EXPLORING THE DISCONNECT BETWEEN THE BODIES OF LITERATURE PERTAINING TO SOCIO-TECHNICAL TRANSITIONS AND TECHNOLOGY MANAGEMENT (PART 2): A LINKAGE ANALYSIS

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ABSTRACT

The importance and value of integrating the concepts of technology management with that in the socio-technical transitions literature has been highlighted in the literature. However, a disconnect still exists between these two bodies of literature. Therefore, this series of two papers investigates this disconnect from two perspectives. Part 1 investigates the disconnect by means of a bibliometric analysis that highlights the limited overlap and integration between technology management and socio-technical transitions. This paper, Part 2, enriches the investigation with a systematic and in-depth exploration of the literature bases used by the respective bodies of literature to gain additional insights into the level of integration (or the lack of it) between the socio-technical transitions literature and that on technology management. Similar to Part 1, this paper also finds that, even though these two fields are not integrated from a conceptual or theoretical perspective, it is evident that, to some extent, they share scholarly roots.

OPSOMMING

Die belangrikheid en waarde van die integrasie van die konsepte van tegnologiebestuur met dié in die sosio-tegniese oorgangsliteratuur is in die literatuur uitgelig. Daar bestaan egter steeds 'n skeiding tussen hierdie twee literatuurliggame. Daarom ondersoek hierdie reeks van twee artikels hierdie ontkoppeling vanuit twee perspektiewe. Deel 1 ondersoek die ontkoppeling deur middel van 'n bibliometriese analise wat die beperkte oorvleueling en integrasie tussen tegnologiebestuur en sosio-tegniese oorgange uitlig. Hierdie referaat, Deel 2, verryk die ondersoek met 'n sistematiese en diepgaande verkenning van die literatuurbasisse wat deur die onderskeie literatuurliggame gebruik word om bykomende insigte te verkry oor die vlak van integrasie (of die gebrek daaraan) tussen die sosio-tegniese oorgange literatuur en dit oor tegnologiebestuur. Soortgelyk aan Deel 1, vind hierdie referaat ook dat, al is hierdie twee velde nie geïntegreer vanuit 'n konseptuele of teoretiese perspektief nie, dit duidelik is dat hulle tot 'n mate wetenskaplike wortels deel.

1 INTRODUCTION

Technology plays an undisputed role in the quest for sustainable development. The technology and innovation management literature provides many concepts that are central to understanding the role of technology in sustainable business development [1], and the importance of technology management in the context of sustainable development has been argued in the literature [2]. Recently, scholars have also argued the importance of integrating the concepts of technology management and socio-technical or sustainability transitions [3], [4]. However, a bibliometric analysis that compared the respective bodies of literature relating to technology management and socio-technical transitions found “no concrete evidence

of integration or significant similarity in foundational concepts used in both bodies of literature" [5][1]. De Kock and Brent [5] further proposed that the bibliometric analysis and subsequent findings be enriched by a systematic and in-depth assessment of the literature bases (i.e., the references used by the respective bodies of literature) to clarify further the level of integration and overlap between the technology management and socio-technical transitions literature, in order ultimately to provide a starting point for the development of an integration strategy between technology management and sustainability transitions.

The bibliometric analysis undertaken in Part 1 [5] of this two-part investigation considered 331 documents that resulted from a keyword search that was focused on socio-technical transitions, and 4 740 documents that resulted from a keyword search focused on technology management (see Table 1). It emerged that only two documents ([6], [7]) are present in both sets of documents. Therefore, in order to investigate further where the two bodies of literature overlap and possibly integrate, this paper explores the links between the socio-technical transitions and the technology management bodies of literature, based on the references used by each set of documents (given the data sets that were extracted, as shown in Table 1 and as described in detail in [5]), to elucidate the level of integration between these two bodies of literature. The literature bases (the references used by each article) of both document sets are compared, and this detailed comparison is used to identify overlaps in the literature that are used as the basis for the research in the bodies of literature, thus aiming to elucidate further the extent to which there is an overlap, and to what extent these two bodies of literature share intellectual roots.

Table 1: Bibliometric analysis search statistics [5]

	Documents in search	Number of references	Total citations	Total unique authors	Total authors
Socio-technical transitions set	331	17 445	6 512	555	716
Technology management set	4 740	112 498	36 331	8 078	8 573
Combined set	2	N/A	N/A	3	3

2 MATERIALS AND METHODS

The methodology followed in this two-part investigation into the disconnect between technology management and socio-technical transitions is shown in Figure 1. As mentioned above, a bibliometric analysis was conducted in Part 1 that had two phases, while Part 2 deals with the linkage analysis (LA) and has five phases. Similar approaches to evaluating the landscape, overlap, and integration of bodies of literature have been used throughout the literature [8]–[11]. The remainder of this paper thus focuses on the LA, and the remainder of this section focuses on the LA methodology.

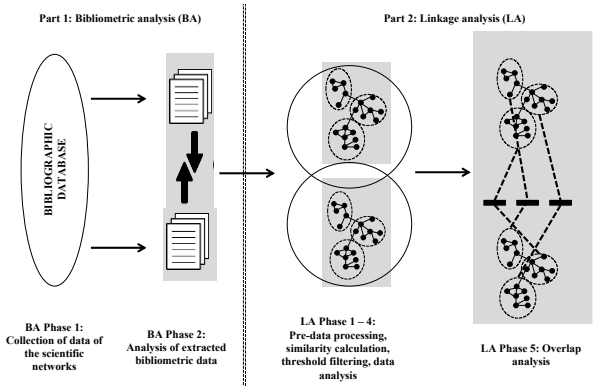

Figure 1: Schematic representation of the methodology [5]

[1] De Kock and Brent [5] is Part 1 of the two-part investigation into the disconnect between the bodies of literature pertaining to socio-technical transitions and technology management. As the title of this article states, this is Part 2.

2.1 Linkage analysis (LA) method

For all the documents that were extracted and used in Part 1 [5], only two documents[2] formed part of the combined search (see Table 1). Thus, in order to evaluate the level of overlap and integration between the two sets of literature, the references associated with both scientific networks were evaluated to identify references in documents in both the technology management and socio-technical transitions scientific networks. The linkage used in this research inquiry refers to the cross-network method that is applied to reveal the linkage between the two scientific networks.

Because only two documents were found in both data sets, the references used in the socio-technical transitions and technology management documents respectively were compared with the aim of identifying the references that are used in both scientific networks. Thus the two data sets exported from Scopus (containing 331 documents and a resulting 17 445 references in the socio-technical transitions network, and 4 740 documents and a resulting 112 498 references in the technology management network)[3] were used in the LA.

The input data for the linkage analysis was exported from the Scopus website using the .txt output format. Each '*Entry*' (i.e., a document resulting from the search) in the input file has a title, author list, and bibliography list. Each bibliography list contains multiple items, referred to here as '*References*'. The comparison of the data sets was done in two separate exercises, each comparing the references found in one data set with the references found in the other data set with the aim of achieving two respective outputs:

i. A list of references from the technology management set of documents that are also present in the socio-technical transitions set of documents; and
ii. A list of references from the socio-technical transitions set of documents that are also present in the technology management set of documents.

Ultimately, the two lists referred to above were used in Section 3 to identify and highlight the level of integration and overlap between the two sets of documents. In order to perform the LA, the data sets extracted from Scopus were used in a process that had four steps (LA Phases $1 - 4$), each of which is described below.

2.1.1 LA Phase 1: Data pre-processing

This phase primarily entailed the sanitation of the data sets (References (R)) in the bibliography list. For each reference in the respective data sets, the following operations were performed:

1. Normalisation of references (correction heuristic). After the normalisation process, all that remained was the title of the reference, and any additional (nonsense) text that was not removed by the heuristic. This included:
    a. Conversion of all text (reference strings) to lowercase;
    b. Converting unicode to ASCII[4];
    c. Replace all foreign glyphs with the nearest Roman equivalent, or remove them;
    d. Remove all author and publication metadata;
    e. Remove all common abbreviations;
    f. Remove all punctuation and redundant white spaces; and
    g. Remove all URLs, dates, and page numbers.
2. Combine all references (R) of an entry (E) with white spaces (i.e., $R_E^1 = R_1 + R_2 + \cdots$).
3. Repeat processes in steps 1 and 2 for the second set of references.

[2] The two documents that are present in both the technology management (TM) and the socio-technical transitions (STT) primary document sets are *Spontaneous emergence versus technology management in sustainable mobility transitions: Electric bicycles in China* [6], and *The transformative capacity of new technologies* [7].

[3] It should be noted that, during the linkage analysis programming, each reference was given a unique identifier; thus, should two or more documents in either of the scientific networks cite the same document, this document would have a number of unique identifiers (equal to the number of documents in the primary document sets that cite that specific reference). However, this duplication was accounted for in LA phase 5.

[4] ASCII (American Standard Code for Information Interchange) is a character encoding standard. ASCII codes represent text used in computers, telecommunications equipment, and other devices (http://www.asciitable.com/).

The normalisation and combining of the references in both data sets (the data sets with the references from the two scientific networks) was followed by the similarity calculation phase. The aim was to determine how likely a combined Reference *(R)* (i.e., the output from steps 2 and 3 above) of an *Entry i* (i.e., R_E^i) from the technology management set of references was to contain a single reference from the socio-technical transitions list of references, and vice versa.

The *edit distance algorithm*[5] was used during the similarity calculations. This algorithm found the best match for the references in the first set of references within the second set of references, and vice versa. The maximum value for the edit distance would be achieved if one had to insert a completely new reference into the reference list of the entry's references against which the reference was compared. Thus the value would be equal to the length of the reference string. Consequently, we calculated the similarity coefficient as being $\frac{e}{N}$, where N is the length of the string and *e* is the edit distance of the string.

2.1.2 LA Phase 2: Similarity calculation

The similarity calculation phase had two steps. First, a core algorithm was applied to measure the likelihood that an *Entry (E)* would contain a bibliography item; thus reference *(R),* since the references could not be directly matched. The second step of *LA Phase 2* was the higher-level operation that yielded the similarity value *(v)*, which indicated how likely it was that an edit operation referred to each reference.

LA Phase 2a: Core algorithm

For the purpose of this study, a measure of how likely an *Entry (E)* contained a bibliography item, thus reference (R), was needed. Since the references could not be directly matched (owing to discrepancies in the format, spelling, etc. between references), a modified edit distance algorithm was used as the core algorithm. The edit distance algorithm yielded the number of edit operations (insertion, deletion, or substitution) necessary to ensure that *E* contained *R*. The maximum value of the edit distance was reached when the whole text of *R* had to be inserted into *E*. Hence the similarity value $V = \frac{e}{|R|}$, where *e* is the number of edit operations.

LA Phase 2b: Higher-level operation

During this phase, the similarity value (*v*) was calculated. In order to calculate *v*:

$$\text{Let } E_1 = \text{the first set of entries;}$$

$$\text{Let } E_2 = \text{the second set of entries;}$$

Then each $e \in E_i$ had a set of references (bibliography entries), R_e. Taking a higher-level view, the objective was then to know for each $e \in E_1$ all $q \in E_2$ that had an overlapping bibliography entry within them. Thus, in set notation, for each $e \in E_1$:

$$Q = \{q | (q \in E_2 \; and \; q's \; references \; overlap \; with \; e's)\} \quad (1)$$

To determine this, each reference *Rq* was taken from some $q \in E_2$ and compared with the full bibliography text of some $e \in E_1$. This yielded a similarity value (*v*) that indicated how likely it was that *e* had a reference to *Rq*.

2.1.3 LA Phase 3: Threshold filtering

This phase filtered out *q*'s based on their similarity values, *v*'s. If *v* was less than the threshold, then *q* was not included in *Q*.

To summarise, the process described in LA phases $1 - 3$ compared all references (referred to as $R_{TM}1$, $R_{TM}2$, $R_{TM}3$, and so forth in Figure 2) resulting from a document (referred to as '*TM Entry 1*' in Figure 2) in the technology management scientific network with the references resulting from all the documents in the socio-technical transitions scientific network (referred to as $R_{STT}1$, $R_{STT}2$, $R_{STT}3$, and so forth in Figure 2) to establish the similarity between each reference in the technology management network and each reference

[5] In computer science, 'edit distance' is a way of quantifying how dissimilar two strings (e.g., words) are from one another by counting the minimum number of operations required to transform one string into the other (Skiena, S. [1997]. *The algorithm design manual*, Springer, New York).

in the socio-technical transition scientific network, and vice versa. The key objective, as stated, was to determine which references were used and, for any that were used, the frequency of their use in both scientific networks. Owing to the significant inconsistencies found in the bibliographic data extracted from Scopus, a similarity calculation was used to determine which references were present in the scientific networks, since a direct comparison was not possible. Comparing the data sets 'as-is' would have yielded a far lower number of references, as a large number of references were not cited correctly and/or were not the same.

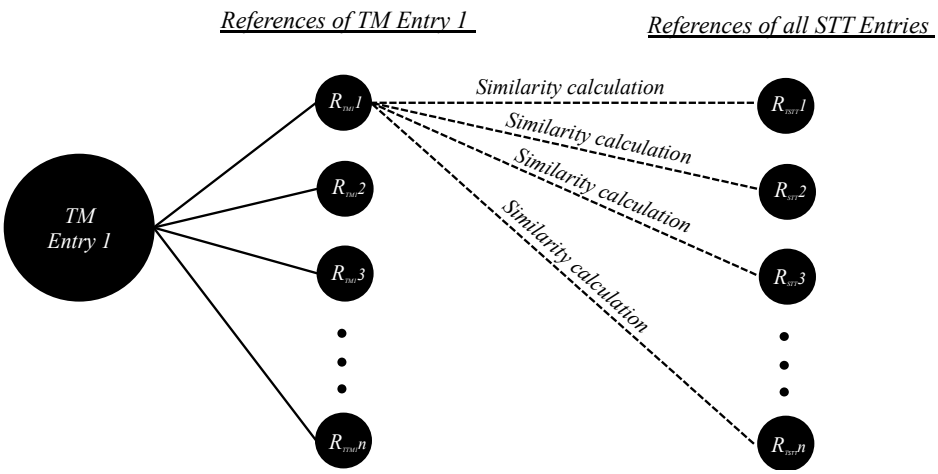

Figure 2: Schematic representation of similarity calculation process

2.1.4 LA Phase 4: Data analysis

The results from LA Phases 1 — 3 yielded more than 3.9 billion data entries — namely, the total number of similarity comparisons that were performed when comparing all references from the two scientific networks[6]. An 'entry' was a line item showing the document (*Entry*) from the first set of documents, the document (*Entry*) from the second set of entries (whose references were compared with those in the first set of entries), and the references in the second set that were similar to the references in the first set. Similarly, the output from the second set of entries was the document from the first set of entries whose references were, in turn, compared with those in the second set of entries, and the references in the first set that were similar to the references in the second set. Each reference (in both sets one and two) was given a unique identifier at the start of LA phase 1. This meant that references that were the same would have different unique identifiers. However, the duplication did not influence the final results, as care was taken not to include duplicated values. Nevertheless, the duplication of the references found in each set that evaluated the similarity between the references used in the two document sets was analysed, as this indicated the frequency of the reference in the scientific network of that specific *Entry*.

In Phase 4, the similarity results — namely, the percentage similarity between two references — were evaluated. With the vast inconsistencies between the referencing styles and the information included in the nearly 130 000 references that were used in this research inquiry, a 75% or greater similarity between two references was deemed to mean that two such references were the same reference. However, there were references with a 75% similarity that, upon further investigation, were found not to be the same reference. Because the primary aim of the research inquiry was to identify and evaluate the overlap and integration of these two bodies of knowledge, this did not have a significant impact on the results. Furthermore, in the final set of results (refer to Table A.1), each reference was checked against the raw reference data and corrected if required to ensure that the correct number of occurrences was reported.

2.1.5 LA Phase 5: Results

The output from LA phases 1 — 4 was two data sets:

[6] In order to assess the similarity between the references in both datasets, each of the 17 445 STT references was compared with each of the 112 498 TM references; thus 17 445 x 112 498 comparisons resulted in 1 962 527 610 data entries. Similarly, the opposite comparison (i.e., 112 498 TM references compared with 17 445 STT references) produced the same number of data entries; thus there was a total of 3 925 055 220 similarity comparison data entries.

1. A data set containing all the TM references that were also present in the STT scientific network. Thus all the TM references that were shown in this data set had a minimum similarity of 75% with at least one STT reference. This data set also showed the number of times that each TM reference with a similarity score of at least 75% occurred in the STT scientific network. In addition, the frequency of the occurrence of the TM reference in the TM data set was also shown.
2. Similarly, a data set containing all the STT references that were also present in the TM scientific network. Thus all STT references that were shown in this data set had a minimum similarity of 75% with at least one TM reference. This data set also showed the number of times that each STT reference with a similarity score of at least 75% occurred in the TM scientific network. In addition, the frequency of the occurrence of the STT reference within the STT data set was also shown.

The output was subsequently analysed in order to identify the areas (based on the similarity between references used by both networks) where (significant) overlap(s) occurred. Three different kinds of overlap between the TM references and the STT references were considered:

1. The most prominent references in both data sets[7] (i.e., in the data sets where an overlap had already been identified — the two data sets described above). This included:
    a. the top 50% most prominent STT references that were also a TM reference; and
    b. the top 50% most prominent TM references that were also an STT reference.
2. References with at least 10 instances / occurrences within both data sets.
3. References with at least 10 instances in one data set and five in the other:
    a. a reference with an occurrence / instance of 10 in the TM data set and an occurrence / instance of five in the STT data set; and
    b. a reference with an occurrence / instance of 10 in the STT data set and an occurrence / instance of five in the TM data set.

The three different sets of overlap set out above provided the titles of references that occurred in both the TM and the STT data sets, with a varying number of instances or frequencies that each reference occurred in each scientific network.

From the above results, which essentially entailed the articles that cited the same references — thus the articles from which references were present in both the TM and the STT data sets — a data set containing the articles that drew from the same theoretical foundations (in other words, used the same references) was compiled. This set of articles was subsequently evaluated, and is discussed in Section 3. This was also used to expand the set of articles that could be used to evaluate the overlap between the technology management and socio-technical transitions bodies of literature — in other words, to expand the set of the two identified documents in Table 1.

3 LINKAGE ANALYSIS (LA): RESULTS AND ANALYSIS

This section explores the linkages between the socio-technical transitions and technology management bodies of literature, based on the references used by each set of documents (given the data sets extracted, as described in Section 2), to elucidate the level of integration and overlap between these two bodies of literature, and to identify the extent to which these two bodies of literature share intellectual roots.

3.1 Linkage analysis results

The results of the various phases of the linkage analysis are outlined below. Table 2 and Table 3 show the references of the 4 740 technology management documents and the 331 socio-technical transitions documents respectively that had a similarity score of 75% or above (refer to Step 2: Linkage analysis in Section 2).

3.1.1 Data pre-processing outcome

The respective sets of references were normalised (see Section 2, LA Phase 1: Data pre-processing for the approach) in order to have two data sets that showed only the titles of the references. Each document, as well as each reference in each of the two sets, was given unique identifiers (within each set). Essentially,

[7] This refers to the data sets in which an overlap had already been established (i.e., the output datasets described above with an acceptable similarity score, as discussed in LA Step 4: Data analysis) between the two scientific data sets.

each data set contained the unique number for each entry, with the corresponding numbers for the references associated with each entry and the title of each reference. The titles were used in the similarity calculation.

3.1.2 Similarity calculation outcome

The outcome of the similarity calculation phase was a data set showing the similarity scores. Thus the similarity scores of all the references in the technology management set of documents were calculated, enabling the identification of all references associated with the technology management documents (*Entries*) that had a similarity score of 75% or more with the references associated with the socio-technical transitions set of documents. As mentioned in Section 2, references with a similarity score of 75% or higher were regarded as also being in the set with which they were compared. Similarly, the references associated with the socio-technical set of documents with a similarity score of at least 75%, and thus were also deemed to be present in the references associated with the technology management set of documents, were identified.

Table 2 and Table 3 summarise the results. Here it is important to note again that each reference in each document was given a unique identifier. Thus, if the same reference (*R*) was cited by a number of *Entries* (*E*), the specific reference was counted in each instance where the similarity score was 75% or higher. From Table 1, 112 498 references were present in the technology management data set, and a large number of these references were cited by more than one of the technology management documents (*Entries*). This was not a matter for concern, as both the frequency of documents that overlapped and the content and/or focus of the references that overlapped were of interest here. This point is highlighted simply because the number of references that were found to be present in both data sets did not necessarily indicate the number of unique references (the identification of the unique references was dealt with separately).

Table 2: Similarity results from similarity calculations for socio-technical transition (STT) references (R)

STT documents & references compared with TM references	**100% similarity**	**90% — 99.99% similarity**	**80% — 89.99% similarity**	**75% — 79.99% similarity**
STT references	1 820	1 993	1 719	1 066
Number of occurrences	6 395	6 403	9 580	5 803

Table 3: Similarity results from similarity calculations for technology management (TM) references (R)

TM documents & references compared with STT references	**100% similarity**	**90% — 99.99% similarity**	**80% — 89.99% similarity**	**75% — 79.99% similarity**
TM references	3 080	2 922	3 393	2 811
Number of occurrences	19 305	7 270	12 446	15 257

Table 4 shows an example of the results yielded by considering which references in the technology management set of documents overlapped with references in the socio-technical transitions set of documents. The example in Table 4 shows that the article by Geels [12], “Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study”, was cited by five documents in the technology management set of documents, and by 122 documents in the socio-technical transitions set of documents. Similarly, the data on the overlap of references cited by the socio-technical set of documents that were also cited by documents in the technology management set were identified.

Table 4: Examples of output from similarity calculations

Normalised title of reference (normalised during step i of LA Phase 1)	**Unique identifier of ‘TM reference’**	**Number of documents in the STT set of documents that also cited this reference**
Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case study	81 092	122
	111 781	122
	42 219	122
	69 636	122

Subsequent to the data gathered from the results of the similarity analysis, a further analysis was done on the results (the two data sets described above, as well as in the first part of LA Phase 5), to retrieve a list of references that adhered to the criteria set out in the second part of LA Phase 5 — i.e., (i) the most prominent references in both data sets, (ii) references with at least 10 instances / occurrences in both data sets, and (iii) references with at least 10 occurrences in one data set and five in the other. The outcome of this analysis is shown in Table A.1. By applying the set of criteria outlined above, a set of 119 references was yielded. These 119 references appeared 3 557 times as references used by documents in the technology management set of documents, and 1 538 times as references in the socio-technical transitions set of documents.

Table 5 summarises the different overlaps that were considered, as well as the corresponding number of articles found in each overlap group, and the number of articles that overlapped between these groups (refer to the matrix shown on the right in Table 5).

Table 5: References overlap 'groups'

Number of references per group	
Overlap 'group'	**Number of references**
Most prominent STT references	32
Most prominent TM references	87
10 TM references & 10 STT references	15
10 TM references and 5 STT references	30
10 STT references and 5 TM references	21

Number of references overlapping between groups					
Overlap 'group'	**Most prominent STT references**	**Most prominent TM references**	**10 TM references & 10 STT references**	**10 TM references and 5 STT references**	**10 STT references and 5 TM references**
Most prominent STT references	-	7	11	11	17
Most prominent TM references	-	-	9	20	9
10 TM references & 10 STT references	-	-	-	15	15
10 TM references and 5 STT references	-	-	-	-	15
10 STT references and 5 TM references	-	-	-	-	-

3.2 Analysis of overlapping references

In order to identify the areas of integration between the socio-technical transitions and technology management bodies of knowledge, and thus to identify to what degree these two bodies of knowledge overlapped and integrated concepts, and to what extent the concepts of the two bodies of knowledge were included in the respective fields, two approaches were taken:

1. An holistic analysis of the resulting overlap from three perspectives:
    a. The resulting overlap (the 119 references highlighted above) were analysed, and insights and inferences drawn;
    b. A cluster analysis; and

c. A correspondence analysis of the results from the linkage analysis.

2. The most significant overlaps in the above-mentioned set of references, which represented the overlap between technology management and socio-technical transitions, were analysed in order to elucidate further the overlap and integration (or lack of it) between the technology management and socio-technical bodies of literature.

3.2.1 Holistic analysis of the resulting overlap

In this section, the 119 references identified through the linkage analysis as references that were cited by *Entries* in the technology management and socio-technical transitions bodies of literature were analysed.

3.2.1.1 Overview of the resulting overlap

The references considered to represent the overlap between the bodies of literature of technology management and socio-technical transitions (as shown in Table A.1) represent 0.007% and 0.001% of the references found in the socio-technical transitions and technology management bodies of knowledge respectively. These are arguably, by any standard, a (very) small percentage of the references under consideration, and so are the second (quantitative) indication (the first being that only two articles were present in both bodies of literature) of the disconnect between technology management and socio-technical transitions.

When the references with the highest number of occurrences in the technology management set were considered (shown in Table 6), it was evident that innovation was a prominent topic. In addition, strategic management and the literature dealing with competitive advantage, economics, and technological change featured strongly. It should be noted that there was a strong focus on the level of analysis at firm or organisational level. It was evident that 'technology management' did not explicitly feature as a key focus here, but instead was implied through the focus areas; and socio-technical transitions or sustainability transitions were not in this group of key focus areas.

Table 6: Highest number of occurrences in the technology management set

Key focus	Normalised title of reference (normalised during step i of LA Phase 1	Number of times as technology management reference	Number of times as socio-technical transitions references
Innovation	diffusion of innovations fre york	145	15
Research methodology	case study research design and methods sage london	129	17
Innovation	absorptive capacity a new perspective on learning and innovation administrative science quarterly	124	2
Innovation	the knowledge creating company how japanese companies create the dynamics of innovation oxfor	124	2
Innovation	the innovator s dilemma harvard business schoo	118	18
Competitive advantage and strategic management	dynamic capabilities and strategic management strategic management	98	4
Competitive advantage	firm resources and sustained competitive advantage	92	2
Economics	an evolutionary theory of economic change harvar	83	26
Research methodology	building theories form case study research acad manag rev	74	10
Economics	the theory of economic development harvar ma	74	6
Innovation	architectural innovation the reconfiguration of existing product technologies and the failure of existing firms administrative science quarterly	64	5
Innovation	mastering the dynamics of innovation boston harvard business school	63	3
Competitive advantage	the competitive advantage of nations macmillan london	62	2

Competitive advantage and strategic management	competitive strategy techniques for analyzing industries and competitors fre york	60	2
Innovation / technological innovation	profiting from technological innovation implications for integration collaboration licensing and public policy research policy	60	1
Technological change	technological discontinuities and organizational environments adm sci q	54	7
Economics	capitalism socialism and democracy new york harper row	52	9
Technological innovation	technological paradigms and technological trajectories research policy	51	22
Strategic management	a resource based view of the firm strategic management	51	2
Organisational science	a dynamic theory of organizational knowledge creation organization science	50	1

However, when the references with the highest number of occurrences in the socio-technical transitions set that were also present in the technology management set were considered (shown in Table 7), there was a strong presence of documents that focused on transitions to sustainability and/or socio-technical transitions — possibly indicating an area of integration between the two bodies of knowledge under consideration. Also, as mentioned earlier (and as shown in Table 5), seven references fell within both the 'most prominent STT' and the 'most prominent TM' references; the focus of this (very limited) number of references was equally split between economics, innovation, social theory, and the social studies of technology; and one article focused on research methodologies.

Table 7: Highest number of occurrences in the socio-technical transitions set

Key focus	**Normalised title of reference (normalised during step i of LA Phase 1**	**Number of times as technology management reference**	**Number of times as socio-technical transitions references**
Technological change	technological transitions as evolutionary reconfiguration processes a multi level perspective case study research policy	5	122
Transition to sustainability	system innovation and the transition to sustainability theory evidence and policy cheltenham edward elgar	4	100
Socio-technical transitions	typology of sociotechnical transition pathways research policy	5	99
Transition to sustainability	the governance of sustainable socio technical transitions res policy	4	88
Technological change and environmental sustainability	technological change human choice and climate change resources and technology eds battell	3	86
Technological change	regime shifts to sustainability through processes of niche formation the approach of strategic niche management technology analysis and strategic management	5	77
Innovation	from sectoral systems of innovation to socio technical systems insights about dynamics and change from sociology and institutional theory research policy	6	64
Social studies of technology.	the social construction of technological systems cambridge ma mi	20	55
Transition to sustainability	p innovation studies and sustainability transitions the allure of the multi level perspective and its challenges research policy	1	47
Transition to sustainability	experimenting for sustainable transport the approach of strategic niche management london gbr pp ix spo	2	35
Interlocking technological, institutional and social forces, climate change	understanding carbon lock in energy policy	2	32

Socio-technical transitions	the dynamics of transitions in socio technical systems a multi level analysis of the transition pathway from horse drawn carriages to automobiles technol anal strat manage	1	32
Socio-technical transitions	technological transitions and system innovations a co-evolutionary and sociotechnical analysis cheltenham edward elgar	2	31
Transition to sustainability	the multi level perspective on sustainability transitions responses to seven criticisms environ innov soc trans	1	28
Social theory	the constitution of society	24	27
Economics	an evolutionary theory of economic change harvar	83	26
Technological change	networks of power electrification in western society 1880 1930 johns hopkin	7	25
Socio-technical change	of bicycles bakelites and bulbs theory of socio technical change mi ma	6	25
Research methodology	science in action how to follow scientists and engineers through society cambridge ma harvar	13	24
Technological development	shaping technology building society and eds mi ma	10	24

When specifically considering the *Entries* in the technology management body of literature that referred to the references that dealt with transitions to sustainability (i.e., the articles in the technology body of literature that referred to the *Reference* in the 'most prominent' overlap group), the 29 occurrences of references focusing on socio-technical transitions from a sustainability perspective or sustainability transitions (as a broad term) yielded a corresponding 17 *Entries* in the technology management set of documents. Thus there were 17 technology management *Entries* that referenced these most prominent *'STT References'* that specifically focused on socio-technical and/or sustainability transitions. Given that the objective was not only to identify references that overlapped, but also to expand the set of two identified documents in Table 2, the two articles that referenced the 'most prominent STT references' were in fact the two articles that were present in both bodies of literature (referred to in Table 1) — namely, the work of Dolata [7] and of Wells and Lin [6], clearly highlighting again the very limited overlap between these two bodies of knowledge.

Further considering the *Entries*, the references that dealt with transitions to sustainability (i.e., the articles in the technology management body of literature that referred to the references in the 'most prominent' overlap group), and by considering the keywords used in these *Entries*, it was clear that the key concepts that were addressed were in line with the findings when the most frequently used keywords were analysed for both sets of *Entries* in Part 1 of this investigation [5]. Figure 3 shows the most prominent keywords and 'keyword groups' found in these *Entries*. From this, and as highlighted earlier, innovation, technology, and sustainability were areas in which the technology management and socio-technical transitions bodies of literature overlapped. However, 'socio-technical transitions' was also present as a keyword.

	Keyword groups	Count	Keywords	Count
	Innovation	11	Innovation	4
			Innovation strategy	1
			Organisational innovation	1
			Technological innovations*	1
			Patterns of innovation	1
			Radical innovation	1
			Technology and innovation studies*	1
			Technological innovations	1
Technology	Other technology related keywords	10	Technological change	2
			Communications technology	1
			Technological innovations*	1
			Technology	1
			Technology system	1
			Marine technology	1
			Technology and innovation studies*	1
			Technology strategy	1
			Technological regimes	1
	Technology management	8	Technology management	6
			Automotive technology management	1
			Strategic technology management	1
	Sustainability	5	Sustainability	4
			Sustainable development	1
	Socio-technical transitions	4	Socio-technical transitions	1
			Socio-technical transformation	1
			Socio-technical change	1
			Regime transformations	1

* Keywords in both the 'Technology' and 'Innovation' keyword groups.

Figure 3: Most prominent keywords and 'keyword group'

From the above analysis, it can be concluded that there was an overlap at a high level and in respect of broad concepts (such as innovation, technology, and sustainability); but even these overlaps were based on a very small part of the data sets gathered at the start of the linkage analysis. The extent to which one had to delve into the data sets to find arguably minuscule overlaps in concepts was vast, and such concepts were then only indicative of overlaps and the integration of concepts at a high level and in broad terms.

The next section considers the correspondence and cluster analyses of the 119 references considered to represent the overlap between the bodies of literature of technology management and socio-technical transitions (as shown in Table A.1).

3.2.1.2. Correspondence analysis and cluster analysis

For the correspondence analysis, the standardised residual[8] for each of the references (T_1-T_{119}) was calculated and subsequently displayed on a plot showing the varying degrees of the strength of the prominence of the references to either the technology management domain or the socio-technical transitions domain. The plot is shown in Figure 4**.** The greater the negative standardised residual, the less prominent was the relationship with a domain, and the greater the positive standardised residual, the more prominent was a reference in a specific domain. This also meant that the closer the standardised residuals were to zero, the smaller the difference in the prominence of such references in the respective bodies of literature, as well as a relatively significant overlap. Figure 4 shows the references in Table A.1, given their prominence in either the technology management or the socio-technical body of literature, based on their unit variance[9]. For example, a reference with a higher occurrence in the technology management body of knowledge will be placed closer to the technology management coordinate value in Figure 4[10]. The closer the coordinates of a references ($T_1 - T_{119}$) are to zero, the more equal the occurrence in both bodies of literature, since the standard residual of such references are close to zero.

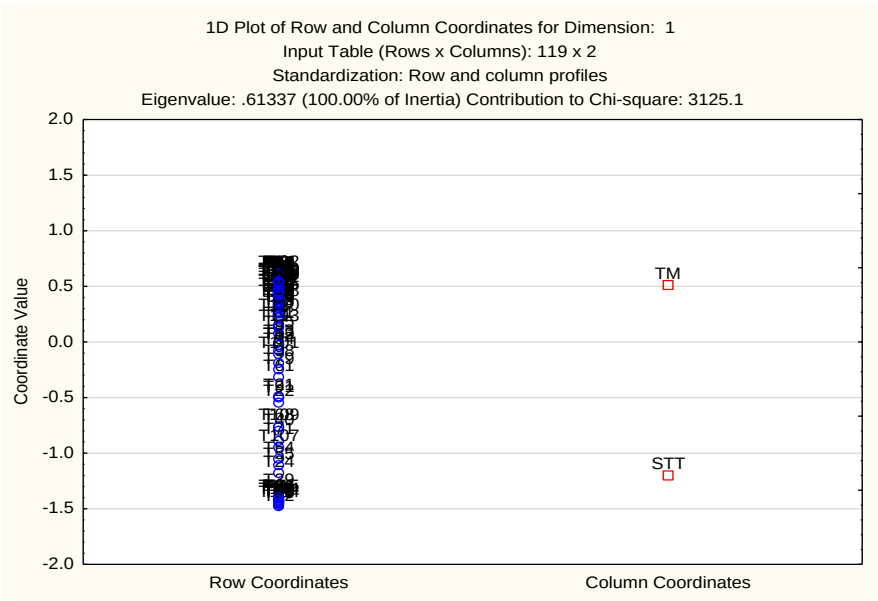

Figure 4: Plot showing the varying degree of the strength of the relationship / prominence of references in either the technology management (TM) domain or the socio-technical transitions (STT) domain

[8] The standardised residual is calculated by dividing the residual (which is the difference between the observed and the predicted value of some variable) by the square root of the residual mean square. This produces scaled residuals that have, approximately, a unit variance.

[9] Variance is a measure of variability, defined as the expected value of the square of the random variable around its mean (see also the previous footnote).

[10] It should be noted that the coordinate value is used as the standardised residual alongside an arbitrary value (that is the same for all *References*) in order to show graphically the spread of *References*, and that some are more strongly linked to the technology management body of literature while some are more strongly linked to the socio-technical transitions body of literature.

Subsequent to the correspondence analysis, and based on the calculated standardised residuals, a cluster analysis was performed. A cluster analysis aims to group data objects or data points on the basis only of information found in the specific data that describe such data points and the relationship between data points. The goal of cluster analysis is to group data objects together in a cluster that are similar (or related) to one another. The greater the similarity between the data points in a specific group, and the larger the differences between different groups, the more distinct the clusters.

For the purposes of this study, the goal of the cluster analysis was to determine whether, from a statistical perspective, there were references that could be grouped together (clustered) in order to draw insights from such clusters about the overlap landscape between the technology management and socio-technical bodies of literature (depicted here as the TM or STT domains). Again, as mentioned, the references used by the *Entries* of these two bodies of knowledge were considered in order to evaluate the overlap, as only two *Entries* were found in the overlap (refer to Table 1).

The correspondence and cluster analyses provided an abstraction from the individual data points presented in Table A.1 to the clusters in which those data points resided. In this specific case, when data points (i.e., the references) were grouped in the same cluster, it meant that such references had similar standardised residuals, and therefore had a similar prominence in their respective bodies of literature.

Figure 5 shows the dendrogram that was developed on the basis of the references presented in Table A.1 and the correspondence analysis discussed above. From Figure 5, depending on the selected linkage data, a number of different sets of clusters can be identified. In Figure 5, as depicted by the red line, a linkage distance of 31.581 yields five clusters. The selection of a linkage distance to identify clusters is a subjective decision. When considering the dendrogram in Figure 5, one can see that there are either three (should a linkage distance of between 50 and 60 be taken) or five (should a linkage distance of between 20 and 50 be taken) distinct clusters. The alternatives to this would be nine or 12 clusters if a linkage distance of about 11 or 5 respectively were selected. It is argued that, given the results found with the selected linkage distance (31.581) and the five clusters that this yields, sufficient insight is given into the overlap landscape for the purposes of this study.

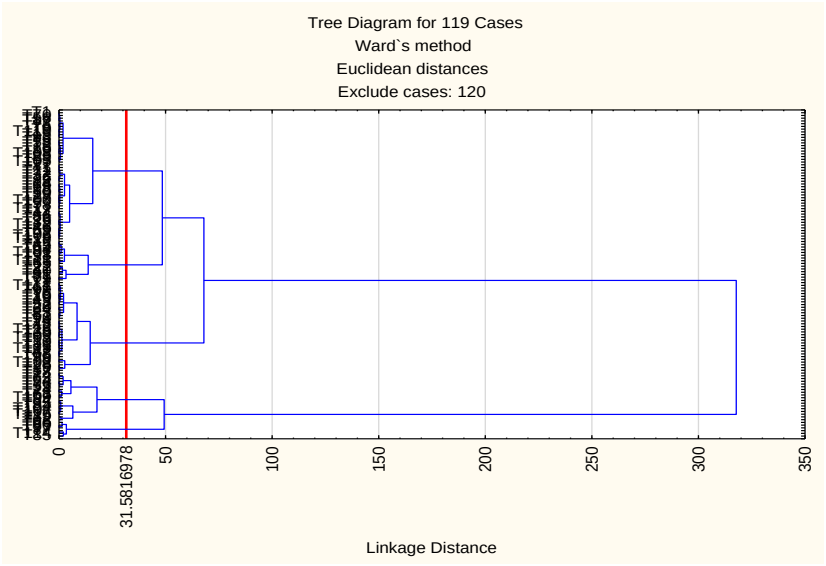

Figure 5: Dendrogram developed based on the references presented in Table A.1 and the corresponding correspondence analysis

Figure 6 shows the cluster membership of the five clusters resulting from the dendrogram, clearly indicating the domain within which each cluster (and therefore the references contained in each cluster) is more prominent. Clusters 1, 2, and 5 (and thus also the references associated with these clusters) have a greater prominence in the socio-technical transitions body of literature than in the technology management body of literature (relative to the other clusters, a greater positive standardised residual for socio-technical transitions, and relative to the other clusters a greater negative standardised residual for technology management), with cluster 2 (with average standardised residuals of -0,58 and 0,88 for technology management and socio-technical transitions respectively) having the average standardised residuals closest

to zero, indicating a relatively high degree of similarity in the prominence of the references in the respective bodies of literature, as well as a relatively significant overlap. Clusters 3 and 4 have a greater prominence in the technology management body of literature than in the socio-technical transitions body of literature — namely, positive standardised residuals for technology management, and negative standardised residuals for socio-technical transitions.

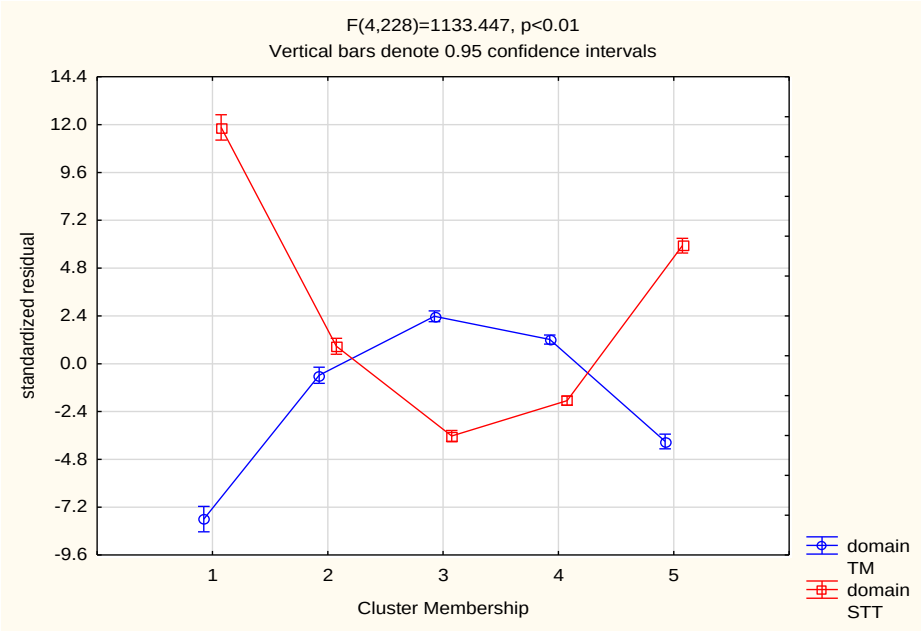

Figure 6: Cluster membership

Figure 6 shows the clusters across the set of references shown in Table A.1. The five clusters identified through the correspondence and cluster analyses described above are discussed below.

- *Cluster 1*
  As discussed above, the references in Cluster 1 were strongly associated with the STT domain, and thus with the socio-technical transitions body of literature. In other words, these references, relative to the other references identified in this overlap between the technology management and socio-technical transitions bodies of literature, consider topics that are explicitly and directly related to conceptual framings of socio-technical transitions and/or sustainability transitions — namely, the governance of socio-technical transitions, transition to sustainability theory, and a typology of socio-technical transition pathways.
- *Cluster 5*
  Similar to Cluster 1, Cluster 5 also had a stronger association with the socio-technical transitions body of literature than with technology management. However, the references were less prominent in the socio-technical transitions literature than the references in Cluster 1, and were more prominent in the technology management body of literature than the references in Cluster 1. When the references in Cluster 5 were considered, even though they were still strongly associated with socio-technical transitions and transition pathways from a conceptual perspective, some more applied and/or case studies based on socio-technical transitions were present. Another theme that was evident here was the social aspects that have to be considered when technology and the impact of technology are considered.
- *Cluster 2*
  Considering the outcome of the correspondence and cluster analyses, Cluster 2 had a slightly stronger association with the socio-technical transitions body of literature than with the technology management body of literature (see Figure 6). As might be expected, the references in this cluster were not concerned with socio-technical transitions, from neither a conceptual nor a practical/applied perspective — as was the case with Clusters 1 and 5; however, the references in this cluster were concerned most prominently with economics, technology-related topics (competing technologies, technological paradigms, and technology in organisations), innovation, and also articles dealing with

research methodology. One article dealt with social science. Interestingly, the Brundland Report (1987) was also found in Cluster 2.

- *Cluster 4*
  The references in Cluster 4 had a stronger association with the technology management body of literature than with the socio-technical transitions body of literature (see Figure 6). When the 47 references in this cluster were briefly considered, themes and topics that were evident included technology-related themes (such as technology acceptance, technology roadmaps, and technical change), innovation, economics, organisational theory, strategic management and competitive advantage, and social science. A number of references were concerned with research methodology. However, here there was no clear coherence between the topics addressed by these references, like the references in Cluster 1 and Cluster 5, for example (but to a lesser extent). Both Cluster 2 and Cluster 4 had standardised residuals that were relatively close to zero for both the technology management and socio-technical transitions bodies of literature; thus the fact that no clear themes emerged from these clusters is not surprising.
- *Cluster 3*
  Cluster 3 is the one that had the strongest association with technology management, but not as strong as that of Clusters 1 and 5 with socio-technical transitions. Even though the association with technology management was relatively similar to that of Cluster 4, there was a noticeable difference in the prominence of these references with the socio-technical transitions body of literature compared with that of Cluster 4 (see Figure 6). The topics covered seemed slightly more defined in Cluster 3 than in Clusters 4 and 2, with innovation being a theme/topic that emerged quite strongly. Similar to Cluster 4, topics related to strategic management and competitive advantage and organisational theory were also present. A number of references addressed research methodology. It is worth noting that the references in this cluster were more obviously focused on the organisational level as the unit of analysis than clusters with a stronger association with the socio-technical transitions body of literature.

3.2.2 Most significant overlaps (absolute values)

When the 'most significant' overlaps of those identified in Section 2 under *LA Phase 5: Results* were considered — this was taken as all overlaps where the number of times that a *reference* was used / occurred in the technology management set and the number of times that a reference was used / occurred in the socio-technical transitions set was at least five[11] or higher — 37 references emerged (as shown in Figure 7). Not surprisingly, of these 37 references, 30 were also in either the 'most prominent STT references' (that also had a presence in the technology management body of literature), or in the most prominent technology management references (that also had a presence in the socio-technical transitions body of literature), or in both. Also, as could be expected, given the outcome of the cluster and correspondence analyses above, all 15 references that were in Cluster 2 were also present in this set of references. Furthermore, if the references that formed part of Clusters 1, 3, 4, and 5 were considered, the distribution in terms of prominence between technology management and socio-technical transitions was relatively equal, with 10 references (Clusters 1 and 5 in Figure 7) being more prominent in the socio-technical transitions body of knowledge, and 12 references (Clusters 3 and 4 in Figure 7) being more prominent in the technology management body of knowledge.

As also could be expected — especially given the insignificant overlap between the two concerned bodies of knowledge when considering the small number of documents (two) found in the combined search (refer to Table 1) — the overlap considered in Figure 7 was not indicative of any specific dimensions across which these bodies of knowledge shared intellectual roots; some of these references were sources that discussed research methodologies and/or seminal papers, and so were expected to be present in these (and other trans- or multidisciplinary) fields. This was not because the content related to either socio-technical transitions or technology management, but rather because of the foundational concepts discussed in such documents, and they could be considered to have a high likelihood of being present in most multi- and trans-disciplinary bodies of knowledge that consider management sciences, engineering, technology, and social sciences. However, these 37 documents were analysed further to identify relevant overlaps and to infer — at least to an extent — the intellectual roots shared between the technology management and socio-technical transitions bodies of literature. The authors and year of publication of the references under consideration here are shown in Figure 8 and discussed below.

[11] The average overlap across the 119 references in Table A.1 was 4.3; thus the most significant overlaps were those that were above average — at least 5.

Overlap group					Normalised title of reference (Normalised during step i of LA Phase 1)	# of times as TM reference (thus the number of times an TMentry cites this reference)	# of times as STT reference (thus the number of times an STTentry cites this reference)
Most prominent STT refs	Most prominent TM refs	10 each way	10 TM, 5 STT	10 STT, 5 TM			
T66	x				regime shifts to sustainability through processes of niche formation the approach of strategic niche management	5	77
T85	x			x	technological transitions as evolutionary reconfiguration processes a multi level perspective case study research	5	122
T114	x			x	typology of sociotechnical transition pathways research policy	5	99
T12			x		basics of qualitative research techniques and procedures for developing grounded theory london sage	11	5
T21		x	x	x	clio and the economics of qwerty am econ rev	11	12
T22	x	x	x	x	competing technologies increasing returns and lock in by historical events econ j	14	17
T31		x		x	economic action and social structure the problem of embeddedness sociol	17	5
T40	x			x	functions of innovation systems a new approach for analysing technological change technol forecast soc change	8	16
T45				x	institutions institutional change and economic performance cambridg ma	11	5
T61			x	x	our common future world commission on environment and development oxfor	15	12
T65				x	qualitative data analysis an expanded sourcebook sage publications thousand oaks ca	14	5
T79	x	x	x	x	technical change and economic theory london pinter	24	17
T83	x	x	x	x	technological paradigms and technological trajectories research policy	51	22
T91	x	x	x	x	the constitution of society	24	27
T94		x		x	the duality of technology rethinking the concept of technology in organizations organization science	16	8
T98				x	the innovation journey oxfor	12	5
T101				x	the iron cage revisited institutional isomorphism and collective rationality in organizational fields american socio	15	8
T113		x		x	theory building from cases opportunities and challenges academy of management	16	5
T10		x		x	architectural innovation the reconfiguration of existing product technologies and the failure of existing firms adn	64	5
T13		x	x	x	building theories form case study research acad manag rev	74	10
T20	x	x	x	x	case study research design and methods sage london	129	17
T28		x	x	x	diffusion of innovations fre york	145	15
T99	x	x	x	x	the innovator s dilemma harvard business schoo	118	18
T111		x		x	the theory of economic development harvar ma	74	6
T3		x		x	a national systems of innovation theory of innovation and interactive learning pinter publishers london	28	7
T9	x	x	x	x	an evolutionary theory of economic change harvar	83	26
T19		x		x	capitalism socialism and democracy new york harper row	52	9
T82		x		x	technological discontinuities and organizational environments adm sci q	54	7
T93		x		x	the discovery of grounded theory strategies for qualitative research aldine publishing chicago il	27	6
T110		x		x	the structure of scientific revolutions chicago university of chicag	29	7
T39	x			x	from sectoral systems of innovation to socio technical systems insights about dynamics and change from sociolo	6	64
T54	x			x	networks of power electrification in western society 1880 1930 johns hopkin	7	25
T55	x			x	of bicycles bakelites and bulbs theory of socio technical change mi ma	6	25
T68	x	x	x	x	science in action how to follow scientists and engineers through society cambridge ma harvar	13	24
T71	x	x	x	x	shaping technology building society and eds mi ma	10	24
T107	x	x	x	x	the social construction of technological systems cambridge ma mi	20	55
T109	x		x	x	the social shaping of technology ope	12	22

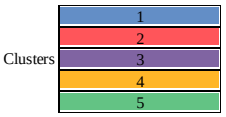

Figure 7: Most significant reference overlaps and clusters

Focus area	Author(s)	Publication date	Cluster		Normalised title of reference (Normalised during step i of LA Phase 1)	# of times as TM reference (thus the number of times an TMentry cites this reference)	# of times as STT reference (thus the number of times an STTentry cites this reference)
T	Kemp, R., Schot, J., Hoogma, R.	1998	1	T66	regime shifts to sustainability through processes of niche formation the approach of strategic niche management	5	77
T	Geels, F.W.	2002	1	T85	technological transitions as evolutionary reconfiguration processes a multi level perspective case study research	5	122
STC	Geels, F.W., Schot, J.	2007	1	T114	typology of sociotechnical transition pathways research policy	5	99
RM	Strauss, A., Corbin, J.M.	1998	2	T12	basics of qualitative research techniques and procedures for developing grounded theory london sage	11	5
E	David, P.A.	1985	2	T21	clio and the economics of qwerty am econ rev	11	12
T	Artur, W.	1989	2	T22	competing technologies increasing returns and lock in by historical events econ j	14	17
E	Granovetter, M.	1985	2	T31	economic action and social structure the problem of embeddedness sociol	17	5
I	Hekkert, M.P, Suurs, R.A.A., Negro, S.O., Kuhlmann, S., Smits, R.E.H.M.	2007	2	T40	functions of innovation systems a new approach for analysing technological change technol forecast soc change	8	16
E	North, D.C.	1990	2	T45	institutions institutional change and economic performance cambridg ma	11	5
B	Brundtland, G.	1987	2	T61	our common future world commission on environment and development oxfor	15	12
RM	Miles, M.B., Huberman, A.M.	1994	2	T65	qualitative data analysis an expanded sourcebook sage publications thousand oaks ca	14	5
E	Dosi, G., Freeman, C., Elson, R.N., Silverberg, G., Soete, L.	1988	2	T79	technical change and economic theory london pinter	24	17
T	Dosi, G.	1982	2	T83	technological paradigms and technological trajectories research policy	51	22
S	Giddens, A.	1984	2	T91	the constitution of society	24	27
T	Orlikowski, W.J.	1992	2	T94	the duality of technology rethinking the concept of technology in organizations organization science	16	8
I	Van De Ven, A.H., Polley, D.E., Garud, R., Venkataraman, S.	1999	2	T98	the innovation journey oxfor	12	5
S	DiMaggio, P.J., Powell, W.	1983	2	T101	the iron cage revisited institutional isomorphism and collective rationality in organizational fields american socio	15	8
RM	Eisenhardt, K.M., Graebner, M.E.	2007	2	T113	theory building from cases opportunities and challenges academy of management	16	5
I	Henderson, R., Clark, K.B.	1990	3	T10	architectural innovation the reconfiguration of existing product technologies and the failure of existing firms adn	64	5
RM	Eisenhardt, K.	1989	3	T13	building theories form case study research acad manag rev	74	10
RM	Yin, R.K.	2003	3	T20	case study research design and methods sage london	129	17
I	Rogers, E.M.	1995	3	T28	diffusion of innovations fre york	145	15
I	Christensen, C.M.	1997	3	T99	the innovator s dilemma harvard business schoo	118	18
E	Schumpeter, J.A.	1961	3	T111	the theory of economic development harvar ma	74	6
E	Nelson, R.R., Winter, S.G.	1982	4	T9	an evolutionary theory of economic change harvar	83	26
E	Schumpeter, J.A.	1942	4	T19	capitalism socialism and democracy new york harper row	52	9
I	Lundvall, B.A.	1992	4	T3	a national systems of innovation theory of innovation and interactive learning pinter publishers london	28	7
T	Anderson, P., Tushman, M.	1990	4	T82	technological discontinuities and organizational environments adm sci q	54	7
RM	Glaser, B.G., Strauss, A.L.	1967	4	T93	the discovery of grounded theory strategies for qualitative research aldine publishing chicago il	27	6
RM	Kuhn, T.P.	1962	4	T110	the structure of scientific revolutions chicago university of chicag	29	7
I	Geels, F.W.	2004	5	T39	from sectoral systems of innovation to socio technical systems insights about dynamics and change from sociolo	6	64
T	Hughes, T.P.	1983	5	T54	networks of power electrification in western society 1880 1930 johns hopkin	7	25
STC	Bijker, W.E.	1995	5	T55	of bicycles bakelites and bulbs theory of socio technical change mi ma	6	25
RM	Latour, B.	1987	5	T68	science in action how to follow scientists and engineers through society cambridge ma harvar	13	24
T	Bijker, W.E., J. Law	1992	5	T71	shaping technology building society and eds mi ma	10	24
T	Bijker, W.E., Hughes, T.P., Pinch, T.	1987	5	T107	the social construction of technological systems cambridge ma mi	20	55
T	Mackenzie, D., Wacjman, J.	1999	5	T109	the social shaping of technology ope	12	22

Figure 8: Key focus areas per cluster of the references in the most significant overlaps (absolute values)

When considering the references shown in Figure 8, which were deemed the most significant overlaps in terms of the references found in the TM and STT bodies of knowledge respectively, eight were concerned with the **science of research and/or research methodologies** (denoted 'RM' in Figure 8); these were the studies of Strauss and Corbin (1998), Eisenhardt (1989), Yin (2002), Miles and Huberman (1994), Latour (1978), Glaser and Strauss (1967), Kuhn (1962), and Eisenhardt and Graenber (2007). These eight references could be considered indicative of an overlap in respect of research methodologies and/or approaches, but were not indicative of the dimensions across which these bodies of knowledge shared intellectual roots.

Of the remaining 29 references (thus excluding the references that were concerned with the science of research and/or research methodologies):

- Seven focused on **economics, economic development, or economic theory** (denoted with 'E' in Figure 8). These were the studies of David (1985), Granovetter (1985), Dosi *et al*. (1988), Schumpeter (1942), Schumpeter (1961), Nelson and Winter (1982), and North (1990).

- Seven focused on **innovation and innovation studies** (denoted with 'I' in Figure 8). These were the studies of Henderson and Clark (1990), Rogers (1995), Lundvall (1992), Christensen (1997), Geels (2004), Hekkert *et al*. (2007), and Van de Ven *et al*. (1999).
- Ten focused on **technological related themes such as technology adoption, technological change, social studies of technology, and technological development** (denoted with 'T' in Figure 8). These were the studies of Artur (1989), Hughes (1983), Dosi (1982), Mackenzie and Wacjman (1999), Kemp *et al*. (1998), Bijker and Law (1992), Anderson and Tushman (1990), Geels (2002), Orlikowski (1992), and Bjiker *et al*. (1987).
- Two focused on **social studies** (denoted with 'S' in Figure 8). These were the studies of Giddens (1984) and DiMaggio and Powell (1983). The Brundtland report (1987) (denoted with 'B' in Figure 8) was also part of this set of references.
- Two documents — the studies of Bijker (1995) and Geels (2007) — focused on **socio-technical change** (denoted with 'STS' in Figure 8). However, Bjiker (1995) did not consider socio-technical change from a sustainability perspective, but rather described where technologies come from and how societies deal with them. The work by Geels (2007) considered various transition pathways for development along 'technological trajectories', but also not with a specific focus on sustainability.

It is interesting to note that two of the above-mentioned 29 articles — the studies of Hekkert *et al*. (2007) and Geels (2007) — formed part of the 'STT Entries' (i.e., the 311 socio-technical transition articles referred to in Table 1). None of the 29 articles under consideration here was also found in the 'TM Entries' (the 4 740 technology management articles referred to in Table 1).

4 DISCUSSION

The linkage analysis highlighted the most prominent areas of overlap between the technology management and socio-technical transitions bodies of literature, based on the references that the documents (Entries) in these bodies of literature cited. The linkage analysis yielded 119 references (out of a possible 17 445 socio-technical transitions references and 112 498 technology management references) that were present in both bodies of literature, thus representing the overlapping documents cited by the respective bodies of literature. As stated, significant or prominent overlaps were identified (refer to LA Phase 5: Results in Section 2); however it is argued that the criteria used to identify such significant or prominent overlaps were justified, given that they allowed for all overlaps of five or more to be included in the set, as well as any overlaps that were less than five but that were in the top half of references in either one of the bodies of literature. This meant that 0.007% of the socio-technical transitions references were also technology management references, and 0.001% of the technology management references were also socio-technical transitions references — the second quantitative indication that there is a disconnect between these two bodies of literature.

The areas of focus that emerged when the references with the highest number of occurrences in the respective bodies of literature, as well as the seven references that fell within both the 'most prominent STT' and the 'most prominent TM' references, were considered (refer to Table 6 and Table 7), were innovation, strategic management and competitive advantage, economics, technological change, socio-technical transitions, and social studies. An expanded set of articles was established, and the keyword analysis of this set of articles again highlighted that the areas of (limited) overlap were strongly geared towards innovation- and technology-related concepts. Interestingly, only here (at this significantly detailed level of analysis) did technology management and socio-technical transitions feature.

The correspondence and cluster analyses highlighted similar findings; the areas of overlap related to:

1. science of research and/or research methodologies;
2. economics, economic development, and economic theory;
3. innovation and innovation;
4. technology-related themes such as technology adoption, technological change, social studies of technology, and technological development;
5. strategic management and competitive advantage;
6. social studies; and
7. socio-technical change.

It is interesting to note the trend that, as one moved through the clusters from those with the most prominence in socio-technical transitions to those with a stronger prominence in technology management,

it was clear how the references increasingly dealt with a unit and level of analysis that was at the level of organisations in Cluster 3, as opposed to at the macro-level of society or the economy in Clusters 1 and 5.

Taking a step back, and considering the total number of references found in the two data sets (17 445 and 112 498 for the socio-technical transitions and technology management data sets respectively; refer to Table 1), the overlap discussed above (of 29 references) was arguably negligible. Even though insights have been gained from considering the overlaps, they remain apparently insignificant.

5 CONCLUSION

From the various analyses performed and documented in this investigation (both Part 1 [5] and the current Part 2), one could conclude that the level of integration between the fields of technology management and socio-technical transitions is tiny. The overlaps that have been highlighted throughout this study, and that are summarised in Section 4, are primarily in respect of key concepts that are present in both bodies of literature, but arguably only at an aggregate level. There are no overlaps that emerge in respect of conceptual framings that are fundamental to either technology management or socio-technical transitions. It could be argued that the overlaps highlighted in these papers are partly as a result of the nature of the two bodies of literature, in that they are inter-, trans-, and multidisciplinary.

Ultimately, from the research and analysis conducted and discussed throughout this study, and the multiple perspectives from which the overlap of and integration between technology management and socio-technical transitions have been considered, it is concluded that the fields of technology management and socio-technical transitions have not been integrated at a conceptual or theoretical level.

An interesting observation is that there is one technology management concept that emerges, even though, in the broader scope of things, it could be considered still to be a limited emerging theme in both bodies of literature: **technology roadmapping**. This theme was found three times in Cluster 3 and twice in Cluster 4. Even though this is not indicative of a significant overlap of conceptual framings, it can be noted as an emerging area where technology management and socio-technical transitions might have been integrated.

Even though there is clear evidence that the fields of technology management and socio-technical transition are not integrated from a conceptual or theoretical perspective, it is evident that they do share intellectual roots across a number of dimensions — primarily those concepts related to innovation and technology. However, the unit and level of analysis at which these key dimensions were used in their respective fields largely differed: the unit and level of analysis was at the level of organisations in Cluster 3, as opposed to the macro-level of society or the economy in Clusters 1 and 5; and the unit and level of analysis was at the level of organisations in Cluster 3, as opposed to the macro-level of society or the economy in Clusters 1 and 5.

It can thus be concluded that the integration of socio-technical transitions approaches, concepts, frameworks, and aspects with those of technology management theories and practices, and vice versa, are not adequately addressed in the literature. Given the role of technology, and of its management, more research efforts are required across these bodies of knowledge to address the grand challenges [3], [4] and to enable a just transition to sustainability.

An important area for future research would be the further integration of technology management and socio-technical transitions concepts. For example, the various modes of interaction that have been defined between technologies could provide for further clarification of technology management considerations. It is commonly accepted that the mode of interaction between technologies can shift from one mode to another, and so it is suggested that specific technology management strategies be developed for each mode of interaction. It is also important to note that multi-mode interactions between technologies are possible, and that technologies can thus interact according to a number of interaction modes. Incorporating these theoretical notions into future research would add further value to the debate about how technology should be managed in the context of transitions.

Given the comprehensive investigation into the extent to which technology management and socio-technical transitions have been integrated, and the conclusion that there is no concrete evidence of integration of or significant similarity in the foundational concepts used in both bodies of literature, it is evident that there is a need for more informed, nuanced, and sophisticated theories, frameworks, models, tools, and techniques to support our understanding of how and where to integrate the concepts of technology management and socio-technical transitions. Similarly, future research needs to provide

guidance on how socio-technical transitions and technology management research could advance in a way that addresses critical issues regarding epistemological tensions, problem identification and definition, the selection of system boundaries, the unit and level of analysis, and the role of technology management research in relation to socio-technical transitions research, and vice versa.

6 ACKNOWLEDGEMENT

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APPENDIX A

Table A.1: References used by both the technology management and socio-technical transitions scientific networks where (significant) overlap(s) occur.

	Overlap group					Normalised title of reference (Normalised during step i of LA Phase 1)	# of times as TM reference (thus the number of times an TMentry cites this reference)	# of times as STT reference (thus the number of times an STTentry cites this reference)
	Most prominent STT refs	Most prominent TM refs	10 each way	10 TM, 5 STT	10 STT, 5 TM			
T1		x				a critical look at technological innovation typology and innovativeness terminology a literature prod innov mana	18	3
T2		x				a dynamic theory of organizational knowledge creation organization science	50	1
T3		x		x		a national systems of innovation theory of innovation and interactive learning pinter publishers london	28	7
T4		x				a new product growth model for consumer durables manag sci	32	1
T5		x				a resource based perspective on information technology capability and firm performance an empirical investigat	16	2
T6		x				a resource based view of the firm strategic management	51	2
T7		x				a theoretical extension of the technology acceptance model four longitudinal field studies management science	26	1
T8		x				absorptive capacity a new perspective on learning and innovation administrative science quarterly	124	2
T9	x	x	x	x	x	an evolutionary theory of economic change harvar	83	26
T10		x		x		architectural innovation the reconfiguration of existing product technologies and the failure of existing firms adr	64	5
T11		x				asset stock accumulation and sustainability of competitive advantage management science	27	1
T12				x		basics of qualitative research techniques and procedures for developing grounded theory london sage	11	5
T13		x	x	x	x	building theories form case study research acad manag rev	74	10
T14		x				burns stalker the management of innovations tavistock publications london	22	1
T15		x				business cycles a theoretical historical and statistical analysis of the capitalist process mcgraw hill new yor	17	3
T16		x				business dynamics systems thinking and modeling complex world mcgraw hill new york	22	4
T17		x				business models business strategy and innovation long range plann	19	1
T18	x					can cities shape socio technical transitions and how would we know if they were res policy	1	21
T19		x		x		capitalism socialism and democracy new york harper row	52	9
T20	x	x	x	x	x	case study research design and methods sage london	129	17
T21			x	x	x	clio and the economics of qwerty am econ rev	11	12
T22	x		x	x	x	competing technologies increasing returns and lock in by historical events econ j	14	17
T23		x				competitive strategy techniques for analyzing industries and competitors fre york	60	2
T24	x					constructing transition paths through the management of niches path dependence and creation eds lawrence erlb	3	16
T25		x				customer power strategic investment and the failure of leading firms strategic management	18	2
T26		x				customization of technology roadmaps according to roadmapping purposes overall process and detailed modules	16	1
T27		x				development of an instrument to measure the perceptions of adopting an	21	1
T28		x	x	x	x	diffusion of innovations fre york	145	15
T29		x				dynamic capabilities and strategic management strategic management	98	4
T30		x				dynamic capabilities what are they strategic management	36	1
T31		x		x		economic action and social structure the problem of embeddedness sociol	17	5
T32		x				emergence triple helix of university industry government relations science and public policy	28	1
T33		x				evaluating structural equation models with unobservable variables and measurement error research	33	1
T34	x					experimenting for sustainable transport the approach of strategic niche management london gbr pp i x spo	2	35
T35		x				explicating dynamic capabilities the nature and microfoundations of sustainable enterprise performance strategic	16	1
T36		x				exploration and exploitation in organizational learning organ sci	42	4
T37		x				firm resources and sustained competitive advantage	92	2
T38		x				first mover advantages strateg manage j	23	1
T39	x				x	from sectoral systems of innovation to socio technical systems insights about dynamics and change from sociolo	6	64
T40	x				x	functions of innovation systems a new approach for analysing technological change technol forecast soc change	8	16
T41		x				h process innovation reengineering work through information technology harvard business schoo ma	26	1
T42		x				innovation mapping the winds of creative destruction res policy	36	2
T43		x				innovation the attacker s advantage macmillan london	44	1
T44		x				inside the black box technology and economics cambridg	23	2
T45				x		institutions institutional change and economic performance cambridg ma	11	5
T46		x				knowledge management and knowledge management systems conceptual foundations and research issues mis q	17	1
T47		x				leonard core capabilities and core rigidities a paradox in managing new product development strategic managem	38	1
T48		x				leonard wellsprings of knowledge building and sustaining the sources of innovation harvard business schoo	32	1
T49		x				managing innovation integrating technological market and organizational change wiley chichester	47	1
T50		x				markets and hierarchies analysis and antitrust implications new york fre	23	1
T51		x				mastering the dynamics of innovation boston harvard business school	63	3
T52		x				motorola s technology roadmap process research management september october	42	1
T53		x				national innovation systems a comparative analysis new york oxfor	22	3
T54	x				x	networks of power electrification in western society 1880 1930 johns hopkin	7	25
T55	x				x	of bicycles bakelites and bulbs theory of socio technical change mi ma	6	25
T56		x				organisational learning a theory of action perspective addison wesley reading ma	21	4
T57		x				organization and environment harvar ma	26	2
T58		x				organizational culture and leadership jossey bass san francisco	16	2
T59		x				organizational innovation a meta analysis of effects of determinants and moderators academy of management	17	1
T60		x				organizational strategy structure and process mcgraw hill	39	2
T61			x	x	x	our common future world commission on environment and development oxfor	15	12
T62	x					p innovation studies and sustainability transitions the allure of the multi level perspective and its challenges rese	1	47
T63	x					processes and patterns in transitions and system innovations refi ning the co evolutionary multi level perspective	1	22
T64		x				profiting from technological innovation implications for integration collaboration licensing and public policy res	60	1
T65				x		qualitative data analysis an expanded sourcebook sage publications thousand oaks ca	14	5
T66	x					regime shifts to sustainability through processes of niche formation the approach of strategic niche management	5	77
T67		x				science and technology roadmaps ieee transactions on engineering management	49	1
T68	x		x	x	x	science in action how to follow scientists and engineers through society cambridge ma harvar	13	24
T69		x				sectoral patterns of technical change taxonomy theory research policy	22	1
T70		x				sensemaking in organisations sage london	18	3
T71	x		x	x	x	shaping technology building society and eds mi ma	10	24
T72		x				smith interorganizational collaboration and the locus of innovation networks of learning in biotechnology admin	25	1
T73		x				social network analysis methods and applications cambridg	16	2
T74	x					socio technological regimes and transition contexts system innovation and the transition to sustainability theory	1	21
T75		x				sources procedures and microeconomic effects of innovation literature	19	4
T76	x					spatial perspective on sustainability transitions res policy	1	17
T77	x					system innovation and the transition to sustainability theory evidence and policy cheltenham edward elgar	4	100
T78		x				systems thinking systems practice wiley chichester	25	2
T79	x	x	x	x	x	technical change and economic theory london pinter	24	17
T80	x					technological change human choice and climate change resources and technology eds battell	3	86
T81		x				technological discontinuities and dominant designs a cyclical model of technological change administrative scie	37	1
T82		x		x		technological discontinuities and organizational environments adm sci q	54	7
T83	x	x	x	x	x	technological paradigms and technological trajectories research policy	51	22
T84	x					technological transitions and system innovations a co evolutionary and sociotechnical analysis cheltenham edwa	2	31
T85	x				x	technological transitions as evolutionary reconfiguration processes a multi level perspective case study research	5	122
T86		x				technology foresight using roadmaps long range planning	18	1
T87		x				technology policy and economic performance lessons from japan pinter	16	2
T88		x				technology roadmapping a planning framework for evolution and revolution technological forecasting and socia	38	1
T89		x				the age of the smart machine the future of work and power new york basic books	19	3
T90		x				the competitive advantage of nations macmillan london	62	2
T91	x	x	x	x	x	the constitution of society	24	27
T92		x				the delphi method techniques and applications reading ma	17	1
T93		x		x		the discovery of grounded theory strategies for qualitative research aldine publishing chicago il	27	6
T94		x		x		the duality of technology rethinking the concept of technology in organizations organization science	16	8
T95	x					the dynamics of transitions in socio technical systems a multi level analysis of the transition pathway from horse	1	32

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	Overlap group					Normalised title of reference (Normalised during step i of LA Phase 1)	# of times as TM reference (thus the number of times an TMentry cites this reference)	# of times as STT reference (thus the number of times an STTentry cites this reference)
	Most prominent STT refs	Most prominent TM refs	10 each way	10 TM, 5 STT	10 STT, 5 TM			
T96		x				the economics of industrial innovation pinter london	48	3
T97	x					the governance of sustainable socio technical transitions res policy	4	88
T98				x		the innovation journey oxfor	12	5
T99	x	x	x	x	x	the innovator s dilemma harvard business schoo	118	18
T100		x				the innovator s solution creating and sustaining successful growth harvard busines	21	1
T101				x		the iron cage revisited institutional isomorphism and collective rationality in organizational fields american socie	15	8
T102		x				the knowledge creating company how japanese companies create the dynamics of innovation oxfor	124	2
T103		x				the machine that changed the world macmilla	43	3
T104	x					the multi level perspective on sustainability transitions responses to seven criticisms environ innov soc trans	1	28
T105		x				the myopia of learning strategic management	17	2
T106		x				the relational view cooperative strategy and sources of interorganizational competitive advantage acad manage r	17	1
T107	x	x	x	x	x	the social construction of technological systems cambridge ma mi	20	55
T108		x				the social psychology of organizing second ed reading addison wesley	19	3
T109	x		x	x	x	the social shaping of technology ope	12	22
T110		x		x		the structure of scientific revolutions chicago university of chicag	29	7
T111		x		x		the theory of economic development harvar ma	74	6
T112		x				the theory of planned behavior organizational behavior and human decision processes	20	2
T113		x		x		theory building from cases opportunities and challenges academy of management	16	5
T114	x				x	typology of sociotechnical transition pathways research policy	5	99
T115	x					understanding carbon lock in energy policy	2	32
T116		x				user acceptance of computer technology a comparison of two theoretical models management science	36	2
T117		x				user acceptance of information technology unified view mis quarterly	29	3
T118		x				von democratizing innovation mi mass	17	1
T119		x				von the sources of innovation oxfor york	40	2

APPENDIX B

Table B.1: References used by both the technology management and socio-technical transitions scientific networks where (significant) overlap(s) occur, grouped according to clusters

			Overlap group								
			Most prominent STT refs	Most prominent TM refs	10 each way	10 TM, 5 STT	10 STT, 5 TM	Normalised title of reference (Normalised during step 1 of LA Phase 1)	# of times as TM reference (thus the number of times in TM entry in this reference)	# of times as STT reference (thus the number of times in STT entry in this reference)
Cluster 1	1	T66	x					regime shifts to sustainability through processes of niche formation the approach of strategic niche management	5	77
	1	T77	x					system innovation and the transition to sustainability theory evidence and policy cheltenham edward elgar	4	100
	1	T80	x					technological change human choice and climate change resources and technology eds battell	3	86
	1	T85	x				x	technological transitions as evolutionary reconfiguration processes a multi level perspective case study research	5	122
	1	T97	x					the governance of sustainable socio technical transitions res policy	4	88
	1	T114	x				x	typology of sociotechnical transition pathways research policy	5	99
Cluster 2	2	T12				x		basics of qualitative research techniques and procedures for developing grounded theory london sage	11	5
	2	T21			x	x	x	clio and the economics of qwerty am econ rev	11	12
	2	T22	x		x	x	x	competing technologies increasing returns and lock in by historical events econ j	14	17
	2	T31		x		x		economic action and social structure the problem of embeddedness sociol	17	5
	2	T40	x				x	functions of innovation systems a new approach for analysing technological change technol forecast soc change	8	16
	2	T45				x		institutions institutional change and economic performance cambridg ma	11	5
	2	T61			x	x	x	our common future world commission on environment and development oxfor	15	12
	2	T65				x		qualitative data analysis an expanded sourcebook sage publications thousand oaks ca	14	5
	2	T79	x	x	x	x	x	technical change and economic theory london pinter	24	17
	2	T83	x	x	x	x	x	technological paradigms and technological trajectories research policy	51	22
	2	T91	x	x	x	x	x	the constitution of society	24	27
	2	T94		x		x		the duality of technology rethinking the concept of technology in organizations organization science	16	8
	2	T98				x		the innovation journey oxfor	12	5
	2	T101				x		the iron cage revisited institutional isomorphism and collective rationality in organizational fields american socio	15	8
	2	T113		x		x		theory building from cases opportunities and challenges academy of management	16	5
Cluster 3	3	T2		x				a dynamic theory of organizational knowledge creation organization science	50	1
	3	T4		x				a new product growth model for consumer durables manag sci	32	1
	3	T6		x				a resource based view of the firm strategic management	51	2
	3	T8		x				absorptive capacity a new perspective on learning and innovation administrative science quarterly	124	2
	3	T10		x		x		architectural innovation the reconfiguration of existing product technologies and the failure of existing firms adm	64	5
	3	T13		x	x	x	x	building theories form case study research acad manag rev	84	10
	3	T20	x	x	x	x	x	case study research design and methods sage london	129	17
	3	T23		x				competitive strategy techniques for analyzing industries and competitors fre york	60	2
	3	T28		x	x	x	x	diffusion of innovations fre york	145	15
	3	T29		x				dynamic capabilities and strategic management strategic management	98	4
	3	T30		x				dynamic capabilities what are they strategic management	36	1
	3	T33		x				evaluating structural equation models with unobservable variables and measurement error research	33	1
	3	T37		x				firm resources and sustained competitive advantage	92	2
	3	T42		x				innovation mapping the winds of creative destruction res policy	36	2
	3	T43		x				innovation the attacker s advantage macmillan london	44	1
	3	T47		x				leonard core capabilities and core rigidities a paradox in managing new product development strategic managem	38	1
	3	T48		x				leonard wellsprings of knowledge building and sustaining the sources of innovation harvard business schoo	32	1
	3	T49		x				managing innovation integrating technological market and organizational change wiley chichester	47	1
	3	T51		x				mastering the dynamics of innovation boston harvard business school	63	3
	3	T52		x				motorola s technology roadmap process research management september october	42	1
	3	T60		x				organizational strategy structure and process mcgraw hill	39	2
	3	T64		x				profiting from technological innovation implications for integration collaboration licensing and public policy res	60	1
	3	T67		x				science and technology roadmaps ieee transactions on engineering management	49	1
	3	T81		x				technological discontinuities and dominant designs a cyclical model of technological change administrative scie	37	1
	3	T88		x				technology roadmapping a planning framework for evolution and revolution technological forecasting and socia	38	1
	3	T90		x				the competitive advantage of nations macmillan london	62	2
	3	T96		x				the economics of industrial innovation pinter london	48	3
	3	T99	x	x	x	x	x	the innovator s dilemma harvard business schoo	118	18
	3	T102		x				the knowledge creating company how japanese companies create the dynamics of innovation oxfor	124	2
	3	T103		x				the machine that changed the world macmilla	43	3
	3	T111		x		x		the theory of economic development harvar ma	84	6
	3	T116		x				user acceptance of computer technology a comparison of two theoretical models management science	36	2
	3	T119		x				von the sources of innovation oxfor york	40	2
Cluster 4	4	T1		x				a critical look at technological innovation typology and innovativeness terminology a literature prod innov mana	18	3
	4	T3		x		x		a national systems of innovation theory of innovation and interactive learning pinter publishers london	28	7
	4	T5		x				a resource based perspective on information technology capability and firm performance an empirical investigat	16	2
	4	T7		x				a theoretical extension of the technology acceptance model four longitudinal field studies management science	26	1
	4	T9	x	x	x	x	x	an evolutionary theory of economic change harvar	83	26
	4	T11		x				asset stock accumulation and sustainability of competitive advantage management science	27	1
	4	T14		x				burns stalker the management of innovations tavistock publications london	22	1
	4	T15		x				business cycles a theoretical historical and statistical analysis of the capitalist process mcgraw hill new yor	17	3
	4	T16		x				business dynamics systems thinking and modeling complex world mcgraw hill new york	22	4
	4	T17		x				business models business strategy and innovation long range plann	19	1
	4	T19		x		x		capitalism socialism and democracy new york harper row	52	9
	4	T25		x				customer power strategic investment and the failure of leading firms strategic management	18	2
	4	T26		x				customization of technology roadmaps according to roadmapping purposes overall process and detailed modules	16	1
	4	T27		x				development of an instrument to measure the perceptions of adopting an	21	1
	4	T32		x				emergence triple helix of university industry government relations science and public policy	28	1
	4	T35		x				explicating dynamic capabilities the nature and microfoundations of sustainable enterprise performance strategic	16	1
	4	T36		x				exploration and exploitation in organizational learning organ sci	42	4
	4	T38		x				first mover advantages strateg manage j	23	1
	4	T41		x				h process innovation reengineering work through information technology harvard business schoo ma	26	1
	4	T44		x				inside the black box technology and economics cambridg	23	2
	4	T46		x				knowledge management and knowledge management systems conceptual foundations and research issues mis q	17	1
	4	T50		x				markets and hierarchies analysis and antitrust implications new york fre	23	1
	4	T53		x				national innovation systems a comparative analysis new york oxfor	22	3
	4	T56		x				organisational learning a theory of action perspective addison wesley reading ma	21	4
	4	T57		x				organization and environment harvar ma	26	2
	4	T58		x				organizational culture and leadership jossey bass san francisco	16	2
	4	T59		x				organizational innovation a meta analysis of effects of determinants and moderators academy of management	17	1
	4	T69		x				sectoral patterns of technical change taxonomy theory research policy	22	1
	4	T70		x				sensemaking in organisations sage london	18	3
	4	T72		x				smith interorganizational collaboration and the locus of innovation networks of learning in biotechnology admin	25	1
	4	T73		x				social network analysis methods and applications cambridg	16	2
	4	T75		x				sources procedures and microeconomic effects of innovation literature	19	4
	4	T78		x				systems thinking systems practice wiley chichester	25	2
	4	T82		x		x		technological discontinuities and organizational environments adm sci q	54	7
	4	T86		x				technology foresight using roadmaps long range planning	18	1
	4	T87		x				technology policy and economic performance lessons from japan pinter	16	2
	4	T89		x				the age of the smart machine the future of work and power new york basic books	19	3
	4	T92		x				the delphi method techniques and applications reading ma	17	1
	4	T93		x		x		the discovery of grounded theory strategies for qualitative research aldine publishing chicago il	27	6
	4	T100		x				the innovator s solution creating and sustaining successful growth harvard busines	21	1
	4	T105		x				the myopia of learning strategic management	17	2
	4	T106		x				the relational view cooperative strategy and sources of interorganizational competitive advantage acad manage r	17	1
	4	T108		x				the social psychology of organizing second ed reading addison wesley	19	3
	4	T110		x		x		the structure of scientific revolutions chicago university of chicag	29	7
	4	T112		x				the theory of planned behavior organizational behavior and human decision processes	20	2
	4	T117		x				user acceptance of information technology unified view mis quarterly	29	3
	4	T118		x				von democratizing innovation mi mass	17	1
Cluster 5	5	T18	x					can cities shape socio technical transitions and how would we know if they were res policy	1	21
	5	T24	x					constructing transition paths through the management of niches path dependence and creation eds lawrence erlb	3	16
	5	T34	x					experimenting for sustainable transport the approach of strategic niche management london gbr pp ix spo	2	35
	5	T39	x				x	from sectoral systems of innovation to socio technical systems insights about dynamics and change from sociolo	6	64
	5	T54	x				x	networks of power electrification in western society 1880 1930 johns hopkin	7	25
	5	T55	x				x	of bicycles bakelites and bulbs theory of socio technical change mi ma	6	25
	5	T62	x					p innovation studies and sustainability transitions the allure of the multi level perspective and its challenges rese	1	47
	5	T63	x					processes and patterns in transitions and system innovations refi ning the co evolutionary multi level perspective	1	22
	5	T68	x		x	x	x	science in action how to follow scientists and engineers through society cambridge ma harvar	13	24
	5	T71	x		x	x	x	shaping technology building society and eds mi ma	10	24
	5	T74	x					socio technological regimes and transition contexts system innovation and the transition to sustainability theory e	1	21
	5	T76	x					spatial perspective on sustainability transitions res policy	1	17
	5	T84	x					technological transitions and system innovations a co evolutionary and sociotechnical analysis cheltenham edwa	2	31
	5	T95	x					the dynamics of transitions in socio technical systems a multi level analysis of the transition pathway from horse	1	32
	5	T104	x					the multi level perspective on sustainability transitions responses to seven criticisms environ innov soc trans	1	28
	5	T107	x	x	x	x	x	the social construction of technological systems cambridge ma mi	20	55
	5	T109	x		x	x	x	the social shaping of technology ope	12	22
	5	T115	x					understanding carbon lock in energy policy	2	32