore each other's creations" (p. 191).

Our QAP matrix analysis of the review network and citation network points to another logical outcome, which places emphasis on familiarity: mathematicians who closely review each other's papers also tend to cite each other. If a mathematician becomes familiar with a piece of work and has the appropriate knowledge background to make evaluative or critical remarks, it makes sense that he might use that work to build upon new ideas in his own research. The opposite makes sense as well: a researcher who regularly cites the work of a particular colleague is also likely to agree to write reviews of that colleague's publications.

With the data that we have collected, our selected authors in Singularities research may be described and compared to each other on the basis of contribution roles. Each role is derived from the publication, co-citation, citation, and review data used to create Figures 2, 3 and 4. The roles also stem from our observations of the authors nodal positions on the three figures. Below, we list five types of contribution roles, which can be described separately, but need not be mutually exclusive. Multiple roles, or role configurations (including roles not identified here, e.g., supervising; mentoring) can make up an author's complete contribution profile. For instance, THOM is listed as a *star*, but he was also *influential* to many early members of the Singularity Theory community. Likewise, GIBLIN is a *member* of the Singularity community, but he has also been a strong *supporter* (*reviewer*) of many of his colleagues' work.

1) *Stars*: mathematicians who are central to the specialty area, i.e., highly co-cited with others in the specialty. Stars are also cited by researchers in all of mathematics, not just their specialty members. They have a significant reputation in mathematics as a whole, including a capacity to become award winners. Mathematicians who fit this role include HIRONAKA, MILNOR, THOM, MATHER.

2) *Influentials*: mathematicians who are well-published and highly cited or co-cited. Their work is influential to the specialty area's development, thus they are central to the invisible college's intellectual structure. Mathematicians who fit this role include ARNOLD, ZARISKI, WALL, TESSIER, LE DUNG TRANG, WHITNEY, BRIESKORN, DAMON, LOOIJENGA

3) *Members*: mathematicians with moderate-to-strong publication records who are cited by their specialty colleagues. Members often collaborate with other specialty members; hence their position is slightly more peripheral than stars and influentials, but they are still major contributors to the invisible college. Mathematicians who fit this role include BIERSTONE, MILMAN, PARUSINSKI, GUSEINZADE, VAN STRATEN, TIBAR, KURDYKA.

4) *Supporters (reviewers):* mathematicians who are members of the specialty research area, but participate often in support work – in this case, the writing of reviews. Their publication output may or may not be strong, but the amount of work that they do as reviewers is significant. Mathematicians who fit this role include JANECZKO, WAHL, GIBLIN, STEVENS, CHILLINGWORTH.

5) *Juniors*: mathematicians who are former students of senior members in the specialty; relatively young researchers who are focused on developing their research profile. Their publication output is not as strong as other members, and they tend to be peripheral to the intellectual structure of the network. Mathematicians who fit this role include COMTE, ORRO, KAZARIAN, ARTAL.

Figure 8 shows a mapping of the five different contribution roles and how they fit within Singularity Theory's basic co-citation (intellectual) structure. The extent to which these roles support the invisible college or enable it to function effectively requires further in-depth study concerning the mathematicians' behaviors and degree of investment in role-related activities.

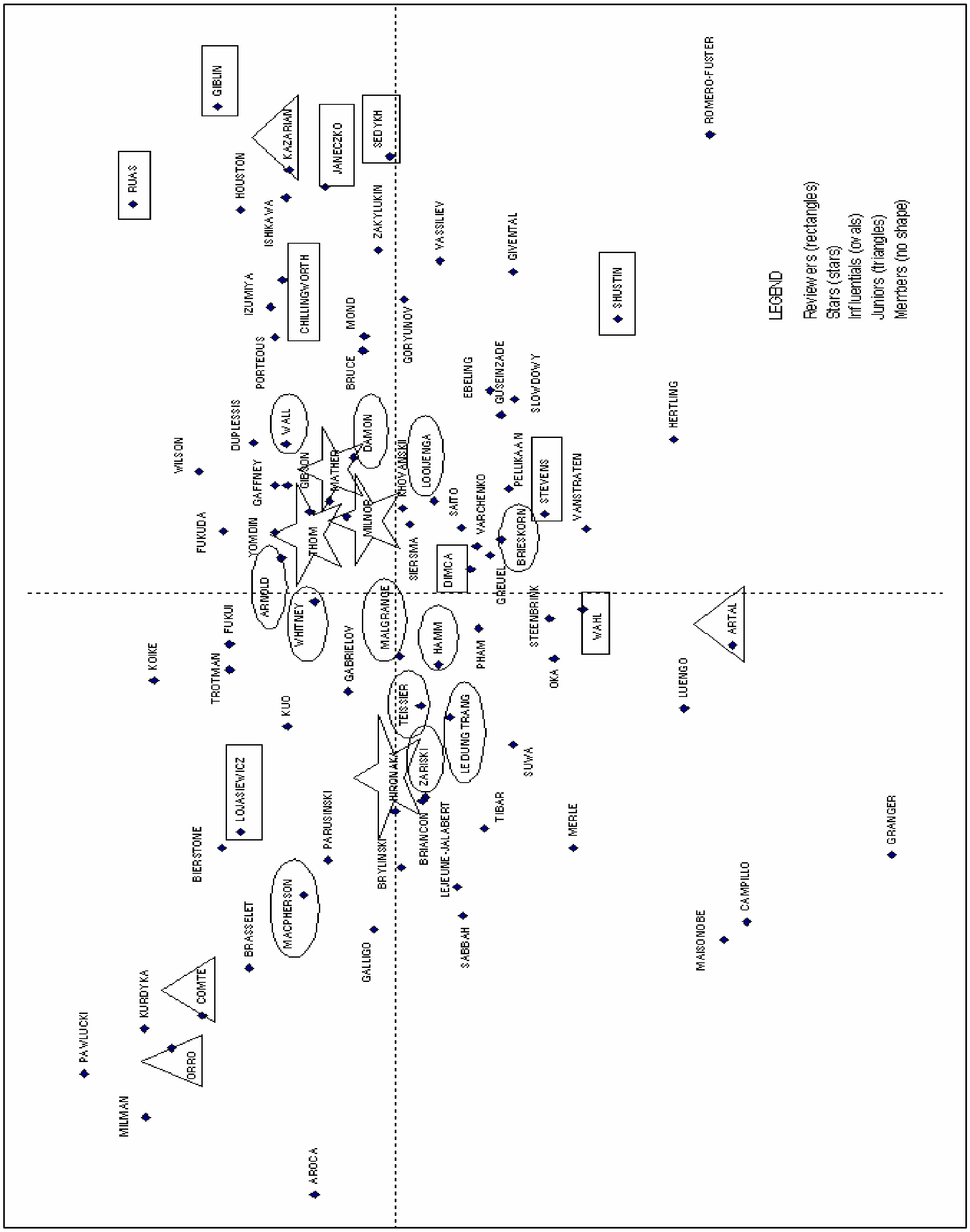

Figure 8. Roles within Singularity Theory research.

This study of the Singularities community possesses interesting research implications concerning other forms of support work. For instance, attention has recently been given to referee work in science (another voluntary activity) and the introduction of a new impact measure termed the 'referee factor'. The 'referee factor,' defined mathematically by Rousseau (2006), "could be built in to standard assessments of performance, acting as an incentive for people to [referee] manuscripts" (Wilson & Lancaster, 2006, p. 812). According to Wilson and Lancaster, some scholars do not referee enough papers for publication; hence this is something that needs to be monitored. Unfortunately referee work is generally kept anonymous; therefore it is not so easy to measure. Now, if it is true that support work (including referee work) is a role-based activity, as we show in this study, then perhaps it is unrealistic to state the following: "for the system to be fair, all scientist should be refereeing two to three times as many articles as they submit"(Wilson & Lancaster, 2006). Our notion of roles and role-based contributions implies that a scientist's informal, formal, and volunteer-related contributions is closely tied to the type of role he/she possesses within a research community and may not change unless his/her overall profile (role configuration) changes. For example, in order for a research *star* or *influential* to referee two to three times as many articles as he or she produces, this scientist might need to minimize work associated with other areas of contribution – i.e., organizing international meetings, mentoring Ph.D. students; traveling to give special seminars, etc.

If the distinction between roles makes sense, then we may also consider the implications for developing systems-based research evaluations, i.e., evaluations directed towards laboratory teams, specialty research areas, or invisible college networks. General statements about the number of reviews a scientist must write, or papers he/she must referee relative to his or her publication output are not useful if they neglect the importance of roles. A sports team, for instance, needs players to perform different functions on the field (e.g., defense; goalkeeping; forward). Not everyone can play the forward position at one time; thus it is important to recognize that an invisible college operates according to the same principle. Different roles have to be performed by scientists at different times in an invisible college in order to develop and maintain the communication system, and ensure that it is operating successfully. If we evaluate researchers from this type of network on one dimension only (e.g., his/her degree of citedness) we fail to recognize the possible impact he or she can have when playing other critical roles. Future assessments at a systems level can tell us whether or not necessary roles are fulfilled in a specialty or invisible college network and where changes could be made to create improvements. Moreover, a good review factor, similar to the suggested referee factor (Rousseau, 2006), might be a useful measure in this type of evaluation.

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In: D. Torres-Salinas & H. Moed (eds.) *Scientometrics and Informetrics 2007*. Madrid: Cindoc-CSIS, 803-813

Appendix Table 1. Alphabetical list of Singularity Theory authors (n=85) and data categories.

AUTHOR	Year of 1st publication	Number of MathSci publications	Average cocitation rate with other invisible college members	Citations received by indivisible college members	MathSci review contributions	Review contributions to Invisible College	External review contributions	Reviews received inside the invisible college	Reviews received 'outside' the invisible college
ARNOLD	1957	412	68	503	1	0	1	15	108
AROCA	1971	29	2	11	37	5	32	0	9
ARTAL	1991	15	3	16	33	10	23	2	8
BIERSTONE	1973	45	14	85	5	2	3	6	20
BRASSELET	1973	78	4	26	48	11	37	1	33
BRIANCON	1973	34	14	105	0	0	0	2	15
BRIESKORN	1964	44	25	134	23	2	21	3	23
BRUCE	1979	112	19	183	0	0	0	13	28
BRYLINKSI	1975	86	7	49	10	0	10	2	47
CAMPILLO	1978	72	2	15	17	0	17	4	40
CHILLINGWORTH	1967	44	2	0	164	22	142	1	27
COMTE	1996	11	1	5	19	11	8	0	9
DAMON	1973	68	18	120	15	8	7	10	28
DIMCA	1976	77	12	60	85	31	54	9	36
DUPLESSIS	1975	39	9	73	4	3	1	9	8
EBELING	1962	112	6	34	0	0	0	5	40
FUKUDA	1966	69	5	43	16	15	1	2	29
FUKUI	1985	39	3	30	38	16	22	4	12
GABRIELOV	1968	48	10	66	1	0	1	3	24
GAFFNEY	1976	42	11	84	1	1	0	9	15
GALLIGO	1973	50	5	34	10	4	6	3	24
GIBLIN	1968	76	2	16	151	57	94	6	26
GIBSON	1969	41	15	120	9	5	4	6	19
GIVENTAL	1980	52	5	38	0	0	0	3	26
GORYUNOV	1978	61	7	56	0	0	0	9	16
GRANGER	1967	21	0	2	0	0	0	0	11
GREUEL	1975	79	17	118	15	4	11	3	34
GUSEINZADE	1966	89	5	37	1	0	1	8	33
HAMM	1971	39	16	118	69	26	43	3	19
HERTLING	1993	22	1	3	0	0	0	2	10
HIRONAKA	1957	62	30	198	24	1	23	4	29
HOUSTON	1997	23	2	5	18	15	3	3	5
ISHIKAWA	1983	54	1	6	0	0	0	8	14
IZUMIYA	1978	104	4	20	38	14	24	10	31
JANECZKO	1982	78	3	14	99	38	61	9	24
KAZARIAN	1993	20	2	9	11	4	7	4	7
KHOVANSKII	1978	69	7	40	1	1	0	3	33
KOIKE	1979	33	2	20	16	0	16	7	8
KUO	1965	48	9	64	0	0	0	5	24
KURDYKA	1984	39	4	26	0	0	0	3	15
LE DUNG TRANG	1970	105	25	167	11	5	6	8	41
LEJEUNE-JALABERT	1971	37	6	47	2	0	2	0	21
LOJASIEWICZ	1950	100	15	82	151	5	146	4	55
LOOIJENGA	1971	54	24	235	2	0	2	4	24
LUENGO	1981	41	2	14	0	0	0	3	23
MACPHERSON	1967	86	7	37	4	1	3	1	56
MAISONOBE	1979	37	1	8	0	0	0	1	13
MALGRANGE	1953	139	22	145	0	0	0	3	59
MATHER	1965	78	37	301	25	0	25	4	40
MERLE	1973	25	4	14	3	1	2	6	9
MILMAN	1976	43	1	12	17	9	8	4	24
MILNOR	1950	149	63	273	11	0	11	0	82
MOND	1978	49	9	77	1	0	1	10	15
OKA	1972	76	8	44	23	5	18	6	33
ORRO	1983	14	1	9	20	9	11	3	7
PARUSINSKI	1985	49	7	48	18	7	11	8	18
PAWLUCKI	1984	26	3	24	28	12	16	1	10
PELLIKAAN	1988	43	3	11	4	0	4	2	16
PHAM	1963	54	13	83	0	0	0	2	23
PORTEOUS	1960	25	5	63	42	17	25	1	11
ROMERO-FUSTER	1983	41	0	9	40	27	13	4	9
RUAS	1986	33	1	1	53	18	35	5	11
SABBAH	1978	69	8	41	1	0	1	3	18
SAITO	1971	59	19	126	0	0	0	3	30
SEDYKH	1981	44	2	5	61	15	46	5	19
SHUSTIN	1980	87	2	11	114	19	95	3	45
SIERSMA	1973	39	14	92	1	1	0	6	13
SLODOWY	1978	39	5	25	2	2	0	1	17
STEENBRINK	1975	56	13	91	16	2	14	4	27
STEVENS	1984	33	4	21	140	60	80	2	14
SUWA	1969	71	2	8	11	0	11	1	27
TEISSIER	1970	68	26	201	25	9	16	3	31
THOM	1949	168	34	175	3	1	2	4	51
TIBAR	1984	46	4	18	79	27	52	5	12
TROTMAN	1976	45	5	33	36	16	20	5	16
VAN STRATEN	1985	40	3	17	14	3	11	3	22
VARCHENKO	1975	158	19	117	0	0	0	5	39
VASSILIEV	1990	59	4	19	0	0	0	1	22
WAHL	1974	38	10	65	187	41	146	1	23
WALL	1955	196	34	247	1	1	0	10	88
WHITNEY	1940	46	27	163	81	2	79	1	27
WILSON	1976	37	4	23	76	36	40	3	14
YOMDIN	1973	72	3	13	43	9	34	6	31
ZAKALYUKIN	1983	41	6	69	42	20	22	5	12
ZARISKI	1940	86	24	163	83	0	83	4	32