UNIVERSITY^{OF} BIRMINGHAM University of Birmingham Research at Birmingham

Can lean and agile organisations within the UK automotive supply chain be distinguished based upon contextual factors?

Qamar, Amir; Hall, Mark

DOI: 10.1108/SCM-05-2017-0185

License: Other (please specify with Rights Statement)

Document Version Peer reviewed version

Citation for published version (Harvard):

Qamar, A & Hall, M 2018, 'Can lean and agile organisations within the UK automotive supply chain be distinguished based upon contextual factors?', *Supply Chain Management: An International Journal*, vol. 23, no. 3, pp. 239–254. https://doi.org/10.1108/SCM-05-2017-0185

Link to publication on Research at Birmingham portal

Publisher Rights Statement:

Amir Qamar, Mark Hall, (2018) "Can Lean and Agile organisations within the UK automotive supply chain be distinguished based upon contextual factors?", Supply Chain Management: An International Journal, https://doi.org/10.1108/SCM-05-2017-0185

General rights

Unless a licence is specified above, all rights (including copyright and moral rights) in this document are retained by the authors and/or the copyright holders. The express permission of the copyright holder must be obtained for any use of this material other than for purposes permitted by law.

•Users may freely distribute the URL that is used to identify this publication.

•Users may download and/or print one copy of the publication from the University of Birmingham research portal for the purpose of private study or non-commercial research.

•User may use extracts from the document in line with the concept of 'fair dealing' under the Copyright, Designs and Patents Act 1988 (?) •Users may not further distribute the material nor use it for the purposes of commercial gain.

Where a licence is displayed above, please note the terms and conditions of the licence govern your use of this document.

When citing, please reference the published version.

Take down policy

While the University of Birmingham exercises care and attention in making items available there are rare occasions when an item has been uploaded in error or has been deemed to be commercially or otherwise sensitive.

If you believe that this is the case for this document, please contact UBIRA@lists.bham.ac.uk providing details and we will remove access to the work immediately and investigate.

Can Lean and Agile Organisations within the UK Automotive Supply Chain Be Distinguished Based upon Contextual Factors?

Purpose:

The purpose of this paper was to: (1) Robustly distinguish whether firms were implementing lean or agile production in the automotive supply chain; and (2) by drawing on contingency theory as our theoretical lens, independently determine whether lean and agile firms could be distinguished based upon contextual factors.

Design/methodology/approach:

Primary quantitative data from 140 firms in the West Midlands (UK) automotive industry were obtained via a constructed survey. Analysis incorporated the use of logistic regressions in order to calculate the probability of lean and agile organisations belonging to different groups amongst the contextual factors investigated.

Findings:

We found that lean and agile firms co-exist in the automotive supply chain and that lean firms were found to be at higher tiers of the supply chain while agile firms were found to be at lower tiers.

Originality/value:

The originality of this study lies within the novel methodological attempt used to distinguish lean and agile production, based upon the contextual factors investigated. We not only theoretically approve the importance of contingency theory, but contest the 'received wisdom' within Supply Chain Management. These are: (1) That automotive supply chains will comprise of organisations that predominantly adopt lean production methods; and (2) That in supply chains comprising of both lean and agile organisations, the firms closer to the customer will adopt more flexible (agile) practices, while those who operate upstream will adopt more efficient (lean) practices. Our findings have implications for theory and practice, as lean and agile firms can be found in the automotive supply chain without any relationship to the physical value adding process. In order to speculate as to why our findings contest existing views, Resource-Dependence-Theory, and more specifically, a power perspective, was invoked. We provide readers with a new way of thinking concerning complicated supply chains and urge that the discipline of Supply Chain Management adopt a 'fourth' supply chain model depicting a new lean and agile supply chain configuration.

Key Words: Lean, Agile, Contextual Factors, Automotive, Contingency Theory.

1.0 Introduction

'Received wisdom' suggests that automotive supply chains are predominantly lean in nature. That same 'wisdom' also suggests that where lean and agile firms coexist in a supply chain, the agile firms will be located downstream, close to the customer, while the lean firms will be located further upstream (Mason-Jones et al., 2000). In this paper, we seek to overturn, or at least challenge, these assertions. Although scarce, previous literature (Yusuf & Adeleye, 2002; Shah & Ward, 2003; Narasimhan et al., 2006; Reichhart & Holweg, 2007; Gunasekaran et al., 2008; Hallgren & Olhager, 2009; Purvis et al., 2014) has incorporated the use of performance measures when distinguishing lean and agile simultaneously within a singular study. However, inconsistencies amongst the lean and agile literature have resulted in authors placing greater emphasis on the role of contextual factors (Godinho Filho et al., 2016). Contingency Theory (CT) suggests that firms align their performance priorities with their contextual factors. Therefore, it is reasonable to question whether or not lean and agile production concepts have a relationship with contextual factors, namely firm age, firm size and positional tier within the supply chain (SC), especially the automotive supply chain (ASC). The ASC has been considered an underdeveloped area with regard to contextual factors (Marodin et al., 2016). Shah & Ward (2003) and Bayo-Moriones et al. (2010) have previously advocated that for the successful implementation of any manufacturing practice, contextual factors need to be considered, as such characteristics may act as a driving force behind the production strategy employed. On the contrary, contextual factors may also act as a barrier when firms seek to implement certain strategies, such as lean production (Marodin & Saurin, 2015; Marodin et al., 2017a). With this in mind, it should be possible to determine the manufacturing strategy pursued by a firm by looking at its contextual attributes. However, there is a sense of ambiguity within the literature concerning lean and agile production. There is a scarcity in studies solely focussing on lean and agile production relative to contextual factors, especially supply chain (SC) positional tier (Jasti & Kodali, 2015; Marodin et al., 2016; Tortorella et al., 2017a, 2017b). This highlights the research gap that this study seeks to fill. With this in mind, the objectives of this study were to: (1) Robustly distinguish whether firms were implementing lean or agile production; (2) Independently determine if lean and agile firms can be distinguished based upon contextual factors. Thus, the main research question for this study was presented as:

RQ. Can lean and agile organisations within the automotive supply chain be distinguished based upon contextual factors?

2.0 Theoretical Foundation

Being conscious of Chicksand *et al.*'s (2012) and Walker *et al.*'s (2015) concern that only approximately one third of studies within the realms of SCM and Operations Management

(OM) incorporate the use of a theoretical tradition to ground their research, the main overarching theory which grounded this research was Contingency Theory (CT). CT has been advocated as a major theoretical lens through which to view organisations (Sousa & Voss, 2008). CT advocates that no theory, and in turn method, is applicable in every circumstance (Lawrence & Lorsch, 1967). In essence, this approach suggests that there is no single best way to design an organisation and that organisations may need to match their priorities in line with factors that are contingent in the environment. Sousa & Voss (2008) also asserted that the context in which a firm is based may play a role in the relationship between practice and performance, and that researchers should not focus solely on analysing management practices, but must also investigate the context in which firms are positioned. As a result, CT and contextual factors are becoming more popular within the domain of SCM (Demeter & Matusz, 2011; Huo et al., 2014; Kembro et al., 2014; Tortorella et al., 2015; Marodin et al., 2016; Marodin et al., 2017a, 2017b; Tortorella et al., 2017a, 2017b). Given this, we incorporated three contextual factors when seeking to distinguish between lean and agile production, namely firm size, firm age and positional tier within the SC. Furthermore, we limited our selection of the sample to just the automotive industry within the West Midlands (UK), as industry and country contexts have both been indicated as factors which can impact the results of research (Demeter & Matusz, 2011; Marodin et al., 2016). In addition, the West Midlands automotive industry has experienced significant reshoring, thus it is an interesting industry to examine (Qamar, 2016).

3.0 Distinguishing Lean and Agile Production

Lean production is a concept which ensures high levels of efficiency via the elimination of all non-value adding activities (waste) and the effective flow of goods, thus improving productivity and quality levels (Tortorella & Fettermann, 2017). By contrast, agile production emphasises the ability to respond quickly to sudden changes in the market environment as effectively as possible (Narasimhan *et al.*, 2006; Gunasekaran *et al.*, 2008). Flexibility and speed have been continually associated with agile production (Purvis *et al.*, 2014), whereas cost and efficiency are repeatedly associated with lean production (Narasimhan *et al.*, 2006; Gunasekaran *et al.*, 2008). However, in order to distinguish between lean and agile production, Da Silveira & Slack (2001) suggested that differences in manufacturing strategies can be explained via the examination of organisations' resources and capabilities. With this in mind, we looked to explore the existing literature that has advocated key Tools, Practices, Routines and Concepts (TPRCs) (i.e. resources and capabilities) associated with each manufacturing paradigm (see Table 1). Initially, we identified previous studies (Soriano-Meier & Forrester, 2002; Vazquez-Bustelo & Avella, 2006) that have outlined a scorecard to assess the levels of lean or agile production. Building on this, we next conducted key word searches that included the terms

'lean' or 'agile' relative to 'tool' or 'practice' or 'routine' or 'concept'. We limited our search between the years 1990-2014. Our intention was not to list every single TPRC associated with each production strategy, but to focus on identifying TPRCs that have repeatedly been associated with lean and agile production in prior research. Chronologically, as the agile production concept was introduced after the lean production concept, it was no surprise that there were fewer agile TPRC citations in the 1990's, when compared with lean TPRCs. In total, our search identified twenty-two TPRCs related to lean and agile production. Table 1 illustrates some of the key studies that have repeatedly associated the TPRCs with lean, agile or leagile production. Importantly, certain TPRCs ('j-o' in Table 1) were associated with both lean and agile production, hence we refer to them as 'hybrid'. These overlapping TPRCs can explain the confusion between each of the approaches within the existing literature. Although there are similarities amongst the remaining TPRCs, they clearly highlight different strengths between the two production strategies, complementing Skinner's (1969) assertion that no strategy can compete on all measures of performance.

Practices	Lean	Agile
a) Elimination of	White et al. (1999); Sanchez & Perez	-
Waste	(2001); Soriano-Meier & Forrester	-
	(2002); Hopp & Spearman (2004);	-
	Rawabdeh (2005); Malmbrandt &	-
	Ahlström (2013); Kull et al. (2014).	-
b) Continuous	Flynn <i>et al.</i> (1999); White <i>et al.</i> (1999);	-
Improvement	Sanchez & Perez (2001); Soriano-	-
	Meier & Forrester (2002); Taj &	-
	Morosan (2011); Clark et al. (2013);	-
	Malmbrandt & Ahlström (2013);	-
	Sundar et al. (2014); Belekoukias et al.	-
	(2014).	-
c) 5S	Womack & Jones (1996); Bamber &	-
	Dale (2000); Feld (2000); Sweeny	-
	(2003); Lee-Mortimer (2006);	-
	Abdulmalek & Rajgopal (2007).	-
d) Zero Defects	Emiliani (1998); Murman et al. (2002);	-
	Soriano-Meier & Forrester (2002);	-
	Hopp & Spearman (2004); Sahoo et al.	-
	(2008); Malmbrandt & Ahlström	-
	(2013).	-
e) Production	Womack et al. (1990); Abdulmalek et	-
Smoothing	al. (2006); Abdulmalek & Rajgopal	-
	(2007); Shah & Ward (2007); Saurin et	-
	<i>al.</i> (2011).	-
f) Line Balancing	Schroer (2004); Lee-Mortimer (2006);	-
	Malmbrandt & Ahlström (2013);	-
	Sundar <i>et al.</i> (2014).	-
g) Value Stream	Womack & Jones (1996); Murman et	-
Mapping	al. (2002); Hopp & Spearman (2004);	-
	Lee-Mortimer (2006); Malmbrandt &	-
	Ahlström (2013); Sundar et al. (2014);	-
	Belekoukias et al. (2014).	-

Table 1: Lean, Agile and 'Hybrid' Tools, Practices, Routines & Concepts (TPRCs)

h)	Total	Feld (2000); Abdulmalek & Rajgopal	-
	Productive	(2007); Shah & Ward (2007); Taj &	-
	Maintenance	Morosan (2011); Sezen et al. (2012);	-
		Belekoukias et al. (2014).	-
i)	Cellular	Shah & Ward (2003); Lee-Mortimer	-
	Manufacturing	(2006); Abdulmalek & Rajgopal	-
		(2007); Kull et al. (2014); Sundar et al.	-
		(2014).	-
j)	Just-in-Time	Boyer (1996); Gunasekaran (1999);	Takahashi & Nakamura (2000);
		Sanchez & Perez (2001); Soriano-	Sharifi & Zhang (2001); Jin-Hai <i>et al.</i>
		Meier & Forrester (2002); Abdulmalek	(2003); Vazquez-Bustelo & Avella
		& Rajgopal (2007); Shah & Ward	(2006); Shah & Ward (2007); Inman
		(2007); Taj & Morosan (2011); Kull <i>et</i>	<i>et al.</i> (2011);
		<i>al.</i> (2014); Belekoukias <i>et al.</i> (2014).	
k)	Kanban	Flynn <i>et al.</i> (1999); White <i>et al.</i> (1999);	Takahashi & Nakamura (2000);
		Schroer (2004); Abdulmalek &	McCullen & Towill (2001); Sharifi &
		Rajgopal (2007); Shah & Ward (2007);	Zhang (2001); Vazquez-Bustelo &
		Rahman <i>et al.</i> (2013); Sundar <i>et al.</i>	Avella (2006)
		(2014); Belekoukias <i>et al.</i> (2014).	
I)	Multifunctiona	Koufferos <i>et al.</i> (1998); Sanchez &	Gunasekaran (1998); Sharp <i>et al.</i>
		Perez (2001); Soriano-Meier &	(1999); Yusuf <i>et al.</i> (1999); Maskell
	Teams/Machin	Forrester (2002); Bhasin (2011); Saurin	(2001); Vazquez-Bustelo & Avella
	es	<i>et al.</i> (2011); Maimbrandt & Anistrom (2012)	(2006); Erande & Verma (2008).
	T-4-1 O 14	(2013).	Sharifi & Zhang (2001), Lin Hai at al
m)	Total Quality	Boyer (1996); Abdulmalek & Rajgopal	Sharifi & Zhang (2001); Jin-Hai <i>et al.</i>
	Management	(2007); Shan & Ward (2007) ; Taj & Managan (2011) ; Dalaharshing at al	(2003); Vazquez-Bustelo & Avella
		(2014) (2011); Delekouklas et al.	(2006).
	Employee	(2014). P over (1006): Ashenge at al. (2006):	Gunagakaran (1008); Sharm at al
II)	Employee	Boyer (1990), Achanga <i>et al.</i> (2000), Videl (2007): Pose <i>et al.</i> (2011): Tei k	(1000); Yuguf et al. (1000) ; Crocitto
	Empowerment	More san (2007) , Rose <i>et al.</i> (2011) , Taj &	(1999), Tusui <i>et al.</i> (1999), Ciocido & Youssof (2003): Vazquoz Bustalo
		Worosan (2011).	& Toussel (2005), $\sqrt{azquez-Busielo}$ & Avella (2006)
0)	Setun	Womack <i>et al.</i> (1990): Bamber & Dale	Iravani et al (2004): Ismail et al
0)	Reduction	(2000): Feld (2000) : Lee-Mortimer	(2006): Erande & Verma (2008) :
	(SMED)	(2006); Abdulmalek & Raigonal	Matt (2010): Abraham <i>et al.</i> (2012)
	(211222)	(2007): Shah & Ward (2007) : Saurin <i>et</i>	······································
		<i>al.</i> (2011): Sundar <i>et al</i> (2014): Kull <i>et</i>	
		al. (2014); Belekoukias et al. (2014).	
p)	Virtual	-	Gunasekaran (1998:1999); Sharp et
1 /	Enterprise	-	al. (1999); Yusuf et al. (1999);
	-	-	Maskell (2001); Sharifi & Zhang
		-	(2001); Dowlatshahi & Cao (2006);
		-	Vazquez-Bustelo & Avella (2006);
		-	Tseng & Lin (2011).
q)	Core	-	Yusuf et al. (1999); Sharp et al.
	Competence	-	(1999); Maskell (2001); Jin-Hai et al.
	Management	-	(2003); Erande & Verma (2008);
		-	Tseng & Lin (2011).
r)	Knowledge	-	Yusuf et al. (1999); Maskell (2001);
	Driven	-	Ismail et al. (2006); Vazquez-Bustelo
	Enterprise	-	& Avella (2006); Erande & Verma
		-	(2008).
s)	Reconfiguration	-	Yusuf et al. (1999); Maskell (2001);
		-	Vazquez-Bustelo & Avella (2006);
		-	Erande & Verma (2008); Tseng &
		-	Lin (2011); Vinodh & Kuttalingam
		-	(2011).
t)	Rapid	-	Gunasekaran (1998:1999); Sharp et
1	Prototyping	-	al. (1999); Yusuf et al. (1999); Onuh

	-	& Hon (2001); Vinodh &
	-	Kuttalingam (2011).
u) Concurrent	-	Gunasekaran (1998); Sharp et al.
Engineering	-	(1999); Sharifi & Zhang (2001); Jin-
	-	Hai et al. (2003); Vinodh &
	-	Kuttalingam (2011); Tseng & Lin
	-	(2011).
v) IT Driven	-	Gunasekaran (1998:1999); Sharp et
Enterprise	-	al. (1999); McCullen & Towill
	-	(2001); Coronado (2003);
	-	Dowlatshahi & Cao (2006); Vazquez-
	-	Bustelo & Avella (2006).

4.0 Literature Review

4.1 Manufacturing Age

Shah & Ward (2003) asserted that the age of the firm may play a pivotal role in the strategy employed, as older firms may be more resistant to change. This view is complementary to organisational sociology, which proposes that the age of the firm is inversely related to the rate of innovations (Stinchombe, 1965). This view is also in line with the thinking behind evolutionary economics (Nelson & Winter, 1982), as organisational routines (such as manufacturing practices) have been identified as a source of inertia (Hannan & Freeman, 1984). Although Osterman (1994) did not associate firm age with the adoption of 'newer' practices, Shah & Ward (2003) and Haddach et al. (2016) did find certain lean TPRCs to be affiliated with age. More specifically, older organisations have been associated with higher levels of lean implementation (Marodin et al., 2015). Although Tortorella et al. (2015) presented mixed findings, they did go on to find that older manufacturing plants found it more difficult to adapt their organisational culture in a way that favoured certain dimensions of lean production (openness, participation, teamwork transparency). As there are mixed findings within the literature, we used the resistance to change idea to conceptualise our hypotheses. For instance, chronologically, the agile concept was introduced after the lean concept, and by applying the notion of resistance to change, it may be suggested that 'older' organisations are more likely to implement lean practices (due to inertia brought about by their organisational routines), whereas 'younger' organisations may be more likely to implement agile practices. Thus, the following two hypotheses were developed:

 H_{Aa} . Lean firms are more likely to be older in age when compared with agile firms.

 H_{Ab} . Agile firms are more likely to be younger in age when compared with lean firms.

4.2 Firm Size

Sousa & Voss' (2008) review of CT in OM highlighted that the literature deems firm size to be an important contextual factor. The importance of firm size can even be traced back to Child & Mansfield (1972), who suggested that procedures and administrative tasks tend to be more complex in larger firms. Sousa & Voss (2008) illustrated inconsistencies within their review. For instance, studies that purely focused on quality management (Ahire & Golhar, 1996) found little to no evidence of firm size effects. However, studies investigating the application of lean production did find firm size to account for some effects (Shah & Ward, 2003). Furthermore, previous findings have asserted that larger firms are more likely to adopt lean practices (Narasimhan et al., 2006; Bonavia & Marin, 2006; Bhasin, 2012; Marodin et al., 2016), and that smaller firms are more likely to adopt agile practices (Cohen & Klepper, 1992). More recently, Marodin et al. (2017a, 2017b) emphasised that larger companies are more likely to successfully implement lean practices. The positive association between lean production and large firms stems from the notion that large firms possess greater availability of capital and technological resources (Shah & Ward, 2003; Dora et al., 2013), thus they have greater bargaining power than small firms. Bhasin (2012) also found that larger organisations were more likely to successfully adopt lean as an ideology as opposed to just a set of practices. This was supported by Godinho Filho et al. (2016), who suggested that small organisations lacked an understanding to what it means to be lean. Tortorella et al. (2017a) found that larger firms were more likely to implement 15 lean supply chain practices as opposed to smaller firms, findings that were also confirmed by Susilawati et al. (2015) and Tortorella et al. (2017b). Netland (2016) suggested that small and large sized organisations may require different lean implementation approaches. However, Furlan et al. (2011) found no correlation between firm size and the implementation of lean production within organisations in Europe, Asia and North America. Lucato et al. (2014) also found little evidence to suggest that there was a relationship between the extent to which lean was being implemented within organisations and the size of a firm. Belekoukias et al.'s (2014) findings also went on to demonstrate that certain lean TPRCs were associated with small organisations as opposed to large organisations. Although there are mixed findings concerning firm size and lean production (Negrao et al., 2017), as the literature generally associates lean and agile production with large and small organisations respectively, the following two hypotheses were developed:

H_{MSa} . Lean firms are more likely to be larger in size when compared with agile firms.

 H_{MSb} . Agile firms are more likely to be smaller in size when compared with lean firms.

4.3 Supply Chain Positional Tier

Mason-Jones et al. (2000) suggested that SCs, generally speaking, can either be lean, agile or 'leagile' (Drake et al., 2013), as depicted in Figure 1. The latter (leagile) SC, also referred to as the hybrid SC (Huang et al., 2002), is a combination of both paradigms encompassing a total SC strategy which involves a decoupling point. The lean approach is best suited when a market is highly predictable with strong foundations of supply certainty. In contrast, the agile approach is more suitable for turbulent SCs (Drake et al., 2013), where customer requirements often change, resulting in unpredictability and the need for innovative products of shorter life-cycles (Cox & Chicksand, 2005). Naylor et al. (1999) noted that a lean strategy is not a suitable strategy for all SCs, as SCs have unique demand and supply characteristics that require different ways of working operationally, both internally and externally. Often, it is necessary to implement the 'leagile' approach as there are decoupling points within particular SCs that require a lean approach at one point and an agile approach at another. Essentially, the decoupling point refers to the point in a SC at which order-driven and forecast-driven orders meet (Hoekstra & Romme, 1992). Mason-Jones et al. (2000) suggested that when operating within a 'leagile' SC, lean manufacturing systems are located at the lower levels of the SC and operate upstream, enabling a level schedule in output. In contrast, agile systems are generally located at the top or higher levels of the 'leagile' SC and operate downstream from the decoupling point, ensuring there is an agile response capable of delivering to unpredictable market demand. More recently, Vinodh & Aravindraj (2013) acknowledged that the 'leagile' SC paradigm has been gaining importance within the fields of lean and agile production and that it requires further development.

Figure 1 – Lean, Agile and 'Leagile' SCs



Source: Adapted from Mason-Jones et al. (2000).

Although the literature asserts that Automotive Supply Chains (ASCs) are lean, there are contingencies in the ASC that may influence the degree to which a firm is lean as opposed to agile. For example, Original Equipment Manufacturers (OEMs) are undoubtedly key players within the ASC, as they control the design, quantity required and the costs of components (Hallavo, 2015). Furthermore, OEMs will typically encourage, or even require, their closest suppliers to also implement lean production, as this will enable them to achieve their desired operational performance (Morris et al., 2004). For instance, Marodin et al. (2016) suggested that Toyota and Honda developed a collaborative lean relationship with their closest suppliers. Furthermore, first-tier suppliers produce goods that are of more added value relative to firms positioned lower down the ASC, who have to devise a manufacturing strategy that emphasises speed and a broader range of products, i.e. one that is more flexible (Doran, 2004; Boonsthonsatit & Jungthawan, 2015). With this in mind, one may argue that firms positioned lower down the ASC are more agile than lean. Considering this in conjunction with Mason-Jones et al.'s (2000) assertions that if a SC, such as the ASC, does encompass both lean and agile systems (i.e. 'leagile'), are lean firms operating upstream and agile firms operating downstream? There is limited literature that has explored the agile concept relative to different tiers of a SC. Although recently, authors have started to acknowledge the importance of lean production relative to different tiers within a SC (Marodin et al., 2017a). However, lean literature concerning positional tier (Sezen et al., 2012; Garza-Reyes et al., 2015; Tortorella et al., 2017a, 2017b) has also presented mixed views, signalling the need for clarification in this area. For instance, Marodin et al. (2016) found that firms situated in the top tiers of an ASC, closer to the end customer, were more likely to be adopting lean practices relative to those firms located in the lower tiers of an ASC, which supports the findings of Boonsthonsatit & Jungthawan (2015). Tortorella et al. (2017a) sided with this, as findings from their study revealed firms positioned closer to the customer implemented lean practices to a greater extent when compared with firms positioned lower down the ASC. On the contrary, Sezen at al. (2012) did not find any difference between the degree to which lean production was being adopted between first and second tier suppliers. Meanwhile, Tortorella et al. (2017b) found that firms positioned lower down the SC, more specifically third and fourth tier suppliers, were implementing lean practices to a greater degree compared to firms positioned at the top of the SC. Tortorella et al. (2017b) argued this anomaly may have occurred because firms positioned lower down the Brazilian ASC are often owned by an oligopoly and they therefore had a degree of bargaining power to influence and drive several aspects of their respective SC. Panizzolo et al. (2012) suggested that examination of lean production in developing economy countries should be approached differently than in developed countries, as socio-economic variables may influence managerial decisions in a different way. In summary, within the ASC, the literature

generally sides with lean production being more associated with firms closer to the end customer, whereas firms positioned lower down the ASC are said to be competing on flexibility, hence, they are agile. Thus, although Mason-Jones *et al.* (2000) suggested that 'leagile' SCs consist of lean and agile firms at the top and lower tiers of the SC respectively, in association with the discussion presented in this section, we conceptualised the following hypotheses:

 H_{PTa} . Lean firms are more likely to be positioned at the top tiers of a SC when compared with agile firms.

 H_{PTb} . Agile firms are more likely to be positioned at the lower tiers of a SC when compared with lean firms.

5.0 Methodology

5.1 Sampling

In total, 1,710 manufacturing firms were identified as the population operating within the West Midlands (UK) ASC. We contacted approximately 25% of firms within the original population. In total, 450 Managing Directors and Operational Directors were contacted via emails and LinkedIn, asking for their participation in completing a survey questionnaire. A total of 140 surveys were completed revealing a response rate of 31%. All data were obtained within a 6-month period in 2014.

5.2 Distinguishing Lean & Agile Firms

In order to distinguish lean, agile and 'hybrid' firms through the use of the constructed survey, we asked participants to state which manufacturing strategy (lean, agile, hybrid) was being implemented to the greatest extent within their organisation. In total, 77 firms asserted that they were implementing a lean strategy, 63 firms stated they were adopting an agile strategy, and no firm reported as following a 'hybrid' strategy. However, to improve the rigour when distinguishing between lean and agile firms, we also asked participants to state the extent to which the twenty-two TPRCs from Table 1 were being implemented within their organisation on a Likert scale ranging from 1 (zero levels) to 5 (high levels). The mean values were calculated between each of these three bundled TPRCs groups (lean, agile, hybrid) and depending on which group scored the highest, firms were distinguished as being lean, agile and 'hybrid'. No firm scored the highest within the 'hybrid' group, hence, our investigation was focused to just lean and agile. In total, 74 and 66 firms were identified as pursuing lean and agile production respectively, which was 97% consistent with the original responses. As the technique by which lean and agile firms were distinguished involved a scorecard consisting of Likert-scale questions, it is important to test the reliability of these constructs, as Hair *et al.*

(1998, p.118) stated that "any summated scale should be analysed for reliability to ensure its appropriateness before proceeding to an assessment of its validity". With this in mind, our investigation employed Cronbach's alpha to test the internal consistency reliability amongst the TPRCs investigated. Cronbach's alpha is widely used in the social sciences when determining levels of inter-reliability amongst a range of items. Vogt (1999) suggested that values greater than 0.70 suggest that the sub-items are measuring the same construct. The results are presented in Table 2. All the TPRCs that were ascribed to lean production acquired a Cronbach's alpha score of 0.72. However, with the exclusion of TPRCs associated with both lean and agile production, the Cronbach's alpha score increased to 0.82. On the other hand, all the TPRCs associated with agile production acquired a Cronbach's alpha score of 0.70, and with the exclusion of TPRCs affiliated with both (i.e. the leagile ones) this Cronbach's alpha score increased to 0.92. Although the Cronbach's alpha score for the hybrid strategy was also above the threshold criteria, as no firm scored highest within the hybrid strategy, the inclusion of leagile was omitted from this study. As both lean and agile manufacturing TPRCs were identified as scoring well above the 0.70 threshold, it is viable to assert that the named TPRCs were indeed internally consistent and reliable.

Manufacturing Strategy	Number of Items	Cronbach's Alpha
Lean	15	0.72
Lean excluding hybrid TPRCs	8	0.82
Hybrid	7	0.73
Agile	13	0.70
Agile excluding hybrid TPRCs	7	0.92

Table 2: Reliability of TPRCs Associated with Lean and Agile production

In addition, in order to test the validity of using two factors (lean and agile), as opposed to three factors (lean, agile, leagile), this study made use of confirmatory factor analysis (CFA). Kaiser (1960) suggested that the number of factors should depend on the number of factors with eigenvalues greater than one. Results from the CFA revealed that the three factors (lean, agile and hybrid) had eigenvalues greater than one, however, the third factor's (hybrid) eigenvalue was marginally over the value of 1. Considering that the two factor solution accounted for 69% of the variance, as opposed to 75% with the three factor solution, it was deemed appropriate to exclude the examination of a third factor. In summary, we propose that the ASC can be 'hybrid/leagile' in nature because it consists of lean and agile firm; however, the individual, constituent firms within the ASC can be distinguished as being either lean or agile.

5.3 Non-Respondent Bias

Initially, 42 organisations returned the survey within the first two months, 64 organisations returned the survey after a reminder email during months 2-4, and finally a further 34 firms returned the survey after a second reminder within months 4-6. In order to test for non-respondent bias, using Armstrong & Overton's (1977) technique, late respondents were considered as a surrogate for non-respondents. With this in mind, the first 30 surveys received were compared to the last 30 received surveys. T-tests were conducted using firm sales and strategy employed, however, the results indicated that there were no significant differences between both groups, organisations were deemed to be representative of the West Midlands automotive industry, suggesting no significant non-respondent bias.

6.0 Analysis

Analysis with regard to contextual factors involved the use of logistic regressions in SPSS. Researchers (White *et al.*, 1999; Moayed & Shell, 2009) incorporate the use of logistic regressions when predicting the probability/odds ratio of categorical placement or category membership concerning a dependent variable based upon multiple independent variables. Logistic regressions are used to measure the relationship between the dependent variable, which is categorical in nature, with one or more independent variables. This relationship is measured via estimating the probability by using a logistic function. The independent variables in this study were lean/agile and coded as 1 or 0 respectively. The dependent variables were firm age, firm size, and positional tier, and the parameters concerning each of the dependent variables are outlined within the upcoming sections.

6.1 Firm Age

Based on Shah and Ward's (2003) suggestions, firms were grouped into three age categories, namely: firms operating for less than 10 years; firms operating between 10 and 20 years; and firms operating over 20 years. For convenience, these age categories were coded as 'young', 'established' and 'mature' respectively. Models 1a and 2a utilise young firms as the reference category, whereas Models 3a and 4a use mature firms as the reference category.

	Model 1a						Model 2a			
(Ref cate	gory is y	oung & a	agile is k	base)		(Ref category is young & lean is base)				base)
Firm Size	L/A	В	Sig	Exp (B)		Firm Size	L/A	В	Sig	Exp (B)
Established	L(1)	.047	.931	1.048		Established	A (1)	047	.931	.954
	A (0)						L (0)			
Mature	L (1)	.627	.173	1.872		Mature	A (1)	627	.173	.534
	A (0)						L (0)			
	Mo	odel 3a				Model 4a				
(Ref cate	gory is r	nature &	lean is	base)		(Ref category is mature & agile is base)				base)
Firm Size	L/A	В	Sig	Exp (B)		Firm Size	L/A	В	Sig	Exp (B)
Young	A (1)	.627	.173	1.872		Young	L (1)	627	.173	.534
	L (0)	•	•	•			A (0)	•	•	•
Established	A (1)	.580	.171	1.786		Established	L (1)	580	.171	.560
	L(0)	•		•			A (0)	•	•	•

Table 3: Firm Age Regression Results

Results from Model 1a suggest that when comparing lean firms against agile firms, lean firms were (1.048-1=.048) 4.8% and (1.872-1=.872) 87.2% more likely to be established and mature respectively, relative to being young. On the other hand, results from Model 2a suggest that agile firms in comparison with lean firms were (1-.954=.046) 4.6% and (1-.534=.466) 46.6% less likely to be established and mature respectively, relative to being young. Results from Model 3a found that when comparing agile firms against lean firms, agile firms were (1.872-1=.872) 87.2% and (1.786-1=.786) 78.6% more likely to be young and established respectively, relative to being mature. However, Model 4a revealed that lean firms, when compared to agile firms, were (1-.534=.466) 46.6% and (1-.560=.440) 44% less likely to be young and established respectively, relative to being mature. Although the results from each of the models do imply that lean firms were more likely to be older and more established and agile firms were more likely to be younger in age, these findings were not of significance Therefore, hypotheses H_{Aa} and H_{Ab} were both **rejected**.

6.2 Firm Size

Next, using a technique previously deployed by Bhasin (2012), organisations were categorised as small when employing equal to or less than 50 employees, medium when employing greater than 50 but equal to or less than 250 employees, and as large when employing more than 250 employees. The results concerning firm size and manufacturing strategy are reported in Table 4.

	L	ean	A	gile	Total		
	Number	% of firms	Number	% of firms	Number	% of firms	
	of firms		of firms		of firms		
Small	27	37%	22	33%	49	35%	
Medium	32	43%	34	52%	66	47%	
Large	15	20%	10	15%	25	18%	
Total	74	100%	66	100%	140	100%	

Table 4: Firm Size

Results from Table 4 portray fairly consistent proportions between the size of the firm and manufacturing strategy employed. Although there are a greater number of lean firms that were large in comparison with agile firms, there are also a larger number and proportion of firms that were small and lean in comparison with agile and small firms. In order to statistically test whether there was a significant relationship between manufacturing strategy and firm size, once again logistic regressions were conducted, the results of which are presented in Table 5. Models 1b and 2b involve small firms as the reference category, whereas Models 3b and 4b use large firms as the reference category.

	N	lodel 1b				IVIODEI 2D				
Ref ca	tegorv i	s small &	lean is b	base.	Ref ca	Ref category is small & agile is base.				
		_								
Firm	L/A	В	Sig	Exp (B)	Firm Size	L/A	В	Sig	Exp (B)	
Size										
0120										
Medium	A (1)	.265	.483	1.304	Medium	L (1)	265	.483	.767	
	L (0)	•	•	•		A (0)	•	•	•	
Large	A (1)	201	.688	.818	Large	L (1)	.201	.688	1.222	
	L (0)					A (0)				
	Ν	Aodel 3b			Model 4b					
Ref categ	gory is la	arge & lea	ın is bas	se.	Ref category is large & agile is base.				base.	
Firm	L/A	В	Sig	Exp (B)	Firm Size	L/A	В	Sig	Exp (B)	
Size										
Small	A (1)	.201	.688	1.222	Small	L (1)	201	.688	.818	
	L (0)					A (0)				
Medium	A (1)	.466	.328	1.594	Medium	L (1)	466	.328	.627	
	L (0)					A (0)				

Table 5: Firm Size Regression Results

When comparing agile firms against lean firms, Model 1b shows agile firms to be (1.304-1=.304) 30.4% more likely and (1-.818=.182) 18.2% less likely to be medium and large respectively, relative to being small. Model 2b shows that lean firms, in comparison to agile firms, were (1-.767=.230) 23% less likely and (1.222-1=.222) 22.2% more likely to be medium and large respectively, relative to being small. Model 3b shows that agile firms, in comparison to lean firms, were (1.222-1=.222) 22.2% and (1.594-1=.594) 59.4% more likely to be small and

medium respectively, relative to being large. Finally, Model 4b shows that lean firms, in comparison to agile firms, were (1-.818=.182) 18.2% and (1-.627=.370) 37% less likely to be small and medium sized respectively, relative to being large. Results from all four models in Table 5 demonstrated a positive association between lean manufacturing and large organisations, and a positive association between agile firms and small organisations. However, as the P values are not less than 0.05 in either of the regressions, these statements were not of significance. Thus, hypotheses H_{MSa} and H_{MSb} were both **rejected**.

6.3 Positional Tier

Table 6 reports on the number of lean and agile firms at varying levels of the ASC. Out of the possible 140 firms, 16 (11%) firms were Original Equipment Manufacturers (OEMs), 36 (26%) firms were 1st tier suppliers, 32 (23%) firms were 2nd tier suppliers, 33 (24%) firms were 3rd tier suppliers and 23 (16%) firms were 4th and 5th tier suppliers within the ASC. With the exception of OEMs and 4th & 5th tier suppliers, there seemed to be a fairly consistent total number of firms who were 1st, 2nd and 3rd tier suppliers within the ASC. Table 6 suggests that the majority of lean organisations seem to be positioned at the higher (top) end of the ASC, as 16% and 34.5% of lean organisations are OEMs and 1st tier suppliers respectively, but further down the SC, the percentage of lean organisations decreases. On the contrary, the majority of agile organisations appear to be positioned at the lower end of the ASC with 27% and 29% of agile organisations classified as 4th & 5th and 3rd tier automotive organisations respectively. A cumulative 21% of agile firms within this study were OEMs & 1st tier suppliers, which is notably less than the cumulative 50.5% of lean organisations who were OEMs and 1st tier suppliers.

Positional Tier	Le	an	Agi	Total		
	Number	% of	Number	% of	Number	% of
	of firms	firms	of firms	firms	of firms	firms
OEM	12	16%	4	6%	16	11%
1 st	26	34.5%	10	15%	36	26%
2 nd	17	23%	15	23%	32	23%
3 rd	14	18.5%	19	29%	33	24%
4 th & 5 th	6	8%	18	27%	23	16%
Total	74	100%	66	100%	140	100%

Table 6: Lean and Agile Systems within the ASC

Next, in order to statistically test if lean and agile firms were positioned at different levels of the SC, we incorporated the use of multinomial logistic regressions (Table 7). Automotive tiers within the SC were categorised into three levels, namely; top, middle, bottom. The top of the SC consisted of OEMs and 1^{st} tier suppliers, the middle of the SC consisted of 2^{nd} tier suppliers, and the bottom of the SC consisted of 3^{rd} and 4^{th} & 5^{th} tier suppliers. Models 1c and 2c involve

middle firms as the reference category, whereas Models 3c and 4c used top firms as the reference category.

	Model 1c						Model 2c			
Ref cat	egory is	middle &	lean is	base.		Ref ca	Ref category is middle & agile is base			
SC Position	L/A	В	Sig	Exp (B)		SC Position	L/A	В	Sig	Exp (B)
Тор	A (1)	-1.025	.010	.359		Тор	L (1)	1.025	.010	2.787
	L (0)						A (0)			
Bottom	A (1)	1.003	.061	2.727		Bottom	L (1)	-1.003	.061	.367
	L (0)						A (0)			
Model 3c										
	N	lodel 3c		•			N	1odel 4c	•	
Ref c	№ ategory	lodel 3c is top & le	ean is ba	ase		Refo	N category i	lodel 4c s top & ag	gile is ba	se.
Ref c SC	N ategory L/A	lodel 3c is top & le B	ean is ba	ase Exp		Ref o SC	N category i L/A	lodel 4c s top & aរួ B	gile is ba Sig	se. Exp
Ref c SC Position	N ategory L/A	iodel 3c is top & le B	ean is ba Sig	ase Exp (B)		Ref o SC Position	N category i L/A	lodel 4c s top & aរួ B	gile is ba Sig	se. Exp (B)
Ref c SC Position Middle	N ategory L/A A (1)	lodel 3c is top & le B 1.025	ean is ba Sig .010	ese Exp (B) 2.787		Ref o SC Position Middle	N category i L/A L (1)	1odel 4c s top & ag B -1.025	gile is ba Sig .010	se. Exp (B) .359
Ref c SC Position Middle	N ategory L/A A (1) L (0)	lodel 3c is top & le B 1.025	ean is ba Sig .010	ese Exp (B) 2.787		Ref of SC Position Middle	N category i L/A L (1) A (0)	1odel 4c s top & ag B -1.025	gile is ba Sig .010	se. Exp (B) .359
Ref c SC Position Middle Bottom	N ategory L/A A (1) L (0) A (1)	lodel 3c is top & le B 1.025 2.028	ean is ba Sig .010 .000	ese Exp (B) 2.787 7.600		Ref of SC Position Middle Bottom	N category i L/A L (1) A (0) L (1)	lodel 4c s top & ag B -1.025 -2.028	gile is ba Sig .010 .000	se. Exp (B) .359 .132

Table 7 – Positional Tier Regression Results

When comparing agile firms to lean firms, results from Model 1c suggest that agile firms were (1-0.359=.640) 64% less likely and (2.727-1= 1.727) 172.7% more likely to be positioned at the top and bottom of the SC respectively, relative to the middle of the SC. Model 2c shows that lean firms, in comparison with agile firms, were (2.787-1= 1.787) 178.7% more likely and (1-0.367 = 0.63) 63% less likely to be positioned at the top and bottom of the SC respectively, relative to the middle of the SC. The P value was less than 0.05 for only two of these findings, therefore lean firms were significantly more likely to be positioned at the top of the SC relative to the middle of the SC, and agile firms were significantly less likely to be positioned at the top of the SC, relative to the middle of the SC. Although results portrayed agile firms as being more likely to be positioned at the bottom of the SC, this cannot be reported as being of significance as the P value (0.061) was above the 0.05 threshold. In order to investigate whether lean and agile firms are distinguishable based upon the positional tier to which they belong in the SC, this study conducted two more regressions (Models 3c & 4c). Model 3c shows that agile firms, in comparison to lean firms, were (7.600-1=6.60) 660% more likely to be positioned at the bottom of the SC relative to the top of the SC. Model 4c shows that lean, in comparison to agile firms, were (1-0.132=0.868) 86.8% less likely to be positioned at the bottom of the SC relative to the top of the SC. Furthermore, the P value is less than 0.05 for both of these findings. With this in mind, lean firms were significantly less likely to be positioned at the middle and bottom of the SC relative to the top of the SC, and agile firms were significantly more likely to be positioned at the middle and bottom of the SC relative to the top of the SC. Based upon the findings presented in Table 7, hypotheses H_{PTa} and H_{PTb} were **accepted**.

7.0 Discussion

The main contribution of this study is the finding that Contingency Theory (i.e. contextual factors) can play a part in differentiating between lean and agile organisations, especially the positional tier. However, results obtained in this study refuted some of the misconceptions concerning lean and agile production relative to contextual factors (Hines et al., 2004; Marodin et al., 2016; Tortorella et al., 2017a). For instance, although lean firms were expected to be larger and older in age when compared with agile firms, the results concerning these contextual factors were not of significance. Therefore, lean and agile firms could not be differentiated based upon firm size or firm age. Thus, our findings side with Furlan et al. (2011) and Lucato et al. (2014). However, positional tier was an important and significant factor that could distinguish lean and agile organisations. With this in mind, it is important to extend the discussion (Sezen et al., 2012; Garza-Reyes et al., 2015; Marodin et al., 2016; Marodin et al., 2017a, 2017b; Tortorella et al., 2017a, 2017b) concerning the role of positional tier within the ASC. Figure 2, which we have called the Lean Agile Automotive Supply Chain (LAASC) Model, is a simple visual aid to show where lean and agile firms were positioned within the ASC. Triangles are used to represent the size of the ASC, for example, the limited number of OEMs at the top and a vast number of 3rd and 4th & 5th tier suppliers at the base. The shading of the two triangles is of great importance. Looking at the lean triangle and agile triangle, there is an inverse relationship between the shading concerning each of the triangles. This reflects a high concentration of lean and agile firms operating downstream and upstream within the ASC respectively.



Figure 2 – The Lean and Agile Automotive Supply Chain (LAASC) Model

Although findings concerning positional tier share similarities with recent lean studies (Marodin et al., 2016; Tortorella et al., 2017a), findings from this study are in direct contradiction to traditional thinking behind lean, agile and 'leagile' SCs. For instance, Mason-Jones et al. (2000) suggested that when operating within a 'leagile' SC, a decoupling point occurs where lean and agile activities meet. Firms within SCs were our unit of analysis. It is these organisations that provide the components and parts to construct the finished vehicle and which, together, form the value chain. In other words, the physical value chain is made up of firms carrying out production activities in order to produce the final product. Given this, our conception of the decoupling point is the point at which the majority of firms switch from predominantly employing TPRCs associated with lean production to TPRCs associated with agile production. In our analysis, this occurred at the third tier and beyond. 'Leagile' SC literature suggests that lean firms are located at the lower levels of a SC and operate upstream, enabling a level schedule in output. In contrast, agile firms are located at the top or higher levels of the respective 'leagile' SC, and operate downstream from the decoupling point, ensuring there is an agile response capable of delivering to an unpredictable marketplace. However, findings from this study suggest that when operating within a complex SC, lean firms were found to be operating downstream, whereas agile firms were found to be operating upstream. Therefore, by taking the LAASC Model into account, it may be argued that firms implementing lean TPRCs, who compete on costs and efficiency levels, are more likely to be located at the top of the SC. In contrast, firms implementing agile TPRCs, who compete on flexibility and speed, are more likely to be located at the lower end of the SC. Although this directly contests Mason-Jones et al. (2000) as well as received wisdom, these varying competitive priorities within different tiers of the ASC are in line with assertions made by Doran (2004) and Boonsthonsatit & Jungthawan (2015). Furthermore, Marodin et al. (2016) and Tortorella et al. (2017a) also found firms to be leaner at the top tiers of an ASC and although their research did not look into the concept of agility, their findings did reveal firms positioned at the lower levels of the ASC to be less lean. In contrast, results contest findings by Tortorella et al. (2017b). However, as mentioned previously, Tortorella et al. (2017b) suggested their findings may have been an anomaly as the Brazilian ASC encompasses firms of oligopoly status lower down the ASC, which is why Panizzolo et al. (2012) suggested that SCs in developed and developing countries should be treated separately in this regard.

In terms of generalisability, we propose that the LAASC Model is applicable when the final product is complex, requiring thousands of components. However, in terms of SCs producing simpler final goods, which only require few components, the LAASC Model may not be applicable and Mason-Jones *et al.*'s (2000) description of lean, agile and 'leagile' SCs may be

more appropriate. In order to provide a speculative insight into why lean and agile firms were found at different levels of the ASC, we turn to the literature surrounding CT and Resource-Dependence Theory (RDT). RDT has become one of the most useful theoretical stances within organisational theory and strategic management (Hillman et al., 2009). Within RDT, the firm is viewed as an open system that is reliant on multiple contingencies within the external environment (Pfeffer & Salancik, 1978). To understand the behaviour within an organisation, it is necessary to understand the context of that behaviour. Literature surrounding RDT has power at its heart (Touboulic et al., 2014) where an organisation's success can be attributed to power maximisation (Ulrich & Barney, 1984). In essence, one organisation's ability to exercise power over another will play a part in its success, where levels of dependency are crucial. Singh et al. (2011) stressed that RDT has only been scarcely explored and needs further development. Cox et al. (2001) stated that there are fundamental weaknesses concerning descriptive approaches to SCs within business management, as authors tend to exclude examining the importance and complexity of power. Cox (2001) asserted that there are four general buyer and supplier positions concerning power, namely; buyer dominance, interdependence, independence and supplier dominance. During times of buyer dominance, buyers will generally be able to achieve all they desire operationally and commercially at the expense of their suppliers (Cox et al., 2004). Considering our LAASC Model suggested that lean firms were generally found to be operating at the top tiers of the ASC, we can say that as there are few buyers and many suppliers, agile firms, who are the suppliers to lean buyers, are in a position of high buyer dependency. Therefore, when OEMs or even first-tier suppliers require changes, as they are in a positon of buyer dominance, they can acquire the benefits operationally at the expense of their suppliers, which is a concern within the automotive industry also identified by Singh et al. (2005). This may explain why firms operating at the top levels of the ASC are seen to be implementing the TPRCs associated with cost reduction, higher efficiency and quality levels (lean), whereas firms positioned lower down the ASC were found to be implementing TPRCs associated with gaining advantage in terms of speed and flexibility (agile). Thus, the results imply that OEMs and first-tier suppliers are prioritising cost and quality performance and require firms at the lower levels of the ASC to be able to accommodate changes in design at great speed, supporting Marodin et al.'s (2017a) assertions. Although Turner (2005) suggested that European automotive industries may be 'leagile' as opposed to lean, due to the positional tier to which lean and agile firms were predominantly operating, our findings support Doran (2004) and Boonsthonsatit & Jungthawan (2015) assertions. In essence, firms positioned at the top tiers (downstream) of the ASC produce goods of higher added value relative to firms positioned lower down (upstream) in the ASC, who are more flexible in nature. Crute et al. (2003) also asserted that firms find it extremely difficult to implement lean systems when in a

position of low negotiation power, which goes hand-in-hand with the discussion presented in this section.

8.0 Contributions

Several contributions are made. First, by examining the relevant TPRCs we identified a holistic mode by which lean and agile firms could be distinguished. Second, our results contribute towards clarifying the general misunderstandings related to the contingent nature of lean and agile production (Hines et al., 2004; Tortorella et al. 2017a). As lean and agile firms can be determined in the automotive supply chain without any relationship to the physical value adding process our results have theoretical implications. For instance, the idea that lean can be implemented as 'best practice' within all companies is refuted, as contingent variables, such as positional tier, can be an influential and significant factor. Although Marodin et al. (2016) found that lean production was not only being implemented in large-volume and low-variety companies, such as OEMs and first-tier suppliers, our results did not convey the same argument. For instance, firms positioned lower down the ASC, were generally found to be implementing TPRCs associated with flexibility (agile) as opposed to efficiency (lean). Firm size and firm age did not portray levels of significance; however, they did illustrate signs of bearing a relationship between lean and agile production. Third, the use of logistic regressions when calculating the probability of lean and agile firms belonging to different contextual groups can arguably hold more meaning and relevance when compared to previous studies. Fourth, we developed the LAASC Model that directly refutes Mason-Jones et al.'s (2000) existing views which, we feel, suggests that the field of SCM requires a new way of thinking concerning lean and agile firms within complicated SCs. Fifth, we contribute to the scarce literature that involves the use of both lean and agile paradigms simultaneously within a singular study. Finally, for practitioners, not only do we present a method that can assist them in determining whether their firms are lean or agile, but we also demonstrate which strategy is being employed to the greatest extent within different tiers of the ASC. For instance, managers can use the results in this study to see that firms positioned at the top tiers of the ASC are generally implementing a lean strategy, whereas firms positioned at the lower tiers of the ASC are generally implementing an agile strategy.

9.0 Conclusion

There is limited research examining lean and agile production relative to the role of contextual factors, especially supply chain positional tier (Jasti & Kodali, 2015; Marodin *et al.*, 2016; Tortorella *et al.*, 2017a, 2017b). Furthermore, there are inconsistent results presented in the literature Negrao *et al.* (2017). With this in mind, first we looked to rigorously distinguish

between lean (cost effective and highly efficient) and agile (speed responsive and highly flexible) firms based upon the core TPRCs employed within their organisations. Next, employing Contingency Theory, the main aim of this study was to determine if the identified lean and agile organisations could be distinguished based upon contextual factors. We did not find a significant relationship between lean and agile production relative to firm size and firm age. Thus, our findings contest certain studies (Shah & Ward, 2003; Marodin et al., 2015; Haddach et al., 2016; Tortorella et al., 2017a, 2017b) and side with others (Furlan et al., 2011; Lucato et al., 2014). In terms of firm size, our findings may have been jeopardised by a large number of SMEs in the sample; therefore, it is crucial for future studies to gain a greater insight in determining if there may be a linkage between each of the manufacturing paradigms under investigation with relation to firm size. However, an interesting phenomenon is revealed concerning the positional tier to which firms belong within an ASC. Our positional tier findings support some of the literature (Doran, 2004; Boonsthonsatit & Jungthawan, 2015; Tortorella et al., 2017a) as lean organisations were primarily found to be positioned at the higher tiers of the ASC, and in contrast, agile firms were chiefly found at the lower levels of the ASC. Therefore, we proposed the Lean Agile Automotive Supply Chain (LAASC) Model as a starting point in moving towards a new way of theoretical thinking. Importantly, this finding is in direct opposition to discussions surrounding the decoupling point within the 'leagile' SC literature. We utilised Contingency Theory and Resource Dependence Theory, and more specifically, we invoked a power perspective to better understand why firms may be positioned in this way. We believe this paper is of theoretical importance to the fields of OM and SCM, with a particular focus on lean and agile literature. In summary, not only does this paper conceptualise a mode in which lean and agile firms can be differentiated, but our discussion also provides a new way of conceptualising a 'leagile' SC, and urges that the discipline of SCM may require a 'fourth' lean and agile SC model.

References:

Abdulmalek, F.A. & Raigopal, J. (2007), "Analyzing the benefits of lean manufacturing and value stream mapping via simulation: a process sector case study", *International Journal of Production Economics*, Vol. 107 No. 1, pp.223-236.

Abdulmalek, F.A., Raigopal, J. & Needy, K. L. (2006), "A classification scheme for the process industry to guide the implementation of lean", *Engineering Management Journal*, Vol. 18 No. 2, pp. 15-25.

Abraham, A., Ganapathi, K. N. & Motwani, K. (2012). "Setup time reduction through SMED technique in a stamping production line", *SASTECH Journal*, Vol. 11 No. 2, pp. 47-52.

Achanga, P., Shehab, E., Roy, R. & Nelder, G. (2006), "Critical success factors for lean implementation within SMEs", *Journal of Manufacturing Technology Management*, Vol. 17 No. 4, pp. 460-471.

Ahire, S.L. & Golhar, D.Y. (1996), "Quality management in large vs small firms", *Journal of Small Business Management*, Vol. 34 No. 2, pp. 1-13.

Armstrong, J.S. & Overton, T. S. (1977), "Estimating nonresponse bias in mail surveys", *Journal of Marketing Research*, Vol. 14 No. 3, pp. 396-402.

Bamber, L. & Dale, B. G. (2000), "Lean production: a study of application in a traditional manufacturing environment", *Production Planning & Control*, Vol. 11 No. 3, pp. 291-298.

Bayo-Moriones, A., Bello-Pintado, A. & Merion-Diaz De Cerio, J. (2010), "5S use in manufacturing plants: contextual factors and impact on operating performance", *International Journal of Quality & Reliability Management*, Vol. 27 No. 2, pp. 217-230.

Belekoukias, I., Garza-Reyes, J.A. & Kumar, V. (2014), "The impact of lean methods and tools on the operational performance of manufacturing organisations", *International Journal of Production Research*, Vol. 52 No. 18, pp. 5346-5366.

Bhasin, S. (2012), "Performance of lean in large organisations", *Journal of Manufacturing Systems*, Vol. 31 No.3, pp. 349-357.

Bonavia, T. & Marin, J.A. (2006), "An empirical study of lean production in the ceramic tile industry in Spain", *International Journal of Operations & Production Management*, Vol. 26 No. 5, pp. 505 531.

Boonsthonsatit, K. & Jungthawan, S. (2015), "Lean supply chain management-based value stream mapping in a case of Thailand automotive industry", in 4th International Conference on Advanced Logistics and Transport, 20-22 May, Valenciennes, France, 2015, IEEE, pp.65-69.

Boyer, K.K. (1996) "An Assessment of Managerial Commitment to Lean Production". *International Journal of Operations & Production Management*, Vol. 16 No. 9, pp. 48-59.

Chicksand, D., Watson, G., Walker, H., Radnor, Z. & Johnston, R. (2012), "Theoretical perspectives in purchasing and supply chain management: an analysis of the literature", *Supply Chain Management: An International Journal*, Vol. 17 No. 4, pp. 454-472.

Child, J. & Mansfield, R. (1972), "Technology, size and organization structure", *Sociology*, Vol. 6 No.3, pp. 369-393.

Clark, D.M., Silverster, K. & Knowles, S. (2013), "Lean management systems: creating a culture of continuous quality improvement", *Journal of Clinical Pathology*, Vol. 66 No. 8, pp. 638-643.

Cohen, W.M. & Klepper, S. (1992), "The trade-off between firm size and diversity in the pursuit of technological progress", *Small Business Economics*, Vol. 4 No. 1, pp. 1-14.

Coronado, A.E. (2003), "A framework to enhance manufacturing agility using information systems in SMEs", *Industrial Management & Data Systems*, Vol. 103 No. 5, pp. 310-323.

Cox, A. & Chicksand, D. (2005), "The limits of lean management thinking: multiple retailers and food and farming supply chains", *European Management Journal*, Vol. 23 No. 6, pp. 648-662.

Cox, A., Sanderson, J. & Watson, G. (2001), "Supply chains and power regimes: toward an analytic framework for managing extended networks of buyer and supplier relationships", *Journal of Supply Chain Management*, Vol. 37 No. 1, pp. 28-35.

Cox, A., Watson, G., Lonsdale, C. & Sanderson, J. (2004), "Managing appropriately in power regimes: relationship and performance management in 12 supply chain cases", *Supply Chain Management: An International Journal*, Vol. 9 No. 5, pp. 357-371.

Crocitto, M. & Youssef, M. (2003), "The human side of organizational agility", *Industrial Management & Data Systems*, Vol. 103 No. 6, pp. 388-397.

Crute, V., Ward, Y., Brown, S. & Graves, A. (2003), "Implementing Lean in aerospace—challenging the assumptions and understanding the challenges", *Technovation*, Vol. 23 No. 12, pp. 917-928.

Da Silveira, G. & Slack, N. (2001), "Exploring the trade-off concept", *International Journal of Operations & Production Management*, Vol. 21 No. 7, pp. 949-964.

Demeter, K.. & Matyusz, Z. (2011), "The impact of lean practices on inventory turnover", *International Journal of Production Economics*, Vol. 133 No.1, pp. 154-163.

Dora, M., Kumar, M., Van Goubergen, D., Molnar, A. & Gellynck, X. (2013), "Operational performance and critical success factors of lean manufacturing in European food processing SMEs", *Trends in Food Science & Technology*, Vol. 31 No. 2, pp. 156-164.

Doran, D. (2004), "Rethinking the supply chain: an automotive perspective", *Supply Chain Management: An International Journal*, Vol. 9 No. 1, pp. 102-109.

Dowlatshahi, S. & Cao, Q. (2006), "The relationships among virtual enterprise, information technology, and business performance in agile manufacturing: An industry perspective", *European Journal of Operational Research*, Vol. 174 No. 2, pp. 835-860.

Drake, P. R., Myung Lee, D. & Hussain, M. (2013), "The lean and agile purchasing portfolio model", *Supply Chain Management: An International Journal*, Vol. 18 No. 1, pp. 3-20.

Erande, A.S. & Verma, A.K. (2008), "Measuring agility of organizations-a comprehensive agility measurement tool (CAMT)", *International Journal of Applied Management and Technology*, Vol. 6 No. 3, pp. 31-44.

Feld, W.M. (2000), Lean Manufacturing: Tools, Techniques, and How to Use Them. CRC Press.

Flynn, B.B., Schroeder, R.G. & Flynn, E.J. (1999), "World class manufacturing: an investigation of Hayes and Wheelwright's foundation", *Journal of Operations Management*, Vol. 17 No. 3, pp. 249-269.

Furlan, A., Vinelli, A. & Dal Pont, G. (2011), "Complementarity and lean manufacturing bundles: an empirical analysis", *International Journal of Operations & Production Management*, Vol. 31 No.8, pp. 835-850.

Garza-Reyes, J.A., Ates, E.M. & Kumar, V. (2015), "Measuring lean readiness through the understanding of quality practices in the Turkish automotive suppliers industry", *International Journal of Productivity and Performance Management*, Vol. 64 No. 8, pp. 1092 – 1112.

Godinho Filho, M., Ganga, G.M.D. & Gunasekaran, A. (2016), "Lean manufacturing in Brazilian small and medium enterprises: implementation and effect on performance", *International Journal of Production Research*, Vol. 54 No. 24, pp. 7523-7545.

Gunasekaran, A. (1998), "Agile manufacturing: enablers and an implementation framework", *International Journal of Production Research*, Vol. 36 No. 5, pp. 1223-1247.

Gunasekaran, A. (1999), "Agile manufacturing: a framework for research and development", *International Journal of Production Economics*, Vol. 62 No.1-2, pp. 87-105.

Gunasekaran, A., Lai, K.-H. & Cheng, T. C. E. (2008), "Responsive supply chain: A competitive strategy in a networked economy", *Omega*, Vol. 36 No. 4, pp. 549-564.

Haddach, A., Ammari, M. & Laglaoui, A. (2016), "Role of Lean, Environmental and Social Practices to Increasing Firm's Overall Performance", *Journal of Materials and Environmental*, Vol. 7 No.2, pp. 505-514.

Hair, J.F., Anderson, R.E., Tatham, R.L. & Black, W.C. (1998), *Multivariate Data Analysis*, Prentice Hall, New Jersey.

Hallavo, V. (2015), "Superior performance through supply chain fit: a synthesis", *Supply Chain Management: An International Journal*, Vol. 20 No. 1, pp. 71-82.

Hallgren, M. & Olhager, J. (2009), "Lean and agile manufacturing: external and internal drivers and performance outcomes", *International Journal of Operations & Production Management*, Vol. 29 No.10, 976-999.

Hannan, M.T. & Freeman, J. (1984), "Structural inertia and organizational change", *American Sociological Review*, Vol. 49 No. 2, pp. 149-164

Hillman, A.J., Withers, M.C. & Collins, B.J. (2009), "Resource dependence theory: a review", *Journal of Management*,

Hines, P., Holweg, M. & Rich, N. (2004), "Learning to evolve: a review of contemporary lean thinking", *International Journal of Operations & Production Management*, 24(10), pp. 994-1011.

Hoekstra, S. & Romme, J. (1992), *Integral Logistic Structures: Developing Customer-Oriented Goods Flow*, Industrial Press Inc., New York, NY.

Hopp, W.J. & Spearman, M.L. (2004), "To pull or not to pull: what is the question?", *Manufacturing & Service Operations Management*, Vol. 6, No.2, pp. 133-148.

Huang, S.H., Uppal, M. & Shi, J. (2002), "A product driven approach to manufacturing supply chain selection", *Supply Chain Management: An International Journal*, Vol. 7 No. 4, pp. 189-199.

Huo, B., Qi, Y., Wang, Z. & Zhao, X. (2014), "The impact of supply chain integration on firm performance: the moderating role of competitive strategy", *Supply Chain Management: An International Journal*, Vol. 19 No. 4, pp. 369-384.

Inman, R.A., Sale, R.S., Green, K.W. & Whitten, D. (2011), "Agile manufacturing: relation to JIT, operational performance and firm performance", *Journal of Operations Management*, Vol. 29 No. 4, pp. 343-355.

Iravani, S.M.R., Buzacott, J.A. & Posner, M.J.M. (2005), "A robust policy for serial agile production systems", *Naval Research Logistics*, Vol. 52 No. 1, pp. 58-73.

Ismail, H.S., Snowden, S.P., Poolton, J., Reid, R. & Arokiam, I.C. (2006), "Agile manufacturing framework and practice", *International Journal of Agile Systems and Management*, Vol. 1 No. 1, pp. 11-28.

Jasti, N. & Kodali, R. (2015), "A critical review of lean supply chain management frameworks: proposed framework", *Production Planning & Control*, Vol. 26 No. 13, pp. 1051-1068.

Jin-Hai, L., Anderson, A.R. & Harrison, R.T. (2003), "The evolution of agile manufacturing", *Business Process Management Journal*, Vol. 9 No. 2, pp. 170-189.

Kaiser, H.F. (1960), "The application of electronic computers to factor analysis", *Educational and Psychological Measurement*, Vol. 20 No. 1, pp. 141-151

Koufteros, X.A., Vonderembse, M.A. & Doll, W.J. (1998), "Developing measures of time-based manufacturing", *Journal of Operations Management*, Vol. 16 No. 1, pp. 21-41.

Kembro, J., Selviaridis, K. & Näslund, D. (2014), "Theoretical perspectives on information sharing in supply chains: a systematic literature review and conceptual framework", *Supply Chain Management: An International Journal*, Vol. 19 No. 5/6, pp. 609-625.

Kull, T.J., Yan, T., Liu, Z. & Wacker, J.G. (2014), "The moderation of lean manufacturing effectiveness by dimensions of national culture: testing practice-culture congruence hypotheses", *International Journal of Production Economics*, Vol. 153, pp. 1-12.

Lawrence, P. R. & Lorsch, J. W. (1967), "Differentiation and integration in complex organizations", *Administrative science quarterly*, pp. 1-47.

Lee-Mortimer, A. (2006), "A lean route to manufacturing survival", *Assembly Automation*, Vol. 26 No.4, pp. 265-272.

Lucato, C.W., Calarge, A.F., Loureiro, J.M. & Calado, D.R. (2014), "Performance evaluation of lean manufacturing implementation in Brazil", *International Journal of Productivity and Performance Management*, Vol. 63 No. 5, pp. 529-549.

Malmbrandt, M. & Ahlstrom, P. (2013), "An instrument for assessing lean service adoption", *International Journal of Operations & Production Management*, Vol. 33 No. 9, pp. 1131-1165.

Marodin, G. & Saurin, T. A. (2015), "Managing barriers to lean production implementation: context matters", *International Journal of Production Research*, Vol. 53 No. 13, pp. 3947-3962.

Marodin, G., Saurin, T., Tortorella, G. & Denicol, J. (2015), "How context factors influence lean production practices in manufacturing cells", *International Journal of Advanced Manufacturing Technology*, Vol. 79, No. 5-8, pp. 1389-1399.

Marodin, G.A., Frank, A.G., Tortorella, G.L. & Fetterman, D.C. (2017a), "Lean production and operational performance in the Brazilian automotive supply chain", *Total Quality Management & Business Excellence*, pp. 1-16.

Marodin, G.A., Frank, A.G., Tortorella, G. & Saurin, T. A. (2016), "Contextual factors and lean production implementation in the Brazilian automotive supply chain", *Supply Chain Management: An International Journal*, Vol. 21 No. 4, pp. 417-432.

Marodin, G.A., Tortorella, G.L., Frank, A.G. & Godinho Filho, M. (2017b), "The moderating effect of lean supply chain management on the impact of lean shop floor practices on quality and inventory", *Supply Chain Management: An International Journal*, Vol. 22 No. 6, pp. 473-485.

Maskell, B. (2001), "The age of agile manufacturing", *Supply Chain Management: An International Journal*, Vol. 6 No. 1, pp. 5-11.

Mason-Jones, R., Naylor, B. & Towill, D.R. (2000), "Lean, agile or leagile? Matching your supply chain to the marketplace", *International Journal of Production Research*, Vol. 38 No. 17, pp. 4061-4070.

Matt, D.T. (2010). "Axiomatic design of agile manufacturing systems". In: Aized, T. Future Manufacturing Systems. Croatia: Sciyo.

Mccullen, P. & Towill, D. (2001), "Achieving Lean Supply through Agile Manufacturing", *International Journal of Manufacturing Systems*, Vol. 12 No. 7, pp. 524-533.

Moayed, F.A. & Shell, R.L. (2009), "Comparison and evaluation of maintenance operations in lean versus non-lean production systems", *Journal of Quality in Maintenance Engineering*, Vol. 15 No. 3, pp. 285-296.

Morris, D., Donnelly, T. & Donnelly, T. (2004), "Supplier parks in the automotive industry", *Supply Chain Management: An International Journal*, Vol. 9 No. 2, pp. 129-133.

Murman, E., Allen, T., Bozdogan, K., Cutcher-Gersbenfeld, J., Mcmanus, H., Nightingale, D. & Warmkessel, J. (2002), "Lean enterprise value: insights from MIT's lean aerospace initiative", Palgrave: Hampshire.

Narasimhan, R., Swink, M. & Kim, S.W. (2006), "Disentangling leanness and agility: An empirical investigation", *Journal of Operations Management*, Vol. 24 No. 5, pp. 440-457.

Naylor, B.J., Naim, M.M. & Berry, D. (1999), "Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain", *International Journal of Production Economics*, Vol. 62 No.1-2, pp. 107-118.

Negrao, L.L.L., Godinho Filho, M. & Marodin, G. (2017), "Lean practices and their effect on performance: a literature review", *Production Planning & Control*, Vol. 28 No. 1, pp. 33-56.

Nelson R.R. & Winter, S.G. (1982), "An evolutionary theory of economic change". Cambridge, MA: *Harvard University Press*.

Netland, T.H. (2016), "Critical success factors for implementing lean production: the effect of contingencies", *International Journal of Production Research*, Vol. 54 No. 8, pp. 2433-2448.

Onuh, S. O. & Hon, K. K. B. (2001), "Integration of rapid prototyping technology into FMS for agile manufacturing", *Integrated Manufacturing Systems*, Vol. 12 No. 3, pp. 179-186.

Osterman, P. (1994), "How common is workplace transformation and who adopts it?", *Industrial & Labor Relations Review*, Vol. 47 No. 2, pp. 173-188.

Panizzolo, R., Garengo, P., Sharma, M.K. & Gore, A. (2012), "Lean manufacturing in developing countries: evidence from Indian SMEs", *Production Planning & Control*, Vol. 23 No. 10-11, pp. 769-788.

Pfeffer, J. & Salancik, G.R. (1978), "The external control of organizations: A resource dependence perspective" New York: Harper & Row.

Purvis, L., Gosling, J. & Naim, M.M. (2014), "The development of a lean, agile and leagile supply network taxonomy based on differing types of flexibility", *International Journal of Production Economics*, Vol. 151, pp. 100-111.

Qamar, A. (2016). "Re-shoring within the UK Manufacturing Industry: An Inevitable Decline?" In: Gardner, E.C. & Qamar, A. *Dissident Voices in Europe? Past, Present and Future*. Newcastle upon Tyne: Cambridge Scholars Publishing, 3-16.

Rahman, N.A.A., Sharif, S.M. & Esa, M.M. (2013), "Lean manufacturing case study with Kanban system implementation", *Procedia Economics and Finance*, Vol. 7, pp. 174-180

Rawabdeh, I.A. (2005), "A model for the assessment of waste in job shop environments", *International Journal of Operations & Production Management*, Vol. 25 No.8, pp. 800-822.

Reichhart, A. & Holweg, M. (2007) "Lean distribution: concepts, contributions, conflicts". *International Journal of Production Research*, Vol. 45 No. 16, pp. 3699-3722.

Rose, A.M.N., Deros, B.M., Rahman, M.A. & Nordin, N. (2011), "Lean manufacturing best practices in SMEs", In Proceedings of the 2011 International Conference on Industrial Engineering and Operations Management (pp. 872-877).

Sahoo, A.K., Singh, N.K., Shankar, R. & Tiwari, M.K. (2008), "Lean philosophy: implementation in a forging company", *The International Journal of Advanced Manufacturing Technology*, Vol. 36 No. 5-6, pp. 451-462.

Sánchez, A. & Pérez, M. (2001), "Lean indicators and manufacturing strategies". *International Journal of Operations & Production Management*, Vol. 21 No. 11, pp. 1433-1452.

Saurin, T.A., Marodin, G.A. & Ribeiro, J.L.D. (2011), "A framework for assessing the use of lean production practices in manufacturing cells", *International Journal of Production Research*, Vol. 49 No. 11, pp. 3211-3230.

Schroer, B.J. (2004), "Simulation as a Tool in Understanding the Concepts of Lean Manufacturing". *Simulation*, Vol. 80 No. 3, pp. 171-175.

Sezen, B. Karakadilar, I.S. & Buyukozkan, G. (2012), "Proposition of a model for measuring adherence to lean practices: applied to Turkish automotive part suppliers", *International Journal of Production Research*, Vol. 50 No. 14, pp. 3878-3894,

Shah, R. & Ward, P.T. (2003), "Lean manufacturing: context, practice bundles, and performance", *Journal of Operations Management*, Vol. 21 No. 2, pp. 129-149.

Shah, R. & Ward, P.T. (2007), "Defining and developing measures of lean production", *Journal of Operations Management*, Vol. 25 No. 4, pp. 785-805.

Sharifi, H. & Zhang, Z. (2001), "Agile manufacturing in practice: application of a methodology", *International Journal of Production Management*, Vol. 21 No. 5/6, pp. 772-794.

Sharp, J.M., Irani, Z. & Desai, S. (1999), "Working towards agile manufacturing in the UK industry", *International Journal of Production Economics*, Vol. 62 No. 1, pp. 155-169.

Singh, P.J., Power, D. & Chuong, S.C. (2011), "A resource dependence theory perspective of ISO 9000 in managing organizational environment", *Journal of Operations Management*, Vol. 29 No. 1–2, pp. 49–64.

Singh, P.J., Smith, A. & Sohal, A.S. (2005), "Strategic supply chain management issues in the automotive industry: an Australian perspective", *International Journal of Production Research*, Vol. 43 No. 16, pp. 3375-3399.

Skinner, W. (1969), "Manufacturing - missing link in corporate strategy", *Harvard Business Review*, Vol. 47, pp. 136-145.

Soriano-Meier, H. & Forrester, P. L. (2002), "A model for evaluating the degree of leanness of manufacturing firms", *Integrated Manufacturing Systems*, Vol. 13 No. 2, pp. 104-109.

Sousa, R. & Voss, C. A. (2008). "Contingency research in operations management practices". *Journal of Operations Management*, Vol. 26 No. 6, pp. 697-713.

Stinchcombe, A. (1965), "Social structure and organizations", In: March, J. (Ed.) *Handbook of Organizations*. Chicago: Rand McNally, pp. 153-193.

Sundar, R., Balaji, A.N. & Kumar, R.S. (2014), "A review on lean manufacturing implementation techniques", *Procedia Engineering*, Vol. 97, pp. 1875-1885.

Susilawati, A., Tan, J., Bell, D. & Sarwar, M. (2015), "Fuzzy logic based method to measure degree of lean activity in manufacturing industry", *Journal of Manufacturing Systems*, Vol. 34, pp. 1-11.

Sweeney, E.J. (2003), "Forms and Facts from One Company's 5S Effort". Lean Enterprise Institute.

Taj, S. & Morosan, C. (2011), "The impact of lean operations on the Chinese manufacturing performance", *Journal of Manufacturing Technology Management*, Vol. 22 No. 2, pp. 223-240.

Tachizawa, E.M. & Yew Wong, C. (2014), "Towards a theory of multi-tier sustainable supply chains: a systematic literature review", *Supply Chain Management: An International Journal*, Vol. 19 No.5/6, pp. 643-663.

Takahashi, K. & Nakamura, N. (2000), "Agile control in JIT ordering systems", *International Journal of Agile Management Systems*, Vol. 2 No. 3, pp. 242-252.

Tortorella, G.L. & Fettermann, D. (2017), "Implementation of Industry 4.0 and lean production in Brazilian manufacturing companies", *International Journal of Production Research*, pp. 1-13.

Tortorella, G.L., Marodin, G.A., Miorando, R. & Seidel, A. (2015), "The impact of contextual variables on learning organization in firms that are implementing lean: a study in Southern Brazil", *The International Journal of Advanced Manufacturing Technology*, Vol. 78 No. 9-12, pp. 1879-1892.

Tortorella, G.L., Miorando, R. & Marodin, G. (2017b), "Lean supply chain management: Empirical research on practices, contexts and performance", *International Journal of Production Economics*, Vol. 193, pp. 98-112.

Tortorella, G.L., Miorando, R. & Tlapa, D. (2017a), "Implementation of lean supply chain: an empirical research on the effect of context", *The TQM Journal*, Vol. 29 No. 4, pp. 610-623.

Touboulic, A., Chicksand, D. & Walker, H. (2014), "Managing imbalanced supply chain relationships for sustainability: A power perspective", *Decision Sciences*, Vol. 45 No. 4, pp. 577-619.

Tseng, Y. H. & Lin, C. T. (2011), "Enhancing enterprise agility by deploying agile drivers, capabilities and providers", *Information Sciences*, Vol. 181 No.17, pp. 3693-3708.

Turner, K.. & Williams, G. (2005), "Modelling complexity in the automotive industry supply chain", *Journal of Manufacturing Technology Management*, Vol. 16 No. 4, pp. 447-458.

Ulrich, D. & Barney, J. B. (1984), "Perspectives in organizations: Resource dependence, efficiency, and population", *Academy of Management Review*, Vol. 9 No. 3, pp. 471-481.

Vázquez-Bustelo, D. & Avella, L. (2006), "Agile manufacturing: Industrial case studies in Spain", *Technovation*, Vol. 26 No. 10, pp. 1147-1161.

Vidal, M. (2007), "Lean production, worker empowerment, and job satisfaction: qualitative analysis and critique". *Critical Sociology*, Vol. 33 No. 1-2, pp. 247-278.

Vinodh, S. & Kuttalingam, D. (2011), "Computer-aided design and engineering as enablers of agile manufacturing: a case study in an Indian manufacturing organization", *Journal of Manufacturing Technology Management*, Vol. 22 No. 3, pp. 405-418.

Vinodh, S. & Aravindraj, S. (2013), "Evaluation of leagility in supply chains using fuzzy logic approach", *International Journal of Production Research*, Vol. 51 No. 4, pp. 1186-1195.

Vogt, W.P. (1999), "Dictionary of Statistics and Methodology: A Nontechnical Guide for the Social Sciences", London: Sage.

Walker, H., Chicksand, D., Radnor, Z. & Watson, G. (2015), "Theoretical perspectives in operations management: an analysis of the literature", *International Journal of Operations & Production Management*, Vol. 35 No.8, pp. 1182-1206.

White, R. E., Pearson, J. N. & Wilson, J. R. (1999), "JIT manufacturing: a survey of implementations in small and large US manufacturers", *Management Science*, Vol. 45 No.1, pp. 1-15.

Womack, J.P. & Jones, D.T. (1996), "Beyond Toyota: how to root out waste and pursue perfection", *Harvard Business Review*, Vol. 74 No. 5, pp. 140.

Womack, J.P., Jones, D.T. & Roos, D. (1990), *Machine that changed the world*, Simon and Schuster, New York, NY.

Yusuf, Y.Y. & Adeleye, E.O. (2002), "A comparative study of lean and agile manufacturing with a related survey of current practices in the UK", *International Journal of Production Research*, Vol. 40 No. 17, pp. 4545-4562.

Yusuf, Y.Y., Sarhadi, M. & Gunasekaran, A. (1999), "Agile manufacturing: The drivers, concepts and attributes", *International Journal of Production Economics*, Vol. 62 No. 1, pp. 33-43.