ISSI NEWSLETTER

QUATERLY E-NEWSLETTER OF THE INTERNATIONAL SOCIETY FOR SCIENTOMETRICS AND INFORMETRICS

ISSN 1998-5460

#51 / VOLUME 13 NUMBER 3

SEPTEMBER 2017

CONTENTS

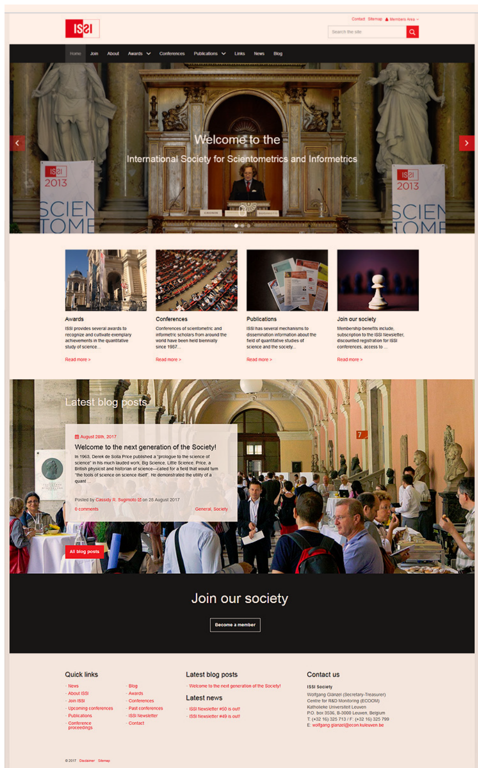
EDITORIAL

NEW ISSI WEBSITE

We are happy to inform our members that the ISSI has launched its modernised website (issi-society.org). In addition to the old content the new website features the following novelties: ▸ card payment of membership fees; ▸ more automated registration/renewal and payment procedures; ▸ easy-to-update user profiles; ▸ contents to all Newsletter issues; ▸ blog.

The new layout and customer interface has been developed by Henri de Winter and Nees Jan van Eck from the CWTS.

The website has been tested thoroughly but it is still in a beta mode—please, let us know if you happen to find any bug.



ISSI e-Newsletter (ISSN 1998-5460) is published by ISSI (http://www.issi-society.org/).
Contributors to the newsletter should contact the editorial board by e-mail.

22nd NORDIC WORKSHOP ON BIBLIOMETRICS & RESEARCH POLICY

9—10 NOVEMBER 2017
HELSINKI, FINLAND

PRE-WORKSHOP: **RESEARCHER VISIBILITY**

8 NOVEMBER 2017

CALL FOR PAPERS

Photo copyright: © Balázs Schlemmer

ABOUT THE WORKSHOP

http://blogs.helsinki.fi/nwb-2017/

ABSTRACT AND POSTER SUBMISSION

The participants who wish to present a research paper or a poster are called for a max. 250-word abstract of their presentation. We are in particular seeking novel ideas or work-in-progress of interest to a Nordic audience and if possible policy-related. You can offer either a paper or a poster. Papers will be presented over a workshop presentation (ca. 20 min.), while posters will be showcased in a poster booster session followed by a free-form discussion. The posters will be on display in the hallways of the workshop site. Please send your abstract by filling this form: https://www.lyyti.fi/reg/nwb2017_callforabstracts

Photo copyright: © Balázs Schlemmer

Photo copyright: © Balázs Schlemmer

Photo copyright: © Balázs Schlemmer

IMPORTANT DEADLINES

Deadline for submission of abstracts is the 15th of September 2017. The authors will be notified of acceptance by the 30th of September 2017.

FURTHER INFO

- For further information, please contact: **Reetta Muhonen**, reetta.muhonen (at) uta.fi
- In social media use the hashtag #NWB2017

KEYNOTE SPEAKERS

- **Stefanie Haustein**
  (University of Ottawa, Canada)
  Open science, social media and the scientific reward system

- **Kim Holmberg**
  (University of Turku, Finland)
  Measuring researchers' online visibility

- **Jesper Schneider**
  (Aarhus University, Denmark)
  'Science in Crisis'? The current challenges of research integrity in the 'soft' empirical sciences and how to study them

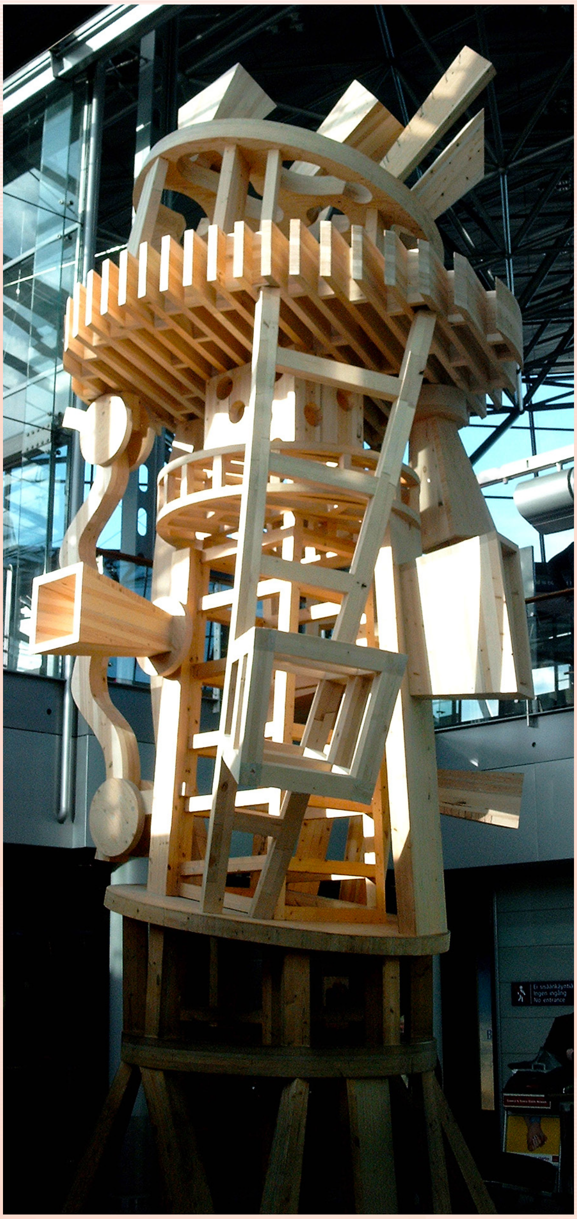


Photo copyright: © Balázs Schlemmer

THE CONFERENCE VENUE

The House of Science and Letters
(in Finnish: Tieteiden talo)
Kirkkokatu 6, Helsinki, Finland

WORKSHOP ORGANIZERS

NWB'2017 is organised by a consortium consisting of the Federation of Finnish Learned Societies (TSV), Helsinki University Library (HULib) and University of Tampere Research Centre for Knowledge, Science, Technology and Innovation Studies (TaSTI).

STEERING GROUP

- **Gunnar Sivertsen**
  (gunnar.sivertsen(at)nifu.no)
- **Birger Larsen**
  (birger(at)hum.aau.dk)
- **Camilla Hertil Lindelöw**
  (camilla.hertil.lindelow(at)sh.se)
- **Susanna Nykyri**
  (susanna.nykyri(at)helsinki.fi)
- **Sigurður Óli Sigurðsson**
  (sigurdur.sigurdsson(at)rannis.is)

REGISTRATION

Deadline for registration is the 23rd October. Please note that at least one of the authors has to register to the conference. You can register here: https://www.lyyti.fi/reg/nwb2017.

The workshop is also open to participants without a presentation.

COSTS OF PARTICIPATION, TRAVEL AND ACCOMMODATION

Participation to the workshop is free. Travel and accommodation have to be arranged and financed by the participants themselves.

COLLNET 2017 CONFERENCE REPORT

MARTIN MEYER

This year's COLLNET meeting took place in Canterbury at the University of Kent, bringing together 40 delegates from 14 countries to present current research on webometrics, informetrics, and scientometrics. It was the 13th Collnet Conference and, in time honoured tradition, Hildrun Kretschmer opened the meeting and presented an overview of how the Collnet community has developed over the years from the very beginning of the network to its current state today pointing to highlights and significant developments in our field. An early highlight of this year's meeting was the award of the Fellowship of the Indian Institute of Scientometrics to Ronald Rousseau who thoroughly enjoyed receiving this honour just as much as we enjoyed following the ceremony.

Photo copyright: © Zsuzsanna Glänzel

More than two and half days of plenary presentations on a wide and varied range of topics followed. Many of the bibliometric papers explored the structure or evolution of scientific fields looking at disciplines – including life sciences, environmental science, economics – as well as more focused areas or specialties, such as public health, hepatitis, semantic web, metaphor and open innovation research. A surprising number of contributions examined social science disciplines and fields. Equally interesting, 'convergence research' seems to be a topic attracting increasing interest. While many studies looked at entire fields

Photo copyright: © Yu Ye

from a global viewpoint, other contributions looked at how literatures developed in specific geographical, often country contexts. Key notes also explored methodological developments, with core document analysis being one example.

Contributions on patent analysis focused on technological areas, such as robotics, specific sectors, such as higher education and universities in a specific country, or on analysing citation universes combining patent and research data.

Research evaluation was another popular topic of this year's meeting. Here particularly interesting contributions focused on exploring the use of online resources such as Google Scholar at institutional level as well as field-specific studies (again, convergence research featured prominently). As the meeting was hosted at the business school, it was not surprising that a presentation also explored the use of bibliometrics for managing research, however, going beyond the more common metrics.

There were also very interesting individual contributions looking at variety of issues, such as citation inequality or how social media reports of research are related to the attention that research receives in the press. Again other presentations focused on publication types, such as dissertations published by University Presses.

Collnet this year was of a size and format that allowed for good discussions and the odd unscheduled presentation, adding a special and very personal note to the meeting. The conference closed with a fitting and moving tribute to Eugene Garfield and, looking to the future, a discussion about informetrics education. Many of us felt that any researcher in the sciences, social sciences and humanities and particularly research managers and relevant policy stakeholders would benefit from a basic appreciation of our field, its tools and approaches.

Conference presentations are made available at the conference website.

INTRODUCING PHILIPPE MONGEON

AWARDEE (2017) OF THE EUGENE GARFIELD DOCTORAL DISSERTATION SCHOLARSHIP

TITLE OF DISSERTATION

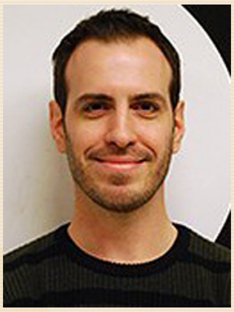
On division of labor and attribution of credit in science: a comparative study of authorship and inventorship practices using paper-patent pairs

ABSTRACT

Authorship is at the core of the reward system of science, as it links individuals with their discoveries. It fuels academic careers by allowing researchers to get recognition for their work, and helps science function as a somewhat meritocratic system. Authorship is also central to the field of bibliometrics, as it is the main component of many of the indicators that we develop, use, promote, or criticize.

But what exactly is a scientific author? This question gains importance in contemporary academia as articles are authored by increasingly large numbers of individuals, and as the relationship between individual contributions and authorship is often unclear. Much research on the topic, in our field and in others, has provided us with a better, though still incomplete, understanding of authorship practices in academia.

Authorship is not the only way for researchers to acquire recognition and advance their career. Patents, for instance, are also recognized and valued as research outputs, and are thus like (and perhaps more than) articles, a source of recognition and career advancement. But what do we know about inventorship practices? How do they compare with authorship practices?



Philippe has been a PhD student at the *École de bibliothéconomie et des sciences de l'information* (EBSI), University of Montreal, since 2013. He has also been a member of the Canada Research Chair on the Transformation on Scholarly Communications, directed by Prof. Vincent Larivière, since its creation in 2014. His doctoral research on authorship and inventorship practices is funded by the Social Science and Humanities Research Council of Canada and is supervised by Prof. Vincent Larivière and Prof. Christine Dufour (University of Montreal). He previously completed a master's degree in Information Science at the University of Montreal. His master's research, also supervised by Prof. Larivière, won the best poster prize at the 14th ISSI conference in Vienna. In 2016, Philippe also spent three months at CWTS as a visiting researcher.

The reward system of science is a central theme in Philippe's research. His work focuses on the practices through which researchers acquire recognition for their work, namely authorship and inventorship. He has also been involved in multiple projects on the scholarly publishing market and on the evaluation of journal usage by scholars and the broader university communities.

When the same discovery is disclosed in both a scientific article and a patent, a unique work gets attributed to two lists of individuals (the authors and the inventors) that may or may not be identical. My doctoral research uses such paper-patent pairs as a tool to better understand authorship and inventorship practices. It provides answers to questions such as: What proportion of authors are, on average, listed as inventors on the associated patents? How is this proportion influenced by factors such as team size, research impact? What is the relationship between researchers' contributions, their position in the list of authors, and inventorship? Is inventorship influenced by individual characteristics of researchers and the power relations between them? What disciplinary differences can be observed?

Despite the numerous research efforts, there remains a large gap in our understanding of the link between authorship and the contributions of individuals involved in a research project. My doctoral research will hopefully help to narrow this gap. As authorship and inventorship supposedly reflect the contributions of individuals, my research will provide insights on the division of tasks in research teams. Furthermore, since inventorship is in principle reserved to individuals who made inventive contributions, whereas more diverse tasks can lead to authorship, my research might shed new light on the limits of authorship as a proxy for the type and extent of individual contributions, and on the limits of individual level bibliometrics.

MODELLING THE TRIPLE HELIX RELATIONSHIPS WITH GAME THEORY: THE RULES OF THE GAME

EUSTACHE MÊGNIGBÊTO
University of Antwerp, Faculty of Social Sciences, Antwerp, Belgium
Bureau d'études et de recherches en science de l'information,
Saint Michel, Cotonou, Republic of Benin
eustache.megnigbeto@uantwerpen.be

INTRODUCTION

The relations between university, industry and government, named as Triple Helix (Etzkowitz & Leydesdorff, 1995, 2000), have been analysed with methods and techniques from different theories, e.g. bibliometrics, network theory, and information theory. In order to measure these relationships, some papers proposed indicators of science-technology interaction like patent citations or inventor/author analysis, publications counts, patents counts, citations, co-authors and related indicators; others are concerned with measuring information flows especially through entropy measures (Meyer, Grant, Morlacchi, & Weckowska, 2014). The mutual information (Leydesdorff, 2003) or the mutual redundancy (Leydesdorff & Ivanova, 2014) and the transmission power (Mêgnigbêto, 2014) based on the Shannon's (1948) information theory are being used for the measurement of the synergy within the Triple Helix innovation system.

The university-industry-government relationships constitute a complex system[1] (Leydesdorff, 2003) that could be analysed

1 Innovation systems are complex systems (cf. Katz, 2006, 2016).

with techniques and tools from cybernetics, information theory, game theory, decision theory, topology or mathematics of relations or factorial analysis (von Bertalanffy, 1973, p. 94). The objective of this paper is to model the Triple Helix relationships using game theory and propose indicators for the measurement of the synergy within an innovation system based on publication as unit of analysis. The article responds to the following research questions: Can the Triple Helix relationships be analysed from a game theory point of view? If so, ii) What may be the rules of the game? A third question derives from the answers to the first two questions: what indicators can be used to measure the synergy within the Triple Helix innovation system?

THE TRIPLE HELIX MODEL OF INNOVATION

The Triple Helix concept introduced by Etzkowitz and Leydesdorff (1995; 2000) is one of the variants of the nonlinear model of innovation (Etzkowitz et al., 2000). It postulates that the interactions between university, industry and government maintain a knowledge infrastructure that generates knowledge of which circulation among innovation actors leads to innovation (Leydesdorff & Etzkowitz, 2001). It differs from other variants of the innovation system by i) pointing out the changing role of the actors, ii) considering the relations between university, industry and government as a communication system and, iii) focusing on the "overlay of communications and expectation" that reshapes the institutional arrangements among actors (Etzkowitz & Leydesdorff, 2000, p. 109). The Triple Helix model reduces the number of innovation actors to the three main ones whereas the innovation system model adds others like financial institutions.

The Triple Helix model relies on collaboration between innovation actors for knowledge creation, sharing and transformation purposes. By doing research, researchers produce information and knowledge; by collaboration means, they increase their productivity (Katz & Martin, 1997) and share information and knowledge (Katz & Martin, 1997). Research collaboration is recognized as crucial for knowledge production and innovation (OECD, 2010, p. 98); it may cover several aspects. It is often used as synonymous of multiple authorships or multiple addresses; that is, research collaboration occurs if two or more scientists cooperate and publish (Katz & Martin, 1997). Even though the measure presents some limitations, in Academia, co-authorship is the most visible indicator of scientific collaboration and has thus been frequently used to measure collaborative activity (Katz & Martin, 1997).

Collaboration is one aspect of the interactions between the Triple Helix actors; Leydesdorff advices however against reducing the Triple Helix relations to "collaboration" (Park, 2014). Indeed, Watson (2013) stated that an interaction may be competitive or cooperative. The OECD (2002, p. 15) affirmed that the concept of interaction between innovators includes three basic ideas: competition, transaction and networking.[2] According to the Triple Helix theory, "innovation actors who coexisted relatively separately, are now moving in a common direction to stimulate both competition and collaboration" (Leydesdorff & Etzkowitz, 2001); Gibbons et al. (1994) supported that the relations between innovations actors "seeks a balance between competition and cooperation". In summary, cooperation, collaboration, competition and transaction contribute to the dynamic within the Triple Helix innovation system.

2 Competition is "the interactive process where the actors are rivals and which creates the incentives for innovation". Transaction "is the process by which goods and services, including technology embodied and tacit knowledge are traded between economic actors". Networking "is the process by which knowledge is transferred through collaboration, co-operation and long term network arrangements". (OECD, 2002, p. 15)..

BASIC INFORMATION ON GAME THEORY

Game theory is a branch of mathematics that deals with how economic actors interact for their interests. Game theory techniques can be used to understand economic, social, political, and biological phenomena (Osborne, 2004, p. 13). It is concerned with the actions of decision makers who are conscious that their actions affect each other; it "is not useful when decisions are made that ignore the reactions of others or treat them as impersonal market forces" (Rasmusen, 2000, p. 30). According to Aumann (1985), game theory can be applied to all situations where peoples' actions are both utility maximizing and interdependent.

Game theory defines a game with four elements : the players, the actions, the payoff and the information (Rasmusen, 2000). Players are the individuals who make decisions. An action is a choice made by a player; usually, there is a set of actions a player can choose from. A payoff means either i) the utility a player receives after the game has been played out; or ii) the expected utility he receives. An information set at any particular point of the game is the reading a player has of the actions the other players have taken or will take. A game may be defined in strategic or an extensive form. Game theory distinguishes two branches: the noncooperative game and the cooperative game. The noncooperative game focuses on the strategies of individual players while a cooperative game focuses of how players behave mainly by the means of coalitions. In a cooperative game, players can bind arrangements.

THE TRIPLE HELIX RELATIONS AS A COOPERATIVE GAME

University, industry and government and the relationships they have with each another constitute the Triple Helix innovation system. They are the motor of innovation, economic growth and social welfare. Sometimes, they produce knowledge individually, and other times they have agreements to produce it jointly throughout bi- or trilateral interactions. So, the actions of one actor may determine the behaviour of the others. Besides, throughout their interactions, university, industry and government increase their individual productivity (Katz & Martin, 1997) in terms of number of publications; in other terms, each intends to maximize its interests while working for the synergy within the innovation system. Therefore, the Triple Helix relationships as described above can be considered as a game and modelled with game theory.

RULES OF THE TRIPLE HELIX'S GAME

PLAYERS, ACTIONS, PAYOFF AND INFORMATION

Defining the rules of a game consists in determining the players, the actions, the payoff and the information (Rasmusen, 2000). In the Triple Helix game, the players are the three main innovation actors: university, industry and government. Actors share knowledge in order to exploit it; the exploitation of knowledge requires it to be produced, circulate and be acquired (Mueller, 2006, p. 1500). Doing research is, therefore, a sine qua non condition for knowledge production. Publications are tangible measure of research activities; hence, not publishing is an unconceivable action for actors of the Triple Helix innovation system or the Triple Helix game. Furthermore, while publishing, the Triple Helix innovation actors could conclude arrangements or not with each another. We conclude that the actions available to the Triple Helix innovation game players are collaborate and not collaborate. We use the number of papers published by actors or the corresponding percentage shares as the game payoffs.

In publication counting, two methods exist: the full counting and the fractional counting (cf. e.g. Leydesdorff & Bornmann, 2011; Waltman & van Eck, 2015). The full counting method fully assigns a publication to each co-author whereas the fractional counting case, a publication is fractionally assigned to each co-author;[3] in this paper, we adopt the fully counting method as done in bibliometric studies dealing with the Triple Helix relationships (e.g. Khan & Park, 2011). Besides, it is not possible to predict if a publication having resulted from collaboration would be published if there were no agreement for research collaboration between the partners. Therefore, we considered such a paper as published by a unique author composed of all its co-authors, i.e. they are not counted as the output of any individual author.

In summary, the Triple Helix game is characterised by the set of three players (university, industry, and government), the set of actions that could be taken (collaborate, not collaborate), the payoff (the number of publications or the corresponding percentage shares) and the information. A game may be defined in strategic or an extensive form; however, a cooperative game is defined in a characteristic form with two elements: i) a set of players, and ii) a characteristic function specifying the values created by different subsets of the players in the game. It implies arrangements between players to form coalitions.

COALITIONS

In a cooperative game, a coalition is a group of players that has the institutional structure to plan and execute actions, including the allocation of the generated value over its members (Gilles, 2010, p. 31). By principle, the empty set and sets of individual players are also considered as coalitions; the coalition that groups together all players is called the grand coalition. As a consequence, the number of coalitions in a n-players game is 2^n; thus, the Triple Helix game counts $2^3 = 8$ coalitions of which set is $P = \{\varnothing, \{u\}, \{i\}, \{g\}, \{u, i\}, \{u, g\}, \{i, g\}, \{u, i, g\}\}$. This means that i) there is no actor within the game; in other words, university, industry and government does publish neither individually nor collectively; this is represented by the empty set $\varnothing$; ii) actors publish individually, perhaps only one publishes, or two or all the three, but there is no collaboration; this yields the one-player coalitions represented by the sets {u}, {i}, {g}; iii) there are three bilateral collaborations yielding the three two-player coalitions represented by the sets {u, i}, {u, g}, {i, g});[4] and, iv) there is one trilateral collaboration yielding the grand coalition represented by the set {u, i, g}).

IS THE PAYOFF TRANSFERABLE?

Let us consider an innovation system consisting of university and industry where university and industry produced U and I papers on their own respectively and UI papers jointly. The total number of publications within the system adds up to U + I + UI, but overall, university produces U + UI papers and industry I + UI papers. Normally, in game theory, the number of papers jointly published by U and I should be counted for one partner only, either U or I – that is the payoff is not transferable – or the two partners should have an agreement to share the output resulting from their collaboration (i.e. UI papers), so the shares, say α and β, should add up to UI – the payoff is transferable. But that is not the case with the full counting method: the paper resulting from a collaboration accounts for both university and industry. Traducing this in game theory language means that the payoff of the coalition formed by university and industry goes

3 Full counting fully assigns a publication to each co-author. For instance, a publication co-authored by four countries counts as a full publication for each of the four countries. In the fractional counting case, a publication is fractionally assigned to each co-author. The weight with which a publication is assigned to a co-author indicates the share of the publication allocated to that co-author. The sum of the weights of all co-authors of a publication equals one. There are many variants of fractional counting (cf. Waltman & van Eck, 2015).

4 In a set, the order of elements is not meaningful, i.e. the set {u, i} is the same as the set {i, u}.

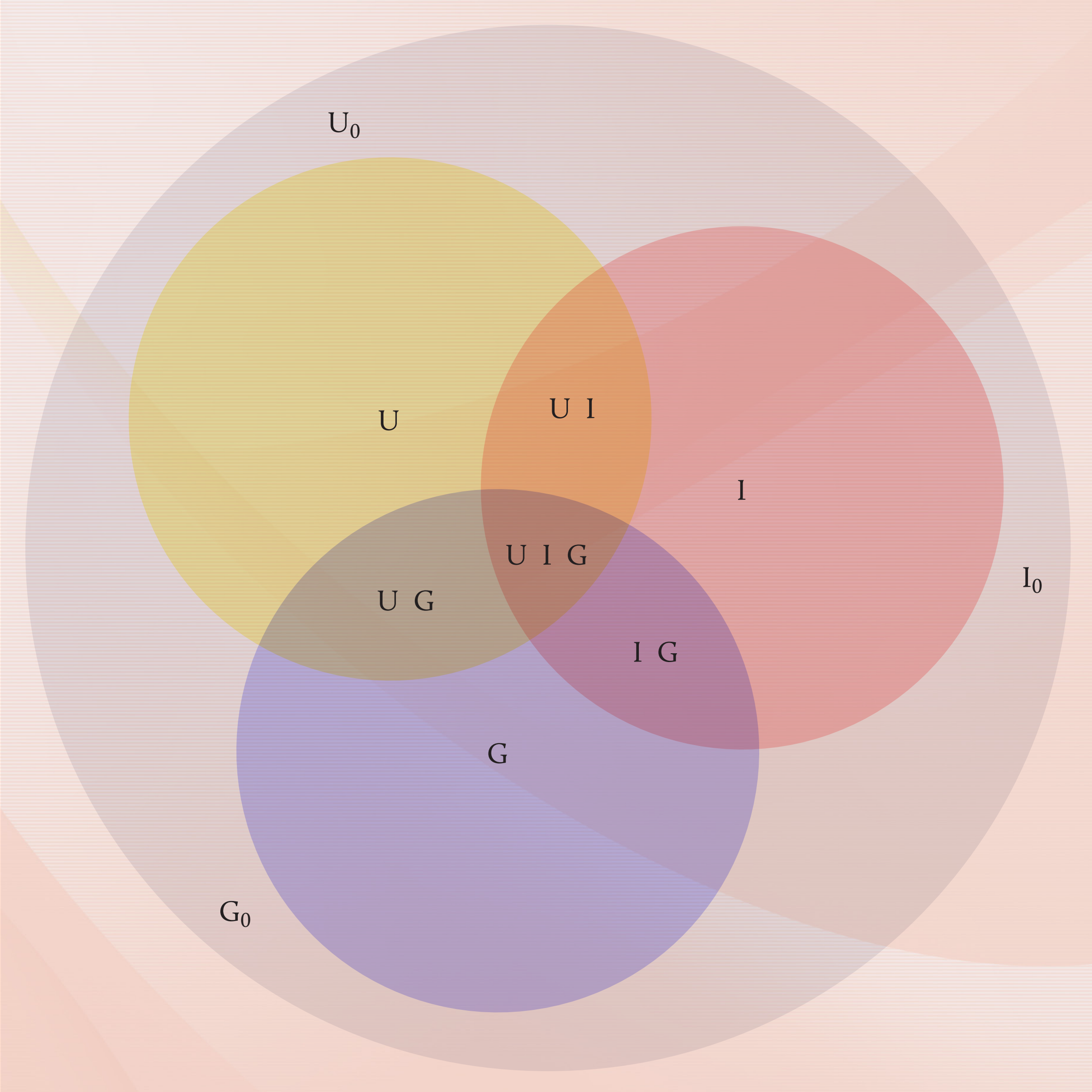


Figure 1. Triple Helix spheres' contributions to the Triple Helix relations

to each part entirely. The two actors that collaborate in publishing get the same utility[5] of their common output. We considered the game as with transferable utility because each member of a coalition benefits from the utility resulting from the coalition actions.

CHARACTERISTIC FUNCTION

In a cooperative game, the characteristic function determines the payoff of each potential coalitions engaged in the game. The basic rules are: i) the total payoff is the payoff of the grand coalition and ii) the empty coalition has a payoff of 0, iii) the payoff of any coalition with at least two members is greater than the sum of the payoffs of individuals composing the considered coalition. Let us consider Figure 1 which represents the basic configuration of the Triple Helix in term of number of publications per sphere (cf. e.g. Khan & Park, 2011).

In Figure 1, U_0, I_0 and G_0 represent the total number of papers university, industry and government published within the considered set of papers, including publica-

5 The utility is measured in term of number of publications and not in term of publications use or the transformation of produced knowledge.

tions produced throughout bi or trilateral collaborations; U, I, G represent the number of papers university, industry and government published on their own respectively; UI, UG, IG represent the number of papers university and industry, university and government, industry and government co-authored respectively: and UIG the number of papers the three actors co-authored. UI, UG and IG exclude UIG. The total number of publications in the considered set is T = U + I + G + UI + UG + IG + UIG, with U_0 = U + UI + UG + UIG, I_0 = I + UI + IG + UIG and G_0 = G + UG + IG + UIG.

Let υ be the characteristic function of the considered Triple Helix game, i.e. the function that associates to each coalition its "interests" in the game, i.e. the number of papers it published or the corresponding percentage share. University produces on its own U papers, industry I papers and government G papers. University and industry produced UI papers jointly. The number UI as the supplement payoff of which benefit has incited the two players to "negotiate" and form a coalition. By binding agreements, university expects getting more than U papers and industry more than I papers. Because the number UI goes to both players, υ({u, i}) = U + I + UI. By the same reasoning, we deduced υ({u, g}) = U + G + IG and υ({i, g}) = I + G + IG. UIG is the result of the "work" of all three players and should not be attributed to any particular one-player or two-player coalition rather to the grand coalition. So υ({u, i, g}) = υ(N) = U + I + G + UI + UG + IG + UIG which represents the total number of papers in the considered set. Therefore, the characteristic function of the Triple Helix game follows:

$$\begin{cases} \upsilon(\varnothing) = 0 \\ \upsilon(\{u\}) = U \\ \upsilon(\{i\}) = I \\ \upsilon(\{g\}) = G \\ \upsilon(\{u, i\}) = U + I + UI \\ \upsilon(\{u, g\}) = U + G + UG \\ \upsilon(\{i, g\}) = I + G + IG \\ \upsilon(\{u, i, g\}) = U + I + G + UI + UG + IG + UIG \end{cases}$$

PROPOSAL OF INDICATORS

The Triple Helix postulates that innovation results from the interactions between actors that create synergy within the innovation system. Therefore, if the Triple Helix relationships of university-industry-government can be modelled with game theory, how can the synergy be measured? "Synergy is the fusion between different aims and resources to create more between the interacting parties than they had prior to the interactions" (François, 2004). The existence of synergy within the Triple Helix innovation system supposes that conditions are fulfilled for actors accept working together to achieve a common goal. It also supposes that actors have the insurance that their interests are secured; in other terms, they accepted the rules of the game, else they could not continue playing.

Game theorists developed a certain number of indicators to characterize a cooperative game with transferable payoff; the main are the core, the Shapley value and the nucleolus. The core of a cooperative game is defined as the set of actions no individual player has an incentive to deviate from. It is so that it leaves "no coalition in a position to improve the payoffs of all its members" (Shapley & Shubik, 1973, p. 40). The core, then, may be considered as the state of the game that ensures both individual and common interests. However, as an indicator, the core has some drawbacks: it is a range of values, not a unique one; besides, it may be empty. Due to the possibility of the emptiness of the core, game theory specialists also use the Shapley value and the nucleolus. The Shapley value measures the fairness while allocating the total payoff to players. When the core exists, it includes the Shapley value. The nucleolus is a measure of the inequity of the sharing of the total payoff of the game.

In our opinion, each of these three indicators attempts to find the conditions for each actor to have its interests secured so that it can continue playing. These conditions determine the existence of synergy within the system. We conclude that the core, the Shapley value and the nucleolus can be used to measure the synergy within a Triple Helix innovation system.

CONCLUSION

In this paper, we demonstrated that the Triple Helix relationships can be modelled with game theory and then analysed following this discipline's principles, methods and techniques. The unit of analysis used is publications the Triple Helix actors authored. We found that the Triple Helix relationships can be considered as a cooperative game with transferable utility. The players are the Triple Helix innovation actors (university, industry and government); they have to choose between collaborate or not collaborate while doing research; their payoff is the number of publications or the derived probabilities. Then, we propose the core, the Shapley value and the nucleolus as indicators for measuring synergy within a Triple Helix innovation system.

REFERENCES

Aumann, R. J. (1985). What is game theory trying to accomplish. In K. Arrow & S. Honkapohja (Eds.), *Frontiers in economics*. Oxford: Basil Blackwell.

Etzkowitz, H., & Leydesdorff, L. (1995). The Triple Helix---University-Industry-Government relations: a laboratory for knowledge-based economic development. *EEASST Review*, *14*(1), 14–19.

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and "'Mode 2'" to a Triple Helix of university–industry–government relations. *Research Policy*, *29*(2), 109–123.

Etzkowitz, H., Webster, A., Gebhardt, C., & Cantisano Terra, B. R. (2000). The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm. *Research Policy*, *29*(2000), 313–330.

François, C. (2004). Synergy. In *International encyclopedia of systems and cybernetics* (p. 741). Berlin: Walter de Gruyter.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). *The new production of knowledge: the dynamics of science and research in contemporary societies*. Sage.

Gilles, R. P. (2010). *The cooperative game theory of networks and hierarchies*. Berlin: Springer.

Katz, J. S. (2006). Indicators for complex innovation systems. *Research Policy*, *35*(7), 893–909.

Katz, J. S. (2016). What is a complex innovation system? *PloS One*, *11*(6). https://doi.org/10.1371/journal.pone.0156150

Katz, J. S., & Martin, B. R. (1997). What is research collaboration? *Research Policy*, *26*(1), 1–18.

Khan, F. G., & Park, H. W. (2011). Measuring the Triple Helix on the Web: longitudinal trends in the university-industry-government relationship in Korea. *Journal of the American Society for Information Science*, *62*(12), 2443–2455.

Leydesdorff, L. (2003). The mutual information of university-industry-government relations: an indicator of the Triple Helix dynamics. *Scientometrics*, *58*(2), 445–467.

Leydesdorff, L., & Bornmann, L. (2011). How fractional counting of citations affects the impact factor: Normalization in terms of differences in citation potentials among fields of science. *Journal of the Association for Information Science and Technology*, *62*(2), 217–229.

Leydesdorff, L., & Etzkowitz, H. (2001). The transformation of university-industry-government relations. *Electronic Journal of*

Sociology, *5*(4). Retrieved from http://www.sociology.org/content/vol005.004/th.html

Leydesdorff, L., & Ivanova, I. A. (2014). Mutual redundancies in interhuman communication systems: steps towards a calculus of processing meaning. *Journal of the Association for Information Science and Technology*, *65*(2), 386–399. https://doi.org/10.1002/asi.22973

Mêgnigbêto, E. (2014). Efficiency, unused capacity and transmission power as indicators of the Triple Helix of university-industry-government relationships. *Journal of Informetrics*, *8*(1), 284–294. https://doi.org/10.1016/j.joi.2013.12.009

Meyer, M., Grant, K., Morlacchi, P., & Weckowska, D. (2014). Triple Helix indicators as an emergent area of enquiry: a bibliometric perspective. *Scientometrics*, *99*(1), 151–174. https://doi.org/10.1007/s11192-013-1103-8

Mueller, P. (2006). Exploring the knowledge filter: How entrepreneurship and university–industry relationships drive economic growth. *Research Policy*, *35*(10), 1499–1508. https://doi.org/10.1016/j.respol.2006.09.023

OECD. (2002). *Dynamising national innovation systems*. Paris: OECD.

OECD. (2010). *Measuring innovation: a new perspective*. Paris: OECD.

Osborne, M. J. (2004). *An introduction to game theory* (Vol. 3). Oxford university press New York.

Park, H. W. (2014). An interview with Loet Leydesdorff: the past, present, and future of the triple helix in the age of big data. *Scientometrics*, *99*, 199–202. https://doi.org/10.1007/s11192-013-1123-4

Rasmusen, E. (2000). *Game and information: an introduction to game theory* (3rd edition). Basil Blackwell.

Shannon, C. E. (1948). A mathematical theory of communication. *The Bell System Technical Journal*, *27*(3), 379-423-656.

Shapley, L. S., & Shubik, M. (1973). *Game theory in economics. Chapter 6 : characteristic function, the core and stable set* (No. R-904/6-NSF) (p. 96). National Research Foundation.

von Bertalanffy, L. (1973). *Théorie générale des systèmes*. Paris: Dunod.

Waltman, L., & van Eck, N. J. (2015). Field-normalized citation impact indicators and the choice of an appropriate counting method. *Journal of Informetrics*, *9*(4), 872–894.

Watson, J. (2013). *Strategy: an introduction to game theory* (3rd ed.). New York—London: W. W. Norton & Company.