Leanness and agility: A comparative theoretical view

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Abstract

Purpose - The main aim of this research is to compare and distinguish between two salient means for improving the management of, and leveraging the effectiveness of, supply chains. Leanness and agility have been considered recently as prominent and successful means for competing. The paper examines the literature on leanness and agility thinking including their definitions, importance and practices. The paper also highlights the argument surrounding the relationship direction between these two concepts.

Design/methodology/approach – A systematic comparative review was conducted on the lean literature and agility literature at three levels: manufacturing, organisation, and supply chain. The systematic review on the lean concept has been conducted based on articles published over the last two decades. The agility concept review was conducted based on the articles published from its inception in 1991 through early 2016.

Findings – a conceptual framework is presented following the in-depth review. The conceptual framework sets out the input, operational practice and output elements necessary for both philosophies to take root successfully. A discussion based on the review of the literature on the direction of the relationship between leanness and agility is also presented, and should also be included in any future empirical testing of the conceptual framework.

Research limitations/implications – The paper is based on a systematic review which extends previous research as it has been conducted in a detailed and clear systematic manner which enables a deepl understanding of the similarities and differences between leanness and agility philosophies from an operational perspective: inputs, operational, and outcomes elements. Future research is required to empirically test the conceptual relationships.

Practical implications - Companies are constantly searching for ways to improve their supply chains. This paper seeks to provide a deep understanding for lean and agility philosophies as important means for achieving this goal. This has been conducted by clarifying the differences, similarities and the direction of the relationship that may exist between these two approaches as means for improving a company's supply chain.

Originality/value – Based on a systematic review on leanness and agility philosophies, a conceptual framework exploring the differences and similarities between both philosophies from an operational systematic perspective is presented.

Keywords – Supply chain management, lean manufacturing, lean enterprise, lean supply, agile manufacturing, agile enterprise, and agile supply chain

Paper type – Literature review

1. Introduction and background

Many studies have highlighted the importance of the supply chain and its management (Shukla et al., 2011; Gorane and Kant, 2015; Sweeney et al., 2015). The area has received increased attention due to today's highly changeable and complex business environment. Leanness and agility are two business philosophies that were first introduced to be applied as production systems. However, they have gone beyond this limited functional area to be applied as a means for doing business, and consequently have been applied at the level of the whole supply chain. Despite the interest, and despite the emergence more recently of the concept of leagile (Potter et al., 2015; Gaudenzi and Christopher, 2015), how these two business concepts compare and contrast and can be applied simultaneously to achieve success for the whole supply chain has not been examined in detail. Little is known for example, about the extent to which they can or do interact in a complementary or opposing fashion. This gap is very concerning as it highlights a lack of guidance for practicing managers facing difficult decisions about where to deploy (often sparse) resources for improvement. It also highlights the absence of a solid foundation for research to build on in its efforts to help provide practitioners with the clearer and more nuanced understanding of how, if and when to prioritise the application of different and potentially complementary elements of the two concepts. To remedy this gap in the literature, in this paper we provide a comparative examination of the two concepts, as an initial building block for the development of a greater understanding of the potentially complex dynamics of the two concepts.

Leanness as a concept was first specified by John Krafcif as a term for the new production system applied by Toyota (Bendell, 2006). The lean approach became widely recognised after the introduction of Womack et al.'s (1990) book. Initially, the lean concept was known as a production system to help in reducing waste in manufacturing departments; however, it went on to be applied as a holistic 'way of doing business' by many companies. Womack and Jones (1994) themselves argued for the lean enterprise as a concept that extends beyond simply a production focus (cited in McIvor, 2001). Recently, it has also entered the supply chain field as a way for improving supply chain performance.

As with the leanness approach, the concept of agility was also introduced initially to be applied in manufacturing. Agile manufacturing can be traced to researchers at Iacocca Institute, Le high University (Yusuf et al., 1999). Agility can be considered as the ability to be flexible and fast alongside the capability of being able to change proficiency (Ramasesh

et al., 2001). Several studies have focused on it as a means for improving the production systems inside organisations (e.g. Narasimhan et al., 2006; Yusuf et al., 1999). Subsequently it has been applied to the whole organisation, and several studies have focused on it as a way of doing business to improve the overall performance of the organisation and its ability to react to market conditions (e.g. Sheriehy et al., 2007). Others have focused recently on the concept as an 'umbrella' combining all the businesses entities within the same supply chain, and encouraging them to work together to improve supply chain performance collectively (Van Hoek et al., 2001).

Recently, there is a new term introduced called 'Leagility'. This describes the belief that leanness and agility philosophies can be applied complementarily within the same supply chain (Potter et al., 2015; Gaudenzi and Christopher, 2015). However, the literature contains ambiguity about the form of the relationship that may exist between the philosophies and the ways in which they can be applied within the same organisation as a means for improving its supply chain.

Much of the recent literature focuses on the fact that individual companies are no longer the source of competition; rather it is their supply chains that are competing in the marketplace (Christopher, 1992). This paper seeks to provide a deep understanding for lean and agility philosophies as important means towards this goal. The main aim is to clarify the differences, similarities and the direction of relationship that may exist between leanness and agility approaches in this supply chain improvement context. This is especially important with the intensive attention on differentiated supply chain strategies for companies offering a variety of products and services in different types of markets, as it is not applicable to implement one supply chain strategy for all types of markets (Hilletofth, 2009). Therefore, this research provides a deep understanding in order to support organisations' decision makers in selecting supply chain strategies suited to every market.

For the methodology of the research, a systematic review has been conducted on the lean literature and agility literature at their three levels: manufacturing, organisation, and supply chain. Two search engines were selected for their relevance, suitability and multidisciplinary nature: ABI/INFORM Global and EBSCO Host. The search string was defined with the purpose of identifying all the papers that compare leanness and agility, and at the same time, narrowing the scope with the purpose of providing deep comparative analysis. Therefore, the search string was "lean"; and "agility"; and "lean and/or agility". The systematic review on lean concept was conducted based on articles published over the

last two decades. The agility concept review was conducted based on the articles published since its inception in 1991 through early 2016. This process identified several hundreds of potential articles. We then applied criteria for selecting those papers suitable for inclusion. The criteria were: firstly, the paper relevance to define lean and/or agility and describe them from their three different levels: manufacturing, organisational, and/or supply chain level. Secondly, the relevance of the papers to provide clear similarities and/or differences between both concepts.. Thirdly, papers published in high ranked peer-review journals were preferred. However, some conference papers and texts were found to be very relevant and provide an important contribution to the analysis and therefore were also included. These criteria were fully met in 51 contributions which were used to develop tables 1, 2, and 3 (the majority (41) were high ranked journal papers; 4 were conference papers; 6 were texts). Each item was analysed and coded to provide a definition and/or a description and/or similarities and/or differences between leanness and agility at the three levels. The collective codes were discussed and then double reviewed to ensure analytical reliability and validity.

The structure of the remainder of the paper is as follows: the next section reviews the relevant literature and provides a deep understanding for the main research constructs: lean thinking, and agility as concepts, and sets out their similarities and differences. Section 3 presents the core elements of the debate surrounding the relationship that exists between the concepts. The purpose of this section is to point to the incompleteness and ambiguity of the existing construction regarding leanness and agility as means for improving supply chains. The final section presents the conclusions based on the study's findings and sets out important directions for further research.

2. Literature review

2.1 *Lean thinking*

Although lean manufacturing as a production system has received important attention from both researchers and industrialists, there is some debate about its roots (Papadopoulou and Ozbayrak, 2005). Arguably, the concept was first coined by John Krafcif to describe the new manufacturing techniques adopted in Toyota by Taiichi Ohno while studying the automobile industry in the 'International Motor Vechicle MIT' programme led by Daniel Roos, James Womack and Daniel Jones (Papadoulou and Ozbayrak, 2005; Bendell, 2006). However, Childerhouse et al. (2000, cited in Aitken et al, 2002), argued that lean

manufacturing systems originated inside the UK, in Spitfire production in the Second World War. Furthermore, even Keirutsu can be traced back to the US automobile industry in 1915 (Drucker, 1995, cited in Aitken et al., 2002). There has also been suggestion that the JIT system was implemented in London during the construction of Crystal Palace (Wilkinson, 2000, cited in Aitken et al., 2002). Despite this debate, lean thinking become well known after the publication of 'The Machine that Changed the World: The Story of Lean Production' (cited in Poppendieck, 2002; Bendell, 2006; McIvor, 2001).

Leanness as a scientific system has been taken to mean a system that aims to use less input to produce greater outputs to meet customer needs, through a fundamental core objective of 'waste reduction' (Li et al, 2005). Motwani (2003) argued that lean manufacturing is an improvement of mass production that involves producing the product right first time, of the required quality, with continuous improvements, using flexible production and reducing any type of waste.

Moving from lean manufacturing to lean organisation, MIT (2000) went beyond the boundaries of the concept as being only a production or manufacturing system, defining leanness as a philosophy that not only includes the practices that take place inside the factory, but that can be considered as a core change in company employees' ways of thinking and hence in their behaviours (cited in Papadoulou and Ozbayrak, 2005). This implies leanness as a way of doing business, and not only as a production system. 'Lean Enterprise' as a term was first introduced by Womack et al. (1990) to explain the fact that 'leanness' can be extended externally and is not confined within the organisational factory boundaries (Papadoulou and Ozbayrak, 2005). Womack and Jones's 1994 text provided detailed discussion of the concept, including five principles for a Lean Enterprise (Papadoulou and Ozbayrak, 2005).

Applying leanness to the supply chain has also been explored in the literature, and Lean Thinking has been extended to cover external relationships, especially with suppliers and customers (Womack and Jones, 1996; Dimanescu et al., 1997; cited in McIvor, 2001), and consequently another term related to leanness, 'lean supply' has emerged. Womack et al. (1990, pp. 138–168) focused on the important role played by suppliers and therefore on the importance of lean supply characteristics. Lamming (1996) provided a lean supply characteristics model that represents the path for future progress (cited in McIvor, 2001). Table 1 provides the salient definitions for 'leanness'.

Table (1): Leanness definitions

Reference	Manufacturing
(Womack et al. 1990, p. 13)	*'Lean producer, by contrast, combines the advantages of craft and mass production, while avoiding the high cost of the former and the rigidity of the later…… Lean Production is "Lean" because it uses less of everything compared with mass production'.*
Krafcik in (1988)	Requires the use of the less of anything through the production of the product including less of labour, space, tools investments, and time, which can lead to keeping the less inventory and achieving few inventory defects, resulting in variety and a greater amount of production.
Production System Design Laboratory of MIT (2000)	*'Is aimed at the elimination of waste in every area of production including customers' relations, product design, suppliers' networks and factory management. Its goal is to incorporate less human effort, less inventory, less time to develop products, and less space to become highly responsive to customer demand while producing top quality products in the most efficient and economic manner possible'.*
Hopp and Spearman (2004)	Production system requires the least possible buffering expenses.
De Traville and Antonakis (2006)	An integrated system aimed at utilising capacity, minimising buffering costs as a result of decreasing variability through the system.
Shah and Ward (2003)	The bundle of practices that collectively produce high quality, lightly stream products that have the least possible waste or no waste.
Papadoulou and Ozbayrak (2005)	A system directed to waste reduction combined with continuous improvement.
Naylor et al. (1999)	A system that requires all forms of waste elimination, including time, and requires a high degree of scheduling.
Narasimhan et al. (2006)	A production system aimed at achieving the least possible waste through the elimination of unnecessary operational processes, inefficient operational processes, or unnecessary buffering costs.
(Li et al, 2005)	A system that aims to use fewer inputs to produce more outputs with a degree of variety to meet customer needs, through a fundamental core objective of 'waste reduction'.
Gaither and Frazier (2002; cited in Narasimhan, 2006)	The process of applying the JIT practices.
	Lean organisation
Womack and Jones (1994)	*'…a group of individuals, functions, and legally separate but operationally synchronised companies. The group's mission is collectively to analyse and focus on a value stream so that it does everything involved in supplying a good or service in a way that provides maximum value to the customer'.*
	Lean supply
Lamming (1996)	*'…..an arrangement [which] should provide a flow of goods, services and technology from supplier to customer [with associated*

	flows of information and other communications in both decisions] without waste'.

2.2 Agility as a concept

Today's business environment is characterised by intense competition (Swafford et al., 2006) and 'globalisation' (Baramichari et al., 2007). Yusuf et al. (1999) argue that the solution is to implement agility principles as an important strategic component. An agile system is described by Gunasekaran and Yusuf (2002) as the system's ability to endure in a continuous competitive environment, including unexpected changes, and its ability to respond to these changes rapidly. This view was supported by Dubey and Gunasekaran (2015), who argue that globalisation requires a high degree of responsiveness, which can be achieved through the use of agile manufacturing. Van Hoek et al. (2001) argued that the agile organisational structure is the path for any organisation to be able to face these dynamic and complex environmental conditions. Being agile, Vokurka and Fliedner (1998) suggest, enables the organisation to more quickly and proactively react to customer needs and more able to enter new markets. Supply chain agility is considered as an important strategic element (Tse et al., 2016).

Agility as a term was first introduced in practice by members of the Iacocca Institute of Lehigh University, USA (Sherehiy et al., 2007; Swafford et al., 2006; Yusuf et al., 1999). It was first mentioned in the literature in the 21st Century Manufacturing Enterprise Strategy Report (1991, cited in McCullen and Towill, 2001). Commercial organisations had begun to search for means to tackle competition from Far Eastern companies (McCullen and Towill, 2001). The Iacocca Report provided them with 'agility': a competitive weapon to enable companies to respond quickly and effectively to any environmental change and at the same time meet the highly changeable demand of customers (McCullen and Towill, 2001). Christopher and Towill (2000) argue that 'agility' as a new business philosophy originated as an extension of the flexible manufacturing system.

Agility, as a concept, is not limited only to manufacturing systems, which has been suggested by Gunasekaran (1999) to include four agility dimensions namely strategies, technology, people and systems) to improve the ability to respond quickly and efficiently to production changes. Jackson and Johansson (2003) argue that agility as a philosophy is an important weapon to keep the whole organisation buoyant inside dynamic, highly competitive business environments. This idea is also supported by the work of Sherhiy et al.

(2007), who argue that many researchers concur that agility goes beyond the realms of production, and should be seen as a philosophy for the overall organisational strategy.

Applying agility to supply chains is much more recentl. Lee and Lau (1999) and Christopher and Towill (2000) argue that applying agility to supply chains emphasises the importance of 'responsiveness' (cited in Sharifi et al., 2006). It can enable organizations within the same supply chain to gain the advantages of agility on a collective basis (Harrison et al. 1999). Sharifi et al. (2006) themselves argue that the drivers behind applying agility to supply chains are similar to those behind the implementation of agility to the manufacturing function, and include the need to proactively cope with change and uncertainties. Gaudenzi and Christopher (2015) suggest that the agile supply chain extends the concept of agile manufacturing by reducing the non-value added activities and reducing the setup time across the company's boundaries.

This notion is supported by Harrison (2000), who argues that it isn't logical to limit the impact of the concept only to inside the production department, and that it should be extended to the whole supply chain. Christopher (2000) and Van Hoek (2001) have endorsed the concept of agility in respect of the organisation's processes and relationships with other members within the supply chains (cited in Baramichai et al., 2007). Table 2 sets out the salient definitions for agility at its three levels (manufacturing; organisation; supply chain).

It is also important to mention that agility should be supported by agile management thinking, where the management is a key enabler for the implementation of agility (Baramichai et al., 2007). In this context, Braunscheidel and Suresh (2009) suggest that agility provides a risk management capability that allows the organisation to quickly respond to present and future problems within its supply chain.

Table (2): Agility definitions

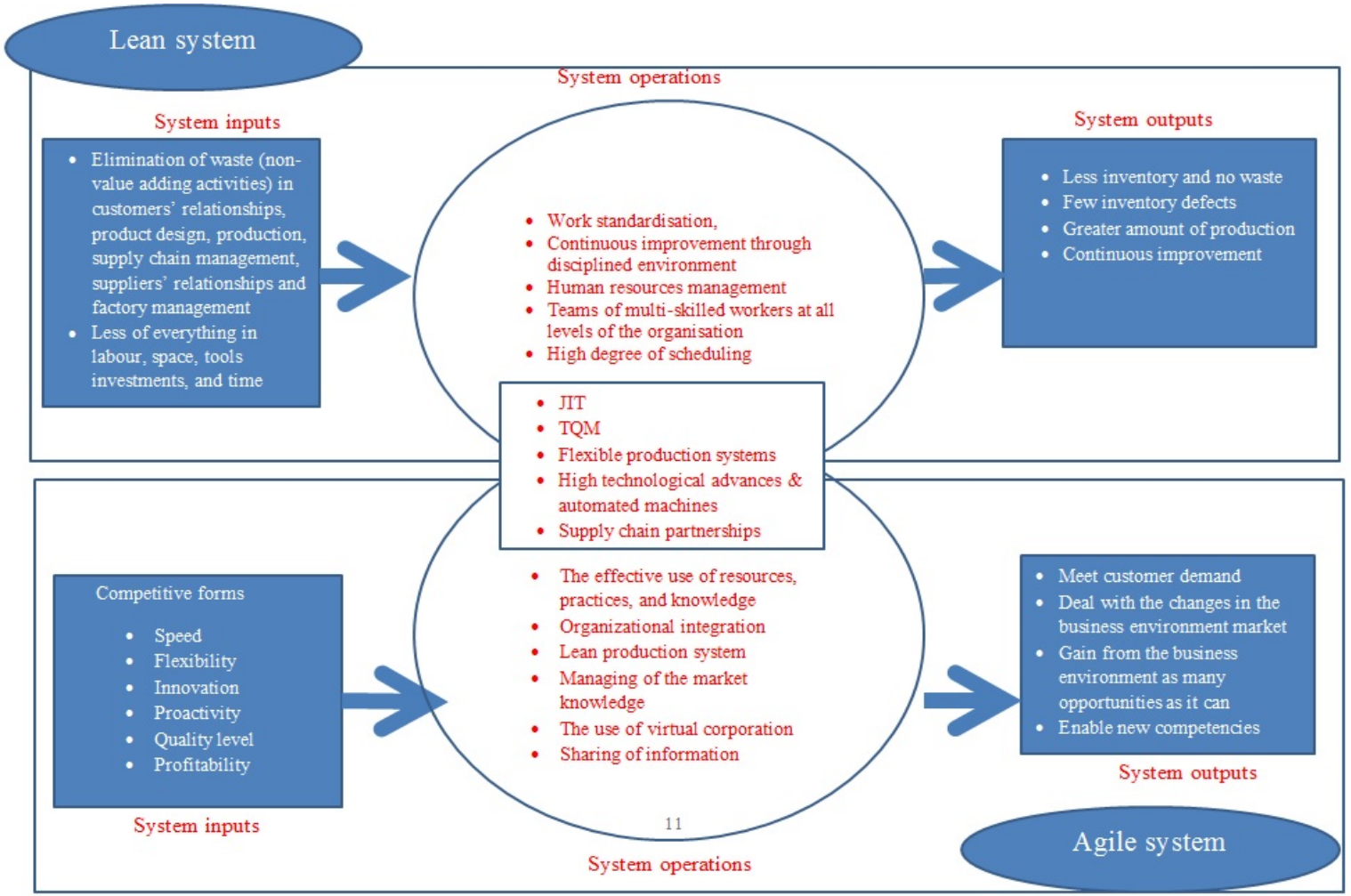
Reference	**Manufacturing agility**
Iacocca Institute of Lehigh University (1991)	A production system with capabilities such as using hard and soft technologies; human resources abilities; educated managerial abilities; and informational abilities in order to match the rapid needs of the changing marketplace, such as speed abilities; flexibility abilities; customers; competitors; suppliers; infrastructure; and responsiveness abilities.
Kidd (1994)	Is associated with organizational integration, including people with skilled and knowledgeable abilities, high advanced technological advances in order to develop high levels of cooperation and innovation to be able to respond to the needs of

	supplying customers with high quality and customized products.
Brown and Besant (2003)	The ability to deal with the changes in the business environment market quickly and effectively.
Prince and Kay (2003)	The ability to react to unexpected changes and deal with highly changeable customer demand concerning price, requirements, quality level, quantity and speed of delivery.
Sharifi and Zhang (1999, 2001)	The ability to determine, react with, and deal with the expected and unexpected changes inside the business marketplace.
Goldman and Nagel (1993)	Is composed of flexible production systems, associated with TQM, JIT production systems as well as lean production systems.
Yusuf et al. (1999)	The successful induction of competitive forms such as speed, flexibility, innovation, proactivity, quality level, and profitability, and the effective use of resources, practices, and knowledge in order to provide products and services to meet customer needs in a changeable business environment.
Fliedner and Vokurka (1997)	The ability to deliver low cost, high quality products in a shorter lead time with great variety in volume sizes in order to be able to improve customer value through customisation.
	Organisational agility
Goldman et al. (1994)	The organisation that has a dynamic nature and an ability to gain a competitive advantage through this dynamic nature, which enables it to focus on developing knowledge and flexible processes to be able to react to the environmental market's changing conditions.
Christopher (2000)	The organisational ability to quickly respond and react to demand changes.
Kidd (2000)	*'…a fast moving, adaptable and robust business. It is capable of rapid adaptation in response to unexpected and unpredicted changes and events, market opportunities as customer requirements. Such a business is founded on processes and structures that facilitate speed, adaptation, and robustness and that deliver a coordinated enterprise that is capable of achieving competitive performance in a highly dynamic and unprofitable business environment that is unsuited to current enterprise practices'.*
Naylor et al. (1999)	The managing of market knowledge and the use of a virtual corporation in order to gain market opportunities inside changeable market conditions.
Christopher and Towill (2000)	The ability to adopt the organisation's structural forms, information systems, logistical systems, and that flexibility is the most important element of agile organisation.
Dove (1996)	The ability of an organisation to live in a highly dynamic changeable environment.
Goldman and Nagel (1995)	*'Dynamic, context specific, aggressively change embracing and growth oriented...succeeding...winning profits, market share, and customers'.*
Jackson and Johansson., (2003)	*'A mind set and not very specific as to how to reach the desired goals'.*

Gehani, (1995)	The ability to satisfy customers' requirements quickly and to frequently introduce new products, and quickly form in and out strategic alliances.
Kumar and Motwani (1995)	*'...ability to accelerate the activities on critical path and ...time-based competitiveness'*.
	Supply chain agility
Sambamurthy et al. (2003)	The organisation's ability to quickly redesign their current processes and develop new processes in an effective timely manner in order to gain advantage when facing unexpected dynamic business conditions.
Baramichai et al. (2007)	*'… an integration of business partners to enable new competencies in order to respond to rapidly changing, continually fragmenting markets. The key enablers of the agile supply chain are the dynamics of structures and relationship configuration, the end-to-end visibility of information, and the event-driven and event-based management.…'*.
Ismail and Sharifi (2006)	The ability of whole supply chain and its members to adjust their network and their operational activities rapidly to be able to face the dynamic and changing needs of their demand.
Prater et al., (2001)	The company's ability to match its physical resources in sourcing, manufacturing and delivery with its speed and flexibility capabilities.
Aitken et al.(2002)	It is the ability to possess demand visibility, to be flexible, to have fast response capability and to have synchronized operational systems.
Fayezi et al. (2015)	*'A compilation of mindset, intelligence and process across SC organisations which enables organisations to respond quickly to the environmental uncertainties and change in a reactive, proactive and, ultimately, predictive manner by relying on their integration in order to fulfil end-customer requirements'* (p. 21).

Based on the review of the literature of lean and agile thinking, the authors were able to construct a theoretical representation for lean and agile systems, as illustrated in Figure 1.

Figure 1: Theoretical representation



From the extensive analysis of the previous research, we argue that the most commonly used themes that have been considered as the inputs for a lean system are: the elimination of waste and non-value added activities (Production System Design Laboratory of MIT, 2000; Papadoulou and Ozbayrak, 2005; Naylor et al., 1999) such as those that may exist within the relationships between the company and its customers and suppliers, waste during the design and production of the product or in supply chain management, and the waste that may result from any managerial concerns. The words 'less of everything' (Womack et al. 1990; Krafcik, 1988) have been repeated several times in the previous research. This input includes less in terms of (or the efficient use of) labour, space, tools, investments, and time. The main practices and methods representing the operations for a lean system include: long-term supply chain partnerships (Harrison, 2000), work standardisation (Harrison, 2000), continuous improvement through disciplined environment (Harrison, 2000), just-in-time (JIT) (Shah and Ward, 2003; Gaither and Frazier, 2002), total quality (TQM) (Shah and Ward, 2003), human resources management (Shah and Ward, 2003), teams of multi-skilled workers at all levels of the organisation (Cox and Blackstone, 1998), use of highly flexible systems (Cox and Blackstone, 1998), increasingly automated machines (Cox and Blackstone, 1998), and a high degree of scheduling (Naylor et al., 1999). These lean system inputs and operations tools can lead to several advantages such as: less inventory and no waste (Krafcik, 1988; Shah and Ward, 2003; Papadoulou and Ozbayrak, 2005), few inventory defects (Krafcik, 1988), greater amount of production (Krafcik, 1988; Cox and Blackstone, 1998), and continuous improvement (Papadoulou and Ozbayrak, 2005).

The previous work on agile thinking has been analysed to show that the system inputs include: the ability to possess competitive forms such as speed, flexibility, innovation, proactivity, quality level, and profitability (Yusuf et al. (1999). These capabilities facilitate the operations of the system, which include: the effective use of resources, practices, and knowledge (Yusuf et al., 1999), as effectiveness can be closely related to the concept of agility (the ability to use everything in a purposeful manner), organizational integration (Kidd, 1994), technological advances (Kidd, 1994; Brown and Bessant, 2003; Price and Key, 2003), flexible production systems (Goldman and Nagel, 1993), TQM (Goldman and Nagel, 1993, Brown and Bessant, 2003), JIT production systems (Goldman and Nagel, 1993; Brown and Bessant, 2003), lean production system concepts (Goldman and Nagel, 1993; Van Hoek et al., (2001), managing of market knowledge (Naylor et al., 1999), the use of virtual corporations (Naylor et al., 1999; Harrison, 2000), sharing of information

(Brown and Bessant, 2003; Baramichai et al., 2007), the integration of business partners (i.e. partnerships with customers/ suppliers) (Brown and Bessant, 2003; Baramichai et al., 2007; Gehani, 1995) and self-management (Harrison, 2000). These system inputs and methods can lead to agile advantages, which include: meeting and responding to the customer demand - which is the ultimate goal of the agile system (Kidd, 1994, Harrison, 2000; Goldman et.al, 1995; Yusuf et al., 1999; Fliedner and Vokurka, 1997; Van Hoek et al., 2001), dealing with changes in the business environment market (Brown and Besant, 2003; Prince and Kay, 2003; Sharifi and Zhang, 2001; Yusuf et al., 1999; Dove, 1996; Sambamurthy et al., 2003; Baramichai et al., 2007; Ismail and Sharifi, 2006), gaining from the business environment as many opportunities as it can (Sharifi and Zhang, 1999; Naylor et al., 1999; Goldman and Nagel, 1995; Sambamurthy et al., 2003), and enabling new competencies (Iacocca Institute of Lehigh University (1991; Baramichai et al., 2007; Kidd, 2000).

From the above delineation, it can be argued that leanness and agility philosophies are important ways of thinking for improving the sustainability of companies. The model illustrates that previous research indicates links between both concepts to the degree that there are some techniques that commonly join lean and agile system together, such as: the use of JIT, TQM, flexible production systems, the supply chain relationships and high technological advances and automated machines. The role of information technology and its impact on agility has been explored in the extant literature. Some studies suggest that information technology has a major enabling role in enhancing agility. Swafford et al.'s (2008) study suggests that information technology has a positive impact on supply chain flexibility, which in turn results in higher supply chain agility and increases in the firm's competitive performance. The role of information technology on leanness is supported by. Ghobakhloo and Hong (2014) who emphasise the importance of information technology investments to achieve a high level of lean implementation.

A key question that now needs to be answered relates to the relationship direction between leanness and agility.

3. Relationship direction between Leanness and Agility

As has been established, there are some common features that may characterise both lean thinking and agile thinking. On the other hand, there are also important differences. Table 3 illustrates our in-depth analysis of the similarities and differences between lean and agile thinking.

From table 3 the main differences between leanness and agility concepts can be summarised as follows:

- Leanness is mainly concerned with reducing waste, while agility is mainly concerned with customer responsiveness.
- Leanness enhances information sharing while agility makes information sharing obligatory.
- Leanness encourages standardisation of work and continuous improvement while agility encourages self-management.

There is clearly a relationship between leanness and agility; however there is a debate in the literature on the direction of this relationship. McCullen and Towill's (2001) study shows that agile production can be considered as a 'precursor' for lean production. The study by Shah and Ward (2003) grouped all the practices for leanness into sets, and put agile manufacturing methods as one component of their JIT set of leanness practices. Similarly, Papadopoulou and Ozbayrak (2005) argue that to achieve a lean enterprise, the organisation should first possess agility capabilities.

Table 3: differences between lean thinking and agile thinking

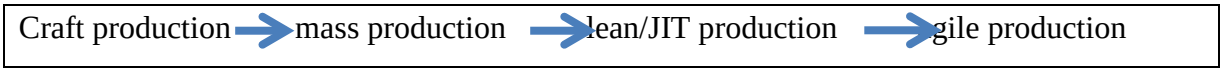
Point of comparison		**Lean Thinking**	**Agile Thinking**
(I) Attributes	**1- Primary goal**	Eliminate waste.	Meet customer demand.
	2- Linkages	With long-term supply chain partnerships.	With virtual supply chain.
	3- Performance measures	Performance measures (e.g. quality, productivity).	Customer-facing matrices (e.g. meeting orders on time in full).
	4- Organising work	Work standardisation, continuous improvement through disciplined environment.	Self-management.
	5- Planning and controlling work	Planning to protect operations through a fixed period in the planning cycle.	Planning for immediate interpretation of customer demand and quick response (Harrison, 2000).
(II) Principles		1- Waste elimination. 2- Value stream identification. 3- Process flow achievement. 4- Pull or Kanban strategy implementation. 5- Continuous perfection searching. (Womack and Jones, 1994)	1- Customer enrichment. 2- Enhancing competitiveness through cooperation. 3- Leveraging the skills of people and information. 4- Mastering change and uncertainty. (Goldman et.al, 1995)
(III) Practices	**1- General Practices**	* JIT. * TQM. * Human resources management (Shah and Ward, 2003)	* JIT system; TQM; Relationships with customers; Partnerships with suppliers; Sharing information; Variety skill training programmes; Use of advanced technological systems. (Brown and Bessant, 2003)

	2- Practices at the manufacturing level	* Pull system. * Waste elimination. * Exchange of high buffering costs with low ones. * Decreasing variability. * Continuous searching for improvement. (Hopp and Spearman, 2004) * JIT. * Managing quality. * Involvement of employees. (McLachlin, 1997)	* Use of advanced technologies in information and communications systems; computer-based manufacturing; modular system. (Price and Key, 2003) * Use of advanced technologies; internal networks; empowerment authority for workers; concurrent working teams. (Sharifi and Zhang, 2001)
	3- Practices at the organisational level	**<u>Lean Organisation</u>** * High agile capabilities. * High responsiveness. * Reduce resource consumption. (Papadopoulou and Ozbayrak, 2005)	**<u>Agile Organisation</u>** * Integrative framework and comprehensive set of standards; self-sufficient module systems; easy re-use of modules; easy plug-in compatibility; easy deferring of commitments; use of redundancy and diversity; interfaced peer-to-peer; control and information distribution; self-management; and easy scalability adjustment. (Dove, 1996)
	4- Practices at the supply chain level	**<u>Lean Supply Chain</u>** * Global operations with local focus. * Alliances and collaboration. * Early supplier involvement * Cost/value analysis jointly. * Transparency. * Two-way information exchange. * Use of Kanban system. * Flexibility in managing capacity. * Synchronized managing of capacity. * JIT.	**<u>Agile Supply Chain</u>** It is achieved through three levels: 1- Principles (use of rapid replenishment and postponed fulfilment). 2- Programmes (organizational and supply agility, driven by demand; quick and flexible response; lean manufacturing system). 3- Actions: use of continuous replenishment programmes; determining of real demand; use of cross-functional teams; managing process system; use of synchronized operations; vendor managing

		* Price reductions as result of joint efforts. * Common agreement on quality standards. * Very high pressure for both suppliers and customers. * Integration in research and design. (Lamming, 1993)	of inventory; reducing waste; standardisation or modular system; using economies of scale approach; reducing set up time; reducing pipeline time. (Christopher and Towill, 2001)
	5- Practices at the Logistics	**<u>Lean Logistics</u>** * Level scheduling. * Demand amplification reduction. * Focusing only on what is pulled from the customer. * Work synchronisation across the whole system. * Planning for most cause reduction through logging irregularities. (Jones et.al, 1997)	**<u>Agile Logistics</u>** The same practices which appear in level three in the supply chain. (Christopher and Towill, 2001)
(IV) Strategic intent		Waste elimination. (McCullin and Towill, 2001)	Diversity of requirements through quick response. (McCullin and Towill, 2001).
(V) Outcome		Use of resources with high quality and in efficient manner. (McCullin and Towill, 2001)	Quick response, achieving mass customisation and resource efficiency.
(VI) Characteristics for supply chain		* Commodity products. * Predictable demand. * Low product variety. * Long product life cycle. * Customer driver is cost. * Low profit margin. * Physical dominant costs * With purchasing to buy goods. * With long term contractual stock out penalties.	* Fashion products. * Volatile demand. * High product variety. * Short product life cycle. * Customer driver is availability. * High profit margin. * Market ability dominant costs. * With purchasing policy is to assign capacity. * With immediate and volatile stock out penalties. * With obligatory information enrichment.

	* Highly desirable information enrichment. * With algorithmic forecasting mechanism. (Mason-Jones et.al, 2000; cited in McCullin and Towill, 2001)	* Consultative mechanism for forecasting. (Mason-Jones et.al, 2000; cited in McCullin and Towill, 2001)
(VII)Market Winner	With cost is the market winner. (Mason-Jones et.al, 2000; cited in McCullin and Towill, 2001)	Service level is the market winner. (Mason-Jones et.al, 2000; cited in McCullin and Towill, 2001)
(VIII) Market qualifiers	1- Quality. 2- Lead time. 3- Service level. (Mason-Jones et.al, 2000; cited in McCullin and Towill, 2001)	1- Quality. 2- Cost. 3- Lead time. (Mason-Jones et.al, 2000; cited in McCullin and Towill, 2001)

On the other hand, several studies support the opposite direction. For example, Harmozi (2001, cited in Narasimhan et al. 2006) argue that for a company to consider itself as possessing world class performance attributes, it should transition from applying lean production into agile production. Van Hoek et al. (2001) also support this way of thinking, where they suggest that the main foci of agility are customer responsiveness and managing the market changes, and that therefore this requires special types of capabilities, among which the most important one is 'Lean Thinking'. Kidd (1994, cited in McCullen and Towill, 2001) also argues that agile production includes lean manufacturing techniques. Similarly, Harrison (2000) argues that agility is connected with long-term strategies, while leanness is more connected with short term strategies, and thus for a supply chain to achieve its long term strategies of matching with the market changes, it should be able first to achieve its short term leanness strategies. Therefore, Harrison argues, that leanness can be considered as an 'enabler' for agility. Robertson and Jones (1999, cited in McCullen and Towill 2001) suggest that achieving agile manufacturing requires achieving lean manufacturing. Christopher and Towill (2000) argue that today's business market is putting great pressure on supply chains to transfer from lean functional supply chains into agile customized supply chains. Vinodh et al. (2009) describe leanness and flexibility as 'cornerstones of AM' (p. 573) and therefore, the company must possess these two capabilities first in order to achieve agility. Narasimhan et al. (2006) conclude from their review, that 'lean manufacturing is a performance/practice state that is *antecedent* to agile manufacturing'. Similarly, the chronological evolution of manufacturing paradigms (cited in, Narasimhan et al., 2006, p. 444) supports this same direction where that leanness precedes agility in the following broad sequence:



Another way of thinking is proposed by other researchers, namely agility and leanness are placed on a continuum, one at each extreme, and that companies should place themselves at a point that suits their particular needs (Naylor et al., 1999; Christopher and Towill, 2001; Gaudenzi and Christopher, 2015). However, this doesn't mean that there is no link connecting agility and leanness or that they are contradictory to each other. For example, Fisher's (1997) supply chain model suggests a link between efficient supply chains and the

functional products, which Naylor et al. (1999) termed 'lean'. Fisher (1997) also found a link between responsive supply chains and innovative products, which Naylor et al, (1999) called agile (cited in Emberson, et.al 2001). Several researchers discuss the link between leanness and agility and whether they can be used together or not. Most of the results show that both concepts can be used separately but within the same supply chain. From this idea a new term appeared, namely 'leagility'. Naylor et al. (1999) suggested that both concepts can be used together within the same supply chain, where leanness should be applied before the decoupling point, and agility should be applied after the decoupling point (cited in Narasimhan et al., 2006). This view is also supported by the work of Christopher and Towill (2001), who discussed three hybrid strategies for using both concepts within a supply chain in a complementary way .The first is the decoupling point, the second is the 'Pareto/80:20' where the lean system techniques should be applied with the volume lines while the agility techniques should be applied with the slow movers. The third strategy is 'surge/base demand separation', where the lean principles should be applied for the demand elements which are characterised by being easily forecasted, while the agility principles should be applied to the elements that are characterised as being highly unexpected.

4. Conclusion

This paper has provided an extensive review of the literature on leanness and agility philosophies. The review highlights substantial research arguing for the importance of leanness and agility concepts as a result of the fact that today's business environment is characterised as highly changeable and complex. The review and synthesis demonstrates also that leanness and agility have gone well beyond application to the production system functional area, and are now highly relevant as means for achieving success along supply chains and hence for supply chain partners, and in a wide range of different types of industries facing differing business conditions. The review has presented the debate surrounding the relationship between both concepts and the direction of that relationship. From our review of the previous research, a conceptual framework showing the different components of lean systems (inputs, system operation, outputs) and agile systems (inputs, system operations, outputs) was extrapolated (Figure 1). The model identifies common components of both concepts and methods that are commonly agreed upon by researchers between these systems (namely, the use of JIT, TQM, flexible production systems and both upstream and downstream supply chain relationships. This conceptual framework has important practical value. It can be used by practitioners to audit the extent of lean and

agile application, and furthermore to assess the level of complementarity in the deployment of leanness and agility already existing in the organisation or its supply chain. This practical analysis will highlight both where effort needs to be maintained, and also where (often sparse) resources available for improvement could or should be prioritised. Moreover, the framework provides guidance to managers on the specific practices that can accomplish the desired improvements in leveraging leanness and agility. This conceptual framework can also be used as a basis for future empirical research in the field to enhance the literature and our understanding of the dynamics and practical application considerations between these essential concepts.

Extending this research to confirm the complementarities and/or opposing forces in their application should be the next steps for future empirical work. The conceptual model presented in this paper for both concepts can be examined in different types of industries facing different challenges and working within differing business environments. The future research should now also focus on the applicability of lean and agile concepts, and their interaction, in industries that have not been examined before in the previous research. This view is endorsed by Pettersen (2009), commenting that the argument suggested by Womack et al. (1990), that the principles of leanness can be applicable for all types of industries may in fact not be the case, and needs to be examined carefully. Pettersen (2009), for example suggests that Japanese companies that are applying lean principles to a high level are mainly automotive manufacturing companies and that all other industries may suffer from other types of challenges that may not need the same level of leanness. The same can be argued with the agility concept; especially supply chain agility. Although it has become regarded as a very important business philosophy, required by any company to enable it to face its market challenges, most research in the literature and previous empirical research has dealt with agility in a limited span of industry types (Chakraborty and Mandal, 2011), such as the automotive industry (Agarwal et al., 2007), electronics (Sharifi, and Zhang, 1999), furniture and fixtures (Swafford et al., 2008), computers and PCs (Christopher and Towill, 2000), clothes and textiles (Bergvall- Forsberg, and Towers, 2007), fabricated metal products (Paulraj and Chen, 2007), mobile industry (Collin and Lorenzin, 2006), lighting industry (Aitken et al., 2002), transportation equipment (Power, Sohal, and Rahman) and plastics (Baramichai, et.al, 2007). Another area for future research concerns the applicability of both concepts in large corporations, multinational companies and SMEs, where the nature and abilities of these types of companies are different. Future research is also required to

investigate the relationship relating leanness and agility with sustainability and environmental issues, where environmental concerns, nowadays, are attracting great attention in academia and in practical life.

Finally, an important research opportunity lies in examining the nature, direction and dependencies inherent in the relationship between both concepts for their successful practical application and whether the relationship direction may differ depending on the scale and type of industry being served by the supply chain.

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