

Bullwhip Effect in Supply Chain for Perishable Product (A Systematic Literature Review)

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Abstract—Bullwhip effect is the most feared phenomenon by the majority of companies because it leads to high operating costs. Bullwhip will also grow along with the increase in network tier or echelon of a distribution system. Bullwhip will become more severe when distributed products are fragile food products and have uncertain lead times and demand. In the systematic literature of this review, we will review the previous research on how to minimize the occurrence of the bullwhip effect. We also compared the differences and similarity models between common bullwhip mitigating models with bullwhip mitigating models for perishable products that have short life cycles. In further research, we will create optimal model to mitigate bullwhip, integrate the use of SCOR Framework to assess supply chain performance in food companies to minimize bullwhip effect. By using SCOR framework, we will be able to know the supply chain structure that is priority to be improved so that bullwhip on perishable product will decrease.

Index Terms—bullwhip effect, cause bullwhip effect, variable of bullwhip effect, perishable product, systematic literature- review (SLR).

I. INTRODUCTION

The bullwhip effect was first introduced by [1], a phenomenon occurring due to the amplification or distortion of demand on each echelon. Basically, the bullwhip effect shows the amount of an order to the supplier is larger than the sale to the buyer, resulting in distortion from upstream [2].

In this research, the issue of bullwhip effect will be discussed on the sale of food in train in Indonesia. In addition, the product handled by this company is a perishable product, the product has resistance products that are not long. So, need handling and the right time for distributing.

The product will be processed and distributed to the on-demand train from the sales on the train area. For example, the train from the station a to destination station d, then the stage is a - b - c - d. Product demand based on the number of train passengers from the station a to b first, then at station b will be re-stock the product accordingly a number of passengers from b to c and so on.

The new thing studied in this study is a way to minimize the occurrence of bullwhip effect in special cases, that is, on the sale of food on the train. What makes

the problem complicated is the dynamic level of food refilling locations. Trains only charge at a particular station when the food supply approaches the lower limit. The author's assumption, echelon that suffered the most severe phenomenon of the bullwhip effect is echelon main warehouse. Uncertain lead time is also the reason for the high bullwhip effect on this echelon. The value of the lead time in question is the time to wait for the train to refill the inventory at a particular station. This condition is said to be erratic because each station has a different distance different so as to produce a different travel time.

So, to mitigating bullwhip effect on supply chain activities in the company, the authors do research. Such research is a review of the systematic literature review. Systematic literature review in this study aims to assess the journal about the bullwhip effect objectively and systematically. The assessment is based on the causes of bullwhip effect, variables and parameters about bullwhip effect and decision variable bullwhip effect. So, it is hoped this journal can help the writer in positioning his research in the future.

II. RESEARCH METHOD

A. Systematic Literature Review (SLR) Overview

A Systematic Literature Review (SLR) is a literature review method used to identify, evaluate, and interpret all studies on a research topic to answer the research question, based on the stages and protocols used for the SLR process [3]. In this study, the author only adopted six of eight existing stages [4]. The stages can be shown in Fig. 1.

Phase 1 is a planning phase that describes the planning done by the author in describing the research that will be done. In this phase aims to direct the search conducted. The components used in this phase are specified research questions, define search scope and strategy, specify data items. Phase 2 is a phase of a conducted review aimed at reviewing previous studies. Stages performed in this phase that is, select primary studies, extract required data. The last phase is the reporting phase, the stage that aims to write the overall results of the previous phases. Research done by the researcher will be cross-checked, and if any errors can be corrected.

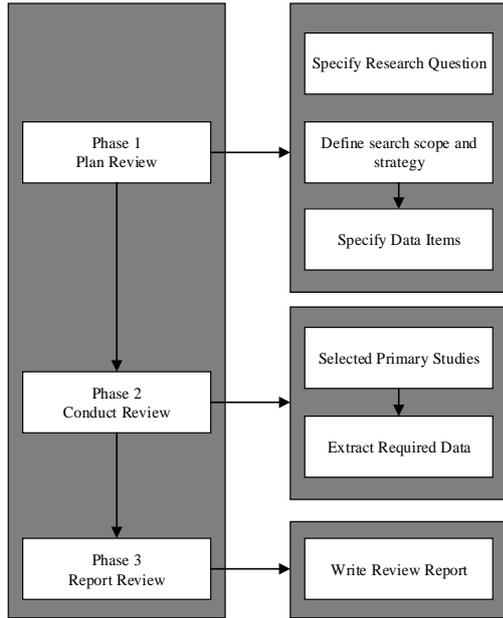


Figure 1. Overview of the systematic literature review.

B. Specify Research Question

A research question is some of the questions used to guide researchers to determine their research reviews. To formulate the research questions, authors should examine whether the research being read is related to the topic to be discussed. The component requirements used to draft the research question are population (subgroup in question), intervention (factor or process in question), outcomes (something of interest to the author), and context (conditions that have been set) TABLE I. [5]. While for the research question can be seen in TABLE II.

TABLE I. COMPONENT STRUCTURE OF RESEARCH QUESTION

Population	Bullwhip effect, bullwhip effect in supply chain
Intervention	The cause of bullwhip, bullwhip variables, model.
Outcomes	The development of mathematical models to mitigating of bullwhip effect by considering the variables affecting the bullwhip effect.
Context	Studied in industrial distribution network. For future research, the authors will use study case at sales on the train in Indonesia. And Perishable.

TABLE II. THE RESEARCH QUESTION

ID	Research Question	Purpose
RQ1	Which journal is the most significant in reviewing mitigating model of bullwhip effect for perishable product?	Identify the most significant journal which reviewing mitigating model of bullwhip effect for perishable product.
RQ2	What evaluation method is used to analyze the journal of mitigating bullwhip effect?	Identify the Evaluation method is used to analyze the journal of mitigating bullwhip effect
RQ3	What is the percentage between journals that discuss perishable product and non-perishable product for mitigating bullwhip effect?	Identify the percentage between journals that discuss perishable product and non-perishable product for mitigating bullwhip effect.

RQ4	What causes affect the occurrence of the bullwhip effect?	Identification causes affect the occurrence of the bullwhip effect.
RQ5	What the variables which became an opportunity to be discussed in mitigating bullwhip effect?	Identify the variables which became an opportunity to be discussed in mitigating bullwhip effect.

C. Define Search Scope and Strategy

Reference collection activity is a search activity conducted by collecting journals or theses used for reference making of this research. The activities performed in the reference search include digital library selection activities, internet search sites, using the database used to search for references. To find the reference used for writing this research, the author uses four popular database libraries:

- Taylor & Francis (<http://www.tandfonline.com>)
- Science Direct (<http://www.sciencedirect.com/>)
- IEEE Explore (<http://ieeexplore.ieee.org/>)
- Informs (<https://pubsonline.informs.org/>)
- Springer (<https://link.springer.com/>)
- And other Journals

In the search, required steps used to build search string in order to obtain journals that match the topic. Here are the steps used to build the search string Fig. 2. [3].

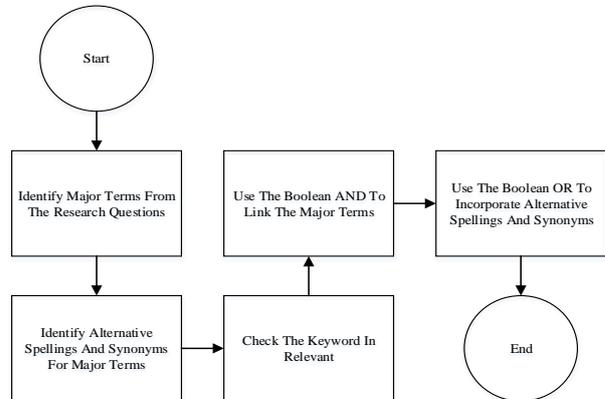


Figure 2. The construction step of search string. [3]

D. Specify Data Items

Data items are data used to support providing information in answering any research questions that have been designed. However, not all item data is used to answer the research question. The explains the usefulness of the data that has been collected based on its use criteria including documentation and research questions. (See Table III.)

TABLE III. DATA ITEMS

Field	Use
Title	Documentation
Authors	Documentation
Year	RQ1
Publisher of the publications	RQ1
Evaluation method	RQ2
The type of product used in the journal	RQ3
Causes effect	RQ4
Variables	RQ5
Model Used for Solve	Documentation

E. Selected Primary Study

Inclusion criteria, which is the conditions that absolutely must be met subject to be included in the research. While the exclusion criteria are a criterion that does not allow the inclusion of certain subjects in the study TABLE IV.

In Fig. 3. shows the process of searching and selection of studies on the research that will be discussed. The search process is done by specifying the selected library, then the search is done using the keyword (if you want to be more specific can be done with the keyword more focused), then the journal list appears. The list of emerging journals is then selected based on the time of publication, by title and abstract. And the final step creates a final list based on the selected journal.

TABLE IV. INCLUSION AND EXCLUSION

Inclusion Criteria	Exclusion Criteria
Published time 2007-2017	Published in form e-Books, web sites, technical reports, and short paper
Focus on bullwhip effect and model of mitigating bullwhip effect and perishable product.	Papers that Focus on summarizes the existing research work, roadmap or survey
Involves measurement method and evaluation of method in completing research	Research conducted without strong validation
Published in Form Doctoral Dissertation or Master's Theses	Published Journal that is not indexed

TABLE V. THE RESEARCH QUESTION LIST OF PRIMARY STUDIES BASED ON DATABASE LIBRARY

	a	b	c	d	e	f
Bullwhip Effect	706	1307	228	180	1428	
Mitigating / minimize/reduce Bullwhip Effect	503	762	93	165	696	
2007 until now	388	645	77	101	537	
Based on perishable product	38	79	6	8	91	
Related Journal	4	16	9	4	4	1

Information:

(a) Taylor & Francis, (b) Science Direct, (c) IEEE Explore, (d) Informs, (e) Springer, (f)And other Journals.

The list of primary studies based on a database library is a table that contains the number of journals of each digital library. The list of primary studies based on a database library is a table that contains the number of journals of each digital library. A number of journals using the keyword "bullwhip effect", Taylor & Francis (706), Science Direct (1307), IEEE Explore (228), Informs (180), and Springer (1428). In order to find relevant journals from listed journals, there are several aspects to consider: mitigating or minimize or reduce of bullwhip effect keywords, the year of the journal (2007-present) and based perishable product. After considering some of these aspects, the number of journals that have been in the data has been reduced, 4 journals for Taylor & Francis, 16 journals for Science Direct, 9 journals for IEEE Explore, 4 journals for Informs, 4 journals for Springer and there are some additional journals from

other libraries that is 1 the total number of relevant journals are 38 journals. (See TABLE V.)

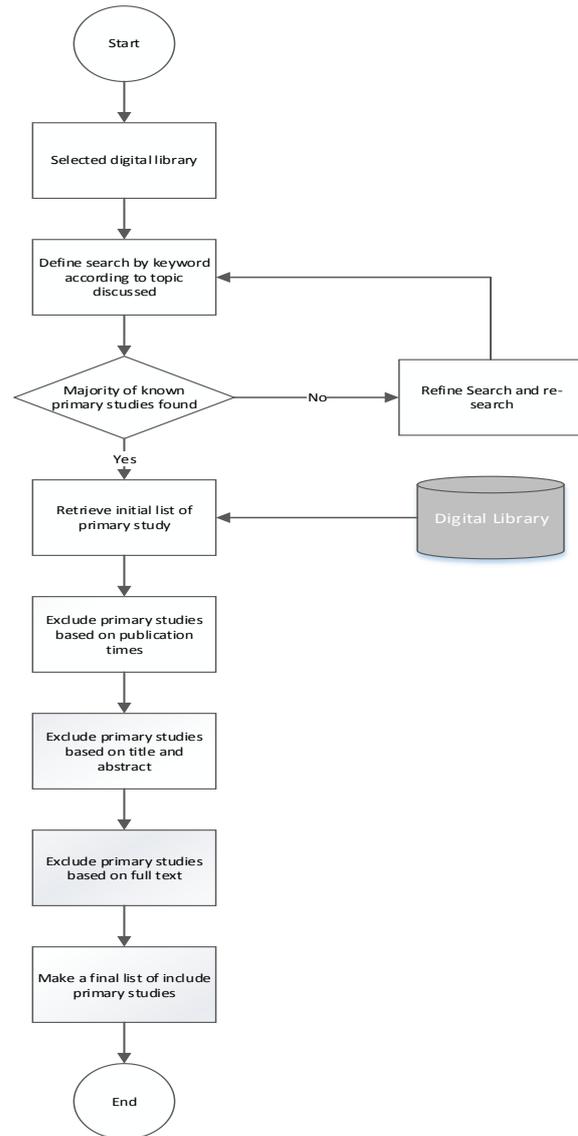


Figure 3. Search and selection of primary studies

F. Extract Required Data

Data extraction is used to collect and classify information according to the primary study that has been selected. The next step is to map the information based on research questions and then use it to answer research questions. In Table VI. shows the mapping of data extracts from previous research questions.

TABLE VI. EXTRACT REQUIRED DATA

Property	Research Question
Research Publication	RQ1
Evaluated Method	RQ2
Type of product	RQ3
Cause of Bullwhip Effect	RQ4
Variable in Bullwhip Effect	RQ5

II. RESEARCH METHOD RESULT & DISCUSSION

This section describes the answers to the research questions discussed in the previous section. For each answer of the research question is illustrated using graphs and statistical values. In addition, the author will display the explanation of each table or graphic presented.

A. Identify Significant Journals Publication

The time distribution is presented to show the development of research on bullwhip effect over time. For example, the authors took several relevant journals for their research reference, the journal published between 2007 until now. From the number of relevant journals, it shows an increase in the number of journals annually used for reference Fig. 5.

In Fig. 6. There are 29 journal publications in related journals which the author has chosen as a reference. Many related journals are derived from the European Journal of Operational Research publications. European Journal of Operational Research (EJOR) is a publication that in the field of operational research methodology (OR) and decision-making practice.

B. Identification Evaluation Method

The method of evaluation is the method used to describe and describe the journals written. evaluation method has a function that is measuring and valuing an object, so as to produce an outcome written into a journal. The method of analysis consists of three steps, fact observation, hypothesis development, and verification or validation of hypothetical. while the simulation method is a technique used to describe and analyze the dynamic based on the fact using the software [2]. From 38 related journals, 23 (58,97%) journals using method analysis, while the remaining 16 (41,03%) journals are journals using simulation method (See TABLE VII.). Most bullwhip effect research on perishable product using simulation, because the age of product based on time is not fixed. (Appendix A)

TABLE VII. THE EVALUATION METHOD

Analytical	[8], [10], [11], [12], [13], [16], [17], [20], [21], [22], [24], [25], [28], [29], [30], [31], [32], [34], [37], [38], [39], [40], [42]
Simulation	[6], [9], [11], [14], [7], [15], [18], [19], [23], [25], [26], [27], [28], [33], [35], [41], [43]

C. Identification Presentage of Perishable Product and Non-perishable Product Journal

After searching from several related journals, it is known that of the 38 journals 7 of them are journals about perishable products. From the minimum number of existing numbers, the authors are interested in developing a model for mitigating bullwhip effect on perishable product.

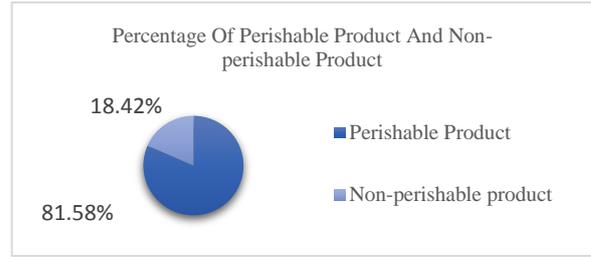


Figure 4. Percentage of perishable product and non-perishable product

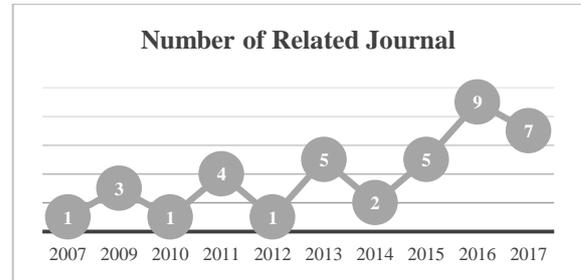


Figure 5. Number of Related Journal

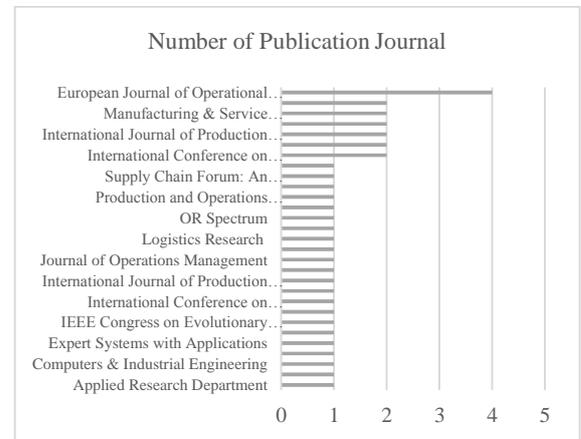


Figure 6. Number of Publications Journal

D. Identification Causes-effect the Occurrence of the Bullwhip Effect.

Previous research has shown the main causes of bullwhip effect is caused by demand forecast updating, order batching, price fluctuation, and shortage gaming [1]. Besides the bullwhip effect is caused by time delay, demand uncertainty, forecast error, batch size, price fluctuation, supply shortage, information sharing, and number echelon [6]. In perishable product, according to bullwhip effect is affected by order variability / order batch, demand variability, ordering cost, consider(s), criteria, demand variability, price, customer satisfaction, lead time, sales variability, forecasts, lost sale, order variability/order batch, shelf life, inventory policy/replenishment policy [7].

There is an age limit for perishable food for still worth selling. This lifespan is also called shelf-life and is usually present on product packaging. Shelf life can also be defined as the period between the moment after the product is manufactured until the purchase of the product

by the retailer and the product still has a satisfactory quality [7]

The above references show several causes of the bullwhip effect in each condition. The existence of a bullwhip effect will increase the supply chain cost and will automatically decrease customer service. Fig. 7. shows 17 causes of bullwhip effect are cost, demand forecasting updating, batching order, price fluctuation, price discount, rationing shortage gaming, rationing shortage gaming, demand variability, time delay, ordering policy, ordering policy, customer satisfaction, capacities storage/transportation, inventory policy/replenishment policy, inventory sharing, number of product, and shelf life. if there is an increase in the 16 factors except sharing information, then the bullwhip effect will increase which will affect the increase of supply chain cost and the decreasing of customer service. but if information sharing decreases it will add bullwhip value.

E. Identify the Variables and Parameters Which Become an Opportunity to be Discussed in Mitigating Bullwhip Effect.

After analyzing the cause of the bullwhip effect, then chart the cause of the bullwhip effect into using the influencing variable. The example for variable cost can consist of holding cost, back order cost, transportation cost, transit cost, and inventory cost. and other variables can be seen in TABLE VIII.

F. Identify of Decision Variables are Used in the Way to Mitigating Bullwhip.

Variables used to determine and consider decisions taken in the objective function of a journal. In this study, the criteria of decision variables consisted of 22 criteria. The decision variable can be seen in the TABLE VIII.

After the mapping of related journals based on decision variables, it is known that the largest percentage of is on lead time variables is 19%, the second position is occupied by 18% forecast, 16% procurement, 11% batch size and procurement, 8% demand pattern, 7% price fluctuation, etc. Of these variables, there are some variables that can only be found on perishable products, for example shelf life. (see Appendix B).

TABLE VIII. VARIABLE AND PARAMETER OF BULLWHIP EFFECT

Variable	Number of Journal	%	Parameter
Product	2	2%	Single Product
			Multi Product
Discrepancy	1	1%	-
Demand Patterns	7	8%	AR (p)
			ARMA (p, q)
			ARIMA (q, d, p)
			Seasonality / Trend
			Not Identified
Forecasting	16	18%	Moving Average
			Exponential smoothing

			Regression Analysis
Lead Time	17	19%	Information lead time
			Production lead time
			Transportation lead time
			Planning lead time
			Order Lead time
Procurement	10	11%	
Price fluctuation	6	7%	Constant
			Variable
Batch size (Order batching)	10	11%	-
Supply Shortage	1	1%	-
Discount Factor	1	1%	-
Inventory control policy (Replenishment Policy)	4	4%	Base Stock Model
			(Q,r) Model
			(s,S) Model
Inventory Sharing	3	3%	-
Reverse Logistics	1	1%	-
Inventory Shrinkage	1	1%	-
Customer service	2	2%	-
Information Sharing	3	3%	VMI
			POS
			None
Stock	1	1%	-
Delay Time	1	1%	-
Order Cycle	1	1%	-
Delivery Time	1	1%	-
Costs	1	1%	Holding Cost
			Back Order Cost
			Ordering Cost
			Transportation Cost
			Transit Cost
			Inventory cost
			Lost sale cost
Shelf Life	1	1%	Long Shelf Life
			Short Shelf Life
Capacity			Production capacity
			Storage Capacity
			Transportation Capacity
Supply chain structure			Serial
			Non-Serial
Market Competition			-

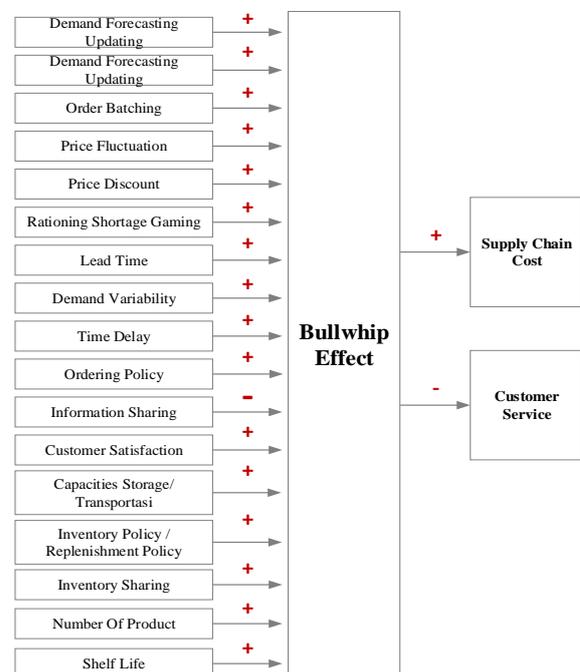


Figure 7. The cause of bullwhip effect

III. CONCLUSION AND FUTURE RESEARCH

The cause of bullwhip effect itself is caused by 17 causes of bullwhip effect are cost, demand forecasting updating, batching order, price fluctuation, price discount, rationing shortage gaming, rationing shortage gaming, demand variability, time delay, ordering policy, ordering policy, customer satisfaction, capacities storage/transportation, inventory policy/replenishment policy, inventory sharing, number of product, and shelf life. One of the causes of bullwhip effect on perishable product is shelf life.

In future research, authors will use case sale on the in Indonesia. As for the steps used by researchers in minimizing the bullwhip effect that is, the first stage is to measure the performance of product distribution activities. Performance measurement is required to perform monitoring and control, besides the purpose of performing this performance measurement is used to determine the less effective activity. As for the model used to perform this performance measurement is the supply chain operations reference (SCOR) model [6]. SCOR model is one model of supply chain operation, which is basically a process-based model that integrates three key elements in management, namely business process reengineering (BPR), benchmarking and best practice analysis (BPA) into a cross-functional supply chain. [6].

The measurement carried out using the bullwhip effect parameter exists on the distribution activity (i.e., information lead time, forecasting methods, etc.). So, the result obtained from the measurement is the performance of each parameter. The parameter that has the lowest value will be used as the variable used to consider the calculation of the bullwhip effect. After getting consider the variable used, the next step is calculation to mitigating the bullwhip effect.

APPENDIX A. STATE OF THE ART (SOTA) (1)

No	Referenc e Journal	Analytica l	Simulatio n	Perishabl e Product	Non-Perishabl e Product
1	[6]		x		x
2	[8]	x			x
3	[9]		x		x
4	[10]	x			x
5	[11]	x	x	x	
6	[12]	x			x
7	[13]	x			x
8	[14]		x		x
9	[7]		x	x	x
10	[15]		x	x	x
11	[16]	x			x
	[17]	x			x
13	[18]		x		x
14	[19]		x		x
15	[20]	x			x
16	[21]	x		x	x
17	[22]	x		x	x
18	[23]		x		x
19	[24]	x			x
20	[25]	x	x		x
21	[26]		x		x
22	[27]		x		x

23	[28]	x			x
24	[29]	x			x
25	[30]	x			x
26	[31]	x			x
27	[32]	x			x
28	[33]		x		x
29	[34]	x			x
30	[35]		x	x	x
31	[36]			x	x
32	[37]	x			x
33	[38]	x			x
34	[39]	x			x
35	[40]	x			x
36	[41]		x		x
37	[42]	x			x
38	[43]		x		x

APPENDIX B. STATE OF THE ART (SOTA) (2)

Journal	Variable																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
[6]					x																		
[9]									x														
[10]						x																	
[11]				x	x																		
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