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Foundations of program management: A bibliometric view

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Abstract

Are programs just scale-ups of projects, or do they represent something unique? Recent articles stress the difference of project and program management, but do neither show consensus nor precise definitions of program management. Our comparative bibliometric study of 517 program articles and 1164 project articles published in the last 21 years in leading scientific business journals identifies similarities and differences in theoretical foundations, indicated by the sources cited, and themes, indicated by the keywords. We show that programs have several theoretical bases, such as organizational theories, strategy, product development, manufacturing and change. Programs take an open system view and seek change in permanent organizations. Projects, in turn, have product development as the dominant theory basis. We elaborate eleven distinctive characteristics of program and project management research. Our study proposes themes upon which future theories and empirical studies of programs can be established.

Keywords: Program management; Project management

1. Introduction

When modern project management emerged between 1930s and 1950s [15], the terms project and program management were used interchangeably [13,15]. Well-known monographs like Archibald's "Managing High-technology Programs & Projects" [1, p. 25] make a distinction between projects and programs by defining the latter as "a long-term undertaking that includes two or more projects that require close cooperation". As the main emphasis of Archibald's book is on projects, the author gives no hints on which practices are specific for programs, but not for projects.

This project-centricity has changed. Since around the turn of the 20th century, project management journals and program management institutions [17,25] define programs, identify program types and good practices in program management. Pellegrinelli [19], building on the conception of Ferns [7], defines a program as a framework for grouping existing projects or defining new projects, and for focusing all the activities required to achieve a set of major benefits (other fairly similar definitions by [6,8,12,13,16,18,21,30]). OGC [17] defines program management as the coordinated organization, direction and implementation of a portfolio of projects and activities that together achieve outcomes and realize benefits that are of strategic importance. PMI [25] defines program management as the centralized coordinated management of a program to achieve the program's strategic objectives and benefits, and emphasizes the programs' long-term benefit orientation, strategic nature, and challenge to integrate and coordinate a complex network of resources.

Recent research efforts obviously try to make sense of various definitions and controversial perspectives on programs and program management. This is clearly seen as suggestions to research different types of programs in

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different contexts. Some empirical studies have developed program typologies, context typologies, and program type-specific management practices. Program typologies deal with the number of projects and locations [6], degree of change and extent to which projects exist at the time of program launch [33], strength of coordination [8], relation of strategy and projects in the program [19,20], and scope in terms of functions involved and extent of change [12]. Also, programs vary in terms of size and resource type, i.e. whether the projects included in the program have clearly stated goals and methods [18,21].

In all, programs have taken a foothold in project management research. Contemporary studies emphasize the strategic orientation of programs, including the program's tight link to business, and the program being a self-directed and renewing organism with its own vision, organizing capabilities, and learning [13,20,32]. Programs have thus drawn attention towards the strategic aspects of major changes. However, at the same time, project research is expanding its view towards wider aspects of project business [2,5,29] and towards a contingency view of projects [27]. Therefore, it is not quite clear whether and how programs differ from projects, and how research in program management can differentiate its contributions from those of project management.

We are concerned about shortcomings and lack of coherence in existing literature:

(1) Current literature uses often loose definitions of the program concept.
(2) It is not clear what are the distinctive features and differences between projects and programs and their management.
(3) Program management literature tends to assume a project-based way of operating while at the same time ignoring earlier discussions on large projects and their management.
(4) Program management literature has not, yet, commonly shared a theoretical foundation upon which it could soundly establish its particular practices.

One of the major gaps of the actual discussion is that the theoretical and practical bases of project and program management are largely ignored. In this article we address the theoretical foundations of project and program management. In order to bring new knowledge into the project and program management community, we are not going back to the well-known project management journals but take a closer look at the leading academic journals which have also analyzed project and program management since many years. Many of these contributions are often ignored.

1.1. Research questions

It is our aim to overcome some of the gaps by analyzing systematically the articles which have been published in the leading business journals in the last 21 years. We use a comparative quantitative longitudinal bibliometric analysis to identify similarities and differences of project and program management in theoretical foundations, indicated by the sources cited, and in themes, indicated by the keywords used. Through this attempt, we hope to bring coherence and develop a more solid foundation for future research on program management. To reach these objectives, we seek answers to the following research questions:

1a. What are the *foundations* of the management of programs, in terms of key sources used in program articles (i.e., in articles that discuss programs)?
1b. What are the *differences* in such *foundations* between programs and projects?
1c. How have the *foundations* of the management of programs and projects *evolved over time?*
2a. What are the *content themes* in programs and their management, in terms of keywords used in program articles?
2b. What are the *differences* in the *content themes* between programs and projects?
2c. How have the *content themes* in the management of programs and projects *evolved over time?*

2. Research method

2.1. Research strategy

This study uses recognized top business journals with high impact rating as a set of its original data sources. In particular, we focused on such areas of business journals that relate to project management's potential application areas: general management and business, strategy, technology and innovation management, and operations management. We limited our search to such journals that have a fairly long, established history and, therefore, purposefully excluded journals started during the past few years. Altogether 23 business journals, available through ISI Web of Science were identified. The business journals included in the analysis are presented in Table 1.

We use the following *terms* when explaining the analysis and results: *article* means any searched or referred sources and may represent also other types of publications, such as books, or chapters in edited books. *Citing articles* form the main data source for the citation and keyword analyses. We distinguish between *project articles* and *program articles* where needed, to denote whether the original search word has been project or program. There were altogether 517 program articles, which were identified by using words 'program' and 'programme' as search word, i.e. the word has been used in the article's title, keywords, or abstract. By using the search word 'project', the search resulted in 1164 project articles. *Cited references* and *referred articles* in turn mean all the findings (original foundations) referred to in the citing articles, while *key sources* are those included in the citation analysis.

Table 1
Business journals used in keyword and citation analysis

Academy of Management Executive
Academy of Management Journal
Academy of Management Review
Administrative Science Quarterly
British Journal of Management
California Management Review
Decision Sciences
Harvard Business Review
IEEE Transactions on Engineering Management
International Journal of Operations Management
International Journal of Technology Management
Journal of Management
Journal of Management Studies
Journal of Operations Management
Journal of Product Innovation Management
Management Science
Organization Science
Organization Studies
Production and Operations Management
R&D Management
Research Policy
Research Technology Management
Strategic Management Journal

We delimited the scope of the data set of our search to articles published in 1986–2006 in the selected business journals. As we did the database search in early June 2006, the number of articles for the year 2006 represents only those articles accumulated to the database at that point of time.

2.2. Citation analysis method

The total number of cited references identified in the reference lists of the 517 program articles was 13,826. Some cited references have been cited from several of the 517 citing articles, and therefore the total number of *different* cited references was 11,742. In our analysis, we are interested in finding key sources from this set of referred articles.

In order to reduce the number of analysis points, we selected a cut-off requirement for selecting the referred article as a *key source*. With the cut-off level of a minimum of 6 received citations from the 517 citing articles, we ended up with 69 key sources, which is a reasonable number for our analysis of theoretical foundations. The 69 referred articles are listed in the Appendix A. There are altogether 570 citations to the 69 key sources.

Of the 1164 project articles, the reference lists included 40,305 cited references of which 24,343 were different. Due to a significantly larger pool of both citing articles and cited references, we used a higher cut-off level (29) for obtaining project key sources. This resulted in a reasonable number of project key sources. The 52 project key sources are listed in Appendix B. There are altogether 2447 citations to these key sources.

We took four main steps to analyze the citation data. Firstly, all the references in citing articles were imported from ISI Web of Science to SITKIS software [26] that prepares the data on cited references for UCINET network analysis program [3] and for desktop office programs for further analyses. Secondly, we used the cut-off points to select key sources, which were then used to test different network models with UCINET, both clustered and unclustered. When selecting the cluster framework, we paid particular attention to finding illustrative, informative and manageable solutions, and ended up with a solution of four clusters for both programs and projects. Clustering was based on co-citation intensity from the citing articles, i.e. articles within each cluster were more often co-cited than across clusters. Thirdly, we analyzed the contents of the resulting clustered networks through reading the abstracts and full articles. Fourthly, we made a comparison between the results of key sources for project articles and program articles. This involved calculating relative shares of each key source of all key sources for both programs and projects, generating a comparison table, identifying commonalities and differences, and calculating chi-square statistics to test whether the differences are significant at the 5%-level for erroneously rejecting the null-hypothesis that there are no differences.

The evolution over time was analyzed by splitting the references to key sources on the overall period (1986–2006) into three 7-year periods (1986–1992, 1993–1999, and 2000–2006). For this purpose, we associated a cluster membership for each cited reference and calculated citation frequencies for clusters in each time period. We sorted the data by cluster and citation frequency, cross-tabulated program and project references, analyzed the article abstracts, and developed coding schemes to identify patterns in the clusters and time periods. Furthermore, we calculated Wilcoxon signed ranks test statistics to estimate whether citation frequencies for the clusters had changed over different time periods.

2.3. Keyword analysis method

The keyword analysis was conducted with the keywords of the 517 program articles and 1164 project articles. A database of the keywords was constructed. Firstly, the database was purified from evident overlaps and redundancies. Keywords 'program', 'programme', and 'project' were removed as they were the original search words for the articles. Additionally, altogether 91 keywords were purified in program database, and 82 keywords in project database, to correct overlaps. Such changes meant that different keywords were combined to form one single keyword, for example: singular and plural forms of the same word (e.g. strategy and strategies, network and networks), two ways to express the same issue (e.g. TQM and Total Quality Management, and R&D and Research and Development), two language versions of the same keyword (e.g. organisation and organization), and two or more ways to present the same keyword (e.g. organization change, organizational change, organizational changes, or work group,

work-group and workgroup). After this, the database included 1394 different keywords from program articles, and 2428 from project articles.

To make the databases manageable, we selected a *cut-off requirement for including the keyword into further analysis.* With the minimum requirement of 5 references from program articles and 12 references from project articles, we selected 65 most frequently mentioned keywords from program articles and 64 keywords from project articles for further analysis. The resulting keywords were sorted and frequencies were tabulated for each keyword. The 65 keywords in the 517 program articles got 687 references, with an average frequency of 11 references per keyword. Similarly, the 64 keywords in 1164 project articles got 2408 references, with an average frequency of 38 references per keyword. The databases were combined, to enable comparison of program and project keywords with chi-square statistics and looking into the keyword contents, differences and combinations.

3. Results on foundations of programs

3.1. Citation analysis for programs

The first inspection of an unclustered solution and table of program cited references revealed that programs are discussed in business journals most intensely in very highly regarded general management, organization, manufacturing, quality and innovation management articles. Secondly, it was apparent that the citations were fairly well spread over the different key sources. With a top citation frequency of 16 [A25], altogether 37 key sources (54% of program key sources) have just 6–7 citations from the citing articles (see Appendix A). Thirdly, we noticed that such sources that would represent original theoretical foundations of the program and project management line of literature cannot be identified in the key sources at all.

We identified four clusters of key sources. In Fig. 1 a circle depicts a key source, and the area of each circle is proportional to the number of citations received by that key source. A line connecting two circles (key sources) indicates that the two articles are referred to from one *same* citing article. The thicker the line, the more there are citing articles that cite to the two referred articles together. By analyzing the cluster contents, we named them as follows (in order of total citation count): (1) Organization theory, (2) Product development, (3) Quality and manufacturing and (4) Work design and change. Of these, Organization theory and Product development dominate in citation frequencies and number of key sources, but also some Manufacturing and quality articles have some very high citation frequencies.

The *organization theory* cluster received 211 citations in program key sources, covering the following areas: (1) fundamental organizational theory sources that elaborate the management of an organization [A6, A12, A15, A21], (2) management of an organization in its market, environment and institutional setting [A3, A4, A7, A9, A10, A13, A16, A18, A20, A22, A23], (3) strategy and organization's resources as sources for competitive advantage [A8, A17, A19, A24], and (4) research methodology with emphasis on qualitative research methods [A1, A2, A5, A11, A14].

The *product development* cluster received 163 citations, covering the following areas: (1) practices and processes in product development [A25, A28, A29, A33, A34, A36, A38, A40], (2) organizational structures, innovation and strategy [A26, A27, A31, A37, A41, A42], (3) speed and acceleration of product development [A35, A39], (4) diffusion of innovations [A32], and (5) research methodology with emphasis on psychometric theory [A30].

The *quality and manufacturing* cluster received 119 citations covering the following areas: (1) quality management and measurement [A43, A48, A49, A50, A51, A54, A55], (2) manufacturing management and productivity [A44, A46, A47, A52, A56, A57], (3) business process re-engineering [A45], and strategy [A53]. In this cluster, many sources addressed Japanese manufacturing and total quality management.

The *work design and change* cluster received 77 citations, covering the following areas: (1) organizational learning [A58, A69], (2) work design, human resource management and productivity [A65, A66], (3) innovation culture [A59], (4) performance management [A67], (5) investments [A64], (6) inter-organizational cooperation and external sources of innovation [A60, A62], (7) economics and national systems of innovation [A68], and (8) research methodology with emphasis on modeling and experimentation [A61, A63]. The work design and change cluster is a small cluster, but its content is fragmented.

3.2. Citation analysis for projects

For comparison purposes, we looked into key sources cited in project articles. The analysis immediately showed that the literature being cited is fairly concentrated. The top citation frequency is 130 [B1], and also the second highest frequency is 110 [B2], the others varying between 29 and 78 citations (see Appendix B). The number of citations is very high, possibly due to the more established foothold of projects in business, as compared to programs. The network of key sources and their co-citations from citing articles is thereby much denser than that of programs.

We identified four clusters, shown in Fig. 2: (1) Product development A (1273 citations, 50.4% overlap with program key sources), (2) Organization and product design (476 citations, 60.7% overlap with program key sources), (3) Knowledge creation (372 citations, 83.3% overlap with program key sources), and (4) Product development B (326 citations, 9.2% overlap with program key sources).

The main difference between clusters *Product development A and B* appears to concern the publication time of cited references: Product development B articles cite older sources than A [e.g. B44, B45, B46, B50]. Cluster Product

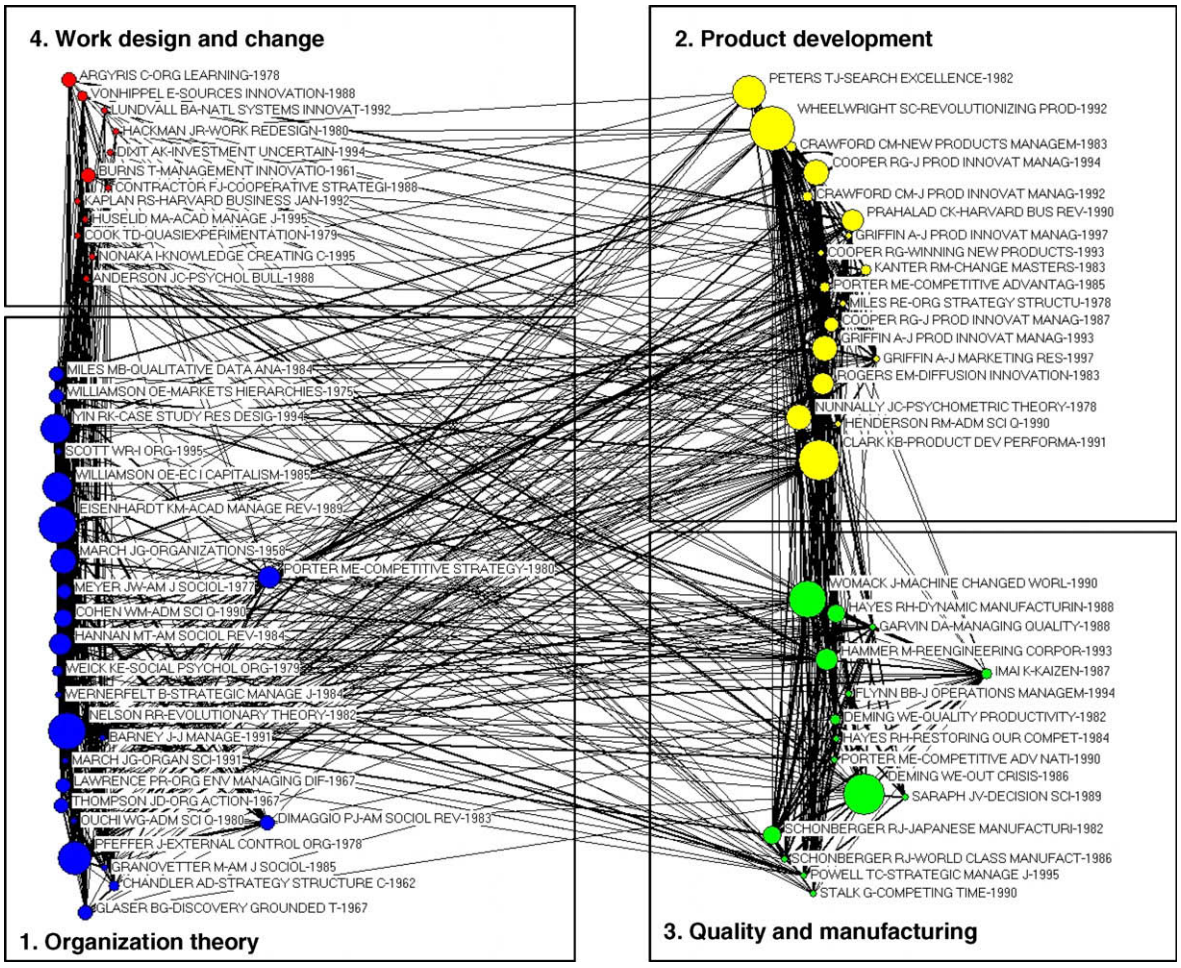

Fig. 1. Clustered network chart for program article key sources. Key source is a cited reference with a minimum of 6 citations from a citing program articles.

development A shows parallels to the Product development cluster identified for program articles.

Organization and product design cluster shows some similarities with the organization theory cluster of the program articles' citations. For project articles, this cluster is more concentrated on organization design and communication problems (interfaces) caused by functional structures of organizations. The dominating paradigm underlying the organization and product design cluster is the information processing view of organization design.

Knowledge creation cluster includes sources that look at the knowledge creating company [e.g. B38, B40], but it also includes sources which discuss aspects of qualitative research [B36, B37, B42].

3.3. Foundation differences between programs and projects

For comparison purposes, the 69 program key sources and 52 project key sources were combined in the same table. *Of the total 96 key sources, only 25 were shared by projects and program articles.* When examining the *relative citation frequencies* for the 25 shared key sources, three showed significant differences: Womack et al. [A44] is significantly more often cited in program articles than project articles ($p < 0.05$); whereas Cooper [B6] ($p < 0.05$) and Clark & Fujimoto [B1] ($p < 0.01$) are significantly more often cited in project articles than program articles. *This means that the common base of key sources is less than 25%: programs and projects have different foundations.*

Altogether 44 key sources were unique for program articles, and 27 were unique for project articles, adding to about 74% of all key sources. These 71 unique key sources generate significant differences between program and project articles ($p < 0.01$ for testing relative frequencies of these 71 unique sources).

3.4. Evolution patterns

To analyze evolution patterns for the foundations, we assigned a cluster membership for each key source, based on its cluster position during the entire period. Thereby we were able to examine how the citations have evolved across the three 7-year periods: (1) 1986–1992, (2) 1993–1999, and (3) 2000–2006.

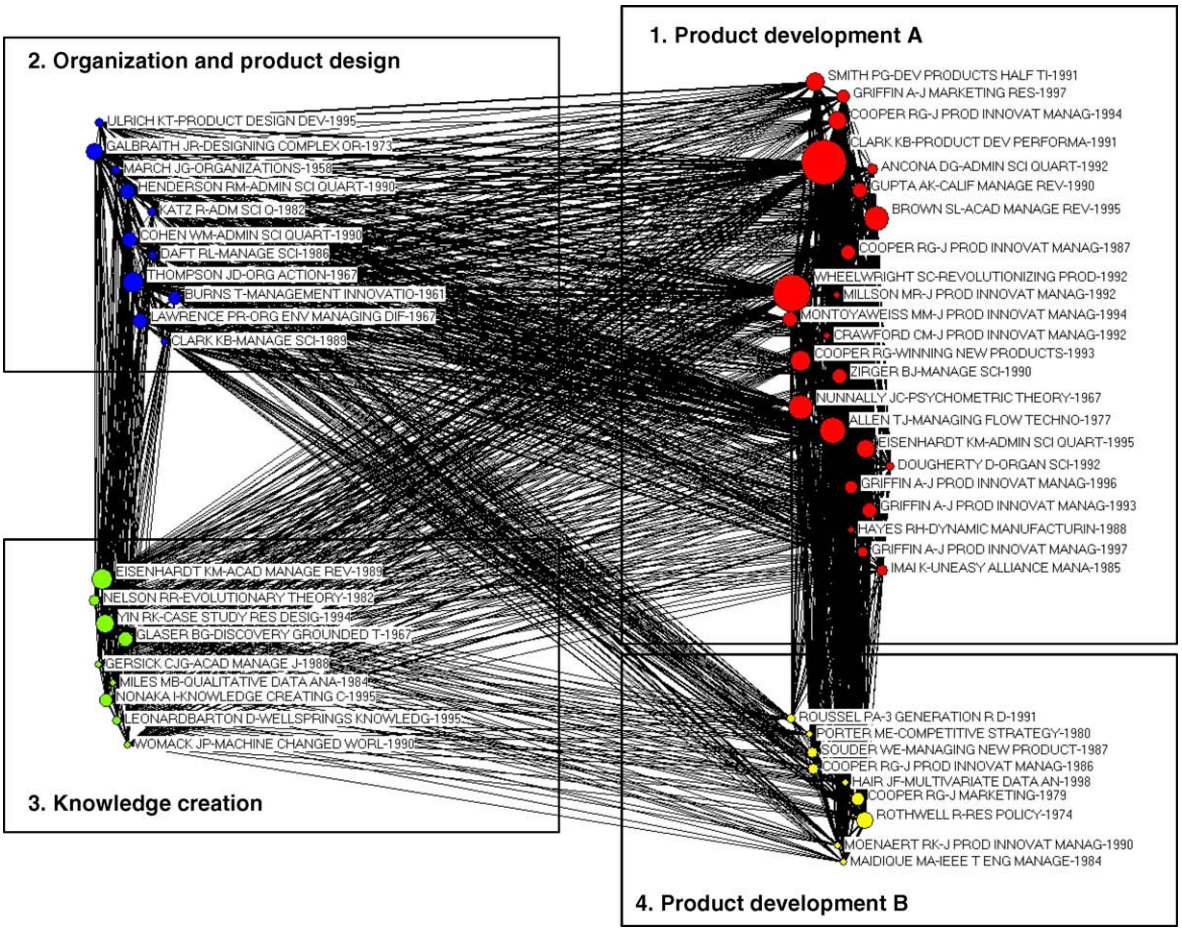

Fig. 2. Clustered network chart for program article key sources. Key source is a cited reference with a minimum of 29 citations from citing project articles.

In general, the number of citing program and project *articles* has increased visibly from the first period to second (Tables 2 and 3, second row). The number of citing program articles has not grown between second and third periods, whereas the number of citing project articles has grown but not as rapidly as between the two first periods.

A similar pattern can be seen in program *key sources,* presented in the last row of Table 2. For all program key sources, we identified a significant growth in citation count between the first two time periods ($Z = -7.11$, $p < 0.001$) and between the first and the third time period ($Z = -7.09$, $p < 0.001$), but not between the second and third period ($Z = -1.32$, n.s.). When the comparison of time periods is repeated for all key source clusters separately, the number of citations has increased significantly from period 1 to 2, and from period 1 to 3 for all key source clusters. Only in Organization theory cluster, the growth of citation count has continued at a significant level also between periods 2 and 3.

Also for project key sources (Table 6, last row) we identified a significant growth in citation count between the first two time periods ($Z = -6.27$, $p < 0.001$), between the first and the third time period ($Z = -6.28$, $p < 0.001$), and also for the second and third period ($Z = -3.89$, $p < 0.001$). In all project key source clusters, the number of citations has increased significantly from period 1 to 2, and from period

Table 2
Evolution of program key source citations by time period

Citing program articles	1986–1992		1993–1999		2000–2006	
Number of citing program articles	43		237		237	
Citations to key sources by program key source cluster, by time period	*N*	%	*N*	%	*N*	%
Organization theory	15	58	84	33	112	39
Product development	6	23	74	29	83	29
Quality and manufacturing	1	4	62	24	56	20
Work design and change	4	15	37	14	36	13
Total	26	100	257	100	287	100

Table 3
Evolution of project key source citations by time period

Citing project articles	1986–1992		1993–1999		2000–2006	
Number of citing project articles	114		460		590	
Citations to key sources by project key source cluster, by time period	*N*	%	*N*	%	*N*	%
Product development A	26	25	518	54	729	53
Organization and product design	38	37	167	17	271	20
Knowledge creation	2	2	119	12	251	18
Product development B	36	35	157	16	133	10
Total	102	100	961	100	1384	100

1 to 3. For Product development A, Organization and product design and Knowledge creation the number of citations has increased also between periods 2 and 3, whereas for Product development B the citation count has dropped slightly but non-significantly.

Evolution of the different clusters becomes apparent when examining the relative shares (percentages in Tables 2 and 3) of each cluster's key sources per time period. Key sources in organization theory, and organization and product design dominated in the first period from 1986 to 1992 in program and project articles, respectively. In the later periods, project articles most often cited sources from the product development area, whereas organization theory remained the main key source cluster for program articles. Project articles have increasingly focused on product development, whereas in program articles the share across different clusters has become more balanced. Quality and manufacturing literature began to influence in program articles from the second period onwards.

4. Results on program content themes

4.1. Keyword analysis for programs

Sixty-five keywords used in program articles were included in the analysis after the cut-off point of 5 references, and this amounted to 687 keyword citations. The number of keyword citations has grown during the three periods from 33 citations (1986–1992) through 263 citations (1993–1999) to 391 citations (2000–2006). The top 16 keywords (of the 65) account for 50% of the total citation count. The top 16 include keywords on *results* (productivity, competitive advantage, impact, performance), *product development* (R&D and innovation), *context* (industry, firms), and *within-company issues* (systems, technology, total quality management, model, strategy, management, organization). The top 16 keywords and their citation count is presented in order of citation frequency in Table 4 (the 15th and 16th keywords had the same number of citations).

Table 4
Top 16 keywords, their citation count in program articles, and cumulative percentages

Keyword	Citation count	Cumulative % of the 687 keyword citations
Innovation	41	5.97
Performance	37	11.36
Model	35	16.45
Management	33	21.25
R&D	23	24.60
Firms	22	27.80
Strategy	21	30.86
Organization	19	33.63
Systems	19	36.39
Technology	19	39.16
Total quality management	16	41.49
Impact	16	43.82
Industry	15	46.00
Competitive advantage	15	48.18
Productivity	13	50.07
New product development	13	51.97

4.2. Keyword analysis for projects

Sixty-four keywords used in project articles were included in the analysis after the cut-off point of 12 references, and this amounted to 2408 keyword citations. The number of keyword citations has grown during the three periods from 72 citations (1986–1992) through 749 citations (1993–1999) to 1587 citations (2000–2006). The top 10 keywords (of the 64) account for 50% of the total citation frequency, which indicates a more focused use of keywords than in programs. As shown in Table 5, the keyword contents among the highest-cited keywords fit to the same topic areas as in programs, with three exceptions. Strategy and systems appear only in programs, not in projects; and success appears only in projects but not in programs. Eight of the top ten keywords of both project and program articles are shared.

4.3. Keyword differences between programs and projects

For comparison purposes, the 65 keywords in program articles and the 64 keywords in project articles were combined in the same table (Appendix C). Besides the actual citation frequencies described above, we looked into the degree of sharing across program and project articles,

Table 5
Top 10 keywords, their citation count in project articles, and cumulative percentages

Keyword	Citation count	Cumulative % of the 2408 keyword citations
Innovation	201	8.35
Performance	160	14.99
New product development	151	21.27
Management	139	27.04
Model	122	32.10
R&D	100	36.26
Organization	97	40.29
Technology	80	43.61
Firms	79	46.89
Success	76	50.04

and the relative proportion of keyword citations per article type.

Of the total 89 keywords, 40 were shared by project and program articles. When examining the relative frequencies for the shared keywords, a majority (31 of 40) represent the same relative proportion of all key source citations of program and project articles. That is, the keyword's percentage share of all keywords is the same, whether in program articles or project articles and the chi-square analysis does not show significant difference. Therefore, the overlap seems to be rather strong. We identified nine significant differences. The keywords Innovation ($p < 0.05$), New product development ($p < 0.001$) and Success ($p < 0.001$) appeared significantly more often in project articles than program articles. The keywords Quality, Science, Organizational change, Systems ($p < 0.05$) and Impact and Competitive advantage ($p < 0.01$) appeared more often in program articles than in project articles.

Twenty-five keywords were unique for program articles, and 24 were unique for project articles. For example, Total quality management, Productivity, Continuous improvement, Economics, Data envelopment analysis and Heuristics were the most frequently cited unique program keywords (from 8 to 16 citations). Similarly, Communication, Information, Integration, Uncertainty, Industrial, and Teams were the most frequently cited unique project keywords (22 to 48 citations). These 49 unique keywords, generated altogether 42 significant differences between program and project articles ($p < 0.01$).

The findings for the keyword analysis portray to some extent similar findings as the citation analysis. In program articles, the unit of analysis often is on a higher level of the organization: e.g. organizational change, quality initiatives, continuous improvement and systems thinking. This was apparent also in the dominance of organizational theory, quality and manufacturing literatures. In project articles, the more typical unit of analysis was on the project or activity level, e.g. the product development project and its success factors.

4.4. Evolution patterns in keywords

We analyzed the evolution in keywords further by ranking them by time periods. Ranks for top 10 keywords for each time period are presented in Table 6. In period 1986–1992, only top 9 is included for both program and project articles because of the low number of citations for each keyword. *Innovation* has become the most important keyword for both project and program articles during the past decades, and also the importance of the keyword

Table 6
Ranks of top 10 keywords by time period

	1986–1992		1993–1999		2000–2006		All, 1986–2006	
	Program	Project	Program	Project	Program	Project	Program	Project
Innovation	6.5	3.5	4	1	1	1	1	1
Performance	2	1	3	2	3	3	2	2
Model	2	2	1	3	7.5	5	3	5
Management			6	4	2	4	4	4
R&D			10	6	5	7	5	6
Firms					4	8	6	9
Strategy		7.5	6	8.5	7.5	10.5	7	
Organization		7.5		10	6	6	9	7
Technology		7.5	2	7		9	9	8
Systems			8.5		9.5		9	
Industry					9.5			
Productivity	6.5		8.5					
Competitive advantage			6					
Success		3.5		8.5		10.5		10
New product development				5		2		3
Communication		5						
Design		7.5						
Impact	2							
Commitment	6.5							
Data envelopment analysis	6.5							
Lagrangian relaxation	6.5							
Satisfaction	6.5							

R&D has become apparent. In the period 1986–1992 innovation was ranked only on place 6 in program articles and on place 3 in project articles. For the period 1993–1999 it already ranked first for project articles and fifth for program articles, and finally first for both project and program articles. In the top 10 keyword lists, results have a strong foothold, which is reflected by the high ranking of the term *Performance* (and *Impact* and *Success*). The keyword *Management* has appeared on the top tens of both project and program articles since the second period and increased in importance, whereas the importance of the keyword *Strategy* has slightly declined over time. The keyword *Model* ranked high in the first and second period in both program and project articles, but its importance has decreased in the last period. The keyword *Firms* has appeared to both project and program articles' top 10 lists only in the third period.

The top 10 lists continue to show a similar pattern of differences between program and project articles as the citation analysis and general keyword analysis. In program articles, broader issues such as *System*, *Industry*, *Competitive advantage* as keywords appear as unique. Program articles' keywords in the first period, however, were very fragmented and difficult to interpret. For project articles, the keyword *New product development* has been used increasingly over time, and also *Technology* has remained important.

5. Synthesis and discussion

5.1. Distinctive characteristics with programs and their comparison to projects

Our study revealed that programs and projects share some foundations and a majority of their top 10 keywords. Despite the overlaps, our results largely confirm Lycett et al. [13] in that programs cannot and should not be treated as scale-ups of projects. Evident differences have been identified especially in terms of main focuses, division between literature clusters, evolution patterns, level of analysis, and specific content themes. Table 7 highlights similarities and differences between programs and projects, further discussed below.

The following discussion explains in more detail the eleven distinctive characteristics of Table 7, by simultaneously explaining the overlaps and differences between programs and projects.

5.1.1. Themes and their evolutionary patterns

According to the citation analysis, projects relate dominantly to the product development theme, but programs relate to a wide variety of management themes, such as manufacturing, quality, organizational change, change in work and industry, and product development. Emphases of different themes evolve in time with programs, whereas

Table 7
Eleven distinctive characteristics with programs and projects

Characteristic	Distinctiveness of programs	Distinctiveness of projects
1. Themes	*Several topical and focused themes* of management science: manufacturing, quality, work and organization change, product development	*One dominant theme*: product development
2. Evolutionary pattern of themes	*Emphases of different themes change in time*. Major changes in industry and society introduce contemporary themes that programs are expected to address	*Evolution within the same thematic line of literature,* product development
3. Dominant theory bases	*Organizational theories and strategy*	*Product development*
4. Additional theory bases	*Several additional theory bases*: product development, manufacturing, quality, and industrial, economic, institutional, work and organizational change	*Organizational theories*
5. Missing theory basis	*Ignorance of original theoretical roots of program and project management*	*Ignorance of original theoretical roots of program and project management*
6. Evolutionary pattern of theory bases	*Evolution towards a balance*. Within organizational theories, evolution towards balance between alternative theories. Between dominant and additional theory bases, from organization theory focus towards more balance among themes	*Increasing focus in product development*
7. Level of analysis	*Organization and its major parts*. However, no evident focus on multi-project organizing	*Single project*
8. Object	*Change of permanent organization*	*Narrowly defined task entity or organizational entity that is temporary*. Permanent organization is taken as given, serving as an influence factor of project success
9. System	Systems thinking	No systems thinking
10. Types of innovation	*Various types of innovations that reflect an open system nature of organizations in their environments*. For example, process innovation, organizational innovation and change, infrastructure and systems innovation	Product innovation
11. Types of outcome	*Wide set of impacts*. Broader, fuzzier and more indirect and far-reaching effects with long-term implications in the future	*Concrete business results*. Direct results that contribute in a foreseeable manner to business success. Focus is on short-term outputs (project or product success)

projects seem to evolve within the same product development theme. Based on the keyword analysis, both programs and projects have focused on very similar content themes of e.g. innovation, performance, model, management, R&D, firms and organization. In comparison to program articles, project articles have maintained a very consistent set of keywords across the years, with some variations in the rankings. New product development and success are unique keywords in projects. Technology has remained among top 10 keywords consistently.

5.1.2. Dominant theory bases

Organizational theories form the dominant theory basis for programs, and product development forms the basis for projects. Despite this difference, the most significant areas of overlap appeared in product development and organization theory clusters of program articles. As one special area of interest, strategy has been a distinguishing factor for programs, as compared to projects, both in citation and keyword analysis [e.g. A8, A17, A19, A24, A31, A37, A42, A53, A63]. Strategy sources seemed to be dominantly included in all program key source clusters. Despite the appearance of 'strategy' as a keyword to some extent also in projects, project key sources did not indicate any particular orientation towards strategy literature.

5.1.3. Additional and missing theory bases

In addition to the dominant product development literature, projects seemed to rely only on organizational theories. Programs that had several additional theory bases: strategy, product development, manufacturing, quality, industries and economic change, institutional change, work and organizational change. A surprising finding was the ignorance of the project-centered theoretical roots of program and project management both by program and project articles.

5.1.4. Evolutionary pattern of theory bases with programs

The number of citations and keywords in different time periods suggests that programs have gained importance in business literature especially in mid-1990s. The number of citing articles and key sources has not continued to grow as rapidly as in the second period or as with project articles. The early citations and keywords in late 1980s were very fragmented and few, but strong growth and continuity have followed. As in organizational theory more generally, older bureaucratic theories and contingency theories have increasingly been complemented with institutional and evolutionary theories in program articles. Programs are strongly embedded in the topical themes of management science: first manufacturing and quality, and more recently product development. According to our citation analysis, the different key source clusters are becoming more balanced in citation quantities.

5.1.5. Evolutionary pattern of theory bases with projects

When compared to programs, projects have a stronger foothold and longer history in management literature, which is apparent in a higher number of citing articles and cited references. Our analysis shows that the foundations of projects and their management in business journals are evidently rooted in product development literature. Over the years, project articles have interestingly evolved within the same line of literature, from the earlier articles of Cluster Product development B to the later articles of Product development A. Also organization and product design has had an important role in the late 1980s and knowledge creation has recently gained importance. Project articles have relied more selectively on organizational design theories and such sources which describe the practices of product development, particularly in the automotive and assembly industries. The early, more balanced set-up across clusters has transformed to more focused product development orientation in project articles.

5.1.6. Level of analysis and object

The level of analysis with programs seems to be an organization and its major parts, whereas project articles seem to focus on single project level issues. Programs relate to an organization and its parts as a whole, and research topics relate to organizational change and renewal of systems and processes. Programs in the business literature, however, do not deal with multi-project organizations or multi-project environments specifically. The object of programs is the change of a permanent organization. With projects, the permanent organization is usually a given factor that dictates criteria and enablers for project success. Therefore, projects represent narrowly defined task entities or temporary organizations.

5.1.7. System, types of innovation, and types of outcome

System was among the top 10 keyword with programs but not with projects, which indicates that programs rely more on systems thinking than projects. Programs address various types of innovations that reflect an open system nature of organizations in their environments. Project articles focus on one specific type of innovation, i.e. product innovation, whereas program articles cover a wider range of product, process, organizational, infrastructure and systems innovations. A typical outcome of a program is a wide set of impacts. When compared to projects, programs result to broader, fuzzier and more indirect and far-reaching effects with long-term implications in the future. Outcomes from projects are concrete business results, which contribute in a foreseeable manner to business success. Such results are expressed in terms of profitability, growth, market share, or change in technology. Project outcomes are focused and narrowly defined short-term outputs that typically can be expected from a single project. Such project outcomes are often contained in the concept of project success.

5.2. Foundation gaps

In addition to distinctive characteristics in programs and projects and their differences, our analysis resulted to clear gaps in foundations of programs and their scientific basis.

5.2.1. Ignorance of original theoretical roots of program and project management

Program and project articles ignore the original theoretical roots of program and project management, particularly: large project studies [14], studies on large projects with a special emphasis on their failures [10,11,21], early project success studies [14,22–24,28], overviews on program and project management evolution [15], and early project management approaches with emphasis on systems view [4]. Based on this surprising observation, we are concerned with the evolution and continuity in the science of programs and projects.

5.2.2. Neglect of inter-project coordination

We have noticed that *inter-project coordination* does not appear as a separate issue in the program and project articles. Inter-project coordination is increasingly discussed in project management journals and among practitioners. In line with other authors (e.g. [2,5,29]), we believe that coping with multi-project landscapes is an essential part of modern project business.

5.2.3. Neglect of inter-organizational issues and theories

We observe a scarcity of *inter-organizational theories* as part of program and project articles. Inter-organizational theories have developed strongly in the last decades, and they have also been discussed as part of the growing project network and governance literature (e.g. [9,31]).

5.2.4. Limited contingency view

Project and program articles seemed to rely on a narrow approach to contingent impacts typical to classical organizational-theoretic view. Complexity, uncertainty and novelty of projects and programs should be used more often as moderators. A wider contingency view on programs and projects should address the different management approaches in the different environments of projects and programs. Future studies should clearly characterize the types of programs or projects they are dealing with, and develop more elaborate contingency frameworks for program and project management.

5.2.5. Lack of industry-specific views

The program and project literatures do not address industry-specific approaches, nor do they include industry-specific knowledge bases that would address program management in certain industry environments. Industries differ in their institutional settings, power structures, supplier–customer relationships, business practices, and partnerships. These industry-specific features have an impact on program and project management. Further research should address program management in different industries, starting for example from the historical roots of project management: construction and civil engineering, power and energy systems, chemical engineering, aerospace and aircraft engineering, and defence and military systems.

5.2.6. Neglect of the interplay between the permanent and the temporary organization

We identified that programs relate to permanent organizations and their changes, whereas projects were conceived as purely temporary organizations. The complex interplay between the temporary and the permanent organization should be studied.

Acknowledgements

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Appendix A. Program key sources by cluster and citations to them from citing program articles

Program key sources by cluster, in order of importance, in terms of the number of citations received	In key sources of project articles 1986–2006	Total number of citations 1986–2006	1986–1992	1993–1999	2000–2006
Cluster Organization theory					
A1 Eisenhardt KM. Building Theories from Case Study Research. Academy of Management Review 1989;14(4):532–550	B35	14	1	5	8
A2 Nelson RR, Winter SG. An Evolutionary Theory of Economic Change. Cambridge: Harvard University Press, 1982	B39	14	1	6	7
A3 Pfeffer J, Salancik GR. The External Control of Organizations: A Resource Dependence Perspective. New York:Harper & Row Publishers, 1978		13	2	4	7
A4 Williamson OE. The economic institutions of capitalism: Firms, markets, relational contracting. New York: The Free Press, 1985		12	1	5	6

(*continued on next page*)

Appendix A (*continued*)

	Program key sources by cluster, in order of importance, in terms of the number of citations received	In key sources of project articles 1986–2006	Total number of citations 1986–2006	1986–1992	1993–1999	2000–2006
A5	Yin RK. Case study research: Design and methods. California: Thousand Oaks, 1994	B36	12	0	5	7
A6	March JG, Simon HA. Organizations. New York: Wiley, 1958	B31	11	2	5	4
A7	Hannan MT, Freeman J. Structural Inertia and Organizational Change. American Sociological Review 1984;49(2):149–164		10	1	3	6
A8	Porter ME. Competitive Strategy: Techniques for analyzing industries and competitors. New York: Free Press, 1980	B51	10	1	5	4
A9	Cohen WM, Levinthal DA. Absorptive-capcity - A new perspective on learning and innovation. Administrative Science Quarterly 1990;35(1):128–152	B28	9	0	4	5
A10	DiMaggio PJ, Powell WW. The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields. American Sociological Review 1983;48(2):147–160		8	0	3	5
A11	Glaser BG, Strauss AL. The Discovery of Grounded Theory: Strategies for Qualitative Research. New York: Aldine Publishing, 1967	B37	8	0	3	5
A12	Lawrence PR, Lorsch JW. Organization and environment: managing differentiation and integration. Harvard University Press: Boston, 1967	B26	8	1	4	3
A13	Meyer JW, Rowan B. Institutionalized Organizations: Formal Structure as Myth and Ceremony. The American Journal of Sociology 1977;83(2):340–363		8	0	3	5
A14	Miles MB, Huberman AM. Qualitative Data Analysis: A Sourcebook of New Methods. Beverly Hills: Sage, 1994	B42	8	0	3	5
A15	Thompson JD. Organizations in Action. New York: McGraw-Hill, 1967	B24	8	2	1	5
A16	Williamson O. Markets and Hierarchies: Analysis and Antitrust Implications. New York: The Free Press, 1975		8	1	3	4
A17	Chandler AD. Strategy and Structure: Chapters in the History of American Industrial Enterprise. New York: Doubleday, 1962		7	1	3	3
A18	Weick KE. The social psychology of organizing. New York: McGraw-Hill, 1979		7	0	5	2
A19	Barney J. Firm Resources and Sustained Competitive Advantage. Journal of Management 1991;17(1):99–120		6	0	3	3
A20	Granovetter M. Economic Action and Social Structure: The Problem of Embeddedness. The American Journal of Sociology 1985;91(3):481–510		6	0	3	3
A21	March JG. Exploration and Exploitation in Organizational Learning. Organization Science 1991;2(1):71-87		6	0	1	5
A22	Ouchi WG. Markets, Bureaucracies, and Clan. Administrative Science Quarterly 1980;25(1):129–141		6	0	2	4
A23	Scott WR. Institutions and organizations. CA: Thousand Oaks, 1995		6	0	3	3
A24	Wernerfelt B. A Resource-Based View of the Firm. Strategic Management Journal 1984;5(2):171–180		6	1	2	3
	CLUSTER TOTAL/Organization theory		211	15	84	112
	Cluster Product development					
A25	Wheelwright SC, Clark KB. Revolutionizing product development. New York: The Free Press, 1992	B2	16	0	7	9
A26	Clark KB, Fujimoto T. Product development performance: strategy, organization, and management in the world auto industry. Boston: Harvard Business School Press, 1991	B1	15	0	7	8
A27	Peters TJ, Waterman RH. In search of excellence: Lessons from America's best-run companies. New York: Warner Books, 1982		13	1	8	4
A28	Cooper RG, Kleinschmidt EJ. Determinants of timeliness in product development. Journal of Product Innovation Management 1994;11(5):381–396	B8	11	0	4	7
A29	Griffin A, Page AL. An interim-report on measuring product development success and failure. Journal of Product Innovation Management 1993;10(4):291–308	B10	11	0	5	6
A30	Nunnally J. Psychometric theory. New York: McGraw Hill, 1967	B5	11	0	4	7
A31	Prahalad CK, Hamel G. The core competence of the corporation. Harvard Business Review 1990;68(3):79–91		10	1	6	3
A32	Rogers E. Diffusion of Innovations. New York: Free Press, 1985		10	0	2	8
A33	Cooper RG, Kleinschmidt EJ. New products - What separates winners from losers. Journal of Product Innovation Management 1987;4(3):169–184	B11	8	1	3	4
A34	Crawford CM. New Products Management. Homewood: Irwin Publishers, 1987		7	1	3	3
A35	Crawford CM. The Hidden Costs of Accelerated Product Development. Journal of Product Innovation Management 1992;9(3):188–199	B23	7	0	5	2

Appendix A (*continued*)

Program key sources by cluster, in order of importance, in terms of the number of citations received		In key sources of project articles 1986–2006	Total number of citations 1986–2006	1986–1992	1993–1999	2000–2006
A36	Kanter RM. Change Masters. New York: Simon and Schuster, 1983		7	0	7	0
A37	Porter ME. The Competitive Advantage: Creating and Sustaining Superior Performance. New York: Free Press, 1985		7	1	3	3
A38	Cooper RG. Winning at new products: accelerating the process from idea to launch. Reading: Addison-Wesley, 1993	B6	6	0	2	4
A39	Griffin A. The effect of project and process characteristics on product development cycle time, Journal of Marketing Research 1997;34(1):24–35	B16	6	0	1	5
A40	Griffin A. PDMA research on new product development practices: Updating trends and benchmarking best practices. Journal of Product Innovation Management 1997;14(6):429–458	B19	6	0	1	5
A41	Henderson RM, Clark KB. Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms. Administrative Science Quarterly 1990;35(1):9–30	B27	6	0	2	4
A42	Miles RE, Snow CC. Organizational Strategy, Structure and Process. New York: McGraw-Hill, 1978		6	1	4	1
	CLUSTER TOTAL/Product development		163	6	74	83
Cluster Quality and manufacturing						
A43	Deming WE. Out of the Crisis. Cambridge Massachusetts: Cambridge University Press, 1986		15	0	8	7
A44	Womack JP, Jones DT, Roos D. The Machine That Changed The World. New York: Rawson Associates, 1990	B43	14	0	8	6
A45	Hammer M, Champy J. Reengineering the Corporation. New York: Harper Business, 1993		10	0	4	6
A46	Hayes R, Wheelright S, Clark KB. Dynamic Manufacturing. New York: The Free Press, 1988		9	0	6	3
A47	Schonberger RJ. Japanese Manufacturing Techniques. New York: Free Press, 1982		9	0	6	3
A48	Deming WE. Quality, Productivity, and Competitive Position. Massachusetts: Cambridge University Press, 1982		7	0	6	1
A49	Imai M. Kaizen: the key to Japan's competitive success. New York: McGraw Hill, 1986		7	0	4	3
A50	Flynn BB, Schroeder RG, Sakakibara S. A framework for quality management research and an associated measurement instrument. Journal of Operations Management 1994;11(4):339–366		6	0	0	6
A51	Garvin DA. Managing Quality: The Strategic and Competitive Edge. Massachusetts: Rath& Strong Incorporated, 1988		6	0	2	4
A52	Hayes RH, Wheelwright SC. Restoring Our Competitive Edge: Competing Through Manufacturing. New York: Wiley, 1984		6	0	4	2
A53	Porter ME. The Competitive Advantage of Nations. New York: Free Press, 1990		6	0	3	3
A54	Powell TC. Total Quality Management as Competitive Advantage: A Review and Empirical Study. Strategic Management Journal 1995;16(1):15–37		6	0	1	5
A55	Saraph JV, Benson PG, Schroeder RG. An instrument for measuring the critical factors of quality management. Decision Sciences 1989;20(4):810–829		6	0	2	4
A56	Schonberger RJ. World Class Manufacturing; The Lessons of Simplicity Applied. New York: The Free Press, 1986		6	0	4	2
A57	Stalk G, Hout TM. Competing Against Time. New York: The Free Press, 1990		6	1	4	1
	CLUSTER TOTAL/Quality and manufacturing		119	1	62	56
Cluster Work design and change						
A58	Argyris C, Schön D. Organizational learning: A theory of action perspective. Reading: Addison Wesley, 1978		8	1	5	2
A59	Burns T, Stalker G. The Management of Innovation. London: Associated Book Publishers, 1966	B29	8	0	6	2
A60	Von Hippel E. The Sources of Innovation. New York: Oxford University Press, 1988		7	1	3	3
A61	Anderson JC, Gerbing DW. Structural Equation Modeling in Practice: A Review and Recommended Two-Step Approach. Psychological Bulletin 1988;103(3):411–423		6	1	1	4

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Appendix A (*continued*)

	Program key sources by cluster, in order of importance, in terms of the number of citations received	In key sources of project articles 1986–2006	Total number of citations 1986–2006	1986–1992	1993–1999	2000–2006
A62	Contractor FJ, Lorange P. Why should firms cooperate? The strategy and economics basis for cooperative ventures: In Contractor FJ, Lorange P, editors. Cooperative strategies in international business. Lexington Books, Massachusetts, 1988, p. 3–30		6	0	5	1
A63	Cook TD, Campbell DT. Quasi-experimentation: Design and analysis issues for field settings. New York: Houghton Mifflin, 1979		6	1	3	2
A64	Pindyck RS, Dixit AK. Investment under Uncertainty. New Jersey: Princeton University Press, 1994		6	0	3	3
A65	Hackman R, Oldham G. Work Redesign. Reading: Addison-Wesley, 1980		6	0	4	2
A66	Huselid MA. The impact of Human Resource Management Practices on Turnover, Productivity, and Corporate Financial Performance. Academy of Management Journal 1995;38(3):635–672		6	0	1	5
A67	Kaplan RS, Norton DP. The Balanced Scorecard: Measures that Drive Performance. Harvard Business Review 1992;70(1):71–79.		6	0	3	3
A68	Lundvall BA. National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning. London: Pinter Publishers, 1992		6	0	1	5
A69	Nonaka I, Takeuchi H. The Knowledge-Creating Company. How Japanese Companies Create the Dynamics of Innovation. New York: Oxford University Press, 1995	B38	6	0	2	4
	CLUSTER TOTAL/Work design and change		77	4	37	36
	TOTAL (sum across key sources)		570	26	257	287

Appendix B. Project key sources by cluster and citations to them from citing project articles

	Project key sources by cluster, in order of importance, in terms of the number of citations received	In key sources of program articles 1986–2006	Total number of citations 1986–2006	1986–1992	1993–1999	2000–2006
Cluster Product development A						
B1	Clark KB, Fujimoto T. Product development performance: strategy, organization, and management in the world auto industry. Boston: Harvard Business School Press, 1991	A26	130	2	58	70
B2	Wheelwright SC, Clark KB. Revolutionizing product development. New York: The Free Press, 1992	A25	110	0	43	67
B3	Allen TJ. Managing the Flow of Technology. Cambridge: MIT Press, 1977		78	10	37	31
B4	Brown SL, Eisenhardt KM. Product Development: Past Research, Present Findings, and Future Directions. The Academy of Management Review 1995;20(2):343–378		73	0	18	55
B5	Nunnally J. Psychometric theory. New York: McGraw Hill, 1967	A30	73	5	28	40
B6	Cooper RG. Winning at new products: accelerating the process from idea to launch. Reading: Addison-Wesley, 1993	A38	62	1	21	40
B7	Smith PG, Reinertsen DG. Developing Products in Half the Time: New Rules, New Tools. New York: John Wiley & Sons, 1998		61	1	32	28
B8	Cooper RG, Kleinschmidt EJ. Determinants of timeliness in product development. Journal of Product Innovation Management 1994;11(5):381–396	A28	58	0	26	32
B9	Eisenhardt KM, Tabrizi BN. Accelerating Adaptive Processes: Product Innovation in the Global Computer Industry. Administrative Science Quarterly 1995;40(1):84–110		57	0	14	43
B10	Griffin A, Page AL. An interim-report on measuring product development success and failure. Jorunal of Product Innovation Management 1993;10(4):291–308	A29	51	0	27	24
B11	CooperRG, Kleinschmidt EJ. New products - What separates winners from losers. Journal of Product Innovation Management 1987;4(3):169–184	A33	49	0	27	22
B12	Gupta AK, Wilemon DL. Accelerating the development of technology-based new products. California Management Review 1990;32(2):24–53		49	2	23	24
B13	Montoya-Weiss MM, Calantone R. Determinants of new product performance - A review and meta-analysis. Journal of Product Innovation Management 1994;11(5):397–417		47	0	16	31
B14	Zirger BJ, Maidique MA. A Model of New Product Development: An Empirical Test. Management Science 1990;36(7):867–883		47	2	26	19

Appendix B (*continued*)

	Project key sources by cluster, in order of importance, in terms of the number of citations received	In key sources of program articles 1986–2006	Total number of citations 1986–2006	1986–1992	1993–1999	2000–2006
B15	Griffin A, Hauser JR. Integrating R&D and marketing: A review and analysis of the literature. Journal of Product Innovation Management 1996;13(3):191–215		45	0	13	32
B16	Griffin A. The effect of project and process characteristics on product development cycle time. Journal of Marketing Research 1997;34(1):24–35	A39	42	0	7	35
B17	Imai K, Nonaka I, Takeuchi H. Managing the New Product Development Process: How Japanese Companies Learn and Unlearn. In: Clark KB, Hayes RH, Lorenz C, Kaplan RS, editors. The Uneasy Alliance: Managing the Productivity-Technology Dilemma, Harvard Business School Press, Boston, USA, 1985		40	2	22	16
B18	Ancona DG, Caldwell DF. Bridging the Boundary: External Activity and Performance in Organizational Teams. Administrative Science Quarterly 1992;37(4):634–665		38	0	12	26
B19	Griffin A. PDMA research on new product development practices: Updating trends and benchmarking best practices. Journal of Product Innovation Management 1997;14(6):429–458	A40	38	0	2	36
B20	Dougherty D. Interpretive Barriers to Successful Product Innovation in Large Firms. Organization Science 1992;3(2):179–202		36	0	14	22
B21	Hayes RH, Wheelright SC, Clark KB. Dynamic Manufacturing. New York: The Free Press, 1988		30	1	21	8
B22	Millson MR, Raj SP, Wilemon D. A survey of major approaches for accelerating new product development. Journal of Product Innovation Management 1992;9(1):53–69		30	0	16	14
B23	Crawford CM. The hidden costs of accelerated product development. Journal of Product Innovation Management 1992;9(3):188–199	A35	29	0	15	14
	CLUSTER TOTAL/Product development A		1273	26	518	729
	Cluster organization and product design					
B24	Thompson JD. Organizations in Action. New York: McGraw-Hill/New Brunswick, 1967	A15	63	6	27	30
B25	Galbraith J. Designing Complex Organizations. Reading: Addison-Wesley, 1973		54	6	17	31
B26	Lawrence PR, Lorsch JW. Organization and environment: managing differentiation and integration. Harvard University Press: Boston, 1967	A12	51	5	20	26
B27	Henderson RM, Clark KB. Architectural innovation - The reconfiguration of existing product technologies and the failure of established firms. Administrative Science Quarterly 1990;35(1):9–30	A41	49	1	18	30
B28	Cohen WM, Levinthal DA, Absorptive-capacity – A new perspective on learning and innovation. Administrative Science Quarterly 1990;35(1):128–152	A9	48	0	19	29
B29	Burns T, Stalker G. The Management of Innovation. London: Tavistock, 1961	A59	43	4	11	28
B30	Daft RL, Lengel RH. Organizational Information Requirements, Media Richness and Structural Design. Management Science 1986;32(5):554–571		36	2	11	23
B31	March JG, Simon HA. Organizations. New York: Wiley, 1958	A6	35	3	18	14
B32	Ulrich KT, Eppinger SD. Product Design and Development. New York: McGraw-Hill, 1995		35	0	7	28
B33	Katz R. The Effects of Group Longevity on Project Communication and Performance. Administrative Science Quarterly 1982;27(1):81–104		33	10	9	14
B34	Clark KB. Project Scope and Project Performance: The Effect of Parts Strategy and Supplier Involvement on Product Development. Management Science 1989;35(10):1247–1263		29	1	10	18
	CLUSTER TOTAL/Organization and product design		476	38	167	271
	Cluster Knowledge creation					
B35	Eisenhardt KM. Building Theories from Case Study Research. Academy of Management Review 1989;14(4):532–550	A1	63	0	20	43
B36	Yin RK. Case study research: Design and methods. California: Thousand Oaks, 1994	A5	60	0	18	42
B37	Glaser BG, Strauss AL. The Discovery of Grounded Theory: Strategies for Qualitative Research. New York: Aldine Publishing, 1967	A11	48	1	18	29
B38	Nonaka I, Takeuchi H. The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation. New York: Oxford University Press, 1995	A69	42	0	6	36

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Appendix B (*continued*)

Project key sources by cluster, in order of importance, in terms of the number of citations received		In key sources of program articles 1986–2006	Total number of citations 1986–2006	1986–1992	1993–1999	2000–2006
B39	Nelson RR, Winter SG. An Evolutionary Theory of Economic Change. Cambridge: Harvard University Press, 1982	A2	37	0	14	23
B40	Leonard-Barton D. The Wellsprings of Knowledge. Cambridge: Harvard Business School Press, 1995		32	0	5	27
B41	Gersick CJG. Time and Transition in Work Teams: Toward a New Model of Group Development. The Academy of Management Journal 1988;31(1):9–41		30	0	12	18
B42	Miles MB, Huberman AM. Qualitative Data Analysis: A Sourcebook of New Methods. Beverly Hills: Sage, 1994	A14	30	0	12	18
B43	Womack JP, Jones DT, Roos D. The Machine That Changed The World. New York: Rawson Associates, 1990	A44	30	1	14	15
	CLUSTER TOTAL/Knowledge creation		372	2	119	251
Cluster Product development B						
B44	Rothwell R, Freeman C, Horsley A, Jervis VTP, Robertson AB, Townsend J. SAPPHO updated – Project Sappho Phase II. Research Policy 1974;3(3):258–291		52	4	36	12
B45	Cooper RG. The Dimensions of Industrial New Product Success and Failure. Journal of Marketing 1979;43(3);93–103		43	6	24	13
B46	Souder WE. Managing New Product Innovations. Lanham: Lexington Books, 1987		41	6	23	12
B47	Cooper RG, Kleinschmidt EJ. An investigation into the new product process – Steps, deficiencies and impact. Journal of Product Innovation Management 1986;3(2):71–85		38	7	17	14
B48	Roussel PA, Saad KN, Erickson TJ, Third Generation R&D: Managing the Link to Corporate Strategy. Cambridge: Harvard Business School Press, 1991		33	0	11	22
B49	Hair JF, Anderson RE, Tatham RL, Black WC. Multivariate Data Analysis. New Jersey: Prentice Hall, 1998		30	2	6	22
B50	Maidique M, Zirger B. A study of success and failure in product innovation: The case of the US electronics industry. IEEE Trans Eng Manage 1984;4:192–203		30	4	15	11
B51	Porter ME. Competitive Strategy: Techniques for analyzing industries and competitors. New York: Free Press, 1980	A8	30	3	13	14
B52	Moenaert RK, Souder WE. An information-transfer model for integrating marketing and research-and-development personnel in new product development projects. Journal of Product Innovation Management 1990;7(2):91–107		29	4	12	13
	CLUSTER TOTAL/Product development B		326	36	157	133
	TOTAL (sum across key sources)		2447	102	961	1,384

Appendix C. Program and project article keywords and their frequencies

Keyword (in order of citation frequency in program articles)[a]	Program articles				Project articles			
	Total 1986–2006	1986–1992	1993–1999	2000–2006	Total 1986–2006	1986–1992	1993–1999	2000–2006
Innovation	41	2	10	29	201	5	63	133
Performance	37	3	12	22	160	9	46	105
Model	35	3	20	12	122	8	44	70
Management	33	0	9	24	139	2	38	99
R&D	23	1	7	15	100	1	31	68
Firms	22	0	6	16	79	1	24	54
Strategy	21	0	9	12	74	3	28	43
Organization	19	0	6	13	97	3	25	69
Technology	19	0	14	5	80	3	30	47
Systems	19	0	8	11	35	0	8	27
Impact	16	3	4	9	24	1	8	15
Total quality management	16	0	7	9				
Industry	15	0	4	11	38	0	10	28
Competitive advantage	15	0	9	6	18	0	6	12
New product development	13	0	4	9	151	1	37	113

Appendix C (*continued*)

Keyword (in order of citation frequency in program articles)[a]	Program articles				Project articles			
	Total 1986–2006	1986–1992	1993–1999	2000–2006	Total 1986–2006	1986–1992	1993–1999	2000–2006
Productivity	13	2	8	3				
Time	11	0	4	7	37	0	8	29
Quality	10	0	5	5	16	1	3	12
Determinants	9	0	1	8	47	0	13	34
Implementation	9	0	6	3	26	2	9	15
Science	9	0	3	6	13	1	3	9
Organizational change	9	0	3	6	12	0	5	7
Continuous improvement	9	0	5	4				
Economics	9	1	1	7				
Perspective	8	0	5	3	39	0	10	29
Design	8	0	2	6	36	3	10	23
United-States	8	0	2	6	25	0	10	15
Behavior	8	1	4	3	17	0	8	9
Commitment	8	2	1	5	14	0	9	5
Manufacturing	8	0	7	1	12	0	5	7
Data envelopment analysis	8	2	5	1				
Heuristics	8	0	5	3				
Failure	7	0	2	5	42	2	19	21
Capabilities	7	0	3	4	19	0	4	15
Algorithm	7	1	3	3				
Costs	7	0	3	4				
Human-resource management	7	0	1	6				
Performance measurement	7	0	4	3				
Small/medium size enterprises	7	0	1	6				
Technology policy	7	0	3	4				
Success	6	0	2	4	76	5	28	43
Networks	6	0	2	4	39	0	8	31
Knowledge	6	0	1	5	33	0	3	30
Decision	6	1	1	4	20	1	6	13
Work	6	0	2	4	20	1	4	15
Framework	6	1	0	5	19	1	2	16
Power	6	0	2	4	18	1	6	11
Government	6	0	3	3				
Lagrangian relaxation	6	2	3	1				
Policy	6	0	2	4				
Cooperation	5	0	0	5	24	0	10	14
Technological innovation	5	0	4	1	16	1	6	9
BPR (Business Process Re-engineering)	5	0	3	2	14	0	9	5
Environment	5	0	1	4	14	1	7	6
Flexibility	5	0	1	4	14	1	2	11
Case studies	5	0	2	3				
Efficiency	5	1	3	1				
Empirical research	5	1	0	4				
Linear programming	5	1	3	1				
Methodology	5	0	3	2				
Outcomes	5	1	2	2				
Satisfaction	5	2	1	2				
Stochastic programming	5	1	3	1				
Subsidies	5	0	1	4				
Turnover	5	1	2	2				
Communication					48	4	17	27
Information					32	0	10	22
Integration					27	0	5	22
Uncertainty					25	1	10	14
Industrial					23	1	15	7
Teams					22	1	6	15
Real options					18	0	2	16
Decision making					17	0	5	12
Development cycle time					17	0	2	15
Selection					17	1	4	12

(*continued on next page*)

Appendix C (*continued*)

Keyword (in order of citation frequency in program articles)[a]	Program articles				Project articles			
	Total 1986–2006	1986–1992	1993–1999	2000–2006	Total 1986–2006	1986–1992	1993–1999	2000–2006
Japan					15	0	9	6
Learning					15	0	2	13
Leadership					14	1	5	8
Organizational learning					14	0	7	7
Simulation					14	1	6	7
Analytic hierarchy process					13	1	5	7
Winners					13	0	7	6
Decision analysis					12	1	2	9
Interface					12	2	6	4
Knowledge management					12	0	2	10
Product innovation					12	0	7	5
R&D management					12	0	5	7
Risk					12	0	2	10
Success factors					12	0	3	9

[a] Missing values mean that the keyword did not appear at all, or that it did not fulfill the cut-off requirement of 5 citations in program articles, or 12 citations in project articles.

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