THE THEORY OF CONSTRAINTS THINKING PROCESSES: A LITERATURE REVIEW

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ABSTRACT

The development of the theory of constraints (TOC) body of knowledge has been largely practice-led, manifested in the diverse nature of applications areas, the diverse use of TOC tools, and in the broader evolution of TOC methodology, methods and tools. This paper reviews the TOC body of knowledge, particularly the TOC Thinking Processes (TPs) and builds on earlier reviews of the literature [1] [2] preceding many developments documented here. The literature is categorized along dimensions that relate to application area, methodology and epistemology, and summarized using descriptive statistics for a 12 year period: 1994 - early 2006. *Keywords:* Theory of Constraints (TOC); thinking processes; literature review

INTRODUCTION

The Theory of Constraints (TOC), conceptualized as a philosophy of continuous improvement, has evolved and expanded its methodological base over time. The TOC methodology now comprises three main streams that can be considered as operations strategy tools, performance measurement systems, and Thinking Process (TP) tools [3]. The TP tools provide a systematic thinking approach to address non-physical constraints. In much the same way as the "5 focusing steps" focus on identifying and managing the constraints on improving performance, the TPs also focus on factors that are currently preventing a system from achieving its goals. Despite an increasing interest in the TP tools amongst academics and practitioners, there has been no review of the TOC literature that relates to work published since 2000. Even though others [1] [2] have already provided reviews of the broader TOC literature, their work was limited to the papers published before 2000. In addition, the recent development of variant TP tools (such as the three cloud approach and the EC-CRB-FRB method) has created a need for clarity about the nature and use of such tools amongst academic and practitioners, and particularly newcomers. Therefore, given that over fifty peer reviewed journal articles have been published since 2000, an extended review of the literature is timely. Thus, this paper aims to

- provide a comprehensive review the TOC TPs literature to identify, categorize and summarize key research issues that have been studied so far;
- develop multiple ways of categorizing the literature according to the nature of the TOC TP tools, methodological development, and application areas;
- suggest future research for TOC TPs. The remainder of the paper is organized so that we next show some basic descriptive statistics relating to TOC TP publications, describe the categorization process and providing summary statistics for those categories. Section 3 briefly overviews the literature based on the TP tools employed. In subsequent sections, the literature related to TP theoretical and methodological issues is discussed, and the literature focused on the application of the TPs to functional domains is reviewed. Finally, we provide a general discussion and concluding remarks.

LITERATURE REVIEW CLASSIFICATIONS

The literature review has been conducted to identify articles published from 1994 to early 2006 in peer reviewed journals, as well as papers published in conference proceedings, in the time period, that is, since the publication of Goldratt's book "It's Not Luck" (1994) [4]. We have also excluded TOC TP-based books and dissertations.

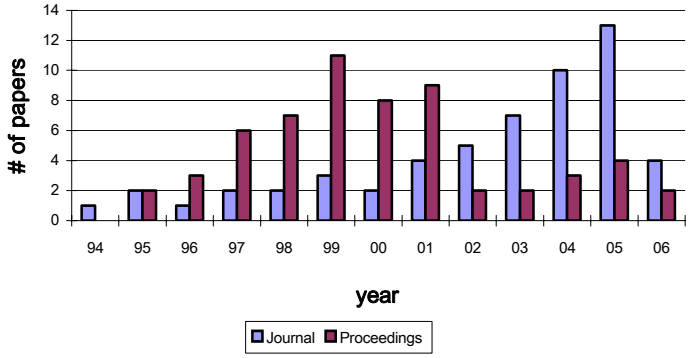


Figure 1: Number of Peer Reviewed Papers — 1994-2006

The review identified 56 papers from 35 refereed journals, and 59 papers from conference proceedings. Figure 1 shows the number of TOC TP papers published each year increased substantially since 2000. No articles on TOC TPs were published in the *Journal of Operations Management*, *Operations Research*, *Management Science* or *Decision Science* suggesting a need to improve scholarly impact would target a specific set of journals. A previous review of the TOC literature [1] classified the literature related to TOC based on the philosophical orientation and application of TOC. This review classifies TOC TP literature using four dimensions; epistemological orientation, theoretical/methodological orientation, application orientation and TP tool orientation.

Table I: Classification of the Literature by Epistemological Orientation

Year	Illustrative Application of Theory	Case Study	Empirical Research	Literature Review	Year total
1994	1				1
1995	2	2			4
1996		4			4
1997	6	2			8
1998	7	1		1	9
1999	11	3			14
2000	7	3			10
2001	6	6	1		13
2002	5	2			7
2003	4	4		1	9
2004	8	4	1		13
2005	9	6	2		17
Early 2006	4	2			6
Total	70	39	4	2	115

The review found that 60% of papers (92/150) sought to explain or demonstrate a diverse set of specific TP tools used individually or in combination with others. Tables III & IV suggest that the EC and CRT are the most used TP tools. The noted diversity of use implies that the application of the TP tools is seen

to be situational and that any combinatorial use of five logic diagrams may be regarded as acceptable by users.

Table II: Classification of the Literature by Theoretical/ Methodological and Application Orientation

	Number of papers	Percent (%)
Theoretical / methodological orientation		
Concept developments	25	
Methodological comparisons	7	
Enhancement/multi-methodology	25	
	57	49.6%
Application orientation-specific		
Whole business applications	7	
Functional applications	32	
Service sector applications	19	
	58	50.4%
Total	115	100%

Table III: Classification of the Literature by TP tools Orientation — 1994 - 2006

TP Tools-in-use	# of papers Reporting Use	% of N (= papers Reporting Use)
CRT	14	15
EC	21	23
CLR	1	1
PRT	1	1
NBR	1	1
CRT, EC	15	17
CRT, EC, FRT	10	11
CRT, EC, NBR	1	1
CRT, FRT, NBR, TT	2	2
CRT, FRT, (NBR)	1	1
CRT, EC, FRT, PRT	1	1
CRT, EC, FRT, PRT, TT	1	1
GCC, CRT, FRT, (NBR)	5	6
EC, FRT	1	1
EC, PRT	1	1
EC, FRT, PRT	1	1
EC/NBR	3	3
FTPA	12	13
Total # of Papers = N	**92**	**100%**

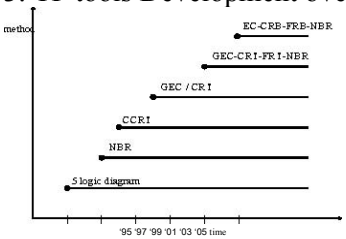
Table IV: TP Tools — Reported Usage — 1994-2006

TP Tools-in-Use	# of Papers Reporting Use	% of N (= papers Reporting Use)	% of n (= All Reported Uses)
EC/GEC	71	77	35
CCRT/CRT	62	67	30
NBR/FRT	39	42	19
PRT	17	19	8
TT	15	16	7
CLR	1	1	1
Total # of Papers = N	**92**	**100**	
Total # of Reported Uses = n	205		100

A LITERATURE REVIEW BASED ON TP TOOLS

Figure 3 provides a timeline summary of the TP tools developed and employed in the TOC TP literature since 1994, indicating that TOC TPs have evolved and expanded over time to suit more specific uses and for ease of use.

Figure 3: TP tools Development over Time



A LITERATURE REVIEW BASED ON EPISTEMOLOGY

Founded on a broader study of TP methodological matters surfacing in the literature review – methodological comparisons, the enhancement of TP methodology and multi-methodology – we offer comment on the future study of TP methodology. For example, we have identified that about one quarter of recent literature focuses on the development of new perspectives of TOC methodology by alignment and integration with other known methodologies such as TRIZ, system dynamics, etc. However, further study examining possible enhancement of TOC by combining it with other methodologies is an important research domain. Firstly, empirical comparative research is worthwhile, and should be more widely attempted. . Secondly, and similarly, there is an absence of any empirical evidence to verify the results of suggested enhancements that arise through integration or multi-methodology. Therefore, an empirical study would be useful to evaluate the merits of such combinations of TOC TP tools. Thirdly, there is a need for examining the multi-methodological use of TOC TPs with other well established tools, methods and methodologies, and as such to strengthen the theoretical foundations of TOC TPs. One possible research issue is the integration of TOC TP tools with cybernetics or with system engineering.

A LITERATURE REVIEW BASED ON APPLICATIONS

Table II shows there have been 40 application papers clustered in three areas: TP applications to the whole business system - organizational performance measures or change management; TP applications in functional areas - supply chain management, marketing and sales, production scheduling, accounting, and quality; and TP applications in the service sector – healthcare, education, the motion picture industry, white-collar services etc. Publication and research gaps can be identified in the research domain relating to applications. Firstly, TOC TP applications targeting an organizational system in its entirety, and further published studies of TP applications relating to performance measure and change management issues would be welcome. Secondly, further study would also be welcome involving TOC TP applications in cross-cultural and different ethical settings. Thirdly, all papers of SCM applications reported here have explored SCM behavior in a single company; hence further cross-sectional studies would also be welcome. Fourthly, we may note that since the reviewed papers are mainly descriptive in nature, further empirical study would be valuable in order to verify the effectiveness of the TOC TP tools in implementation,. Empirical studies involving multiple cases are welcome, and would provide a base for hypothesis testing examining performance differences before and after implementation. Fifthly, publication of further work in other functional domains such as accounting, marketing etc, as well as

multi-functional domains and service industries is recommended. Further work, particularly a comparative study examining the effectiveness of TOC TP implementation in different sectors, or between industry sectors, is recommended.

CONCLUSIONS

This paper was founded in a desire to capture how the development of TOC TP methods and tools has progressed since the TOC TP methodologies were first applied in the POM and OR/MS domains over a decade ago. The paper presents a review of the TOC TP literature, published in refereed journals / and conference proceedings, over a 12 year period - 1994 to early 2006. While the review has identified specific publications and research gaps in each defined category in sections 3, 4 and 5, some common future research topics and approaches have also been identified. Firstly, no work has been published that relates to CSFs or necessary conditions underpinning the effective implementation of the TOC TPs. Further investigation of CSFs, and/or common problems in TOC TP application is required. Secondly, it is contended that lack of published empirical work on the effectiveness of TOC TP application must be addressed, in order to provide critical evaluation of TOC TP tools-in-use. Further empirical studies of both cross-sectional and longitudinal nature would be appropriate, would allow for testing of hypotheses, and strengthen the TOC TPs knowledge base. In particular, further research could be directed towards identifying and measuring performance before and after implementation. Thirdly, the literature reveals an on-going discussion and critique regarding the philosophical underpinnings of TOC as a methodology. The review suggests that there is an unmet need for studies exploring how TOC methods can be applied in situations, not just seen as problematic, but where the problems have positive rather that negative connotations. Finally, it is suggested that it may be worthwhile to identify whether the conventional sequenced use of TOC TP tools should be followed "blindly." Thus, further investigation relating to the methodological appropriateness of different combination or sequenced use of TP tools in specific situations is desirable.

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A full list of references is available from the authors on request.