Future-oriented Technology Analyses: The Literature and Its Disciplines

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"Who's doing what" to advance the field of Future-oriented Technology Analyses (FTA)? This paper draws on two motivations. One was to provide background characterization in conjunction with the Second FTA Seminar (Seville, 2006). The second was to provide perspective for this volume.[b] Characterization of the disciplines publishing in this area helps to frame their differing perspectives on futures research.

Beginning about 2000, a number of us have been working to nurture development of FTA. We prepared a perspective paper[1] to help instigate an initiative to share knowledge and promote new methods. This reviewed the various forms of such future-oriented analyses and their history. It noted the marked shift from relatively narrow focus in the earlier years on technological systems to broadened considerations attendant to innovation in socio-economic contexts. Advances in complexity sciences offer new approaches to deal with such systems. The paper noted the increasing attention to science-based, as opposed to technology-based, innovations. It pointed to the increased availability of science and technology information resources in electronic form as enabling potent new analytics. And it compared interests among government, industry, and academia.

The next phase in the FTA progression involved an expanded group preparing a baseline paper for the First FTA Seminar [Seville, 2004; organized and hosted by IPTS – The Institute for Prospective Technological Studies (www.jrc.es)]. This paper[2] explicitly noted analytical forms that address future prospects, relating especially to technology. These include:

- Technology monitoring, technology watch, technology alerts (gathering and interpreting information)
- Technical intelligence and competitive intelligence (converting that information into usable intelligence)
- Technology forecasting (anticipating the direction and pace of changes)
- Technology roadmapping (relating anticipated advances in technologies and products to generate plans)
- Technology assessment, and forms of impact assessment, including strategic environmental assessment (anticipating the unintended, indirect, and delayed effects of technological changes)
- Technology foresight, also national and regional foresight (effecting development strategy, often involving participatory mechanisms)

The First FTA Seminar focused on new methods to address the expanded interests and challenges to better inform science, technology, and innovation (**ST&I**) management and policy processes.

IPTS, under the leadership of Fabiana Scapolo, has carried forward the FTA initiative. In 2006, the Second FTA Seminar keyed on experiences and issues in having FTA affect decision-making. A Technical Committee helped formulate conference themes, prepared five background papers,

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[b] The former was generated in the context of the Technical Committee for the Second FTA Seminar, of which I served as a member. The second arose in personal discussion with Patrick van der Duin.

and drew papers from the Seminar to form a book and special issues of *Technological Forecasting & Social Change,* and *Technology Analysis and Strategic Management.* In addition, a special issue of the *International Journal of Foresight and Innovation Policy* is in preparation. At the seminar, working groups tackled a number of over-arching FTA issues, generally oriented toward community-building. An ongoing web portal carries these discussions forward (see http://forera.jrc.es/fta/documents.html).

This paper offers a literature profile[3] on the FTA domain. The profile helps to characterize the growing body of FTA knowledge. It provides a base for this volume's consideration of disciplinary differences in treatment of futures research, especially between FTA and market research orientations.

Methods

I downloaded search results from the "Web of Science" on October 16, 2006.[c] I repeated the process on October 30 to capture cited references as well. This seems like a reasonable information resource to use in that it provides excellent coverage of journal articles in the sciences (SCI), decent coverage of engineering, good coverage of social sciences (SSCI), and additional treatment of humanities (AHCI). These sources include technology management and research policy journals. This certainly does not capture all FTA work, no less the broader spectrum that "futures research" can encompass. In particular it leaves out journals not covered by Web of Science (resulting in a bias toward higher prestige and English language, and against developing country literatures). It does not include conference papers (key in certain fields). And, especially vital in the humanities and some social sciences, it leaves out books.[4]

I searched on some 25 different terms, in various combinations. [Some searches failed – e.g., those, such as "future studies" including the term "studies" don't work because this is a stopword; "scenario" and "trend analysis" proved too general.] Terms yielding 10 or more hits are noted in Table 1 [not all phrasing details are shown – e.g., backcasting was also checked as hyphenated "back-casting"]. The premise is that a number of pertinent articles will not use the general FTA terms (e.g., technology foresight or forecasting). For this reason, Delphi, TRIZ, backcasting, and cross-impact were searched explicitly.

[c] ISI "Web of Knowledge" website—for information about access, see: http://scientific.thomson.com/index.html

Table 1. Individual FTA Term Search Tallies in Web of Science [1996-2006]

Delphi	2049
technology assessment	1354
(forecast OR forecasting OR forecasts) SAME (technology OR technologies))	334
("technology roadmap" or "technology roadmaps" or "technology roadmapping")	242
technology foresight	76
roadmapping	62
Tech intelligence	61
(analysis SAME technologies SAME emerging)	57
futures research	47
TRIZ	47
Backcasting	46
cross-impact	35
("foresight program" or "foresight programme")	25
technology monitoring	15
technology watch	13
national foresight	12
technology SAME prospecting	12
Tech mining	10

Unfortunately, the two predominant phrases – Delphi and technology assessment – proved highly problematic. Delphi captured certain physics research as well as articles mentioning the company of that name. Technology assessment mainly yielded "health technology assessment," its own arena of detailed evaluations of medical technologies and programs. To deal with these issues, all results were combined in *VantagePoint*.[d] Duplicates were removed. An iterative process was then used to remove irrelevant articles; create a cleaned file; then check further. Different fields were searched (titles, key terms, journals, full abstract records) to exclude records that seemed to address particle physics, neurology or clinical medicine (health technology assessment), and semiconductor processing. Sets of "out-take" records were reexamined for presence of FTA indicator terms. These were individually checked to re-include if they were judged to relate to FTA. The inclusion scope included decision support approaches. The process is imperfect, but it gains some number of Delphi and technology assessment papers that would otherwise be missed. The resultant set contains articles that are quite inclusive of FTA work, yet do not contain too many "non-FTA" pieces. In information science terms, recall is somewhat selective; precision appears to be reasonably strong.

This yields **1018 FTA-related papers** for 1996-2006 (through Oct. 16). This total is close to that were we to sum the individual searches without including "Delphi" and "technology assessment," although those contribute significantly to this final set. Specifically, "Delphi" contributes 177 and "technology assessment" 169 articles. The next section presents basic activity profile results.[e]

[d] Text mining software especially developed to help clean, analyze, and report on science and technology data search results – see: //www.theVantagePoint.com.

[e] Tallies are based on the Oct. 16 searches. The Oct. 30 search counts are very slightly higher. Those search results were matched against the screened results from Oct. 16, to add "cited references."

Basic Results: FTA Publications

The first question -- how much FTA research publication is there? Figure 1 shows the trend. From 1996 through 2003, this is essentially flat – at a modest level of about 100 articles per year. [Of course this reflects the scholarly literature; it does not capture foresight reports, etc.] Since 2004, coincident with the first FTA seminar, activity seems to be increasing. Note that the value for 2006 is very arguable – the actual count for the year to date is 89; this is herein doubled to approximate what the complete 2006 publications might be (reflecting that the search covers only a partial year and that indexing of articles lags). "Trend analysis" is somewhat encouraging for FTA.

Figure 1. Trend in FTA Publication
[Articles relating to Future-oriented Technology Analysis appearing in Web of Science]

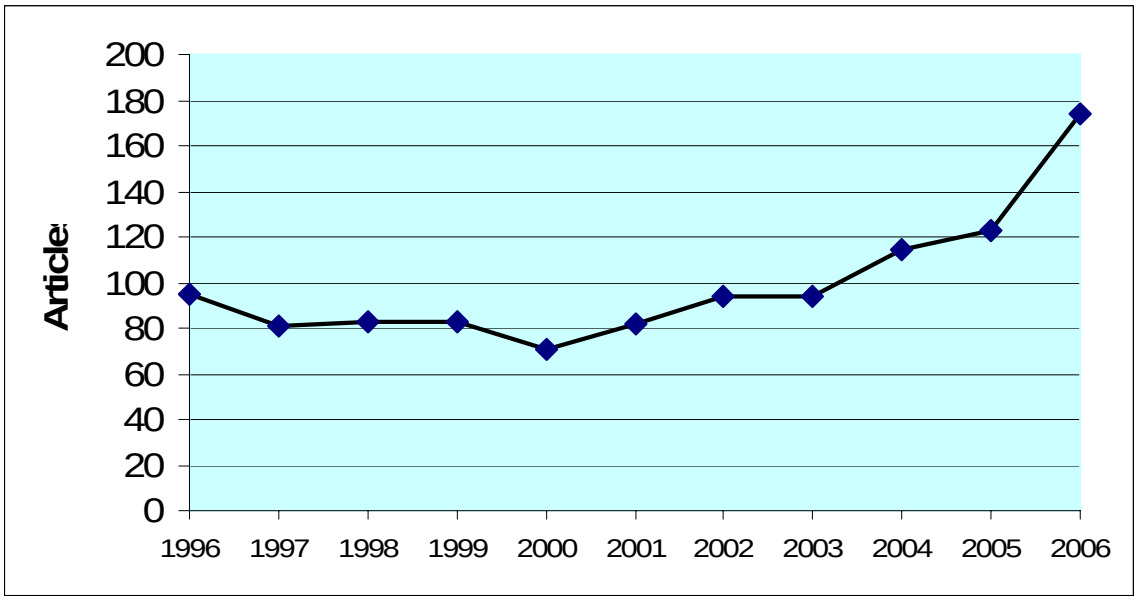
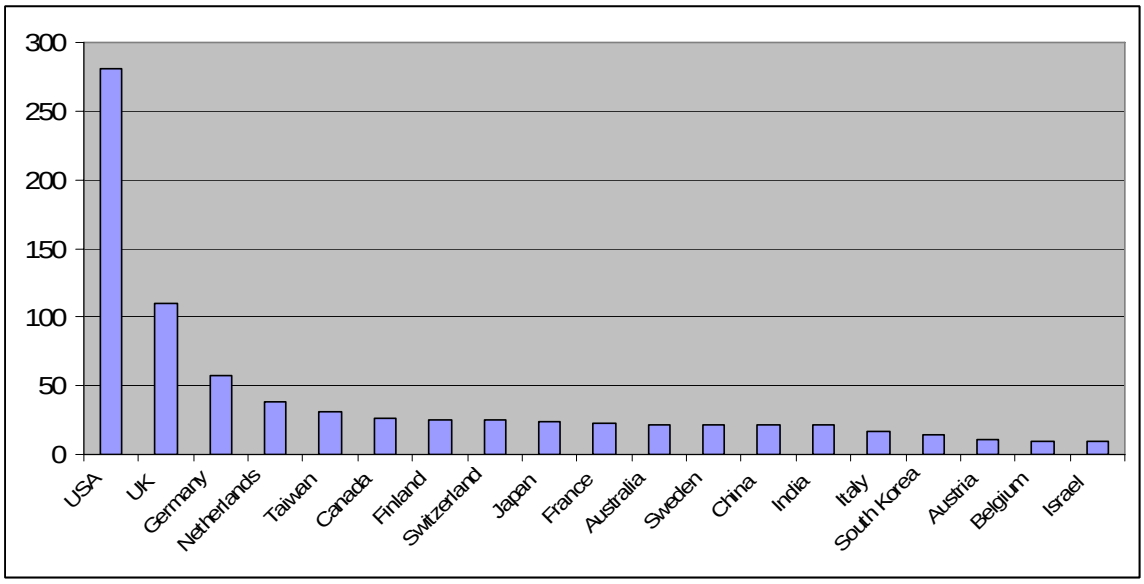


Figure 2 shows the top 19 (of 55 total) countries (those with 10 or more article authorships). These are extracted from the authors' affiliation and address field. The leading FTA publishing nation is the USA. Given the relative inattention of the US Government to formal technology foresight or assessment, this is rather interesting.

Figure 2. FTA-related Articles (with one or more author affiliations in that country)



At the institutional level, FTA research appears broadly dispersed; Table 2 lists the top 20 organizations (plus ties). There are 209 organizations with at least two publications.

Table 2. Leading Organizational Affiliations

Affiliation (Name Only)	#	Fraunhofer Inst Syst & Innovat Res	8
Office of Naval Research (US)	12	Swiss Fed Inst Technol	8
Delft Univ Technol	11	Indian Inst Technol	7
Univ Cambridge	11	Penn State Univ	7
Natl Chiao Tung Univ	10	Univ Karlsruhe	7
Royal Inst Technol	10	Univ Penn	7
Helsinki Univ Technol	9	Georgia Inst Technol	6
Univ Illinois	9	Harvard Univ	6
Univ Manchester	9	Univ Minnesota	6
Univ Texas	9	Univ Twente	6
Chalmers Univ Technol	8	Univ Utrecht	6

It is interesting to examine the sectoral mix of these FTA-generating institutions. Applying a thesaurus that combines certain standard phrasing (e.g., "Univ" as university; "Ltd" or "Corp" as industry), and not trying to capture every one of the originally listed 799 organizations, results in Table 3. Note that the second grouping consolidates several difficult to distinguish types – governmental and non-governmental organizations, and other such institutes. [Not all of the 1018 articles have an identified organizational affiliation.] Not surprisingly, publication of FTA articles is strongly led by the academic community (which has the greatest stake in such publication), but note the substantial participation by government and industry.

Table 3. Leading Authoring Organizations by Sector

Type	# of Articles	# of Authorships	% of Articles
Academic	567	779	58%
Gov't/NGO's/Institutes	174	210	18%
Industry	109	142	11%

Table 4 shows where FTA work is being published (11 journals with 10 or more publications). "TF&SC" is the leader, with strong representation of leading technology management journals. Certain special foci are represented. For instance, the "Journal of Cleaner Production" keys on sustainable development, while "Solid State Technology" shows a number of technology roadmapping articles.

Table 4. Leading FTA Journals

Journal	#
Technological Forecasting & Social Change	114
International Journal of Technology Management	52
Futures	49
Research--Technology Management	26
Abstracts of Papers, American Chemical Society	14
Technovation	13
Journal of Cleaner Production	12
Journal of Forecasting	12
R & D Management	11
Solid State Technology	11
Technology Analysis & Strategic Management	11

I merged three fields that provide good topical content: keywords (authors), with keywords (plus), with title NLP (natural language processing) noun phrases.[6] Table 5 gives the flavor of the FTA articles' content via the top 36 key terms (occurring 10 or more times).

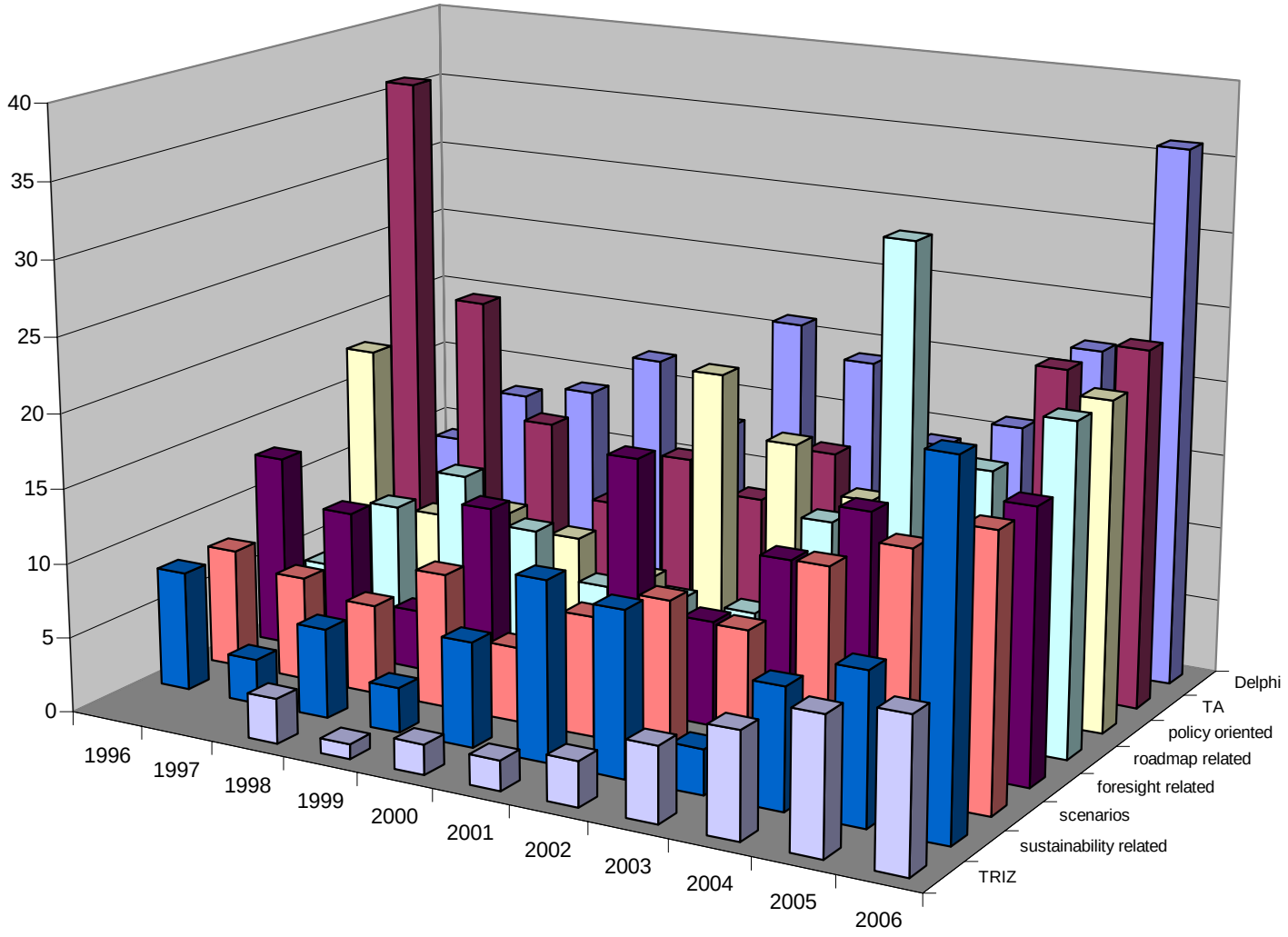
[6] Such "text mining" is accomplished using *VantagePoint* software.

Table 5. Leading Key Terms in the FTA Articles

Key Terms	#		
technology assessment	92	backcasting	16
Technology	48	technology forecasting	15
Innovation	43	Delphi technique	14
Management	36	design	14
Future	35	Impact	13
Science	33	assessment	12
Delphi	32	information	12
Forecasting	28	bibliometrics	11
Delphi method	26	energy	11
Delphi study	25	Industry	11
technology foresight	25	policy	11
Model	22	roadmaps	11
TRIZ	21	Time-series	11
Foresight	19	trends	11
Sustainability	19	application	10
Systems	19	case study	10
Models	17	roadmapping	10
sustainable development	17	technical intelligence	10

Figure 3 consolidates variations on topical term themes (e.g., Delphi) to show the trends in usage over this period (number of articles that include the given terms in keywords or title phrases). Delphi, in the context of FTA or relevant decision support, is the most frequently occurring of these forms. Technology Assessment (TA) has declined markedly, although there is a spike of renewed activity in 2005 (not seemingly due to a single concentrated activity). Foresight is younger in vintage than TA. The Second FTA Seminar focused on policy utility of FTA activities; it is somewhat reassuring to see significant article attention to policy aspects of one sort or another. Sustainability and roadmapping both show increasing tendencies, although not uniformly.

Figure 3. Topical Trends in FTA (tallies for 2006 are doubled to normalize this partial year)



For these analyses, I then expanded the key FTA term selection to include records with these terms in any of the following fields: abstract or title phrases (text-mined via Natural Language Processing – NLP – using *VantagePoint*), keywords (author's), or Keywords Plus (deriving from titles of articles cited by the article in question). I also added "scenarios" to the set included in Figure 3. Table 6 shows the frequency and percentage (of 1018 total articles) mentioning the given term in any of the indicated fields. Many of the terms co-occur in given articles. Overall, at least one of the terms in Table 6 occurs in 67% of the 1018 articles. [Conversely, 33% of the records do not contain any of these terms.]

Table 6. Prevalence of Major FTA Topical Themes and Methods

FTA Topics	# Records	% of Records Mentioning
Delphi	177	17%
TA	169	17%
policy oriented	133	13%
roadmap related	127	12%
foresight related	111	11%
Scenarios	103	10%
sustainability related	83	8%
TRIZ	38	4%

Disciplinary Contributions to the FTA Literature

Our focal interest is on which disciplines contribute, in what ways, to this literature. Web of Science associates journals with "Subject Categories." About 40% of the journals are linked to more than one of 244 Subject Categories (research areas). This analysis will use these Subject Categories ("**SCs**") as its essential building block. SCs provide a good operationalization of "field" or "discipline" on a fine-grained level.

The author has been involved as an evaluator in a major ongoing project called the National Academies *Keck Futures Initiative* (NAKFI). This is a $40 million, 15-year program to boost interdisciplinary research in the U.S. [www.keckfutures.org]. NAKFI has an interest in measuring the extent of interdisciplinary research, but suitable indicators of such pose a challenge.[5] My colleagues and I have devised measures of research "Integration" and "Specialization" using the SCs.[6] I borrow the underlying tools for these analyses, along with the "domain" categorization of SCs that we are developing for NAKFI.

FTA papers are very widely distributed. The 1018 papers appear in 146 (of the 244 total) Subject Categories, of which 114 show at least two papers.[g] Table 7 shows the top 16 areas (the 17th area shows a sizable drop to 25 articles). This sample of FTA articles appears strongly associated with planning, business, and engineering.

[g] The Thomson Scientific Institute for Scientific Information (ISI) associates journals with SCs. A given journal included in the Web of Science could be associated with 1-6 SCs; some 39% of journals in a national sample we studied were linked to more than 1 SC. We thank ISI for providing their thesaurus that links journals to SCs to facilitate these analyses.

Table 7. Leading Subject Categories in which FTA Publications Appear

Subject Category	#
PLANNING & DEVELOPMENT	189
BUSINESS	183
MANAGEMENT	174
OPERATIONS RESEARCH & MANAGEMENT SCIENCE	98
ENGINEERING, INDUSTRIAL	91
ENGINEERING, MULTIDISCIPLINARY	74
ENGINEERING, ELECTRICAL & ELECTRONIC	71
ECONOMICS	69
ENVIRONMENTAL SCIENCES	61
ENERGY & FUELS	51
ENGINEERING, ENVIRONMENTAL	37
INFORMATION SCIENCE & LIBRARY SCIENCE	35
MULTIDISCIPLINARY SCIENCES	35
ENVIRONMENTAL STUDIES	34
ENGINEERING, MANUFACTURING	31
PHYSICS, APPLIED	31

One way to study research knowledge flows is by using citation patterns. The 1018 FTA papers in this set cite (reference) 21,342 sources (i.e., averaging 21 references per paper). A majority of those cite articles appearing in journals. These 1018 papers cite some 11,793 different sources. We apply a Find-and-Replace thesaurus to standardize how journal title terms are used (e.g., whether J or Jour or Journal). Then we apply a thesaurus to associate journal to SC. In this way we have data on the SCs cited by each paper. This allows us to note what Subject Categories contribute to the intellectual content of these FTA papers. [Obviously, such citation is an imperfect measure as authors reference their own work rather heavily and cite the work of others for multiple reasons.]

In general, the fields in which FTA articles appear most heavily are also those upon which their authors draw, especially planning, business, and engineering. However, two of the leading 16 publication forums (SCs) do not appear as leading sources of FTA intellectual capital—"Engineering, Manufacturing"; and "Physics, Applied." Table 8 shows the most frequently cited Subject Categories. Notice the last two listed. Articles in journals associated with "Political Science" are referenced (cited) by 21 of the 1018 FTA papers. Some of those papers reference a Political Science SC more than once; that is why the number of instances is higher (45). Thermodynamics is cited by one fewer paper (20), but many more times in those papers (139). For present purposes, I order the cited SCs by the number of FTA articles that mention them.

Table 8 is presented to allow some quick comparisons. In particular note the source areas, upon which FTA authors draw, that are not prominent venues for publication of FTA work (#Pubs). These include several Computer Science SCs, Statistics and Math-oriented SCs, and several Social Sciences.

Table 8. Leading Subject Categories which FTA Publications Cite

Cited SCs	# Records Cited	# Instances of Being Cited	# Pubs (Top 16)
MANAGEMENT	302	1482	174
PLANNING & DEVELOPMENT	240	686	189
ECONOMICS	236	783	69
BUSINESS	201	840	183
OPERATIONS RESEARCH & MANAGEMENT SCIENCE	194	546	98
ENGINEERING, INDUSTRIAL	134	366	91
MULTIDISCIPLINARY SCIENCES	125	250	35
ENVIRONMENTAL SCIENCES	110	379	61
COMPUTER SCIENCE, INFORMATION SYSTEMS	96	254	
INFORMATION SCIENCE & LIBRARY SCIENCE	93	332	35
ENGINEERING, MULTIDISCIPLINARY	76	112	74
ENGINEERING, ELECTRICAL & ELECTRONIC	67	215	71
SOCIAL SCIENCES, MATHEMATICAL METHODS	64	99	
COMPUTER SCIENCE, INTERDISCIPLINARY APPLICATIONS	61	148	
ENERGY & FUELS	61	347	51
STATISTICS & PROBABILITY	59	131	
ENVIRONMENTAL STUDIES	57	175	61
COMPUTER SCIENCE, THEORY & METHODS	56	135	
MATHEMATICS, INTERDISCIPLINARY APPLICATIONS	55	85	
COMPUTER SCIENCE, ARTIFICIAL INTELLIGENCE	51	115	
SOCIAL SCIENCES, INTERDISCIPLINARY	51	68	
SOCIAL ISSUES	50	67	
COMMUNICATION	42	61	
COMPUTER SCIENCE, HARDWARE & ARCHITECTURE	39	72	
COMPUTER SCIENCE, SOFTWARE ENGINEERING	39	94	
ECOLOGY	38	137	
SOCIOLOGY	38	82	
MATHEMATICS, APPLIED	37	84	
ENGINEERING, ENVIRONMENTAL	36	91	37
METEOROLOGY & ATMOSPHERIC SCIENCES	36	140	
ENGINEERING, CIVIL	32	48	
HISTORY & PHILOSOPHY OF SCIENCE	31	47	
PUBLIC ADMINISTRATION	31	58	
ENGINEERING, CHEMICAL	30	113	
MATHEMATICS	30	32	
WATER RESOURCES	30	81	
PSYCHOLOGY, MULTIDISCIPLINARY	28	36	
ENGINEERING, MANUFACTURING	27	72	
TELECOMMUNICATIONS	27	68	
EDUCATION & EDUCATIONAL RESEARCH	26	40	
GEOSCIENCES, MULTIDISCIPLINARY	24	68	
BUSINESS, FINANCE	23	99	
PSYCHOLOGY, APPLIED	22	34	
POLITICAL SCIENCE	21	45	
THERMODYNAMICS	20	139	

Domains

To grasp patterns, it helps to consolidate the 244 SCs into mega-disciplines, or "**research domains**" (in part because they do not neatly reflect disciplinary groupings). I composed these starting with the grouping of SCs into 9 larger sets offered by Morillo.[7] I refined this based on perceptions of commonalities and general publishing practices. To check these clusters, I examined the co-citation of SCs reflected in a combination of four weeks of US-authored publications from 2005 and 2006 in Web of Science (28,922 articles). I examined several alternative ways to group (cluster) the SCs:

- Two Principal Components Analyses ["factor analyses"] to see which SCs were most highly associated – The resulting 16 factors capture ~120 SCs. I also generated other factor solutions to gain perspective on the extent of association – e.g., 11, 21, and 28 factors.
- Another map of all 244 SCs based on cross-correlation with each other (a different way of looking at co-citation of SCs).
- An autocorrelation map. This is not as effectively clustered as the cross-correlation map.
- Two of the maps seem to work best: the cross-correlation map together with the 16-factor map. These shed light on the degree of association among the SCs that intuitively appear to belong together.
- For the 16 factors, I also generated the corresponding factor matrix and pasted the more inclusive top SCs (with loadings above ~0.2, noting natural gaps) from this into Excel. This extends the factors below the cutoff used in factor mapping.

Principles guiding domain formulation:

- Begin with an intuitively sensible grouping and examine consistency with the statistical clustering, using both cross-correlation and factor mapping.
- Seek relatively few domains, but each domain should generally share research norms within its SCs.
- Allow an "Other" category for SCs that really don't fit into the identified research domains well.

Assignment is not unambiguous; many SCs show some degree of relationship to different domains. But without providing further details, here is how FTA work locates in these resulting 12 larger domains.

Table 9 shows the aggregations. The last column is included to help gauge the scope of these research domains (note that the "engineering, mechanical & related" is quite discrete). The "# of FTA publications" shows where these 1018 papers are published. Because many journals are associated with multiple SCs, the "total" is considerably greater than 1018. The results are interesting:

- FTA is most strongly associated with the "**Quantitative Applications**" domain. [This includes SCs in Applied Math, Computer and Information Sciences, Electrical and Industrial Engineering, Operations Research, Management and Business, and so forth.]
- Yet, **FTA topics appear quite widely**, with over 100 in each of five additional research domains – in descending order: Social Sciences, Physical Sciences, Agricultural/Environmental Sciences, Earth Sciences & Civil Engineering, and Mechanical & Related Engineering.

Table 9. FTA Relationships with Research Domains

Research Domain	# of FTA Publications	# of Times FTA Papers Cite	# of SCs in the Domain
Quantitative Applications	624	6124	26
Social Sciences	275	1496	22
Physical Sciences	132	514	30
Life Sciences -- Agricultural & Environmental	121	1165	26
Earth Sciences & Civil Engineering Related	112	711	17
Engineering -- Mechanical & Related	105	290	4
Life Sciences -- Biomedical	53	549	27
Behavioral Sciences	23	252	20
Other	19	76	18
Health Sciences	14	105	13
Medicine	3	130	23
Humanities	1	19	18
TOTAL	1482	11431	244

The next column, "# of Times FTA Papers Cite," shows what research knowledge contributes prominently to FTA. The authors of the 1018 papers have referenced 11,431 prior journal articles that our journal-SC thesaurus was able to capture [so about 11 per paper]. Notable findings:

- Again, "**Quantitative Applications**" is the primary knowledge source referenced by FTA work
- As with the FTA publication pattern, Social Sciences is second.
- The richness of the reference base indicates that FTA does, indeed, integrate knowledge from a diverse range of sources. We find over 100 citations to papers from 10 of these 12 research domains.

Figure 4 shows the extent of diffusion of the major FTA topical themes (Table 6) across the Research Domains, based on publications (Table 9, "# of FTA publications"). [The research domains are scaled roughly proportionately to their frequency in this literature set.] This mapping suggests that FTA topics are not tightly bound to particular disciplines.

Figure 4. Crossover Among Topical Themes with Research Domains of the FTA Literature

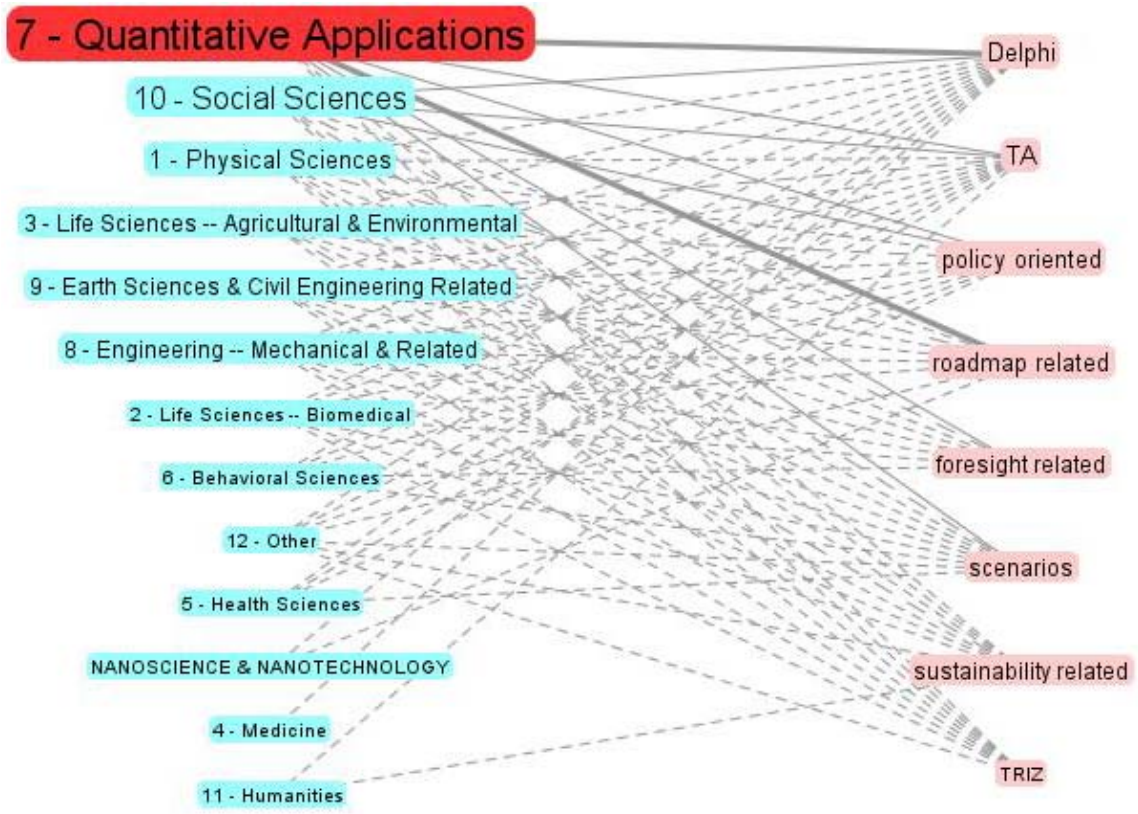


Table 10 parses these same data somewhat differently. This shows only those Research Domains with sizable numbers of FTA publications. It then normalizes the cell frequencies by the relative size of the respective Topic and Domain. Normalization reflects multiplying each cell's row value by its column value, and then summing for each of these cells. The values shown take the cell frequency (e.g., 115 for Delphi appearing in "Quantitative Applications") divided by the expected cell frequency (e.g., 177 papers mentioning Delphi times 624 Quantitative Applications papers). This is divided by the sum over all these cells, so that the percentages shown add to 1.

The cell values in bold show the Research Domains in which the given FTA Topic is relatively most used. For example, "sustainability related" themes are most prevalent in Agricultural/Environmental Life Sciences papers, whereas "TRIZ" appears proportionately most in Mechanical Engineering and Related SCs. So, while Figure 4 shows that topical themes are not tightly localized, Table 10 shows that, neither, are they evenly used across disciplines.

Table 10. Distribution of FTA Topical Themes across the Leading Research Domains

FTA Topics \ Domains	Quantitative Applications	Social Sciences	Physical Sciences	Agri/Environ Science	Earth Sciences/ Civil Engr rltd.	Mech. Engr & rltd.	Biomedical Sciences
Delphi	**1.71%**	**2.02%**	0.35%	**1.53%**	0.83%	0.79%	**2.27%**
TA	1.29%	2.15%	1.32%	2.64%	1.73%	2.49%	1.65%
policy oriented	1.50%	**2.78%**	0.47%	**2.95%**	**2.42%**	**2.23%**	1.16%
roadmap related	**1.94%**	0.89%	**4.40%**	0.43%	0.69%	1.35%	**1.95%**
foresight related	**1.94%**	**2.68%**	1.01%	0.85%	1.32%	**2.53%**	**1.95%**
scenarios	1.58%	**2.54%**	1.33%	**3.15%**	**1.99%**	1.21%	0.30%
sustainability related	0.82%	1.94%	1.20%	**6.69%**	2.82%	0.94%	1.12%
TRIZ	1.73%	0.31%	1.63%	0.36%	0.77%	**5.75%**	1.63%

Discussion

This paper has profiled the FTA research-oriented literature. It composed a search covering three Web of Science databases – Science Citation Index, Social Science Citation Index, and Arts & Humanities Citation Index. The resulting 1,018 articles published over a decade give a fair portrayal of that literature's emphases and trends.

Research-oriented FTA publication rates are modest, but the trend seems upward over the past few years (coincident with the initiation of the FTA seminar series). The U.S. leads in authorship, with a wide dispersion of author affiliations. Not surprisingly, university affiliations lead, but government and industry contribute strongly to this literature. Journals concentrate in technology management, led by *Technological Forecasting & Social Change.* Eight prominent topical themes are identified and plotted over time – Delphi and sustainability analyses show recent surges in attention.

The special interest is to see how the FTA literature distributes across disciplines. To do that, I build upon the Subject Categories (SCs) defined by Web of Science. The leading outlets for FTA articles reside in the Planning & Development, Business, and Management SCs. Those three, along with Economics and Operations Research & Management Science are most cited by the FTA articles. "Research domains" built by clustering the SCs into related groupings help show a larger picture. Publication of the FTA literature centers in the "Quantitative Applications" domain, with a second concentration in "Social Sciences," and significant participation in a range of Life Sciences, Physical Sciences, and Engineering domains. Equally interesting, the literature

FTA papers reference show a similar pattern, drawing upon diverse sources led by Quantitative Applications, with Social Sciences second. Table 10 shows the prevalence of FTA topical themes across the leading research domains for FTA publication.

I hope this provides useful empirical background for the further examination of how different disciplines approach FTA.

Acknowledgements

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