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Function of Value Stream Mapping in Operations Management Journals

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Abstract: Studies of the value stream mapping (VSM) in Western journals report that leveraging VSM as a lean tool results in performance improvements. However, in these articles, VSM is functioning as a tool for partial optimization, attempting to identify and resolve bottlenecks in individual functions and divisions, primarily in production activities. For that reason, the greater the degree to which VSM underpins success, the more it deviates from the original essence of lean production and flow management, promoting overall optimization by focusing on the flows across the value chain, and potentially leading to poorer performance in the overall value flows up to the customer.

Keywords: value stream mapping, lean production system, production and operations management, value chain

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Introduction

The fundamental view of the enterprise taken by management scholars, notably Thompson (1967), is that the firm applies a technical transformation to inputs to produce outputs desired by customers, thus contributing to the economy and society and sustaining the enterprise and continuing its growth. Applying this view of the enterprise to an operations management context, what is important, as pointed out by Fujimoto (1999, 2012) is an understanding of corporate activity as creation and transformation of the design information (i.e., the creation of excellent value flow) ranging from product development to production, procurement, and sales activities. The entire flow of value-creating activities will only rarely be contained within a single function or enterprise; it is brought about by combining activities by multiple, diverse functions and enterprises or entities. It is the level of superiority and excellence around this flow of value creation in which enterprises compete.

Starting in the 1980s, the concept of lean production systems, based on international comparative studies on the characteristics and strengths of production systems at Japanese enterprises, has achieved worldwide acceptance as a key feature of organizations that create value streams more skillfully than their competitors (Fukuzawa, 2019; Holweg, 2007; Shah & Ward, 2003, 2007; Womack, Jones, & Roos, 1990).

An important tool which has come to be used at overseas enterprises in making their production systems for value streams lean is value stream mapping (VSM), an application of the “material and information flow chart” used in Japanese companies.

This paper reviews the ways in which VSM has been framed and analyzed in Western operations management journals, with a focus on the functions and activities to which VSM is applied.

Function of the Value Stream Mapping

(1) Value stream mapping: A guidance of the lean journey

One tool that has been employed to achieve lean value flows in corporate activities is VSM, an adaptation of the "material and information flow chart." It was Rother and Shook (1998) who first coined the use of the term VSM.

VSM was originally proposed by Rother and Shook (1998) as one of the most important tools to engender success on the lean journey, applying the concept of "material and information flow chart" used internally at Toyota in the context of lean production and management. This was one work product of the first lean toolkit project at the Lean Enterprise Institute. Mike Rother, one of the authors, was a lean production systems consultant; John Shook had experience working at Toyota. For them, it was a given to use the "material and information flow chart," a methodology that was used at Toyota to consider value flows in a customer-oriented fashion, make flows visible, eliminate *muda* (waste), and enhance processes going forward. As Rother and Shook (1998) mentioned in the preface, these "mappings" were used as a "communication tool" in their kaizen activities in Toyota.

Rother and Shook (1998) present approaches to improve the overall flow of the supply chain using VSM to visualize the current state of the supply chain (procurement, manufacturing, and sales), discover bottlenecks where waste arises, and eliminate those bottlenecks through workplace improvements. Introducing such VSM-based kaizen activities is expected to lead to performance improvements such as increasing the ratio of the value-adding time and reducing lead times. Subsequently, Rother (2010) explains in detail the notion of KATA, and groups of routines for kaizen and coaching at Toyota. These authors emphasize finding bottlenecks by means of

making things visible.

Liker and Meier (2005) argue that what is important when trying to reduce inefficiencies is to look across the entire range of value creation activities to identify inefficiencies occurring in the entire value stream, rather than focusing on kaizen for individual process steps.

VSM has become more widely used and popular in recent years as an important tool for enhancing the value chain flow. For example, Shou, Wang, Wu, Wang, and Chong (2017) conducted a wide-ranging survey of publications from 1999 through 2016, finding that VSM was being used and was effective not only in manufacturing but also in a broad range of other sectors, including healthcare, construction, product development, and services. Serrano Lasa, Laburu, and de Castro (2008) and Seth, Seth, and Dhariwal (2017) show that applying value stream maps in workplaces in which things are manufactured is also effective in improving the value-adding time in productive work and reducing lead times.

This has been an overview of the progress that has been made in academic research and initiatives to enhance the value chain flow using the "material and information flow chart" that originated in initiatives at Toyota and their adapted form, the lean tool known as VSM.

(2) VSM as a lean "production" tool

To explore trends in research on VSM outside of Japan, we searched the Web of Science for the topics of "value stream map" and "VSM" for the period 1997 through 2019. From the results, we selected and reviewed leading journals in the field of operations management. The journals selected for review in this paper are *International Journal of Production Research*, *Production Planning & Control*, *International Journal of Lean Six Sigma*, *Journal of Manufacturing Technology Management*, *Business Process*

Management Journal, *International Journal of Production Economics*, *Journal of Operations Management*, *International Journal of Operations and Production Management*, [1] and *Production and Operations Management*. We excluded search results clearly unrelated to VSM. [2] Note that we found no hits in the two top operations management journals, *Journal of Operations Management* and *Production and Operations Management*, and another top journal, *International Journal of Operations and Production Management*, had only two articles (Hines & Rich, 1997; Holweg, 2005), a relatively small number. Ultimately, we chose 75 articles for our analysis.

Table 1 shows the number of selected articles and empirical papers by journals, along with the methodology (case study, questionnaire, simulation, combined case study and simulation, and combined case study and questionnaire) and the number of non-empirical articles. Non-empirical articles included two review papers, Shou, et al. (2017) and Vasconcelos Ferreira Lobo, Damasceno Calado, and Dalvo Pereira da Conceição (2018), and one model building paper, Nounou (2018). Table 2 also indicates the unit, function, and activity to which VSM was applied in the empirical papers. Leaving aside papers using questionnaires that asked about the degree of use of VSM, the great majority, albeit with some differences in details, describe VSM in actual subject companies.

As shown in Table 1, most of the studies used a case study methodology, accounting for 69% of the total (Agyapong-Kodua,

[1] Hines and Rich (1997) bring together information on the degree to which the seven tools that existed at the time for mapping value streams proved useful. Of the seven tools, it is processing activity mapping that is most relevant to reducing inefficiency. Hines and Rich (1997) are affiliated with the Lean Enterprise Institute, as are Rother and Shook (1998). Discussing the importance of focusing on the value stream and its visualization led to theorizing about VSM after Rother and Shook (1998).

[2] For example, we excluded the articles about the viable system model.

Table 1. Distribution of method of VSM research

Journal name	# of articles	Empirical					Non-empirical
		case study	questionnaire	simulation	case study & simulation	case study & questionnaire	
International Journal of Production Research	24	16	2	1	3	1	1
Production Planning & Control	17	13	1		2		1
International Journal of Lean Six Sigma	12	9	1		1		1
Journal of Manufacturing Technology Management	8	6	1		1		
Business Process Management Journal	7	5			2		
International Journal of Production Economics	5	1	1		3		
International Journal of Operations and Production Management	2	2					

Ajaefobi, Weston, & Ratchev, 2012; Basu & Dan, 2014; Ben Fredj-Ben Alaya, 2016; Bertolini, Braglia, Romagnoli, & Zammori, 2013; Braglia, Carmignani, & Zammori, 2006; Camgöz-Akdağ & Beldek, 2019; Camgöz-Akdağ, Çalişkan, & Toma, 2017; Carmignani, 2017; Chen, Li, & Shady, 2010; Chiarini, 2011; Choudhary, Nayak, Dora, Mishra, & Ghadge, 2019; Chowdary & George, 2011; Coronado & Lyons, 2007; Cottyn, Van Landeghem, Stockman, & Derammelaere, 2011; Dinis-Carvalho, Guimaraes, Sousa, & Leao, 2019; Dinis-Carvalho, Moreira, Bragança, Costa, Alves, & Sousa, 2015; Green, Lee, & Kozman, 2010; Gutierrez-Gutierrez, de Leeuw, & Dubbers, 2016; Henrique, Rentes, Filho, & Esposto, 2016; Hines & Rich, 1997; Hodge, Goforth Ross, Joines, & Thoney, 2011; Holweg, 2005; Jasti & Sharma, 2015; Jiménez, Tejeda, Pérez, Blanco, & Martínez, 2012; Lacerda, Xambre, & Alvelos, 2016; Librelato, Lacerda, Rodrigues, & Veit, 2014; Liu & Ming, 2019; Matt, 2014; Nagaraj, Jeyapaul, Vimal, & Mathiyazhagan, 2019; Nepal, Natarajarathinam, & Balla, 2011; Powell, Lundeby, Chabada, & Dreyer, 2017; Raghavan, Yoon, & Srihari, 2014; Ramesh & Kodali, 2012; Ratnayake & Chaudry, 2017; Ray & John, 2011; Serrano Lasa, Laburu, & de Castro, 2008; Serrano Lasa, Ochoa, & de Castro, 2008; Serrano Lasa, de Castro, & Laburu, 2009; Seth & Gupta, 2005; Seth,

Seth, & Dhariwal, 2017; Seth, Seth, & Goel, 2008; Singh, Garg, Sharma, & Grewal, 2010; Singh, Kumar, Choudhury, & Tiwari, 2006; Stadnicka & Ratnayake, 2017, 2018; Sunk, Kuhlang, Edtmayr, & Sihn, 2017; Thanki & Thakkar, 2016; Tuli & Shankar, 2015; Tyagi, Choudhary, Cai, & Yang, 2015; Villarreal, Garza-Reyes, & Kumar, 2016; Vinodh, Arvind, & Somanaathan, 2010; Vinodh, Kumar, & Vimal, 2014).

The next most common were combinations of case studies and simulation analysis, making up for 16% of the total (Abdulmalek & Rajgopal, 2007; Bhuvanesh Kumar & Parameshwaran, 2018; Cavdur, Yagmahan, Oguzcan, Arslan, & Sahan, 2019; Gurumurthy & Kodali, 2011; Huang & Liu, 2005; Mishra, Sharma, Sachdeo, & Kandasamy, 2019; Parthanadee & Buddhakulsomsiri, 2014; Persson, 2011; Schmidtke, Heiser, & Hinrichsen, 2014; Stadnicka & Litwin, 2019; Xie & Peng, 2012; Yang & Lu, 2011). Each of these papers includes simulations as a way to compensate for the shortcomings of VSM, including the need to limit the products being addressed, the difficulty of considering various criteria during the envisioning of the desired future state from the current state of thinking about which types of kaizen tactics are appropriate, and the difficulty of writing out by hand.

Quantitative method articles using questionnaires accounted for 8% of the total. These papers were Andreadis, Garza-Reyes, and Kumar (2017); Belekoukias, Garza-Reyes, and Kumar (2014); Garza-Reyes, Kumar, Chaikittisilp, and Tan (2018); Garza-Reyes, Villarreal, Kumar, and Molina Ruiz (2016); Lorenzon dos Santos, Giglio, Helleno, and Campos (2019); and Lugert, Batz, and Winkler (2018).

There was one paper that used simulation analysis alone (Lian & Van Landeghem, 2007), and one that combined a case study with a questionnaire.

All of the empirical studies that used VSM in our review regarded

Table 2. Distribution of application of empirical VSM research

Journal name	# of articles	production	product development	purchase/ logistics/sales/service	supply chain	non-manufacturing sector
International Journal of Production Research	23	20	1	1		1
Production Planning & Control	16	13		2		1
International Journal of Lean Six Sigma	11	10		1		
Journal of Manufacturing Technology Management	8	6		1	1	
Business Process Management Journal	7	3				4
International Journal of Production Economics	5	3	1		1	
International Journal of Operations and Production Management	2	1			1	

VSM as an important tool for helping to achieve lean production systems. The basic commonalities in making progress in empirical research boil down to (1) visualization of the flow of things and information in current production processes; (2) discovering the bottlenecks therein; (3) envisioning the desired future state; (4) holding kaizen workshops to paint scenarios for improvement, carry out kaizen using other lean tools such as the seven QC tools, moving toward the desired state of affairs (or demonstrating outcomes of kaizen case studies); (5) expected results from kaizen in terms of performance; and (6) in cases where the case by itself fails to lead to improvement scenarios, combining with simulation analysis to predict the desired scenario and effects.

Worthy of note in Table 2 is the fact that most applications of VSM, accounting for 78% of the total, are concentrated on production processes (units or activities). When drawing VSM, production management information and lead times for procurements from suppliers or selling to retailers are also noted, but the main targets of the flow improvements using VSM are production processes. In research that targets other manufacturing processes as well, VSM has been used on particular activities involved in the supply chain,[3]

[3] Three empirical articles such as Holweg (2005), Persson (2011), and Seth et al. (2008) focused on the activities throughout the supply chain. However,

as seen in its application to the field of development (Tuli & Shankar, 2015; Tyagi et al., 2015) and to procurement, logistics, and transportation (Aamer, 2018; Garza-Reyes et al., 2016; Gutierrez-Gutierrez et al., 2016; Stadnicka & Ratnayake, 2018; Villarreal et al., 2016). VSM is also being applied to non-manufacturing industries such as health care (Camgöz-Akdağ & Beldek, 2019; Camgöz-Akdağ et al., 2017; Henrique et al., 2016; Xie & Peng, 2012) and service organizations. For example, in Camgöz-Akdağ et al. (2017), process improvements are carried out in the radiology unit, which is a limited application of VSM to a particular unit.

The journals shown in Table 2 are in the field of operations management and as such may well be biased toward the application of VSM to production. The literature search using the Web of Science we did for this paper, however, was not limited to production management; we also included journals in the field of supply chain management. In fact, there is one paper from *Supply Chain Management*, a leading journal in the field of supply chain management, which qualified. This paper, Wee and Wu (2009), applies VSM to the supply chain at Ford's Taiwan Plant. It limits itself, however, to depicting and analyzing VSM that is internal to the plant, from deliveries of parts from suppliers to shipment.

Discussion and Conclusion

As we have seen here, the primary role and function of VSM in Western journals in the field of operations management is as a lean tool for making individual unit and activity streams more efficient; it is most commonly applied in production activities within a

these articles have not been sufficiently done to draw and analyze the VSM in detail and make improvements for the entire supply chain and product development activities.

plant. Using VSM as a lean tool to improve the workplace such as production unit, lean states have long been achieved in specific units and activities. Given the risk of viewing easily understandable tools such as kanban, which are used as a shortcut on the lean journey, the contribution of VSM was to remind people of the importance of looking at the value stream, identifying bottlenecks and blockages within it, and resolving them. It is conceivable that this had the effect of reducing the number of people who got lost on their lean journey.

Applying VSM to particular divisions and functions as has been done in prior studies, moving ahead with kaizen and pushing for partial or unit-level optimizations, can potentially lead to lower overall performance in the supply chain and value chain. For example, even if applying kaizen using VSM to a particular inefficiency improves the flow inside a plant, bottlenecks within the units and activities surrounding the plant, such as purchasing, logistics, sales, and development remain unaddressed, and it is conceivable that bottlenecks between units and activities will increase.

VSM originated as a tool adapted from the "material and information flow chart" that had been used "as a matter of course" (Rother & Shook, 1998) at Toyota to "improve the flow" of a series of customer-oriented values. Subsequently, it seems that as VSM research has progressed and has become popular as an effective lean tool that is used mainly for shortening lead times, improving the value-adding time ratio, and reducing waste in specific departments and activities, it has deviated from the original design concept and flow management seen in the Toyota production system and the lean production system that aimed to realize "overall optimization" by improving the flow of a series of values.

It is important that future research takes a broad view of value creation activities, visualizes and continues to eliminate the various bottlenecks in it, and allocates resources necessary for that purpose

and for collaboration among departments and companies, to consider the ideal way for management to realize overall optimization through coordination. For these reasons, it will be necessary to develop research methods and empirical analysis that focus on improving VSM for use as an overall optimization-oriented tool that can be used to visualize the overall state of the value stream across departments and companies, and facilitate the "awareness" of problems in the overall value stream and promote the improvement activities.

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