THE INTRODUCTION OF OPEN SOURCE INITIATIVES IN SUPPLY CHAIN MANAGEMENT SOFTWARE

GRADUATE RESEARCH PAPER

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Abstract

Adopting more open source technologies into SCM might have a profound effect on the way operations are managed from a technological standpoint if a way-forward were introduced. A thorough review of literature on implementing open source software into SCM programs was conducted, focusing on articles discussing the reduction in IT spending for organizations relying on software to manage their supply chains. Relevant examples of software which could implement an open source function were discussed, and the cost of implementing and maintaining open source software versus the cost of maintaining the status quo. Upon completion of this literature review, readers will have an understanding of the state of the art open source technology in SCM software. More importantly, the focus is to determine gaps in research which must be conducted to expedite the implementation of open source capability in SCM software. The gaps in research discovered throughout the process of this literature review are listed as eight recommended focus areas. Ranging from research determining value-for-money of open source software, to initial systems in which open source software should be introduced in large organizations, these focus areas can serve as a jumping off point for research on open source technology implementation in SCM software.

List of Tables

Table of Contents

I. Introduction

Background

"Free" or "open source" software is computer software which can be acquired freely and modified by users and shared to improve the overall performance of the software for its intended use. The process of open-sourcing software has been around since the late 1960's, however, corporations have been trending away from its use due to an interest in protecting their intellectual property and generating revenue by requiring licenses to update software to newer versions or fix bugs. Recently, organizations have sprung up with the goal of encouraging and facilitating open source initiatives across the entire spectrum of software types. Thus far, there appears to be a gap in open source products and research in the field of supply chain management (SCM). Literature on the subject of open sourcing in SCM is very sparse, and a search of what is considered to be the most prominent open sourcing website (www.SourceForge.net) retrieved only 67 hits in a search for "logistics" and 74 for "supply chain". Of those programs listed, none were usable in any relevant manner by large organizations and several were simply listed as "games" (www.Sourceforge.net, 2018; Schindler, 2009).

SCM is a tenuous term to some, especially in the military context. This paper adopts the following definitions as a starting point and to ensure that the reader understands the background from which the research is coming. The "Supply Chain" refers to organizations within the path along which goods and services move, beginning with manufacture or preparation of basic materials, and ending with

consumption or disposal of the final product by the end user. SCM is defined by the Defense Acquisition University (DAU) as:

> The integration of the supplier, distributor, and customer logistics requirements into one cohesive process to include demand planning, forecasting, materials requisition, order processing, inventory allocation, order fulfillment, transportation services, receiving, invoicing, and payment. Also, the management and control of all materials, funds, and related information in the logistics process from the acquisition of raw materials to the delivery of finished products to the end user

However, SCM can be simply explained as the orchestration of efforts from beginning to end, or what's become known as a "cradle-to-grave" supply chain (www.NCSU.edu, 2017; Welcome, 2009).

Open source software can allow organizations to build better-tailored systems that can be rapidly upgraded or changed to meet emerging requirements. SCM is a quickly-evolving field and capabilities can change drastically at the drop of a hat, but programmers whom are not involved in the process are not kept up to date on the changes and therefore are unable to update the software with new requirements at a speed which is fast enough to affect positive change on the systems within the supply chain. Open source technology could drastically speed that process by allowing users to input their own updates which would perfectly meet their needs, as opposed to users requesting or recommending the capabilities they would like to have to software developers, and receiving a product that does not meet their needs exactly (Hippel, 2004:11).

Objective

Adopting more open source technologies into SCM could have a profound effect on the way large-scale SCM is managed. Studies have shown that in firms where innovation is valued from its individual users, the firm tends to be ahead of the rest of their market in regards to market trends, and are more likely to find suitable solutions to problems, which allows the firm to gain high benefits relative to firms who are not focused on innovation (von Hippel, 2004: 6-7). Open source technology puts immediate innovation capabilities into the hands of users by allowing them to change software in ways that directly improves their effectiveness and efficiency in completing their specific tasks. The objective of this research is to examine open source SCM software by accomplishing a systematic literature review in order to encourage and provide direction for future research into implementing open source technology into supply chain management software. The review follows the six steps and guidelines outlined by Durach, Kembro, and Wieland (2017). Upon completion of this literature review, readers will understand the relevant literature which exists today, as well as the necessity to conduct further research combining Open Source software and SCM. They will also have a framework from which to move forward, using specific focus areas of study in order to make the most meaningful enhancements to the combination of Open Source and SCM.

II. Methodology

A thorough review of literature within the overarching topic of implementing open source software into SCM programs was conducted. Additionally, articles discussing the reduction in IT spending for organizations relying on software to manage their supply chains, relevant examples of software which could implement an open source function, and the cost of implementing and maintaining open source software versus the cost of maintaining the status quo were included.

The literature included was that which could be confirmed as legitimate scholarly works, as well as official government sources. Finally, vendor advertisements and studies were included, but they were required to be relevant to the use of open source technology within the SCM enterprise.

The search for literature focused on key words, simply due to the narrow topic regarding open source technology in SCM systems, and they were as follows:

- Open source and Supply Chain Management
- Supply Chain Management Systems
- Supply Chain Management Software
- Open Source Software

Throughout the search and compilation of research across all sources, only literature which can be certain to contribute to the initial theoretical framework was included. Additionally, careful review of each article ensured that the information contained within was relevant to both SCM and open source software in a manner in which both topics could be combined in order to highlight an existing relationship or gap in the relationship between the two.

For this study, the research aligned with the following six steps as outlined in "Systematic Literature Reviews" (Durach, 2017), and was then further refined based on how those six steps fit into this topic specifically:

1. Define the purpose of the literature review.
    - The objective of this research is to examine open source software SCM by accomplishing a systematic literature review which follows the six steps and their guidelines presented and recommended by Durach, Kembro, and Wieland (2017) in order to encourage and provide direction for future research into implementing open source technology into supply chain management software.
2. Define inclusion criteria.
    - For this study, the requirement to have come from a significantly respected source was somewhat relaxed in order to assure that a wide breadth of open source literature can be included. However, the search was narrow due to the requirement of being relatable to SCM software.
        - To be included in the study, articles were required to meet at least one of the following criteria:
            - Focus on implementation of open source software
            - Supply chain management software
            - Presented by a respected scholarly or governmental source
            - Presented by a vendor offering to implement open source software into SCM organizations

3. Retrieve potentially relevant literature
    - Literature was collected from a multitude of sources ranging from scholarly works and private magazines and newsletters, to cellular phone and tablet application advertisements and crowd-sourced Open Source opportunity forums.
4. Use previous criteria to reduce study size to include only relevant studies
    - Additional weight was placed on the literature which was found to be relevant to both Open Source and SCM, however each piece of literature was considered and reviewed for opportunities where significant improvement could be made by combining the research within to other research discovered during the review. Table 1 on the following page provides a guide to how each article applied in each circumstance and some considerations noted during the literature review.

Table 1. Criteria for Literature Inclusion

Literature	Relevant to Open Source	Relevant to SCM	Considerations
5 Best Open Source Supply Chain Management Software	X	X	Relates to Open Source and SCM/Specific to small businesses
Are There Any Open Source Software for Logistics and Supply Chain Management?	X	X	Relates to Open Source and SCM/Specific to small businesses
3 Open Source Software Tools for Supply Chain Management	X	X	Relates to Open Source and SCM/Specific to small businesses
A New Paradigm for Systematic Literature Reviews in Supply Chain Management		X	Provides a framework for literature reviews in SCM
Open Source Systems: Grounding Research	X		Introduces reasoning and theories behind using or not using Open Source software
Logistics		X	List of current Open Source projects in the field of Logistics
Open source Supply Chain Management Applications	X	X	List of Open Source apps providing assistance in SCM/Specific to small businesses
An Abbreviated History of ACP, One of the Oldest Open Source Applications	X		Introduces the original Open Source software and its capabilities
Supply Chain		X	List of current Open Source projects "supply chain"
Supply Chain Management		X	Provides the DoD definition of SCM
Democratizing Innovation-the Evolving Phenomenon of User Innovation	X		Complete overview of user-centered innovation in Open Source software
How to Manage a Cradle-to-Grave Supply Chain		X	Complete overview of SCM
What is Supply Chain Management?		X	Provides easy-to-understand overview of SCM

* Note: Due to the limited number of articles found to discuss Open Source Software and SCM, all literature found to discuss both was included.

5. Analyze and integrate relevant data into a coherent structure in order to advance the theory presented in the purpose.
    - Research focused on determining what works for whom, how, and under what circumstances. Each piece of literature was analyzed to determine if it was relevant to either Open Source software or SCM. Additional research was conducted to determine feasibility of application to DoD programs in the future.
6. Report the results of the literature review.
    - Will be presented so as to be useful to all parties interested in combining Open Source and SCM, ranging from private sector companies and software developers, to government organizations and end users.

III. Results and Conclusions

There are thousands of articles covering open source software and thousands of articles covering SCM, but when looking to combine the two, it is remarkable how little research has actually been accomplished. The gaps in research regarding how open source software could be used in SCM are precisely what this literature review aims to highlight in order to facilitate future research into specific areas of open source software introduction into SCM.

When researching a topic focusing on the introduction of a new concept, it seemed fitting to start with an article covering the cost of open source innovation. In the book *Open Source Systems: Grounding Research*, the author focuses on the cost of open source technology implementation and, in the end, provides the conclusion that open source software adoption costs are very similar to costs of other types of software which can be used for similar systems. He points out that most companies do not have a good understanding of the liberties and flexibility that open source technology can provide them (Hissam, 2011: 217). Due to this fact, it is not surprising that SCM organizations are not actively seeking to enter the open source market to meet their needs. Immediately, this provides us with an initial finding that research needs to be conducted regarding the possibility of open source technology giving SCM organizations value-for-money that traditional software cannot.

There is a plethora of literature discussing the value of adopting open source software within organizations from both the user standpoint, as well as the software developer standpoint. von Hippel and von Krogh (2004) discussed in

detail many of the values that open source technology can provide to users, although not specifically referring to SCM software. However, the benefits they describe can certainly be expected to have similar effect on both sectors, and possibly even exaggerate them due to the extremely long lag times in updates to SCM software as requested by users based on software developers need to understand the requirement and push out meaningful updates which incorporate all of the user demands at once. Most importantly, they discuss organizations with a focus on innovation by users and the significant benefits realized by those organizations. They point out that it is not simply the actual innovation that causes the organization to garner such benefits, but rather the boost to enjoyment that the empowerment to innovate gives the organization's employees which produces the incredible results. They refer to the fact that an employee who wants or requires a specific feature from their software will not gain enjoyment from submitting the requirement to a manufacturer and waiting for the change to be implemented, possibly not in the manner in which they intended, but will in fact gain immediate benefit from being able to implement that ability on their own in the near-term. They go on to point out that allowing users to innovate using open source software tended to enable the development of software which was able to do new types of things for the first time, where updates from manufacturers tended to simply improve convenience or reliability in currently existing functions (Hippel, 2004:9). Within SCM organizations, employees suffer from frustration in the quickly change landscape of supply chains and the slow-to-implement updates in SCM software that would enable them to do their jobs more quickly and

efficiently. There is a gap in research regarding the effect that the high-speed at which open source technology in SCM would allow updates to be made and the efficiencies that would be realized.

Another focus area that seems to be of great importance to the use of open source technology is the question of why manufacturers or organizations would want to allow the use of open source technology to freely share their code or software with organizations (von Hippel, 2004). This specific area has been heavily researched, however again there has been no specific research conducted to determine its effect on SCM software. Overall, research tends to show that manufacturers who provide software as open source still benefit monetarily from doing so because they are still able to package their software and sell it for specific purposes, only now with the inclusion of free coding and capabilities that were created by users. Additionally, organizations that allow their users to input coding and capabilities into software that is owned by the manufacturer still gain a net increase in value due to employee enjoyment and efficiency that outweighs the fact that their coding has potentially enabled their competitors to use it as well, also at no-cost. Finally, manufacturers attempt to lump previous solutions into updates for organizations using their software which might meet the requirements, but are not specifically tailored to the situation that the organization would like to satisfy. Users of open source software are able to produce a system that accomplishes exactly what they need it to do, and then allow the manufacturer to share or modify that system and sell it to another organization, thus increasing the value for both the manufacturer and the user organization

(Hippel, 2004:9). Further SCM research in this area would have specific benefits because it would allow for SCM organizations to understand what they stand to gain from using open source software and would also highlight the ability to create new capabilities and highlight the ability to make modifications to those capabilities to increase efficiencies and abilities in the software throughout the organization.

This specific topic would almost certainly need to be split to cover both private and governmental SCM software as there are obvious major differences between the two when it comes to "sharing" capabilities. Research would need to be conducted on exactly how an open source initiative would be implemented on such a large scale, while also determining how to use open source software for classified segments of the government's supply chain, or if those portions would need to remain in a traditional system. For use in government SCM systems, the first step would certainly be to determine which system (In-Transit Visibility, parts ordering, inventory, etc.) should initially be switched to open source in order to provide a good test ground as well as gather lessons-learned before moving on to other systems within the supply chain. Once that question has been answered, further research would need to be conducted regarding how users would be trained to use the software and implement changes, as well as how those changes would be reviewed and approved by organization leadership, as well as how they would be shared once they were complete.

Finally, once research has been completed on the preliminary questions, the next major question which would need to be answered is which open source

software should be used? The amount of open source software specifically tailored to SCM that is available on the market today is almost non-existent. A search for software with open source technology for use in supply chains results in approximately eight options. Additionally, there is no review or research covering those programs, simply their websites (or websites advertising for them) giving a spiel on why they would work best for "your" organization and two websites that provided overviews of three-to-five of the programs available (Baker, 2016; www.wesuggestsoftware.com, 2017; www.getapp.com, 2018; Shah, 2016). Although it is encouraging to see that companies are beginning to dabble in open source technology for SCM, it appears they are currently focused on supplying the software to relatively small firms. It would be prudent to conduct research into currently existing open source technology for SCM and compare it to introducing open source capability to existing SCM software to determine which route would create the best solution for most supply chains.

The gaps in research discovered throughout the process of this literature review are listed as eight recommended focus areas in the latter part of this paper. Ranging from research determining value-for-money of open source software, to initial systems in which open source software should be introduced in large organizations, these focus areas should be the jumping off point for the next major impetus on researching open source technology implementation in SCM software.

The gaps in research specific to SCM are more numerous than the research that exists, but there is certainly hope for moving forward. Most of the research regarding open source software could easily be enhanced to include how it would effect SCM quite easily, and thus with enhanced focus, the research could become thorough and encompass most of the field in a relatively short time.

Results of this literature review produced the following eight findings:

1. Research needs to be conducted regarding open source technology giving organizations value-for-money that traditional software cannot.

2. Research needs to be conducted regarding the effect that the high-speed at which open source technology in SCM would allow updates to be made and the efficiencies that would be realized.

3. Research needs to be conducted to understand what SCM organizations stand to gain from using open source software and determine if the ability to create new capabilities and make modifications to those capabilities would increase efficiencies and abilities throughout the organization.

4. Research needs to be conducted to determine exactly how an open source initiative would be implemented for large scale operations, while also determining how to use open source software for classified segments of the government's supply chain, or if those portions would need to remain in a traditional system.

5. Research needs to be conducted to determine the initial systems in which SCM should be tested with open source software in large organizations.

6. Research needs to be conducted to determine whether currently existing open source technology for SCM or if introducing open source capability to existing SCM software would create the best solution for most supply chains.

7. Research needs to be conducted regarding how users would be trained to use the software and implement changes, as well as how

those changes would be reviewed and approved by organization leadership.

8. Research needs to be conducted as to how capabilities would be shared throughout a large organization once they were implemented in one department or section.

IV. Concluding Remarks

The recommendations put forth by this literature review are that the eight areas of research listed in the previous section are presented as focus areas for SCM moving forward. The literature regarding open source software outside of SCM shows potential to have massive benefits within every aspect of SCM. The largest potential falls in the realms of speed at which changes to software and increases in capabilities can be made, value-for-money realization in organizations using SCM software, and employee satisfaction and innovation due to the implementation of open source software in SCM.

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14. ABSTRACT

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