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Franciscus Bakker
University of Groningen

Tillmann Boehme
University of Wollongong, tbohme@uow.edu.au

Dirk Pieter van Donk
University of Groningen

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Keywords
barriers, systems, identifying, integration, chain, supply, internal, thinking

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Identifying barriers to internal supply chain integration using Systems Thinking

Frans Bakker (f.p.bakker@rug.nl)
Department of Operations, University of Groningen, The Netherlands

Tillmann Böhme
School of Management and Marketing, University of Wollongong, Australia

Dirk Pieter van Donk
Department of Operations, University of Groningen, The Netherlands

Abstract
This exploratory site-centred research investigates barriers to internal supply chain integration in practice, using systems thinking. A multi-method procedure termed the Quick Scan Audit Methodology is applied to four engineering to order case companies from two different country settings to identify and categorize the actual barriers to internal supply chain integration. The study establishes that the case-significant barriers to internal supply chain integration chiefly relate to behavioral / cultural factors and the organizational arrangement / structures imposed on employees. A cross-case comparison reveals two major clusters of supply chain integration barriers termed "fire-fighting" and "functional-silo mentalities". The fundamental structures of these clusters are identified.

Keywords: Barriers to integration, supply chain integration, systems theory

1. Introduction
Integration of supply chains – either within or between organization - continues to be a subject of significant research and debate within academe (Towill et al., 2002; Vickery et al., 2003; Droge et al., 2004; Swink et al., 2007; Flynn et al., 2010). The concept of integration originates from a systems perspective: because trade-offs and wider ranging decisions can be made based on shared information and coordination, optimization of the whole system is held to achieve better performance than a string of optimized sub-systems (Christopher, 1998). The purpose of linking internal functions, suppliers, customers and hence of removing barriers that impede the flow of materials and information is accordingly to improve organizational performance and/or supply chain performance. (Van der Vaart & Van Donk, 2004; Goldman et al., 1995; Sabath, 1998). In-depth investigations of the internal barriers to supply chain integration are rare though; noteworthy exceptions include those by Bagchi and Skjoett-Larsen (2002), van Donk and van der Vaart (2005), and Whipple and Frankel (2000). Giménez (2004) pronounced that the barriers to supply chain integration lack a commonly agreed classification schema. Pagell (2004), Giménez (2004), Lambert and Cooper (2000) stated that there is still a lack of understanding of the inhibitors/barriers to internal supply chain integration. According to Richey Jr. et al. (2009), Stevens (1989), Lambert and Cooper (2000) such a lack of knowledge regarding the internal chain would make the successful removal of seams and obstacles in the entire supply chain a challenge. The limited research concerned with barriers in the internal supply chain has focused on organizational structure, measurement and reward systems,

information technology, and operational skills e.g. Wisner et al. (2005), Ellinger et al. (2006), Barki and Pinsonneault (2005), and Barratt (2004). Still, Storey et al. (2005) stated that much of the supply chain literature underestimates organizational and behavioral complexities while Ellinger et al. (2006) observed 'a compelling need to develop a more comprehensive understanding of the behavioral factors that facilitate (or inhibit) inter-functional collaboration'. This remains an important issue since, despite more than 20 years of academic study, there exists a significant gap between supply chain theory and practice, and with many scholars reporting that only few companies engage in extensive or advanced supply chain integration practices (Akkermans et al., 1999; Halldorsson et al., 2008; Towill et al., 2002, Zailani & Rajagopal, 2005).

This leads us to believe that although the existence of barriers to supply chain integration is acknowledged and the barriers categorized, research into the deeper behavioral roots of these barriers is still needed. The main aim of our research is thus to further explore the underlying behavioral grounds of barriers to supply chain integration by an explorative method. The empirical context of this paper is four case studies in The Netherlands and in New Zealand. The remainder of this paper is structured as follows: A review of relevant literature is followed by description of the methodology used to expose the barriers to SCI in the four cases. The four case companies are briefly described, findings are discussed and future research avenues are highlighted.

Literature Review

Supply chain integration is perceived both as the extent to which an organization manages its intra- and inter-organizational processes to achieve effective and efficient flows of products, services, information, money and decisions with the objective of providing maximum value to its customers (Bowersox et al., 2002, Frohlich & Westbrook, 2001; Naylor et al., 1999), and as the endeavor of removing barriers that impede the realization of the utopian, fully integrated, seamless supply chain (e.g. Childerhouse et al. 2011). The focus of this research will be on the challenge of achieving a seamless supply chain rather than on the state of the supply chains investigated (the barriers in the supply chains). Walker et al. (2008) discern that the majority of barriers tend to be internal rather than external. Richey Jr. et al. (2009) conclude that it is more meaningful to examine internal barriers because these are the ones a firm can directly control. The scope of the present study is hence limited to close examination of internal supply chains, which makes it different from the majority of papers that focus on inter-organizational SC integration.

The academe generally agrees that careful examination of the barriers between and within organizations is important as an understanding is crucial to their removal (Giménez, 2004; Romano, 2003). Storey et al., (2005) concentrated on the barriers to customer-responsive supply chain management, which include factors inhibiting the integration of operations, purchasing; Pagell (2004) targeted barriers in logistics; Walker et al., (2008) addressed barriers to environmental supply chain management. The amount of research on how to achieve an integrated supply chain is limited though, and a comprehensive study of the factors inhibiting or enabling integration among the key internal supply chain functions is lacking (Pagell 2004). In a recent review of 35 articles that were variously concerned with internal and external benefits, barriers, and bridges to effective supply chain management, Fawcett et al. (2008) concluded that the resisting forces arise both from the nature of the organization itself, as well as from the people comprising the organization's workforce and earlier, Fawcett et al. (2006) revealed that managers at many firms find it more difficult to collaborate within the four walls of their own company than with outside channel members. It is evident from the literature that barriers to supply chain integration appear in many guises and that they also influence each another (Jharkharia & Shankar, 2005). Nevertheless, relatively little research is devoted to

human factors and to the question of whether these human factors could perhaps form the underlying causes for the barriers to supply chain integration recognized in literature. Because of the systems foundations of the quest for supply chain integration and because of the presumed interdependencies between the factors inhibiting that integration, a systems perspective is occupied. According to Fawcett et al. (2007) *Systems thinking is the holistic process of considering both the immediate local outcomes and the longer-term system-wide ramification of decisions. Whereas traditional functional thinking seeks the local optimum – often at the expense of the overall system's performance – systems thinking aligns efforts; getting everyone to pull in the same direction. (pp. 74-75).* Providing both a means of understanding the situation and of communicating this understanding to others, systems thinking offers a methodology for describing, analyzing, and planning complex systems of different kinds (Jenkins, 1972; Parnaby, 1979). In this study, systems thinking is hence used in studying inhibitors to supply chain integration and in uncovering their underlying causes.

Methodology

Systems theory forms the underlying basis for Quick Scan Audit Methodology (QSAM) and is hence judged to be suitable to investigate barriers to internal supply chain integration in practice. QSAM is a 'rich picture' procedure originating from the Logistics Systems Dynamics Group at Cardiff University. A key characteristic of QSAM is that it aims to achieve an optimum compromise between qualitative and quantitative methods of management theory research, by making maximum use of resources (primarily) in field-based activities in the search for 'meaning of evidence' (Eisenhardt, 1989). A comprehensive overview of the QASM can be found in in Naim et al. (2002).

A key element of QSAM is that data extracted from the supply chain system is analyzed using systems thinking principles to create a cause-effect diagram (Childerhouse and Towill, 2004). Such procedures fulfill the integrated/systems thinking perspective requirement of Edwards and Ram (2006), and also have two further strengths: the cause-effect diagram is developed jointly by the onsite research team members (researcher triangulation is achieved); and, by adopting a holistic/systems perspective, specific issues are combined to provide a complete 'rich picture' of the focal company situation. In addition to the visual depiction of the causes of observed uncertainties, rich pictures of cause-effect feedback loops also act as a guide for future 'high leverage' (maximum benefit/minimum effort) process improvements. Lindberg et al. (2003) emphasize that a chief advantage of the rich picture is in providing an important focus for debate and understanding between various functions in an organization; so that recommended process changes translate into informed agreement. Figure 1 presents one example of such a rich picture.

Figure 1, which is based on an actual feedback session, indicates the main obstacles and barriers obstructing the integrated flow of one Dutch based case company. These collectively give rise to the observed 'major pains', labeled 'loss of spare-parts market share' and 'considerable inefficiencies' that emerged in the situation. The root causes for the identified major pains are predominantly located in strategic management. The organization positions itself as an *engineering to order* company. Yet, the company culture through all functions and ranks remains manufacturing focused and over the past decade NL1 acquired and upgraded much of the required manufacturing capabilities to allow for efficient production. The company is financial performance criteria driven which results in a "busy focusness" and ultimately to high levels of internal uncertainty resulting in the previously mentioned major pains.

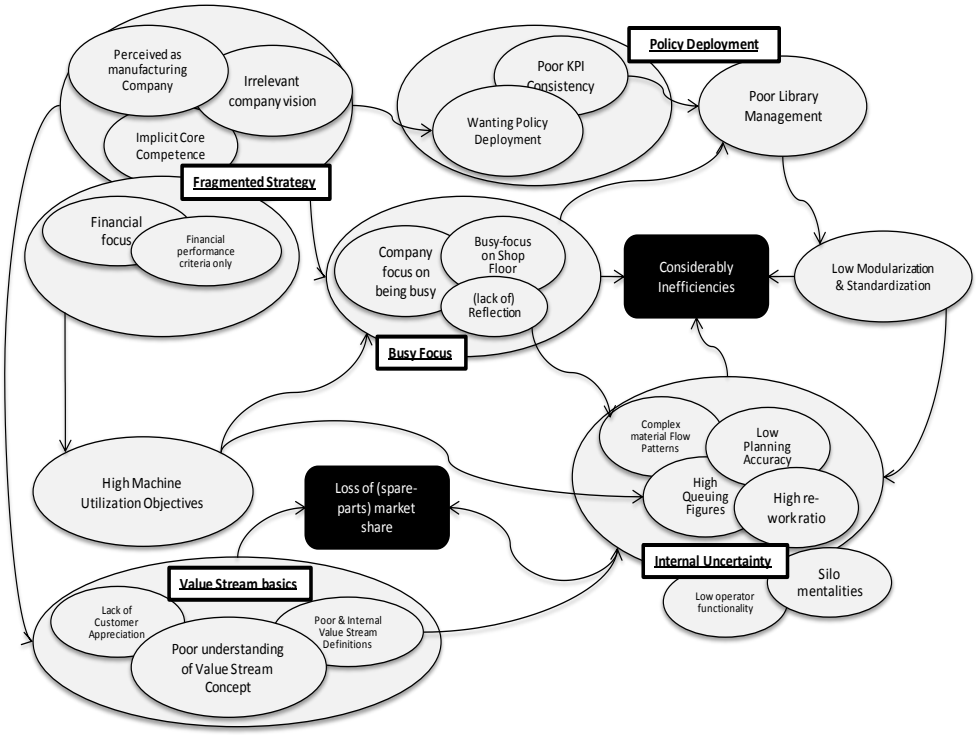

Figure 1- Cause-effect diagram for case company NL1

In total four QSAM audits were conducted between 2006 and 2010. The focal companies comprised two engineering to order companies from the Netherlands and two engineering to order companies from New Zealand. The scope of the research was limited to the investigation of internal processes and here in particular the Product Introduction Process and the Product Delivery Process. Minor attention has been paid to the Marketing and Sales Process. All four companies are of medium size, allowing for broadening the scope to more interdisciplinary research including strategic management, finance as well as information systems (Böhme et al., 2012). NZ1, NL1, and NL2 have a great amount of commonalities including product, market, and value adding steps. NZ2 instead is best described as a boutique foundry, which includes in-house patternmaking capabilities. The selection of New Zealand and Dutch engineering to order companies allow for investigation of two distinct environmental settings, as well as cross-case comparison. Table 1 provides a summary of the four case companies.

Table 1: Summary of the four medium-sized engineering to order case companies

Case Company	Year	Products	Value Adding
NZ1	2006	Multi-tonne machine deployed in construction sites	Engineering, sheet cutting, machining and assembly
NZ2	2008	Design and manufacturer of special purpose machinery and components	Engineering, patternmaking, foundry, large scale machining and welding
NL1	2010	Multi-tonne machine deployed in the mining industry	Engineering, machining, assembly, and testing.
NL2	2010	Multi-tonne machine deployed in the refinery industry	Engineering, procurement, assembly, and testing

Some 100 researcher-days in total were spent in the field investigating real world barriers to integration. Those research days were approximately matched by the Quick Scan sponsor through employee involvement of the sponsoring organizations. In all four cases, the general procedures of QASM were maintained. To facilitate data triangulation, care was taken to acquire overlapping data from different sources. In off-site meetings, researchers assessed the acquired data to come to preliminary clustering of data in preparation of further on-site research. After the second company visit the team of researchers convened to codify the data acquired through interviews and to realize a final clustering of factors impeding supply chain integration. Subsequently, the team of researchers constructed cause and effect models based on the clustered data. With the help of the thus formed cause and effect models, causes were identified as being root-causes (either because an identified factor appeared to be at the beginning of a causal chain or because a hidden factor could be identified as a cause for a phenomenon emerging from the cause and effect model).

Findings

Individual case findings

The key barriers to internal supply chain integration were identified from examination of the four cause-effect diagrams. These barriers were then categorised using the Business Process Reengineering (BPR) change model by Childerhouse et al. (2003) as the authors previously applied this framework to a large variety of case examples with some success. Table 2 shows the identified barriers to internal supply chain integration for each case company.

Table 2: Identified barriers within each category

		Case Companies			
Barrier	**Identified barriers to internal supply chain integration**	**NZ1**	**NZ2**	**NL1**	**NL2**
Culture	• Defensive culture, silo focus, negative towards change	R	R	*B*	*B*
	• Lack of skilled management staff	R	*R*	-	-
	• Lack of skilled shop floor staff	B	B	B	-
	• Union activity creates 'us vs. them' attitude	-	B	-	-
	• Poor knowledge management.	-	B	*B*	B
	• History	-	B	R	R
	Overall Barrier Height (OBH):	**H**	**H**	**H**	**H**
Technology	• IS system supports finance/ accounting only	B	B	-	B
	• Multiple independent information systems	B	B	B	B
	Overall Barrier Height (OBH):	**M**	**M**	**L**	**M**
Finance	• Lack of willingness to invest in sc improvement	B	B	B	-
	• Unable to invest in sc improvement	-	-	-	-
	Overall Barrier Height (OBH):	**L**	**M**	**M**	**L**
Organization	• Organizational structure	*B*	B	-	-
	• Lack of staff training	B	B	B	-
	• Reward System	B	N/A	-	-
	• Geographical dispersion	B	-	-	-
	• Lack of top management support	-	R	R	-
	• Strategic misalignment	*B*	R	*R*	B
	• Competing value streams	*B*	B	*B*	B
	• Insufficient/ inconsistent value stream measures	*R*	B	*B*	B
	• Poor material flow	*B*	B	*B*	-
	Overall Barrier Height (OBH):	**H**	**H**	**H**	**M**

Results for the Culture category in Table 2 show that work culture and attitude in all four case companies are cause for management concern. More importantly, in both New Zealand cases culture and attitude has been identified as a root cause. Hence, managers in these companies struggle to implement supply chain or process improvement programmes due to a culture that encourages resistance to change. Further, lack of skilled management staff is also a frequent root cause in New Zealand's engineering to order sector; particularly due to a lack of strategic appreciation of supply chain management. In NZ1 and NZ2 the majority of key supply chain staff had no tertiary qualifications and gained most of their knowledge by on the job experience. In the case of NZ2, key supply chain positions are held by engineers who lack general management and supply chain management skills. Poor knowledge management is identified as a critical Barrier in NZ2, NL1, and NL2 where many supply chain staff are long-time employees with in-depth tacit knowledge of the plant. In light of the many root causes present, the Culture category overall barrier height (OBH) in all four case companies is indicated in Table 2 as being High.

In the Technology category, it was noted that every case company operates with multiple independent and loosely coupled information systems. These provide inadequate and incomplete end-to-end information to employees, who consequently tend to have little faith in the information provided. It was also noted that most of the available supply chain data is financial in nature. Although this shows the (alleged) bottom line status of the focal company this is not sufficient for supply chain management and operational decision making. Presenting as a common barrier, although with no root causes, the Technology category overall barrier height (OBH) is indicated in Table 2 as being Medium for most case companies.

In the Finance category, the research revealed a stable financial situation for all four case companies. Differences occurred only in their willingness to invest in supply chain process improvement projects and in the bureaucratic procedures involved in working with overseas headquarters. Overall, the Finance category overall barrier height (OBH) for the two of the four case companies is judged medium because NZ2 and NL1 struggle with the top management support/ willingness to invest in supply chain improvements.

In the Organization category, both New Zealand case companies are hierarchically managed and functionally orientated. Lack of top management support was identified as a root cause in two of the four case companies. However, top management support is essential when sub-optimizing one function for the overall good of the end to end process. Misalignment and fragmentation of the overarching company strategy with supply chain strategy creates barriers to process improvement. In the case of NZ2 and NL1 strategic issues were identified as root causes. In all four cases competing value streams are limiting supply chain integration. In most of the cases product flow is frequently interrupted because multiple products require identical resources. This causes queues and large increases in production lead time. The research also reveals a lack of value stream measures in all four case companies. In light of the many root causes present the organization overall barrier height (OBH) for three of the four case companies is indicated in Table 2 as being Major Pain NZ1: Inefficiencies and lost opportunities due to excessive fire fighting. These are rooted in lack of knowledge and training, functional driven KPI's combined with a *shop floor attitude* vs. *management attitude* and a highly inconsistent S&OP process (ambiguity is the norm rather than the exception).

Cross-case analysis

Even so, the QSAM revealed that each organisation suffers from a unique set of interrelated barriers; a cross-case analysis was conducted in the search for pattern. The cross-case comparison of the cause and effect diagrams helped in identifying predictor variables and causal interactions (Stuart et al., 2002). Two major patterns emerged termed (1) functional silos (2) problem solving via fire fighting. Figure 2 reflects a detailed cause and effect situation

frequently observed in the case companies, and shows the interrelation of company culture, people, and organisation factors that act to reinforce the functional silos.

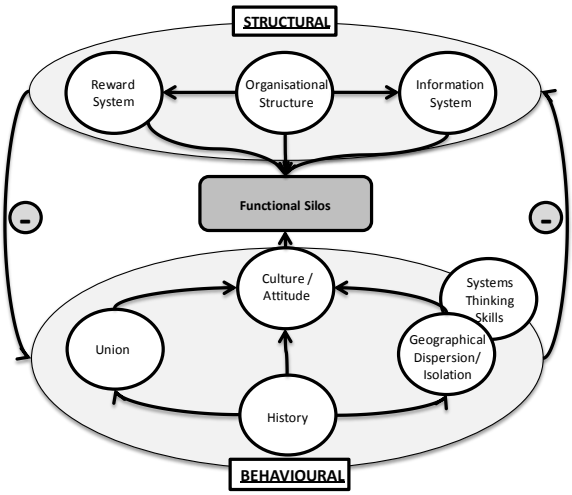

Figure 2- A systems perspective on functional silos

It can be seen that the origins of functional silos are often entrenched in the company history, which influences workplace culture and attitude directly and also indirectly via long-term relations with workplace unions. Also, the physically separation of departments further impacting culture and attitude and reinforcing the functional silos. The presence of independent and loosely coupled information systems also discourages cross functional communication (Disney et al., 2008) and offers poor supply chain visibility. Furthermore, reward systems aligned to hierarchical organisational structures serve to cement in place the functional silo mentality. Finally, Figure 2 indicates that geographically dispersion causes problems for companies attempting to attract qualified staff, which directly impacts the supply chain skills that are available to a company. Hence, the behavioural aspects often observed within culture and attitude can form a negative reinforcing loop with the structural elements within a company resulting in a deep entrenchment of silo mentalities.

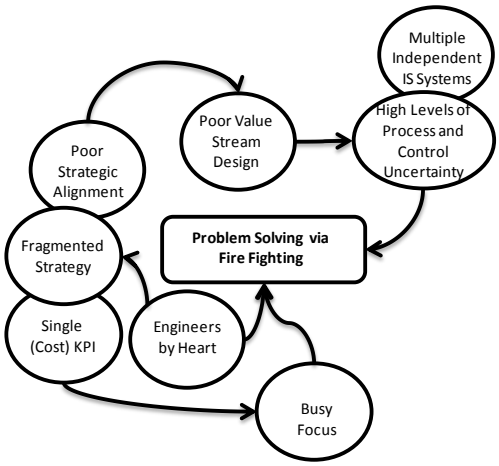

Figure 3- A systems perspective on problem solving via fire fighting

The second commonality observed across all four cases is termed problem solving via fire-fighting (see Figure 3) originated from a partly fragmented and often unclear company strategy. Company visions and strategies were often expressed in financial KPI's resulting in low levels of understanding and buy-in from middle management and shop-floor staff members. The strategic issue filters through resulting in poor strategic alignment and hence poor value stream design; which then leads to high levels of process and control uncertainty. These levels of uncertainty are further enhanced by multiple independent and often inappropriate information systems encouraging high levels of fire fighting activities within the business. The financially driven company strategy encourages cost foci KPI's; which results in a company-wide "obsession" of being busy.

In all four cases, functional silos and a fire-fighting mentality was acknowledged by members of the organization during the feedback presentations (a fire-fighting mentality being indicated on several occasions during the on-site research and explicitly mentioned in the feedback presentations). In the NL2 case, engineers considered themselves to be fire fighters at heart, this worldview permeating the whole organization.

Discussion and Conclusion

The main aim of this paper is to further explore the underlying behavioral grounds of barriers to supply chain integration by an explorative method. First, the current research confirms that the majority of the barriers to internal supply chain integration occur on a cultural and organization level (Lambert & Cooper, 2000; Mentzer et al., 2000; Petersen et al., 2005; Shapiro's, 2001; Storey et al., 2005; Whipple & Frankel, 2000). Lack of top management support, poor strategic management and alignment, and insufficient and inconsistent measurement were identified as common root-causes for hampered supply chain integration. In all four cases competing value streams were constraining internal integration.

Second, the cross-case comparison of the cause and effect diagrams helped in identifying predictor variables and causal interactions (Stuart et al., 2002). Two major behavioural patterns emerged from this exertion are coined (1) "fire-fighting" and (2) "functional-silo mentalities". Both are found to have their roots in the World Views of managers and employees and the soft, sociological characteristics of the organizations and departments investigated. Systems thinking via QSAM enabled the researcher to provide detailed insights into the fundamental structures of these two patterns.

Arguably internal barriers are partially influenced by industrial norms (here engineering to order) and environmental settings these companies are operating in. The geographical isolation of the two New Zealand case examples resulted in a poor uptake of supply chain principles because high caliber supply chain professionals were hard to attract to those remote areas. Also, the two Dutch cases operate in an industry that reintroduces middleman to the supply chain for liability reasons, which results in information distortion and hence an increase in control uncertainty.

In addition to the usual research constraints of time, finance, and access to data several limitations of this research offer avenues for further study in this important area. First, more research is required to validate the various barriers; their categories and the two forthcoming cross case behavioral grounds. Second the research discussed the importance and influence of industry standards and environmental factors to internal supply chain integration; however a stronger contingency theory approach is expected to share even greater insight into the current topic. In addition researchers need to find ways to remove barriers to integration, or at least mitigate their effects. In the future, research initiatives to aid understanding of barrier mitigation may involve a number of key disciplines, including: systems thinking, information theory, industrial dynamics, production economics, social theory, game theory and production/ systems engineering among others.

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