SYSTEM DYNAMICS

A bibliometric analysis of System Dynamics Review

ABSTRACT

System Dynamics emerged in 1956 from the ideas and practical unrest of its creator Jay Wright Forrester about problem solving. When it was associated to structured social thinking it received a boost developing. There was born a new method to represent complex systems and situations, sometimes counterintuitive, which collaborate with the understanding of the complex world where man lives. System Dynamics Society was created and from its core was borne a knowledge transmission vehicle, System Dynamics Review, whose main objective is System Dynamics dissemination. This paper analyzed the publications of this journal in its thirty existence years in order to make a bibliometric study and a social network analysis to form an initial "map" of this scientific field. Were pointed main authorship and co-authorships; authors and their most influential works; the institutions to which the authors were linked; the geographical origin of authors and institutions; partnerships between these authors and their positions in the social network. This compiled data suggests System Dynamics slow spread dissemination and its concentration in the United States around a small number of researchers. This study is only the starting point to rethinking System Dynamics way and the achievement of similar work in other significant journals to complete the "mapping" will be an important tool to enrich data provision in order to have a more accurate indicator to those who could do the difference in this young science.

INTRODUCTION

System Dynamics purpose is to be a system evaluation tool; a reality interpretation mechanism that allows to model its projection over time focused on represented management situations (GARCIA, 2010).

This work intends to create an initial "map" of System Dynamics. It begins the "topography" with the main journal of the area, System Dynamics Review, published by System Dynamics Society. It presents a bibliometric study of this journal, considering all period of its existence combined with authors' social network analysis. It contains statistical information about papers, paper contents, authors, authors' institutions, authors and institution nationality, works and authors referenced and authors' relationships.

The aim of the research is to get a deeper understanding of System Dynamics themes, issues, researchers and practitioners to better understand it´s development path. The importance of this work rests on "thinking about" why System Dynamics field of study is so underdeveloped when compared with other widespread methods like Monte Carlo Simulation, Discrete Event Simulation, Mathematical Programming, etc., whose initial development were cotemporary to the development of System Dynamics.

This article contribution is also to provide organized support material to encourage further forays into the subject.

THE RESEARCH

From 542 texts published on System Dynamics Review volumes from June 1985 to December 2014, 67 were disregarded because they were invitations to symposiums and tributes to some personalities, thus were considered for this bibliometric study 475 texts. Each of these texts in this research will be identified as paper. The item nationality, appointed to papers authors, is based on the nationality of the institution to which they were linked at publication time. All papers were classified according to their characteristics in three group levels: Class, Theme and Subject. Class was split in Theme. Theme was split in Subject. It was stablished two classes Initially papers were cataloged in the "larger" group, called Class. Two Classes were established and divided into groups called Themes. Nine Themes were created in all. Themes were in turn subdivided into smaller groupings called Subjects. This classification was performed in order to identify possible trends or thematic absences. In the Class group the papers were identified as "Applications" and "Theoretical". Applications includes papers that deal with the use of System Dynamics as a tool to study specific subjects, and Theoretical encompasses those papers that deal with the improvement of System Dynamics methods and software. "Applications" Class was divided in eight Themes: "Public Administration", to papers whose themes are experiments, situations and problems involving the public administration; "Learning", to papers whose theme is learning, learning processes and education; "Biological", to papers whose theme is organic life, its development and biological communities; "Economy", to papers whose theme is the economy, its theoretical and practical application; "Human", to papers whose theme is linked to social life; "Organizations", to papers whose theme is the organization; "Sustainability", to papers whose theme is sustainability and, finally, "Technology", to papers whose theme is technology and its relationship with development. "Theoretical" Class presents a unique theme, "System Dynamics", referring to papers whose theme is the development of System Dynamics as a method. It was created thirty "Subject" subdivisions: "Energy", to papers whose subject is distribution of energy and energy sources with regard to their location, organization and mode of transmission; "Public Management", to papers whose subject is public administration in general, strategies and policies, drug trafficking combating and drug use; "Public Health", to papers whose subject is public health management and public health policy; "Public Security", to papers whose subject is public safety and violence; "Transport", to papers whose subject is public transport and planning, policies and public transport companies; "Urbanism", to papers whose subject is urban and rural cities, states and countries planning, from regional expansion and retraction perspective, population allocation and development; "Educational", to papers whose subject is education as a whole, public education, educational institutions and education policies; 3 "Methods", to papers whose subject is learning methods, applied methodologies to education and to groups of scholars and methodological tools; "Organizational", to papers whose subject is organizational learning, learning processes and training in organizations; "Biological Systems", to papers whose subject is biological systems and ecosystems; "Health Management", to papers whose subject is the private health management, health management companies and health plans; "Diseases and Organisms", to papers whose subjects are diseases and behavioral studies of organic communities; "Economic activity", to papers whose subjects are experiments and analysis on market and industry sector; "Base Industry" to papers whose subject is the basic industries such as energy, the mining, metallurgical, etc. in general and conceptual views, analysis and structuring of basic flows such as value and supplies chain;

"Financial Model" to papers whose subject is the analysis of comparative application of models and results and theoretical studies on economic concepts; "Behavior", to papers whose subject is human behavior and social relationships; "Social Model", to papers whose subject is relationship between human groups, communities models; "Strategy and Processes", to papers whose subject is strategy, procedures and organizational processes; "People," to papers whose subjects are human relationships and behavior in the organization; "Policies", to papers whose subject is management and organizational execution policy; "Organizational Resources", to papers whose subject is organizational resources collection and management, except human resources; "Environment", to papers whose subject is environmental respect and the environment; "Sustainability Policies", to papers whose subject is generation, management and evaluation of policies for sustainability; "Natural Resources and Energy", to papers whose subject is the management and exploitation of natural resources, sustainable energy generation and sustainable innovations; "Waste Treatment", to papers whose subject is the treatment of waste; "Biotechnology", to papers whose subject is development of technologies related to human life, biotechnology and cybernetics; "Engineering", to papers whose subject is application and development of process design and construction of instruments and objects; "Information", to papers whose subject is application and development of information technology and software; "Analytical", to papers whose subject is application and the analysis application of system dynamics concepts, modeling, diagrams and feedback; "Conceptual", to papers whose subject is development and analysis of pre-existing and new components of the System Dynamics, System Dynamics history and honors, and finally "Tooling", to papers whose subject is analysis and experience with tools and software built to meet System Dynamics.

RESULTS - PRESENTATION AND ANALYSIS

From June 1985 to December 2014, "System Dynamics Review" published 475 papers. Table 1 presents the numbers obtained from direct measurements. It was 475 papers by 555 authors that belong to 247 institutions distributed through 37 countries. There were 8,668 works cited as reference from 9,141 authors including books, articles, theses, dissertations and research papers in general. Due to the magnitude of the data obtained, for didactic purposes, graphs, charts and tables presented may reflect partial data, which however does not affect the understanding of the analyzed points.

Item	Numbers
Papers	475
Authors	555
Institutions	247
Countries	37
Referenced Authors	9,141
Referenced Works	8,668

Table 1 – General Numbers

Papers

Considering these thirty years, the trend line for paper per year is growing, however slightly. The annual publications average was around 15 papers. Figure 1 shows the number of publications grouped by periods of five years. Despite the upward trend line, stagnation may be observed in papers volume in last two periods.

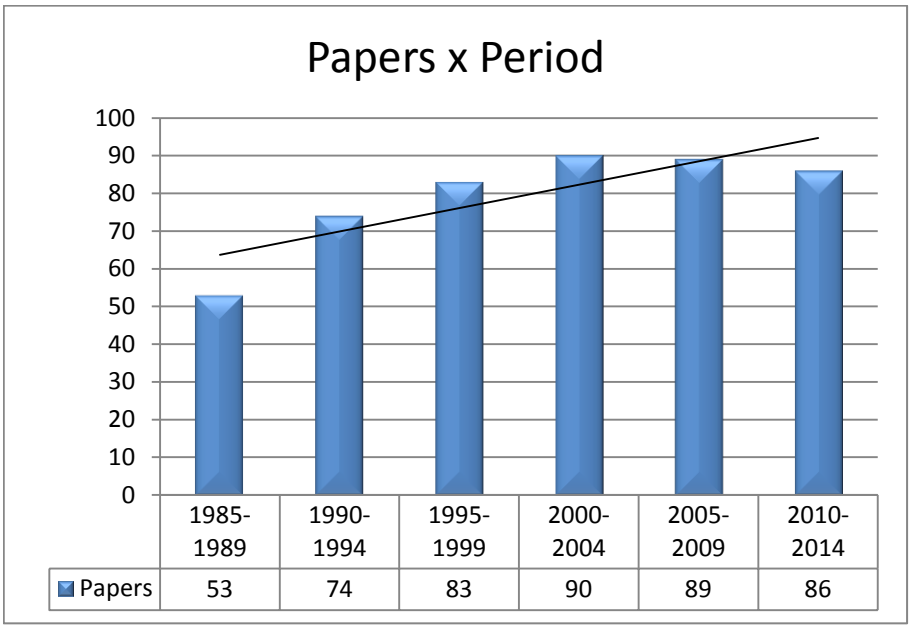

Figure 1 – Publication volume – Period x Period (5 years)

Figure 2 shows a relative balance between the papers distribution in Classes. Figure 3 shows the papers distribution in "Themes". As noted, "System Dynamics" Theme exceeds three times the runner-up "Organizations".

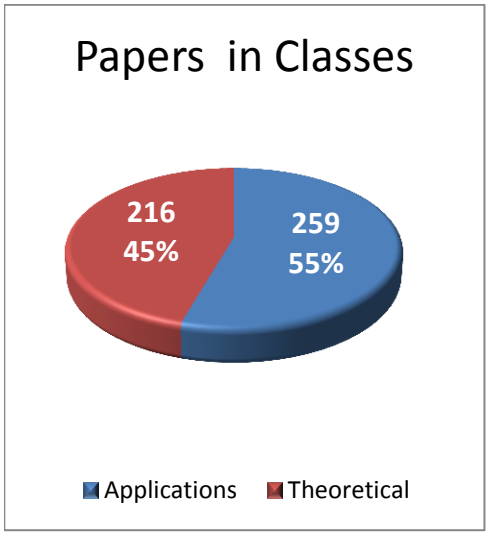

Figure 2 – Paper distribution in Classes

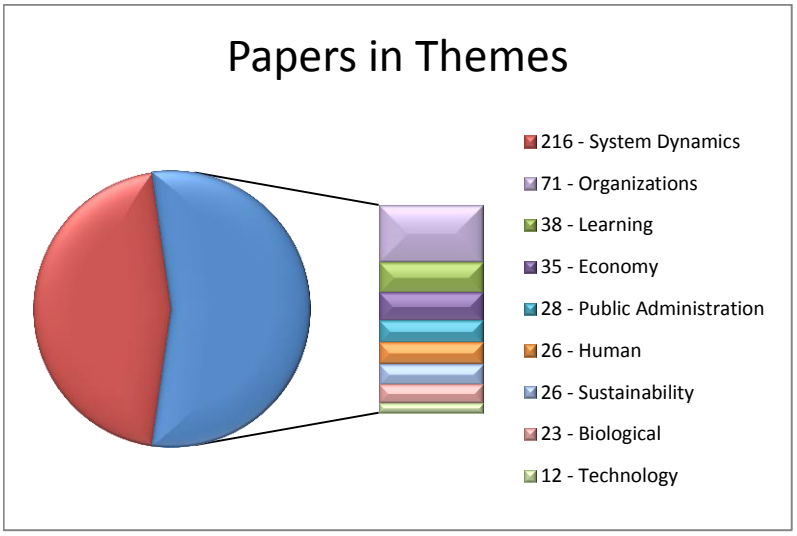

Figure 3 – Paper distribution in Themes

Figure 4 shows the paper distribution in “Subjects”.

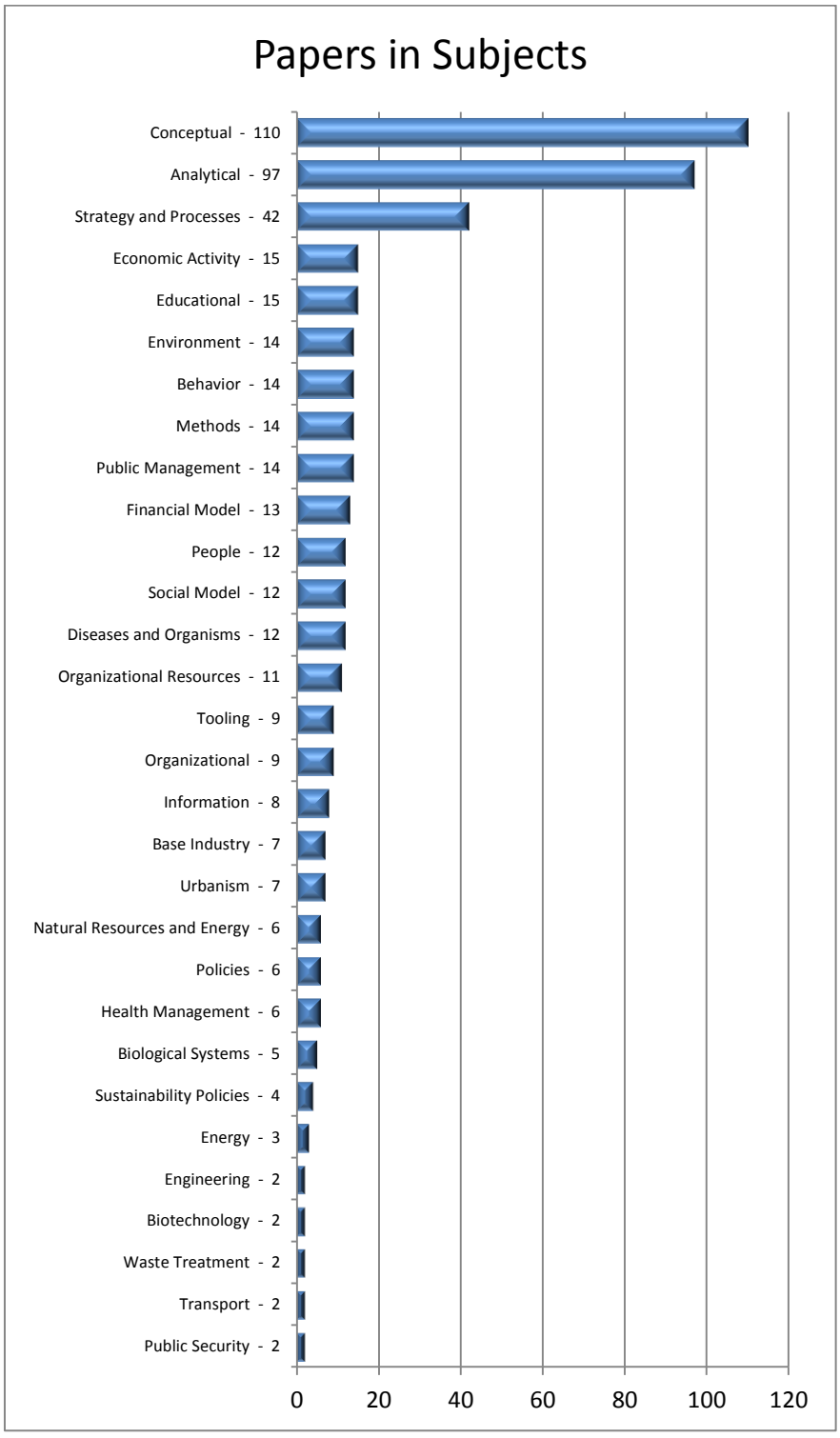

Figure 4 – Paper distribution in Subjects

Although the balance between numbers in “Classes” category, there was preferences on “Subjects”. “Conceptual”, “Analitical” and “Strategy and Processes” subjects have far exceeded their successors.

Table 2 presents three categories grouped with their respective numbers.

Class	Theme	Subject	Papers
Applications	Public Administration	Public Management	14
		Urbanism	7
		Energy	3
		Public Security	2
		Transport	2
	Learning	Educational	15
		Methods	14
		Organizational	9
	Biological	Diseases and Organisms	12
		Health Management	6
		Biological Systems	5
	Economy	Economic Activity	15
		Financial Model	13
		Base Industry	7
	Human	Behavior	14
		Social Model	12
	Organizations	Strategy and Processes	42
		People	12
		Organizational Resources	11
		Policies	6
	Sustainability	Environment	14
		Natural Resources and Energy	6
		Sustainability Policies	4
		Waste Treatment	2
	Technology	Information	8
		Biotechnology	2
		Engineering	2
Theoretical	System Dynamics	Conceptual	110
		Analytical	97
		Tooling	9
Total			475

Table 2 - Paper Categories Distribution

In figure 5 it is possible to observe the representative graphics of "Applications" class themes.

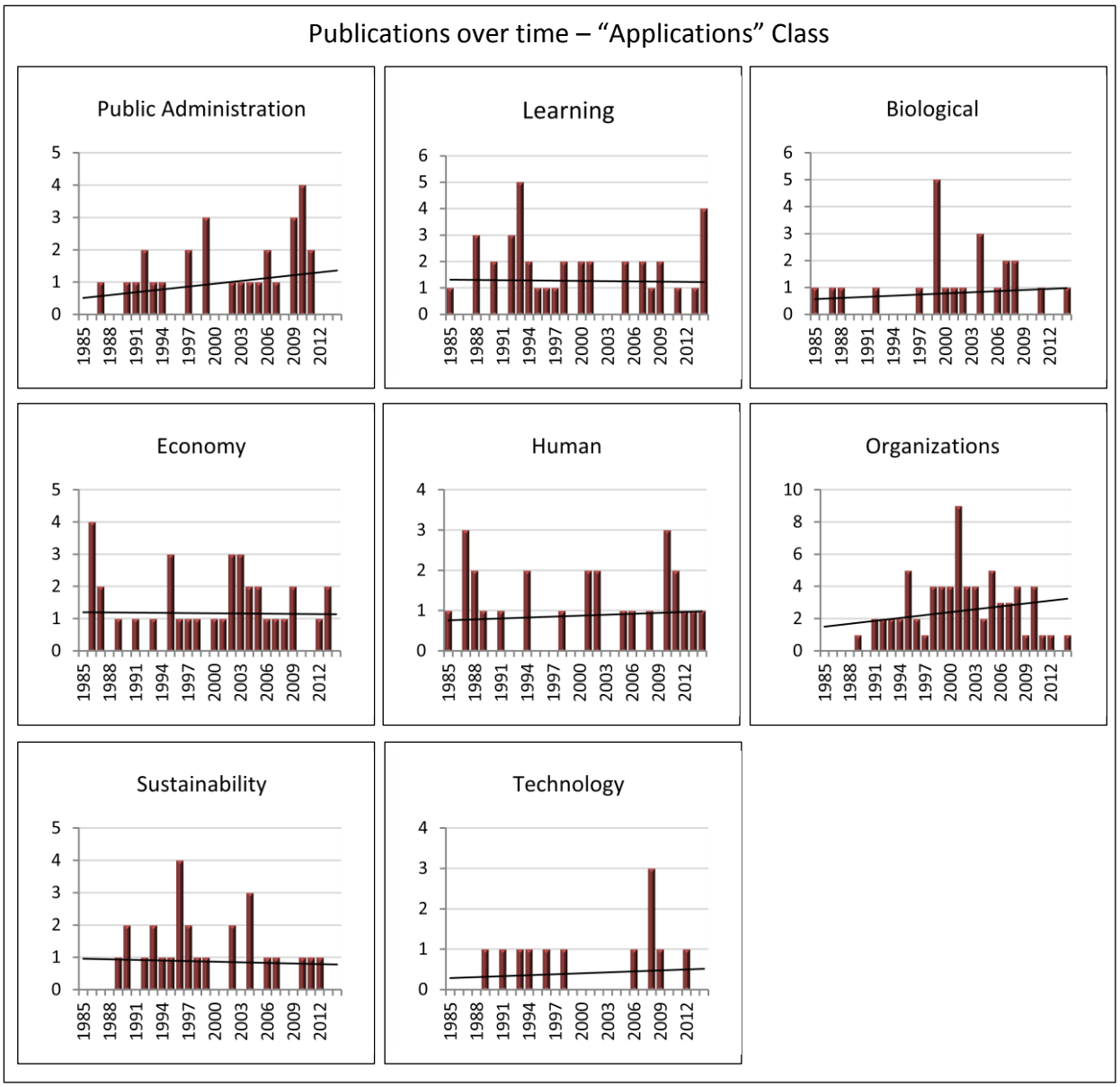

Figure 5 – Publications over time – "Applications" Class

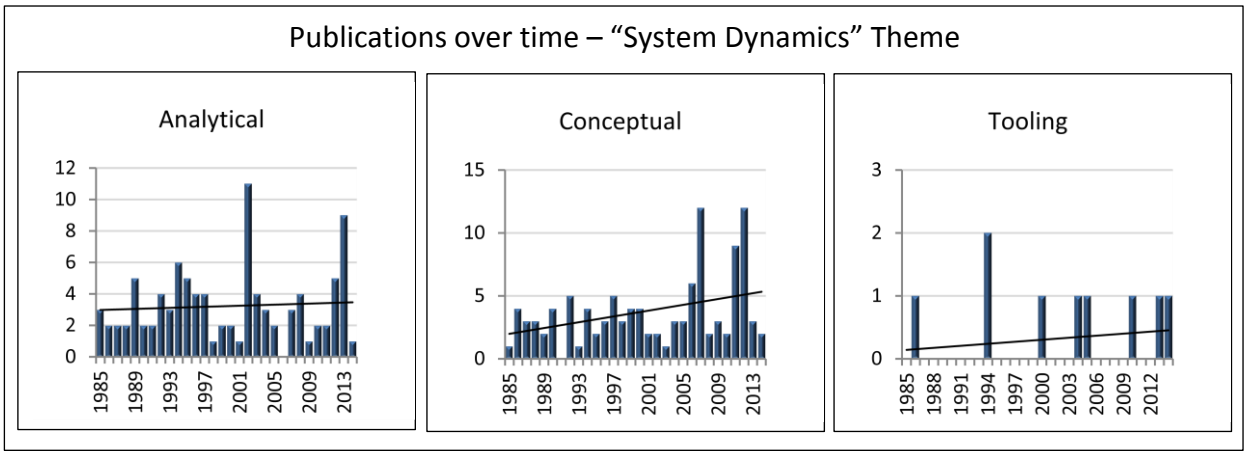

Figure 6 – Publications over time – "System Dynamics" Theme

In Figure 6 there are only the “Dynamic Systems” subjects, once it is the unique theme of “Theoretical” class. Considering the absolute values and the curve trend of each graph, it is not observed significant biases in none of them.

Authors

Table 3 shows the relationship between the number of authors and their production.

Papers	1	2	3	4	5	6	7	8	9	10	11	12	16	17	25	30
Authors	431	58	27	12	5	3	6	3	2	2	1	1	1	1	1	1

Table 3 – Authors number and their production

This relationship leads us to the chart shown in figure 7 which depicts the Lotka's Law. In this graph two curves were outlined, one originated in Lotka concepts. An asymptote curve f (x) = 1 / x^2, that represents the number of author in a scientific community, where "x" represents the number of papers written by authors meaning that there are a few authors that write many papers and vice versa. It can observed that the graphics designed by Table 3 present ratios not perfect asymptote Lotka, however, describe the general and approximate way, providing evidence to confirm his principle. From 555 authors, 431 wrote only one paper and only 27 of then reach the five papers mark, in other words, few authors publish much and yet, many authors publish a few.

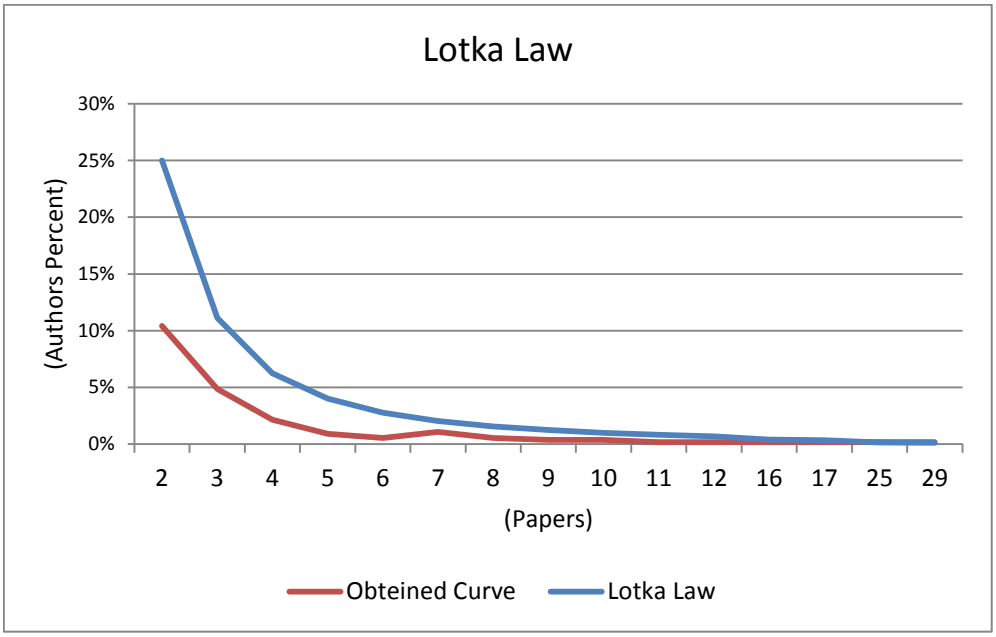

Figure 7 – Lotka law representation

Table 4 shows the authors list, the total number of publications, the total amount of papers in which they were single author, the total they had partnered, the year of first and last journal publication and the institution to which they were linked. The idea of this framework is to represent the "weight" of the author and his productive lifetime in journal.

Author	Papers	Single Author	Partner Papers	First Author	First Public.	Last Public.	Institution
Sterman, JD	30	11	19	13	1985	2014	MIT – S.S.Management
Richardson, GP	25	10	15	12	1986	2014	University at Albany
Saeed, K	17	8	9	10	1986	2013	Worcester Polytechnic
Andersen, DF	16	2	14	6	1988	2013	University at Albany
Homer, JB	12	8	4	12	1985	2014	MIT – S.S.Management
Meadows, DH	11	9	2	10	1987	2007	MIT – S.S.Management
Ford, DN	10	1	9	3	1998	2011	University of Bergen
Vennix, JAM	10	1	9	3	1990	2014	Radboud University
Forrester, JW	9	8	1	8	1987	2013	MIT – S.S.Management
Lane, DC	9	6	3	8	1991	2008	London University
Coyle, RG	8	6	2	8	1985	2001	Royal College of Science
Wolstenholme, EF	8	4	4	6	1986	2007	London South Bank
Grossler, A	8	3	5	5	2000	2014	Radboud University
Morecroft, JDW	7	2	5	5	1985	2008	London Business School
Rahmandad, H	7	0	7	5	2009	2013	Virginia Polytechnic
Barlas, Y	7	2	5	4	1990	2011	Bogaziçi University
Ford, A	7	3	4	4	1995	2010	Washington University
Milling, PM	7	3	4	3	1996	2007	Mannheim University
Mosekilde, E	7	0	7	3	1985	2007	University of Denmark
Mashayekhi, AN	6	4	2	5	1990	2012	Sharif University
Lyneis, JM	6	2	4	4	1999	2011	MIT – S.S.Management
Winch, GW	6	2	4	3	1993	2005	University of Plymouth
Cavana, RY	5	0	5	4	1999	2013	Victoria University
Kampmann, CE	5	2	3	4	1991	2014	Copenhagen School
Radzicki, MJ	5	4	1	4	1989	2007	Notre Dame
Rouwette, EAJA	5	0	5	3	1996	2013	Radboud University
Larsen, ER	5	0	5	0	1988	2006	London Business School

Table 4 - Framework panel

From 555 authors, only 58 didn't published in partnership, or slightly more than 10%, and only 43 authors published two or more papers with the same partners. Figure 8 illustrates this through a network graph.

All authors presented in this chart developed two or more papers with at least one partner. Lines in gray indicate co-authorship in just one paper; blue lines indicate co-authorship in two papers; green lines represent three co-authorship work and the lines in pink and red represent four and nine work co-authored papers, respectively.

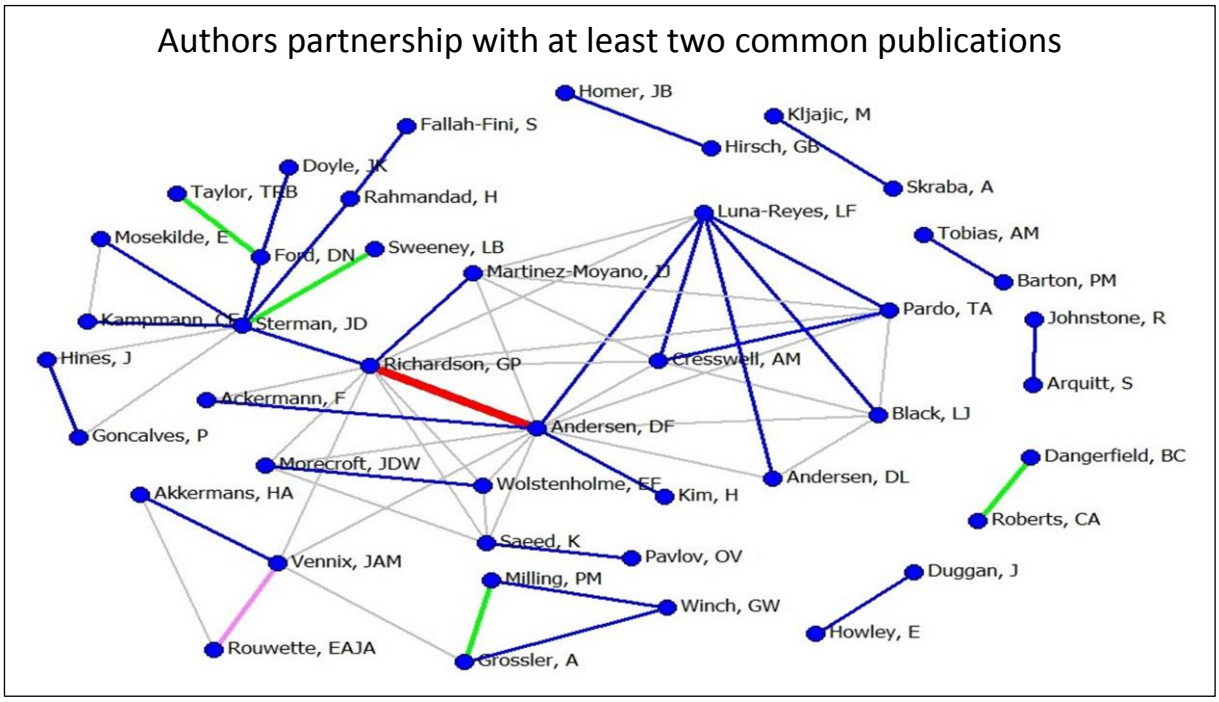

Figure 8 – Relationship between authors with at least two common publications

Table 5 summarizes the co-authorship.

Author	Papers	Single Author	Partn. Papers	Partners Number	Major Freq. Same Partner
Sterman, JD	29	11	18	24	3
Richardson, GP	25	10	15	29	9
Andersen, DF	16	2	14	30	9
Saeed, K	17	8	9	21	2
Vennix, JAM	10	1	9	15	4
Ford, DN	10	1	9	10	3
Mosekilde, E	7	0	7	13	2
Rahmandad, H	7	0	7	11	2
Morecroft, JDW	7	2	5	19	2
Larsen, ER	5	0	5	9	1
Grossler, A	8	3	5	8	3
Cavana, RY	5	0	5	8	1
Rouwette, EAJA	5	0	5	7	4
Barlas, Y	7	2	5	6	1
Wolstenholme, EF	8	4	4	15	2
Homer, JB	12	8	4	10	2
Ford, A	7	3	4	8	1

Table 5 - Partnership papers

Figure 9 is a graphical representation of authors' distribution per country. Just to remind, it was considered as author nationality the nationality of the institution to which the author was linked when the paper was published.

As it can be seen in this figure, over 50% of "System Dynamics Review" authors are concentrated in US and UK.

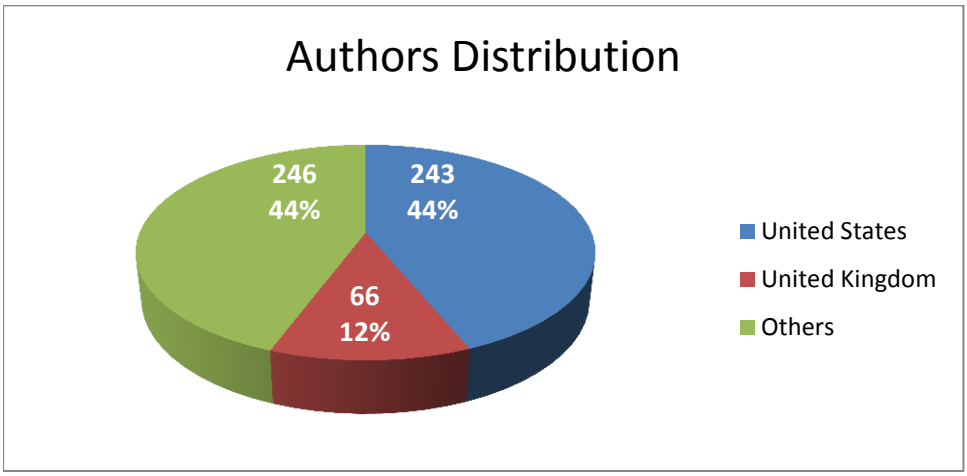

Figure 9 – Authors per country distribution

Figure 10 presents the absolute authors distribution. The graph numbers shows that about 81% of authors are concentrated in only ten countries.

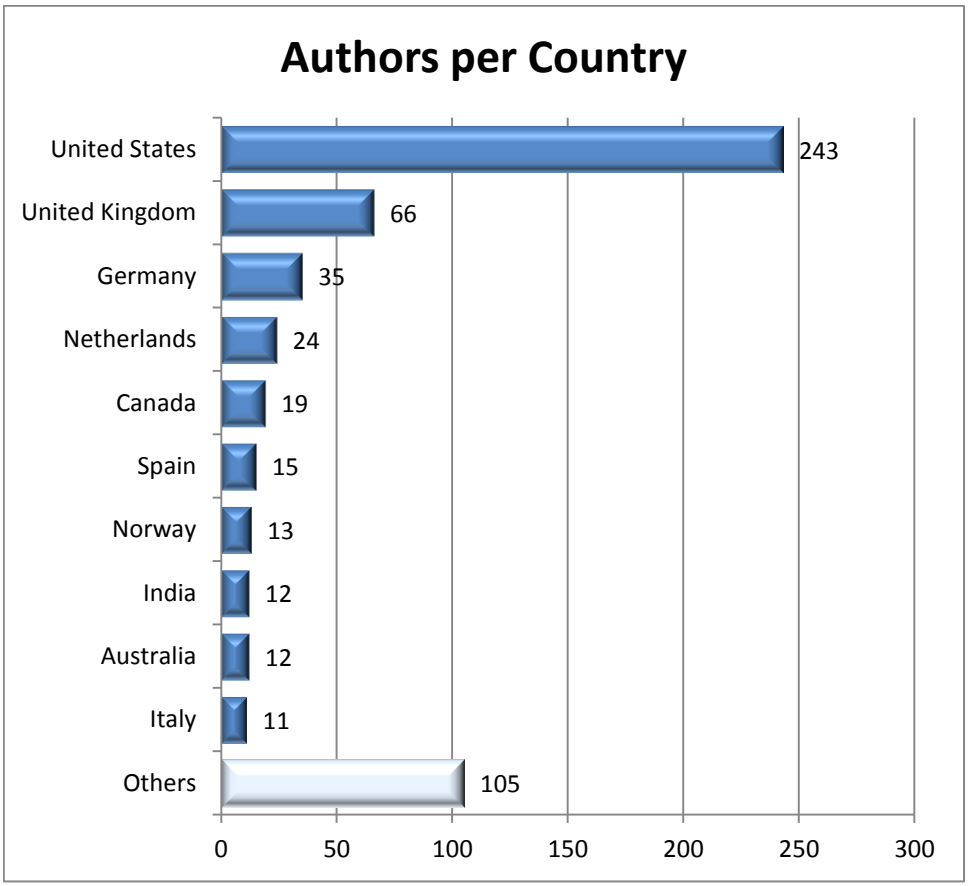

Figure 10 – Absolute authors distribution per country

As the chart shows in Figure 10, United States, United Kingdom and Germany are outliers, indicating extreme concentration in universities of these 3 countries.

Table 6 shows the total amount of authors per institution. There was presented just 18 institutions, which represents 7.3% of the total, but host 32.7% of the total amount of authors with especial emphasis on Sloan School of Management at Massachusetts Institute of Technology - MIT, which alone has 10% of the author.

Institution	Authors	Authors Percentage
M.I.T. - Sloan School of Management	55	9,9%
Mannheim University	11	2,0%
Universitat Stuttgart	10	1,8%
University at Albany	10	1,8%
University of Bergen	10	1,8%
University of Texas	8	1,4%
Virginia Polytechnic Institute and State University	8	1,4%
Radboud University Nijmegen	7	1,3%
University of Illinois	7	1,3%
Washington University	7	1,3%
Bogaziçi University - Istanbul	6	1,1%
Delft University of Technology	6	1,1%
Georgia Institute of Technology	6	1,1%
London Business School	6	1,1%
Technical University of Denmark	6	1,1%
University of Maribor	6	1,1%
Victoria University of Wellington	6	1,1%
Worcester Polytechnic Institute	6	1,1%

Table 6 - Authors per institution

It was observed 972 relationships of 153,735 possible, what means 0.6323% density with an average degree of centralization of 0.75%.

Table 7 shows the network centrality degree of those authors that have obtained an absolute centrality degree from 20 and above.

In studies of network density, the centrality degree of each network element is measured in terms of inputs and outputs to the element, which means that the direction of the relationship is important, thus, a relationship between an element A and B may be different from the relationship between B and A.

Autor	Centrality Degree	Normalized Degree
Andersen, DF	41	0,82%
Richardson, GP	39	0,78%
Sterman, JD	33	0,66%
Saeed, K	22	0,44%
Abdel-Hamid, TK	21	0,42%
Ankel, F	20	0,40%
Battle-Fisher, M	20	0,40%
Gibson, B	20	0,40%
Gonzalez-Parra, G	20	0,40%
Jalali, M	20	0,40%
Kaipainen, K	20	0,40%
Kalupahana, N	20	0,40%
Karanfil, O	20	0,40%
Marathe, A	20	0,40%
Martinson, B	20	0,40%
Mckelvey, K	20	0,40%
Morecroft, JDW	20	0,40%
Murphy, P	20	0,40%
Pintauro, S	20	0,40%
Poucheret, P	20	0,40%
Pronk, N	20	0,40%
Qian, Y	20	0,40%
Sarbadhikari, SN	20	0,40%
Sazonov, E	20	0,40%
Van Oorschot, K	20	0,40%
Venkitasubramanian, A	20	0,40%

Table 7 - Centrlity

In this study, it was considered the possibility of relationship among all its members, resulting that relationship measures between A and B are equal to those between B and A so it was presented just one of them for centrality degree.

The authors' network presented the absolute centrality degree ranging from zero to 41 with 3.50 average value, which corresponded to a range of zero to 0.82% and 0.07% on average.

For intermediation characteristic, called in network analysis tools as betweenness, table 8 presents the data. It was selected up to 0.4%.significance numbers.

Author	Betweenness	Normalized Betweenness
Sterman, JD	11358	7,42%
Richardson, GP	10764	7,03%
Vennix, JAM	4737	3,09%
Ford, DN	4442	2,90%
Saeed, K	3343	2,18%
Andersen, DF	2852	1,86%
Ford, A	2566	1,68%
Lyneis, JM	2551	1,67%
Morecroft, JDW	2520	1,65%
Mosekilde, E	2491	1,63%
Grossler, A	2358	1,54%
Oliva, R	2341	1,53%
Homer, JB	2187	1,43%
Rahmandad, H	1806	1,18%
Cavana, RY	1417	0,93%
Winch, GW	1211	0,79%
Larsen, ER	1169	0,76%
Hines, J	899	0,59%
Sturis, J	828	0,54%
Davidsen, PI	817	0,53%
Wolstenholme, EF	815	0,53%
Goncalves, P	693	0,45%
Aracil, J	614	0,40%
Clark, TD	615	0,40%
Graham, AK	614	0,40%
Jones, A	612	0,40%
Thompson, JP	612	0,40%

Table 8 - Betweenness

Betweenness is the network element ability of being a “connector” on the network, in other words, is the number of nodes that an agent is able to bind. The network presented for this characteristic values ranging from zero to 11,358 that represented in normalized index ranges from zero to 7.42%, with average values of 133 and 0.09%, respectively.

Another index presented in table 9 is the closeness index. This index is the network element ability to connect himself to another network element.

Autor	Farness	Closeness Index
Richardson, GP	193120	0,29%
Sterman, JD	193133	0,29%
Andersen, DF	193207	0,29%
Davidsen, PI	193227	0,29%
Morecroft, JDW	193239	0,29%
Saeed, K	193250	0,29%
Vennix, JAM	193262	0,29%
Wolstenholme, EF	193263	0,29%
Lyneis, JM	193263	0,29%
Randers, J	193266	0,29%
Karsky, M	193267	0,29%
Forrester, JW	193267	0,29%
Spencer, R	193267	0,29%
Radzicki, MJ	193267	0,29%
Paulré, B	193267	0,29%
Pugh, J	193267	0,29%
Ford, DN	193276	0,29%
Mosekilde, E	193279	0,29%
Ghaffarzadegan, N	193285	0,29%
Haxholdt, C	193299	0,29%
Sturis, J	193301	0,29%
Kampmann, CE	193303	0,29%
Luna-Reyes, LF	193305	0,29%
Pardo, TA	193309	0,29%
Cresswell, AM	193309	0,29%

Table 9 - Closeness

In this table, it can be seen as in the previous ones, two types of measurements, in first column the absolute number is the distance representation between network elements, while the second one represents the degree of closeness.

It presents values from 193,120 up to 301,401 with 306,916 average and a closeness range from 0.29% to 0.18% with 0.23% average mark.

As noted, the closeness index keeps on 0.29%, fact that occurs for 208 authors, almost 40% of studied network.

Institutions

Like authors patterns analysed previously, the institutions nationality is heavily concentrated in United States and United Kingdom, however with the presence of Canada. These three countries have 54% of all institutions. Figure 11 shows the results obtained.

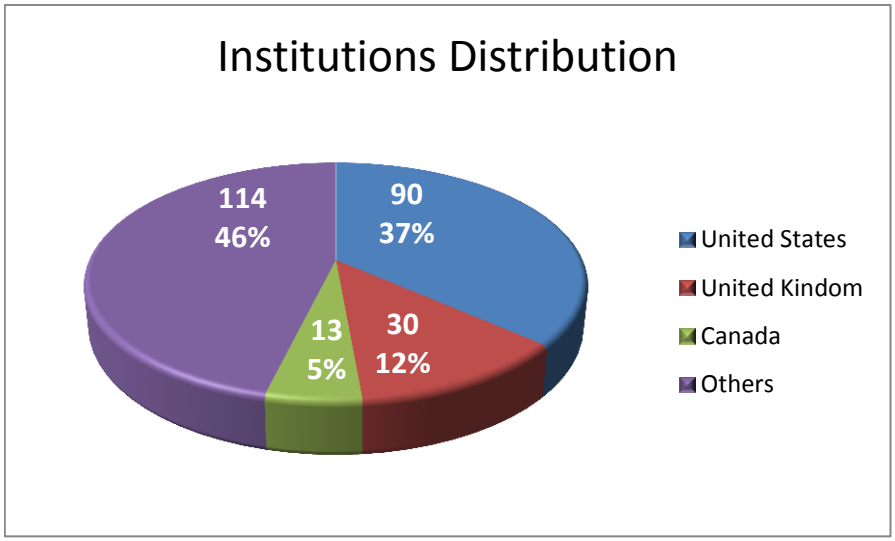

Figure 11 – Institutions distribution

Figure 12 shows the absolute institutions number distribution. Almost 80% of all institutions are concentrated in 11 countries.

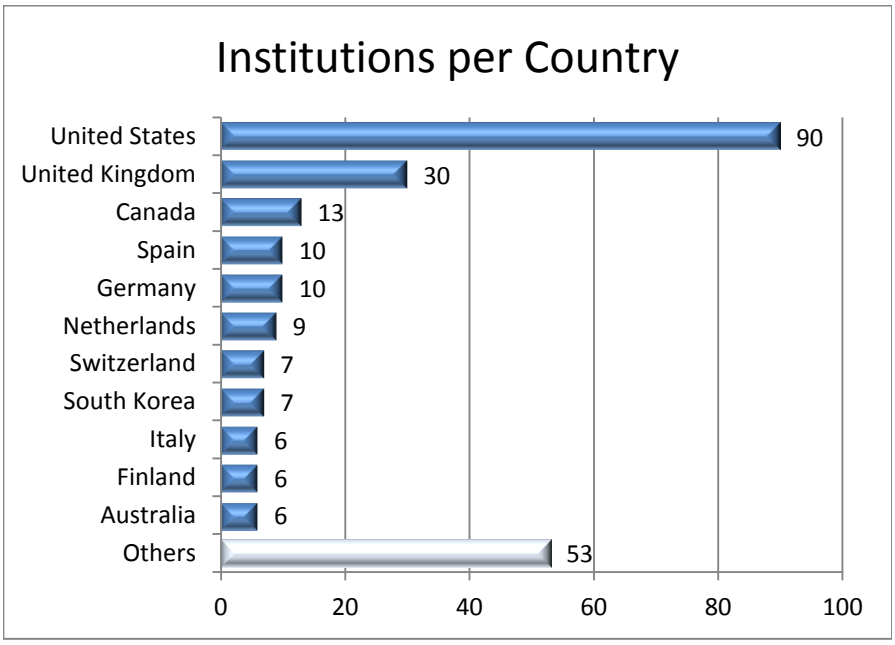

Figure 12 – Institutions per Country

Table 10 presents the institutions representativeness in terms of paper productivity. Only nine institutions exceeded the 2% share rate and together they represent more than 50% of all papers with highlighting to Sloan School of Management at Massachusetts Institute of Technology - MIT. Authors linked to this institution participated in 22.9%.

Institution	Papers	Share
M.I.T. - Sloan School of Management	109	22,9%
University at Albany	38	8,0%
University of Bergen	23	4,8%
Worcester Polytechnic Institute	19	4,0%
Mannheim University	15	3,2%
London Business School	13	2,7%
Radboud University Nijmegen	12	2,5%
Technical University of Denmark	10	2,1%
Harvard University	10	2,1%

Table 10 - Papers per Institution

Analyzing the References

This section presents and analyzes the results obtained with references data. The 475 papers cited 8,668 works, including books, articles, theses, dissertations and research work in general, written by 9,141 authors, discussing a variety of subjects. These data gave rise to table 11.

This table shows the name of the referenced author; overall number of citations that referenced author received; the number of articles which he was referenced; maximum number of citations in a single paper, and it is possible receive multiple quote and the referenced author presence among authors of 475 papers evaluated, indicating the authorship frequency when his presence was confirmed.

In absolute numbers, 405 referenced authors are also authors of “System Dynamics Review” papers, what represents 73% of the authors of the papers analyzed in this research.

Although being the “h” index calculated based on all scientific or scholar works, this index was measured for this journal. It is a kind of specific “h” index related just to this journal. Figure 13 shows the “h” index obtained just to those whose index are greater than 2.

The purpose of this information treatment and index calculation is just to present a significance framework from these authors referenced in the journal.

Author Referenced	Citations Received	Cited in (papers)	Maximun Citation Number Same Paper	Analysed Papers Author
Sterman, JD	916	299	18	29
Forrester, JW	644	279	45	9
Richardson, GP	478	208	13	25
Senge, PM	259	178	7	2
Andersen, DF	237	96	9	16
Morecroft, JDW	212	120	10	7
Vennix, JAM	211	96	12	10
Coyle, RG	173	77	15	8
Meadows, DH	156	85	11	11
Lane, DC	151	70	9	9
Wolstenholme, EF	145	69	8	8
Eden, CL	136	45	14	No
Ford, DN	127	63	16	10
Homer, JB	116	73	8	12
Oliva, R	114	68	7	4
Pugh III, AL	110	105	2	No
Mosekilde, E	105	41	12	7
Meadows, DL	102	62	6	3
Randers, J	95	70	6	3
Lyneis, JM	95	73	6	6
Graham, AK	93	64	7	3
Richmond, B	93	72	7	3

Table 11 - Referenced Authors

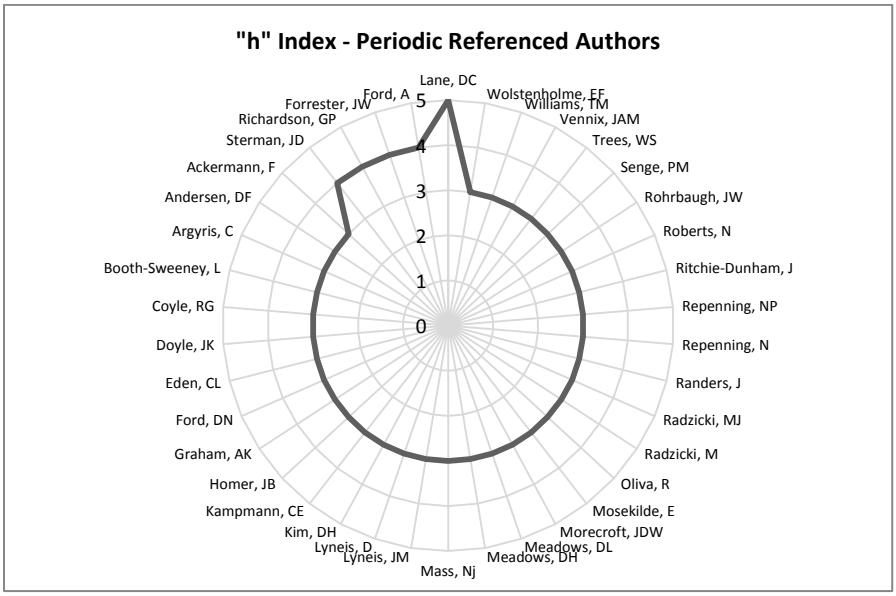

Figure 13 – "h" Index to periodic

For the most cited papers, figure 14 presents the classification of those who had a higher frequency.

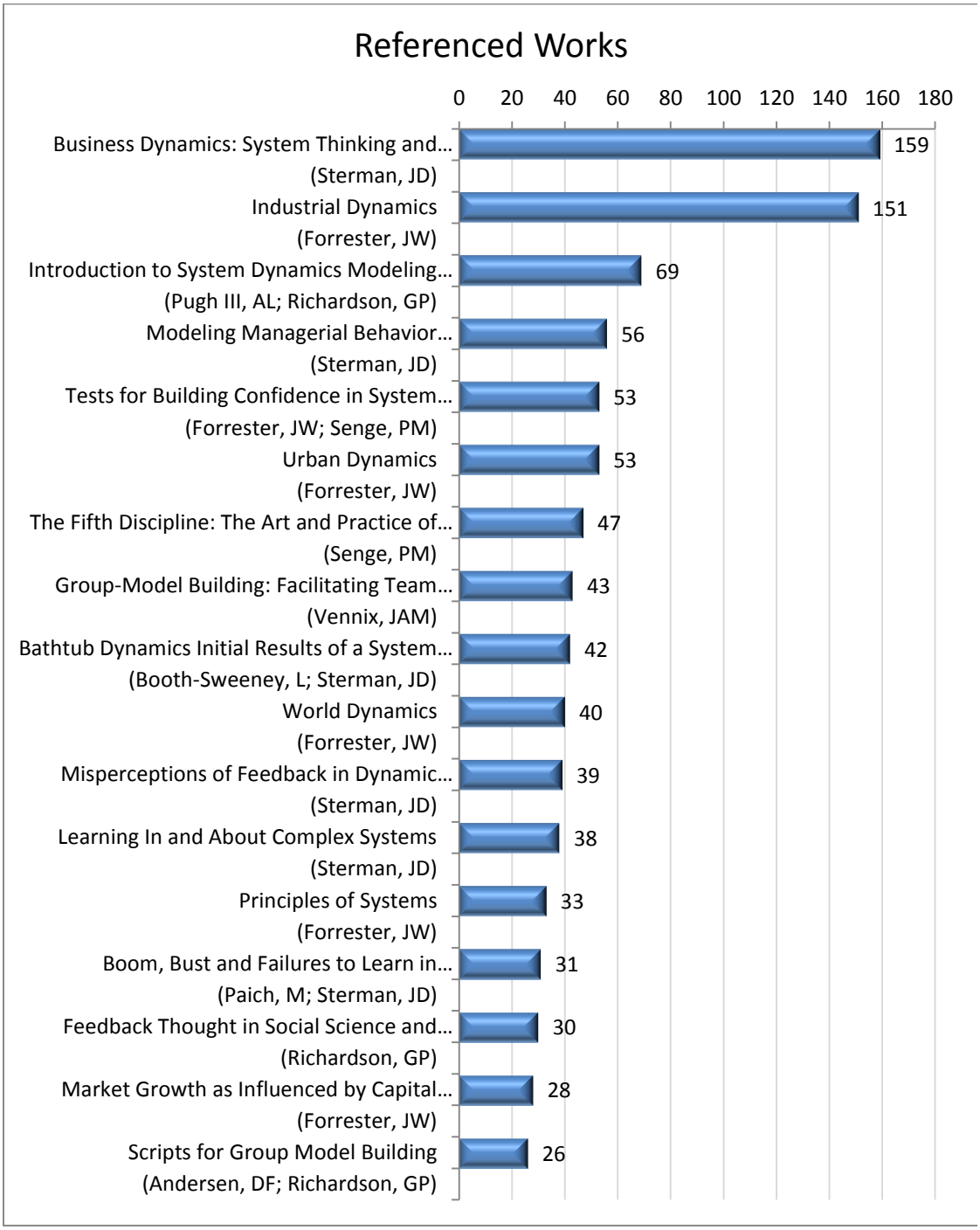

Figure 14 – Referenced works

The first and second ranked works in this list represent 33% and 32% of citations, respectively.

RESULTS SUMMARY

It can be pointed as summary:

a) it were cataloged 475 papers authored by 555 researchers linked to 247 institutions spread in 37 countries, which presented as reference 8,668 publications including books, articles, theses, dissertations and research work in general, written by 9,141 authors;

b) the research found growing trend line on publication amount with an annual average around 15 papers, however considering the publications for five-year periods was observed growth stagnation in last two five-year periods;

c) on content perspective, the division by class has showed balance between publications with 45% of all papers or 216 focused on theoretical subject and 55% of all papers or 259 focused on applications;

d) further from content perspective, "System Dynamics" theme was preferred, surpassing by three times the second ranked, "Organizations", however, even with this observed preference, there were no significant bias to any topic over time, based on absolute numbers of papers and their trend curves;

e) papers classified as "Conceptual", "Analytical" and "Strategy and Processes" have totalized 110, 97 and 42 respectively, that add 249 papers or 52.4% of all papers;

f) the relation between total amount of papers and total amount of authors has confirmed Lotka principle, what means, a few authors publish much and many authors publish a few;

g) on publication volume point of view, Sterman, Richardson, Saeed and Andersen are the best ranked with 30, 25, 17 and 16 papers respectively;

h) only 58 authors did not published in partnership, however only 43 authors have published two or more works with the same partners. Absolute highlight for Andersen – Richardson partnership;

i) a number of 309 authors, or 56% of total are from United States and United Kingdom;

j) 368 authors, or 66% of total, are from United States, United Kingdom, Germany and Netherlands, countries of System Dynamics Society founders origin;

k) despite Japan high socio-economic development, this country has only two institutions and two authors listed;

l) Andersen, Sterman and Richardson are the network centrality, intermediation and closeness indexes top ranked and they are the top six in all rank lists;

m) the authors affiliated institutions are concentrated in United States and United Kingdom reaching the number of 120 institutions or 49% of total;

n) authors of 109 papers were linked to Sloan School of Management at MIT, giving the institute 23% of all papers and 10% of all authors;

o) considering authors referenced list, Sterman, Richardson, Andersen, Senge and Forrester, System Dynamics creator, appear on top five ranked, with highlight to Sterman e Forrester marks of 916 and 644 quotes respectively;

w) 405 authors, or 73% of all are also authors referenced;

q) Lane, Ford, Forrester, Richardson and Sterman were top 5 in calculated “h” index, all of then above 3, highlight to Lane with index 5;

r) the most referenced work was "Business Dynamics: System Thinking and Modeling for a Complex World" from Sterman, closely followed by the "Industrial Dynamics" from Forrester.

CONCLUSION

This research has begun a “map” of System Dynamics field of study. It was cataloged information about papers, their contents, cited works, institutions, authors and relationship between then.

The strong presence of Andersen, Forrester, Richardson and Sterman in many lists represents a starting point for anyone that wants to learn about the field.

As shown, System Dynamics has a strong concentration in the United States, a fact that to the ordinary observer could be considered obvious, however, the same observer could expect a prominent position for Japan, once it is a socio-economic developed nation, but it doesn’t happen.

System Dynamics concentration in a few authors, institutions and countries can be a hindrance to the diffusion and development of field. This can result in lack of interest and critical mass reducing resulting in relevance loss.

There remains the question:

Why System Dynamics field of study is so underdeveloped when compared with other widespread methods like Monte Carlo Simulation, Discrete Event Simulation, Mathematical Programming, etc., whose initial development were cotemporary to the development of System Dynamics?

The next step intended for this work is to update and expand to other journals in order to complete the “topography” and answering that last question.

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