How efforts to achieve resiliency fit with lean and agile practices

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Abstract
Regarding today's volatile and turbulent markets, becoming resilient has become crucially important. While many researchers seek to identify factors that can help firms (and their supply chains) achieve resilience, questions regarding how resilience fits with leanness and agility remain unanswered. This paper aims to answer this question.

Keywords: Resilience, Leanness, Agility

Introduction
Any supply chain can be vulnerable to disruptions that affect the performance outcomes. To encounter and response to these risks and recover from them, efforts to improve resilience are needed to protect these performance outcomes. However, companies are already undertaking efforts to become more lean and/or agile to improve the same performance measures. So managers need to know 'how' efforts to achieve resilience fit with lean and agile practices.

There is the possibility that the efforts to achieve leanness or agility may help, hinder or be unrelated to the efforts to achieve resilience. Melnyk (2007) believes lack of extra resources makes coping with unplanned events impossible and that lean supply chains become more fragile, without buffers in the form of extra capacity, lead time and inventory. Towill (2005) states that agility without resiliency can create an overexposed organization that severe shocks and disruptions can severely damage its performance and threaten its survival.

We have not found any research-to-date to empirically assess how efforts to achieve resiliency fit with efforts to achieve leanness and agility. Our research seeks to answer the research question that "how does resilience fit with leanness and agility?" to fill this gap in the literature.

Literature Review
We carried out a detailed literature review to identify the main initiatives/practices of the three approaches of leanness, agility and resilience (LAR) and to specify the overlapping and non-overlapping areas between them (Table 1).

Managers carry out different initiatives to improve desired performance outcomes. Lean and agile are two such initiatives that have received much attention in recent years

(Hallgren and Olhager 2009). Some authors believe leanness and agility are subsets of the other (Shah and Ward 2003). As such Sarkis (2001) states that agile manufacturing is flexible manufacturing system added to lean manufacturing. Some others believe lean and agile put different emphasis on the same set of dimensions (Narasimhan et al. 2006). Their justification is that there are elements of lean manufacturing especially within JIT that confirm these two concepts can be supportive. The third group believe lean and agile are different and the concept of leagility emerged (Naylor et al. 1999). According to Hoek (2000), the aim of 'leagility' is combining waste elimination or efficiency with customer responsiveness within the same supply chain.

On the other hand, researchers are already raising questions about a third element neglected in these two views and that is the concept of resilience. Juttner (2005) recommends that firms should try to be lean but not too lean since the risks increase dramatically. In a lean supply chain, decreasing inventory as a waste increases the impact of supply chain disruption (Chopra and Sodhi 2004). Konecka (2010) states that agility, is the best way to satisfy more demanding clients. This is due to a lower risk of unsatisfying of the customers, lost orders and too slow responses. However, it has its own risks.

Panomarov and Holcomb (2009) state existing definitions of resilience are contradictory and confusing and that researchers are still trying to develop the unified theory of resiliency. This research uses their definition of supply chain resilience which is "The adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function"(Panomarov and Holcomb 2009: P. 131). Leanness can be defined as developing a value stream to delete all waste, including time, and enabling a level schedule (Naylor et al. 1999). A level schedule means that the manufacturing process must be kept away from volatility, uncertainty and variation. Swafford et al. (2006) define agility as "the supply chain's capability to adapt or respond in a speedy manner to a changing marketplace environment".

Table-1 List of papers reviewed for Leanness, Agility, and Resilience

Lean	Hayes and Pisano 1994, Moore 1998, Ivezic 1999, Sanchez et al. 2001, Van der vorst et al. 2001, Shah and Ward 2003, Treville and Antonakis 2005, Melton 2005, Simpson and Power 2005, Goldsby et al. 2006, Narasimhan et al. 2006, Shah and Ward 2007, Fullerton and Wempe 2008
Agile	Sharifi and Zahng 1999, Hormozi 2001, Sharifi and Zhang 2001, Yusuf and Adeleye 2002, Gunasekaran and Yusuf 2002, Aitken et al. 2002, Jin Hai et al. 2003, Prince and Kay 2003, Christopher and peck 2004, Swafford et al. 2006, Vázquez-Bustelo et al. 2007, Bruanscheidel and suresh 2009, Hallgren and Olhager 2009
Resilient	Bruneau et al. 2003, Christopher and peck 2004, Chopra and Sodhi 2004, Sheffi and Rice 2005, Sheffi 2005, Kleindorfer and Saad 2005, Peck 2006, Tang 2006, Manuj and Mentzer 2008, Ponomarov et al. 2009, Pettit et al. 2010, Bartos and Balmford 2011

Based on our literature review we conclude there are some overlapping and non-overlapping practices/initiatives across leanness, agility and resilience (Table 2). But do these overlaps occur in practice as well? While Konecka (2010) tries to consider lean and agile supply chain management concepts in the aspect of risk management, other studies such as the works of Machado and Duarte (2010) and Azevedo et al. (2011) provide conceptual models of leanness, agility and resilience; however, the issue remains to be settled empirically.

Table2- Overlapping and non-overlapping practices/initiatives between resilience, leanness and agility

Practices/initiatives	Related to resilience	Related to leanness	Related to agility
Business Continuity (BC)	x		
Contingency plans	x		
Decentralization of physical assets in multiple locations	x		
Detection systems in place to detect any supply chain disruption	x		
Delivery of small batches	x		
Establishing communication line in case of a disruption in the supply chain	x		
Security against deliberate intrusion or attack	x		
Alternative modes of transportation in the supply chain	x		
Total preventative maintenance (TPM)		x	
Statistical process control (SPC)		x	
Cellular manufacturing		x	
Efficiency, producing outputs with minimum resources		x	
Integrating different functions in the company			x
Computer based technologies to manage manufacturing processes.			x
Customizing the final product for individual end-customers			x
Increasing ability to respond to rapidly to changing situation somewhere in the supply chain			x
Time-to-market, i.e., introducing new products quickly			x
Quick changeover techniques to reduce process downtime between product changeovers		x	x
Capability to implement new technologies		x	x
Concurrent engineering for overlapping activities in product design to achieve simultaneous development.		x	x
Knowledge management		x	x
Just In Time (JIT)		x	x
Flexible manufacturing equipment to produce different products with the same facilities	x	x	
Visibility – knowing the status of operating assets and the environment within the supply chain	x	x	
Excess capacity in the supply chain to absorb sudden increases in demand	x	x	
Redundant suppliers (two or more suppliers for the same part with these suppliers being capable to substitute each other)	x	x	
Collaboration with suppliers (Ability to work effectively with suppliers for mutual benefit)	x	x	x
Similar continuous improvement initiatives	x	x	x
Cross-functional workforce	x	x	x

Questionnaire Design and Data Collection

We drafted a questionnaire in English based on Table 2. Then it was pre-tested with five supply chain managers and four academics who were asked to review the questionnaire for readability, ambiguity, and completeness (Dillman 1991). Minor changes were made based on these pre-tests. The English questionnaire was then translated into German by a native speaker and translated back into English to ensure similarity of meaning and to guarantee translation equivalence (Craig and Douglas 2005).

The survey carried out was done online in Germany. The survey was sent as an attached email survey during Spring-Summer 2012. Germany was chosen for data collection because of the country's strong base in manufacturing. Manufacturing, Supply Chain, Sourcing/Strategic sourcing and Marketing/Customer relations managers are targeted because it was concluded they are most appropriate ones with their particular knowledge related to supply chain initiatives and practices.

573 emails were sent, 185 questionnaires where answered, 20 of these questionnaires were mostly blank. Following Dillman's Total Design Method (Dillman 1991), Three reminders for following up were sent with the intervals of 1,2 and 4 weeks, resulted in the response rate of 29.84 %. Managers were asked to which extent they think implementing these initiatives and practices would help their organization become lean, agile and resilient. All the questions were on a 5 point Likert scale.

Sample Characteristics

Sample characteristics are summarized in Table 3.

Table 3- Sample Characteristics (%)

Industry Sector		**Area of respondent**		**Plant age**		**No. of employees**	
Manufacturing	55.3	Production	27.9	Less than 10 years	32.3	Less than 100	51.2
Energy and water supply	1.2	Supply Chain	29.7	More than 20 years	59.0	100-249	10.4
				Between 10 and 20 years	8.7	250-499	12.8
Wholesale and retail trade	4.3	Sourcing/Strategic sourcing	10.3			500-999	20.1
mining and quarrying	.6	Marketing/ Customer relations	14.5			More than 1000	5.5
Post and telecommunication	1.2	Other	17.6				
Real estate, renting and business activities	.6	**Years of experience at the position**		**Number of plants**		**Average annual sale**	
Public administration and defense	.6	Less than 5 year	30.5	Less than 3plants	58.1	Less than € 10 Million	46.3
Health and social work	2.5	More than 10 years	56.7	More than 6 plants	31.9	€ 10-50 Million	16.7
Other community,	1.9	Between 5	12.8	Between	10.0	€ 51-100	9.9

social and personal service activities		and 10 years		3 and 6 plants		Million	
Others	31.7	**Years working with the company at the position**				€ 101-250 Million	8.6
		Less than 5 year	36.6			€ 251-500 Million	4.9
		More than 10 years	52.4			More than € 500 Million	13.6
		Between 5 and 10 years	11.0				

Scale Development and Analysis

At first we assessed the reliability and validity of the constructs using SPSS 19 and AMOS 19, including three CFA models using the maximum likelihood estimation method. Since we formed theory-based a priori links between item measures and constructs based on the literature, confirmatory factor analysis was performed. The results of the three CFAs show acceptable values for reliability, with Cronbach's alpha values being above 0.7 in all cases (Swafford et al. 2006). These are the results of final models – in earlier models, some items were deleted to improve Cronbach's alpha for reliability when we were sure this would not affect content validity. Also in running CFAs, modification indices were investigated for improvement. For convergent validity which represents how well the items measures relate to each other with respect to a common concept, and is exhibited by having significant factor loadings of measures on hypothesized constructs (Anderson and Gerbing 1988), items with loading under .5 were deleted in the three CFA models (Inman et al. 2011). The results of significant standardized regression weights of measures on leanness, agility and resilience after reliability and validity tests are presented in Table 4.

Table 4- Significant Standardized regression weights of measures after reliability and validity tests on leanness, agility and resilience

Practices/ initiatives	**Standardized regression weights on resilience**	**Standardized regression weights on leanness**	**Standardized regression weights on agility**
Business Continuity (BC)	.555		
Contingency plans	.602		
Detection systems in place to detect any supply chain disruption	.723		
Establishing communication line in case of a disruption in the supply chain	.691		
Total preventative maintenance (TPM)		.595	
Efficiency, producing outputs with minimum resources.		.593	
Integrating different functions in the company			.565
Increasing ability to respond to rapidly to changing situation somewhere in the supply chain			.602
Time to market			.709

Quick changeover techniques to reduce process downtime between product changeovers		.664	.660
Capability to implement new technologies		.692	.677
Concurrent engineering for overlapping activities in product design to achieve simultaneous development.		.506	.545
Redundant suppliers	.538		.525
Knowledge management			.614
Just In Time (JIT) methodology		.572	
Flexible manufacturing equipment to produce different products with the same facilities			.561
Visibility	.821		.596
Excess capacity in the supply chain to absorb sudden increases in demand			.497
Continuous improvement initiatives	.528	.518	
Cross-functional workforce	.548		.532
Collaboration with suppliers	.573	.543	.604

The fit indices for the three final CFA models are presented in Table 5.

Table 5- Fit indices of CFAs

Constructs and Items	**Cronbach's alpha**	**CMIN/DF**	**GFI**	**CFI**	**RMSEA**
Resilience(R)	.859	1.934	.936	.948	.073
Agile (A)	.870	1.991	.903	.912	.075
Lean (L)	.818	1.854	.946	.948	.070

Conclusion

If we consider all the CFA results for lean, agile and resilience, we can conclude that:
(1)“Business continuity”, “Contingency plan”, “Establishing communication lines” and “Detection systems in place” purely affect resilience. Our literature review showed that these factors also purely affect resilience.
(2) “Visibility”, “Cross trained workforce” and “Redundant suppliers” affects both resilience and agility. For “Visibility” and “Redundant supplier”, literature also mentions that these factors affect agility and resiliency. For “Cross trained workforce”, literature mention it as a factor which affects the three of LAR, while our research shows in industry, the belief is that it affects agility and resiliency rather than lean.
(3) “Continues improvement initiatives” affect lean and resiliency. The result of the literature review showed that this factor helps the three of LAR, while our research shows that it affects leanness and resiliency rather than agility.
(4) “Collaboration with supplier” affects resilience, leanness and agility. The literature also mentions this factor as a factor that affects the three of LAR.

Contributions, limitations, and future research

The contribution of this research is clarifying the concept of resiliency especially regarding previous concepts in supply chain such as leanness and agility, thus shedding light on investigating 'how' efforts to achieve resilience fit with lean and agile initiatives. This will increase clarity within the existing literature stream.

The limitation such as many other survey studies is the issue of generalizability. To establish evidence of statistical generalizability, we need to repeat the study with new samples. Future research is to investigate how leanness, agility and resilience affect the operational performance outcomes.

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