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Critical Success Factors for Implementing Lean Production: The Effect of Contingencies

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Abstract

To facilitate the implementation of lean production, practitioners and researchers have suggested an array of critical success factors. However, despite a broad consensus about what needs to be done, companies still struggle to implement lean. Contingency theory posits the explanation that the common advice is not universal but is instead contingent on the situation. This paper investigates how contingency variables influence what practitioners see as success factors for implementing lean. A survey asked 432 practitioners from 83 factories belonging to two multinational companies for their opinions about what managers should do to ensure the success of the factory-level implementation of lean production. The survey responses were grouped into general success factors, which were then tested for differences across four contingency variables: corporation, factory size, stage of lean implementation and national culture. In general, the analysis supports a generic list of critical success factors, but with some minor exceptions. For example, the stage of lean implementation in a factory influences to a slight extent which factors are perceived as more effectual than others. The paper contributes to the literature on lean production and offer several recommendations for managers striving to implement lean in their firms.

Keywords: *lean production; critical success factors; continuous improvement*

1 Introduction

The interest in lean production has regained momentum over the past few years (Marodin and Saurin 2013; Jasti and Kodali 2015). The recent economic downturn—in an even more open global economy—has forced companies to look for ways to increase productivity and cut costs. For that purpose, lean has become a popular strategy for improving the competitiveness of industrial firms (Womack et al. 1990; Holweg 2007). Today, the term 'lean' describes a production improvement strategy that integrates, and expands on, concepts such as Just-in-Time production (JIT), Total Quality Management (TQM), Six Sigma, Total Productive Maintenance (TPM) and specific human resource management (HRM) practices (e.g., teamwork and flexible manpower) (Shah and Ward 2003; Schonberger 2008). Increasingly, companies use practices drawn from all these sources to develop and tailor their own company-specific *lean production systems* (Netland 2013). These systems are heavily inspired by the Toyota Production System (Womack et al. 1990). The popularity of lean in both practice and research is understandable; both anecdotal case studies and empirical research show that lean companies outperform non-lean companies in terms of operations (Womack and Jones 1996; Swamidass 2007; Mackelprang and Nair 2010).

Despite the many attempts, however, the majority of companies do not succeed with their lean programmes (Lucey et al. 2005; Pay 2008; Schonberger 2008). It has been reported that two out of every three organisational change projects fail (Kotter 1995; Beer and Nohria 2001; Aiken and Keller 2009). According to an article in *Industry Week* in 2007, 70% of all manufacturing plants in the United States employed some form of lean production project, but only one in four of them were satisfied with the outcome (Pay 2008). In particular, it is difficult to sustain momentum beyond the initial implementation of the project (Bateman 2005; Hines et al. 2011; Netland and Ferdows 2014). A negative return on investment is bad in itself, but it also hampers future attempts at implementing lean, which can cause more severe damage to long-term competitiveness.

To assist companies in implementing lean and avoiding costly failures, researchers and consultants have suggested a range of *critical success factors* (CSFs). CSFs can be defined as 'those few things that must go well to ensure success for a manager or an organisation, and, therefore, they represent those managerial or enterprise

areas that must be given special and continual attention to bring about high performance' (Boynton and Zmud 1984, p.17). Numerous lists of the CSFs for implementing lean, TQM, JIT, Six Sigma, TPM and similar improvement templates are available (e.g., Ramarapu et al. 1995; Yusof and Aspinwall 1999; Dayton 2001; Motwani 2001; Sila and Ebrahimpour 2003; Taylor and Wright 2003; Wali et al. 2003; Black 2007; Ahuja and Khamba 2008; Schroeder et al. 2008; Trkman 2010; Brun 2011; Manville et al. 2012; Bortolotti et al. 2015). Generally speaking, there is a strong agreement across such studies as to what constitutes a CSF (Näslund 2013).

Much less clear, however, is whether these prescriptive lists of CSFs are universal or dependent on *contingencies*. Contingency theory holds that there is no best way to lead a firm or a process; instead, the best solution is contingent on the situation (Donaldson 2001; Sousa and Voss 2001). Contingencies are the characteristics of a particular context, which makes every situation different from another. For this reason, Marodin and Saurin (2013, p. 6666) explicitly call for 'investigations on how the company's context influences the success factors.' The present paper addresses this call. It contributes to the literature with an analysis of the effect of contingencies on CSFs when implementing lean production.

While the existing literature on CSFs makes use of case studies (e.g., Henderson and Evans 2000; Scherrer-Rathje et al. 2009), quantitative surveys (e.g., Black and Porter 1996; Losonci et al. 2011; Bortolotti et al. 2015), conceptual reasoning (e.g., Liker 2004; Black 2007) and literature reviews (e.g., Saraph et al. 1989; Sila and Ebrahimpour 2003; Näslund 2013), this paper takes a novel approach: it analyses what practitioners describe—in their own words—as critical for implementing lean in their factories. The opinions are collected through a survey administered to employees of two multinational companies that are seeking to implement lean production systems in their global production networks.

The paper is organised as follows. The next section reviews the literature on the CSFs for production improvement. Specifically, it summarises a collective list of CSFs across 14 existing literature reviews, and then introduces contingency theory to question the rationality of such universal lists. Section 3 presents the research method. The empirical data is analysed in Section 4. Implications for practitioners are discussed in Section 5, which suggests five essential 'bundles of actions' for implementing lean production. Finally, the conclusions, limitations and opportunities for future research are presented in Section 6.

Table 1 – Commonly reported critical success factors among reviews of the improvement programme literature.

Literature reviews	Saraph et al (1989)	Sila & Ebrahimpour (2003)	Karuppusami & Gandhinathan (2006)	Nitin et al. (2011)	Motwani (2001)	Schroeder et al. (2008)	Coronado & Antony (2002)	Brady & Allen (2006)	Kwak & Anbari (2006)	Ahuja and Khamba (2008)	Ramarapu et al. (1995)	Näslund (2008)	Netland & Aspelund (2014)	Marodin & Saurin (2013)	
Improvement programme / **CSF**	**TQM**	**TQM**	**TQM**	**Quality awards**	**TQM**	**Six Sigma**	**Six Sigma**	**Six Sigma**	**Six Sigma**	**TPM**	**JIT**	**Lean, Six Sigma, JIT, TQM**	**Lean, XPSs**	**Lean**	**#**
Management commitment and involvement	X	X	X	X	X	X	X	X	X	X	X	X	X	X	14
Training and education	X	X	X	X	X	X	X	X	X	X		X	X	X	13
Employee participation and empowerment	X	X	X	X	X	X	X	X		X	X		X	X	12
Alignment to strategy and long-term plan		X		X			X	X		X	X	X		X	8
Managing cultural change							X	X	X	X		X	X	X	7
Supplier involvement	X	X	X		X	X	X				X				7
Customer involvement		X	X	X	X	X	X								6
Teamwork		X	X			X		X				X	X		6
Process management	X	X	X	X	X	X									6
Structured approach and project prioritizing				X			X	X	X					X	5
Benchmarking and knowledge transfer		X	X		X							X	X		5
Cross-functional integration		X	X		X	X								X	5
Quality data and analysis	X	X	X	X		X									5
Project management skills							X	X	X			X			4
Performance measurement					X			X				X		X	4
Organisation infrastructure			X				X			X		X			4
Sustain continuous improvement		X								X			X	X	4
Quality control and robust processes	X	X		X							X				4
Use of tools, techniques and technologies							X	X			X				3
Communication							X					X		X	3
Rewards and recognition				X						X				X	3
Job security and social responsibility		X												X	2

2 Literature Review

Identifying and suggesting CSFs for lean, JIT, TQM, Six Sigma, TPM and so on has long been, and continues to be, a topic of great interest in the operations management literature and practice. For this reason, there are many descriptions available. Lists of CSFs for lean have been suggested by, among others, Achanga et al. (2006), Cotte et al. (2008), Losonci et al. (2011) and Vinodh and Joy (2011). CSFs for JIT have been discussed by Goyal and Deshmukh (1992), Mehra and Inman (1992), Chang and Lee (1996) and others. For TQM, lists of CSFs have been provided by, for example, Saraph et al. (1989), Porter and Parker (1993), Black and Porter (1996), Ahire et al. (1996) as well as Taylor and Wright (2003). Similar lists for Six Sigma (or 'Lean Six Sigma') have been suggested by, among others, Henderson and Evans (2000), Antony et al. (2007), Schonberger (2008), Brun (2011) and Manville et al. (2012), and for TPM by Bamber et al. (1999) and Brah and Chong (2004).

Several structured literature reviews already summarise the large number of published papers on CSFs for improvement programmes. Therefore, a review of these reviews can efficiently provide comprehensive coverage of the existing literature.

2.1 Critical success factors according to the existing literature

Table 1 summarises 22 CSFs reported across 14 structured reviews of the literature on TQM, Six Sigma, TPM, JIT and lean.

There is a consensus that the three most important CSFs are 'management commitment and involvement', 'training and education' and 'employee participation and empowerment'. See, for example, the review of 76 TQM studies by Sila and Ebrahimpour (2003), the review of CSFs across 10 national quality awards by Nitin et al. (2011), the review of 201 Six Sigma studies by Brady and Allen (2006) and the review of 102 studies on lean production by Marodin and Saurin (2013). This suggests that managers need to actively lead and support the implementation of lean, provide training and education to ensure that everyone knows what and how to implement lean and involve and empower employees to make the sought-after changes. The existing literature also emphasises the importance of aligning the improvement programme to the business strategy, creating long-term plans, managing cultural changes and involving supply chain partners as key factors among the 22 CSFs presented in Table 1.

Some minor differences across the various improvement programmes are present. For example, the quality management literature emphasises 'process management', 'data quality and analysis' and 'quality control and robust processes' (e.g., Sila and Ebrahimpour 2003; Karuppusami and Gandhinathan 2006), while the Six Sigma literature emphasises 'project management skills' (e.g., Coronado and Antony 2002; Brady and Allen 2006; Kwak and Anbari 2006) and the reviews of lean and JIT emphasise 'managing cultural change' (e.g., Näslund 2008; Marodin and Saurin 2013; Netland and Aspelund 2014). These slight differences can be anticipated for the following reasons: TQM emphasises the use of process data to improve quality performance (Ishikawa 1985), Six Sigma is a project-driven improvement concept (Brady and Allen 2006) and lean emphasises changing the organisational culture (Liker and Hoseus 2008). Irrespective of these differences, there is a high level of consensus regarding the CSFs for implementing various improvement programmes.

A limitation of the existing literature is that the bulk of the CSFs studies are purely conceptual (e.g, Liker 2004; Black 2007) or otherwise single case studies of implementation in one company (e.g., Henderson and Evans 2000; Scherrer-Rathje et al. 2009). In both cases, the possibility for controlling for confounding factors is limited or non-existent. There is a risk that conceptual and single case studies reinforce each other and form a general belief without rigorous testing. Others have used surveys to overcome this challenge (Saraph et al. 1989; Black and Porter 1996; Kumar et al. 2011; Vinodh and Joy 2011). One limitation of survey research is that respondents rate *predefined* lists of factors (Davies and Kochhar 2002). Those studies usually conclude with generic lists of CSFs that have been tested for reliability and validity across the respective samples. However, none of them seem to examine the effect of specific contingencies on CSFs.

2.2 Contingency theory and critical success factors

One fundamental question is whether generic lists of CSFs can be provided in the first place. On the one hand, quality gurus such as Deming (1986), Crosby (1979) and Juran (1988) and proponents of lean production such as Liker (2004) and Womack and Jones (1996) all suggest generic lists of CSFs that have 'universal applicability'. On the other hand, *contingency theory* (Donaldson 2001) suggests that different environments most likely require different approaches.

According to contingency theory, CSFs are most effective if they are tailored to the varying environments. Contingency theory has been used to study the moderating effect on *performance* of implementing lean practices (for an in-depth discussion see Sousa and Voss 2008), but it is hardly ever applied to the study of how *the underlying managerial processes* that seek to implement those practices should be adapted. This study addresses four essential contingencies: the corporation, the size of the factory, the implementation stage of lean in the factory and national culture.

First—following the contingency argument—the ownership of a factory by a specific corporation is expected to impact what factors it sees as critical for implementing lean (Sousa and Voss 2001; Sousa and Voss 2008; Marodin and Saurin 2015). This is due to a combination of reasons: corporations compete with different products, in different markets and with different technologies, organisations and strategies. They have dissimilar histories and organisational cultures. Therefore, when two factories belonging to different corporations attempt to implement their own company-specific versions of lean, it should be expected that the CSFs would also differ. The first research question is: *Do the CSFs for implementing lean vary significantly across corporations?*

Second, many studies have emphasised the importance of factory size in lean implementation (Shah and Ward 2003). In particular, it is argued that small- and medium-sized enterprises (SMEs) face different challenges when implementing lean than those faced by large corporations (White et al. 1999; Yusof and Aspinwall 2000; Achanga et al. 2006; Kumar et al. 2011; Powell et al. 2012). On the one hand, SMEs lack the financial and organisational resources that larger firms often have. On the other hand, SMEs' smaller size can enable them to have a quicker turnaround than larger firms. However, the empirical evidence suggests that it is harder to implement lean production in a smaller sized factory compared to a larger one (White et al. 1999; Shah and Ward 2003). The second research question is: *Do the CSFs for implementing lean vary significantly across factories of different sizes?*

A third contingency variable that is expected to have a significant impact on the implementation of lean is the lean maturity stage of the factory. It has been established that experience plays a noteworthy role in the implementation of a production improvement programme (Jayaram et al. 2010; Easton and Rosenzweig 2012; Swink and Jacobs 2012; Netland and Ferdows 2014). Also, based primarily on case evidence, the literature offers step-wise implementation roadmaps that suggest that CSFs may

change throughout the implementation (Womack and Jones 1996; Ahlström 1998; Netland and Ferdows 2014; Marodin and Saurin 2015). The third research question is: *Do the CSFs for implementing lean vary significantly as factories become more experienced in lean production?*

Fourth, the impact of national culture on the implementation of lean is a recurring theme in the literature (Sousa and Voss 2008). According to Hofstede and Hofstede (2005), national culture is the 'collective programming of the mind' that makes one nation distinctively different from another. National cultures are extremely hard to change because they are deeply ingrained in their societies. Even if some advocates of lean production argue that lean can be implemented irrespective of national culture (Krafcik 1988; Womack et al. 1990), the results of other studies remain contradictory or inconclusive (e.g., Newman and Nollen 1996; Lagrosen 2003; Kull and Wacker 2010; Vecchi and Brennan 2011). There is, however, some agreement in the literature that it is easier to implement lean in collectivistic cultures than it is in cultures characterised by individualism (Naor et al. 2010; Power et al. 2010; Wiengarten et al. 2011). The fourth research question is: *Do the CSFs for implementing lean vary significantly across national cultures?*

3 Research Method

In order to test for the impact of contingencies on the CFSs for lean implementation, a survey design was chosen and two multinational companies in two different industries were selected as the research setting: a global chemicals company (hereafter known as 'Firm C') and a global vehicle manufacturer (hereafter 'Firm V'). While the vehicle industry represents a typical setting for the implementation of lean production, the chemical industry represents a purposely different setting. Limiting the research to one multinational corporation would hold many contingencies nearly constant (e.g., industry, market characteristics, technology, corporate culture, lean programme, etc.), and so including a second corporation facilitates the testing of differences across firms.

3.1 Data

Both Firms C and V seek to implement company-specific lean production systems in all their factories worldwide. The key principles of Firm C's lean production system

are ‘health, safety and environment’ (HSE), ‘TQM’, ‘TPM’, ‘JIT’ and ‘management by objectives’. The key principles of Firm V’s lean production system are ‘HSE’, ‘HRM’, ‘TQM’, ‘TPM’, ‘JIT’ and ‘continuous improvement’. Both firms provided detailed descriptions of their lean production systems. Arguably, these two systems share strong commonalities: both represent typical company-specific lean production systems (c.f. Netland 2013) and both are in accordance with the notion of ‘lean bundles’ in the literature (Shah and Ward 2003; Furlan et al. 2011).

As part of a larger investigation of lean implementation in these two firms, a survey was distributed to the factories. This paper only uses data collected from one of the sections in the survey. It asked an *open-ended question*: ‘In your opinion and experience, what are the three most important direct actions managers can take to improve the implementation of the lean production system in your plant?’ Three free-text fields were provided for the respondents to answer the question. Hence, this paper is based on a text analysis of the opinions of employees in two multinational firms.

The survey was sent to a total of 83 plants, of which 27 plants belong to Firm C and 56 plants to Firm V. Since larger plants naturally have more departments and more complex hierarchies than smaller plants, three to eight respondents were requested depending on the size of the plant (about three for small plants, five for large plants and eight for huge plants). The respondents were chosen to represent managers and staff from different hierarchical positions. All responses were collected during 2012. A total of 432 employees responded to the survey: 120 in Firm C and 312 in Firm V. On average, 5.2 employees responded from each plant, representing 40% senior managers, 28% middle managers, 25% lean production system managers and staff and 7% administrative or technical support.[1] The plants are located in 27 countries on six continents. Hence, the dataset includes a good representation of opinions across different positions in two different firms and from different locations all over the world.

The dataset provides several advantages. First, survey data from a limited number of multinational companies that have launched lean production systems improve the construct validity: managers in these firms know what is meant by ‘lean’ in their firm

[1] The analysis included a test of the differences in perceptions across these four groups of positions. The only statistically significant differences were related to the following two factors ($p<0.05$): senior managers and lean managers rate the importance of ‘participate personally’ higher than the two other position groups, and lean managers rate the importance of ‘use rewards and recognition’ much lower than the other position groups.

(they can consult definitions of the respective lean production systems). Second, having several respondents from each factory (and from several layers of management and staff) increases the internal reliability. Third, basing the analysis on free-text data reduces the bias involved in using pre-defined items in the way most surveys do. In addition, when using free-text data, respondents can suggest factors that researchers have not thought of during the design of the study. The research method also has several limitations, which are discussed in Section 6.1.

3.2 Measures for contingency variables

The measures for contingency variables were as follows: 'Corporation' is naturally measured as belonging to either Firm C (30% of sample) or Firm V (70%). 'Factory size' is measured as the number of employees in the factory, and grouped into three categories: small- and medium-sized plants ("SMEs") (up to 250 employees, 44% of sample), large plants (250–1000 employees, 30% of sample) and huge plants (above 1000 employees, 26% of sample).

'Implementation stage' is measured in different ways for the two firms: For Firm V, it relies on a standardised firm-internal assessment process that scores the factory on a five-point Likert scale. The assessment was carried out by a team of professional plant-external lean experts and covers more than 100 items to measure lean implementation. For Firm C, it relies on a separate survey asking seven lean experts from the corporate office to individually score each of the 27 factories according to their lean implementation on a seven-point Likert scale. The plant scores from both firms were used to separate all plants into three maturity stages: low maturity plants (36% of respondents), intermediate maturity plants (34%) and high maturity plants (30%).

The analysis of 'National culture' differentiates between 'collectivistic culture' (43%) and 'individualistic culture' (57%), as defined by Hofstede and Hofstede (2005). The Hofstede scale runs from 0 to 100. Plants located in countries that score 50 or lower on the Hofstede Individualism dimension were categorised as collectivistic cultures, whereas those with a score above 50 were categorised as individualistic cultures. Individualistic cultures in the sample include Australia, Belgium, Canada, Czech Republic, France, Germany, Norway, Poland, South Africa, Spain, Sweden, the United Kingdom and the USA. Collectivistic cultures in the sample include Brazil, China, Egypt, India, Indonesia, Japan, Malaysia, Mexico, Oman, Saudi Arabia, Thailand, Turkey, United Arab Emirates, Venezuela and Vietnam.

3.3 Analysis

A total of 1036 usable answers from 432 respondents in the two firms were grouped into success factors in several steps. First, two researchers independently grouped samples of the answers into factors. These factors were discussed iteratively before a final set of 24 factors was decided on and used.

All mentions of each factor by all respondents were counted, resulting in a general ranked list of the most referred to success factors. The answers from a respondent were given the same weight (i.e., they were not weighted according to the most, second most and third most important factor). We removed repetitions; in cases where one respondent had repeated a success factor, we only counted one mention, which reduced the number of included answers in the final sample to 1015.

The categorisation was tested for measurement reproducibility using inter-rater reliability analysis (Gwet 2012). A third person proficient in lean production was asked to independently assign each of the included answers to one of the 24 defined factors. As we had 24 categories, the risk for agreement by chance, which is the argument for reporting chance-corrected agreement coefficients (e.g., Cohens' Kappa) instead of simple agreement percentage (Gwet 2012), is not substantial. We calculated an inter-rater agreement percentage of 64.4%, which is acceptable.

The tests for the effect of contingencies were conducted by comparing the scores of different subsets of the sample with the general list of the total sample. To analyse differences between two categorical variables, the *chi square goodness of fit test* is appropriate (Sharp 1979). It tests whether there are significant differences between the observed and expected values (Balakrishnan et al. 2013). In simple terms, if the contingencies matter, then the lists of CSFs for different contingencies would differ from the average values with statistical significance. Because the chi square goodness of fit test is less applicable when the number of cases in each category of a subset goes below five (Cochran 1952), caution is used when drawing conclusions for the least mentioned practices in the subsets.

Table 2 – Ranking of success factors for lean implementation, with chi-tests for the effect of contingencies.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Rank	**Success factor**	**Total #**	**Total %**	**Corporation**			**Factory size**				**Lean maturity stage**				**National culture**		
				Firm C	*Firm V*	*Chi test corp.*	*SME*	*Large*	*Huge*	*Chi test size*	*Low*	*Inter.*	*High*	*Chi test stage*	*Indiv.*	*Coll.*	*Chi test culture*
1	Lead actively	160	15.8 %	12 %	17 %	0.06	14 %	19 %	15 %	0.23	14 %	15 %	18 %	0.32	16 %	15 %	0.52
2	Participate personally	91	9.0 %	6 %	10 %	0.07	7 %	10 %	11 %	0.15	5 %	10 %	13 %	**0.01****	10 %	8 %	0.26
3	Educate employees	78	7.7 %	10 %	7 %	**0.05***	9 %	5 %	8 %	0.14	10 %	6 %	7 %	0.22	7 %	9 %	0.15
4	Educate managers	68	6.7 %	4 %	8 %	**0.03****	5 %	6 %	10 %	**0.03***	5 %	8 %	7 %	0.39	8 %	5 %	0.07
5	Communicate. inform and discuss	64	6.3 %	6 %	7 %	0.61	6 %	8 %	5 %	0.38	7 %	7 %	5 %	0.43	6 %	6 %	0.88
6	Set and follow-up targets	63	6.2 %	7 %	6 %	0.69	7 %	7 %	4 %	0.41	7 %	5 %	6 %	0.78	6 %	6 %	0.96
7	Involve and support employees	56	5.5 %	4 %	6 %	0.31	5 %	6 %	5 %	0.79	3 %	6 %	8 %	0.07	6 %	5 %	0.75
8	Dedicate human resources	55	5.4 %	7 %	5 %	0.16	6 %	6 %	3 %	0.23	7 %	5 %	3 %	0.09	5 %	6 %	0.73
9	Use lean tools and methods	51	5.0 %	7 %	4 %	0.07	6 %	3 %	7 %	0.08	4 %	5 %	6 %	0.73	5 %	5 %	0.57
10	Integrate lean in everyday business	50	4.9 %	3 %	6 %	0.14	5 %	4 %	6 %	0.78	4 %	6 %	6 %	0.37	6 %	4 %	0.11
11	Develop vision and roadmap	37	3.6 %	3 %	4 %	0.75	3 %	5 %	4 %	0.31	4 %	3 %	4 %	0.73	4 %	3 %	0.51
12	Use rewards and recognition	36	3.5 %	6 %	3 %	**0.01****	5 %	2 %	3 %	0.11	7 %	3 %	1 %	**0.00****	2 %	5 %	**0.01***
13	Monitor and audit implementation	32	3.2 %	3 %	3 %	0.58	3 %	2 %	4 %	0.53	4 %	2 %	4 %	0.25	3 %	4 %	0.43
14	Standardise and manage discipline	23	2.3 %	2 %	2 %	0.72	1 %	3 %	3 %	0.12	2 %	3 %	2 %	0.46	3 %	2 %	0.42
15	Find and share best practices	23	2.3 %	3 %	2 %	0.14	3 %	2 %	2 %	0.60	4 %	2 %	1 %	**0.03***	2 %	3 %	0.38
16	Stepwise approach	23	2.3 %	3 %	2 %	0.31	3 %	2 %	1 %	0.09	2 %	3 %	1 %	0.34	2 %	2 %	0.70
17	Focus on areas and prioritise activities	21	2.1 %	2 %	2 %	0.93	2 %	2 %	2 %	0.94	1 %	3 %	1 %	0.12	2 %	2 %	0.36
18	Invest time and money	20	2.0 %	2 %	2 %	0.59	3 %	1 %	1 %	**0.03***	2 %	4 %	0 %	**0.00****	2 %	2 %	0.46
19	Benchmark others	16	1.6 %	2 %	1 %	0.48	2 %	1 %	1 %	0.50	2 %	1 %	2 %	0.31	1 %	3 %	**0.01***
20	Emphasise team concept	13	1.3 %	1 %	1 %	0.61	1 %	1 %	2 %	0.58	1 %	2 %	1 %	0.42	1 %	1 %	0.73
21	Use external experts	12	1.2 %	2 %	1 %	0.12	2 %	1 %	1 %	0.50	3 %	1 %	0 %	**0.01***	1 %	2 %	**0.03***
22	Hold regular implementation meetings	12	1.2 %	2 %	1 %	**0.03***	1 %	1 %	1 %	0.83	2 %	1 %	1 %	0.54	1 %	2 %	0.10
23	Emphasise safety and job attractiveness	6	0.6 %	1 %	1 %	0.84	0 %	1 %	1 %	0.33	0 %	0 %	1 %	0.12	1 %	0 %	0.63
24	Commit corporate management	5	0.5 %	0 %	1 %	0.64	0 %	1 %	0 %	0.91	0 %	0 %	1 %	0.30	0 %	1 %	0.45
	SUM	1015	100 %	100 %	100 %		100 %	100 %	100 %		100 %	100 %	100 %		100 %	100 %	

Notes: Percentages in columns E, F, H, I, J, L, M, N, P and Q show distribution of mentions for the respective contingency variable.
Confidence intervals in columns G, K, O and R: * $p < 0.05$ and ** $p < 0.01$

4 Results

Table 2, columns A through D, ranks the most referred to success factors across the total sample. It summarises the mentions in numbers (column C) and percentage (column D) for each of the factors (Appendix A, Table A-1, includes three example statements for each factor). A comparison of Table 1 and Table 2 shows a strong resemblance between the general rankings of CSFs in the literature with those referred to in the sample of this research. However, the tests for the effects of contingencies (columns E through R) reveal that a few of the factors are seen as relatively more effectual under certain circumstances.

4.1 Effect of corporation on the perceived CSFs for implementing lean

The first research question asks whether there are differences in CSFs between corporations. Table 2, columns E through G, shows only a few statistically significant differences between Firm C and Firm V, even though these firms are extensively different: they belong to different industries, have different ownership, follow different growth strategies, have different corporate cultures and are of considerably different sizes. Moreover, their lean programmes differ due to company-specific elements (c.f. Section 3.1). Considering this from a contingency theory perspective, it is unexpected that only four out of 24 CSFs differ with statistical significance at the 0.05 confidence interval (chi square $p<0.05$). Hence, the two different firms in this sample seem to largely agree on which factors are important for implementing lean.

The firms vary significantly in their judgements of the following factors: 'Educate managers' is valued higher in Firm V than in Firm C (8% vs. 4%, respectively), whereas the opposite holds true for 'Educate employees' (7% vs. 10%). However, educating employees and educating managers remain among the top-ten factors for both firms. The differences in relative importance may be due to existing training programmes in the firms. For example, for several years, Firm C has offered a lean training academy for managers and might hence prioritise educating the rest of the workforce.

Firm C also rates 'Use rewards and recognition' higher than Firm V (6% vs 3%). As will be discussed later, the use of reward and recognition schemes is also rated higher by early-stage factories and factories located in countries characterised by

collectivistic cultures, which makes it hard to interpret this difference. Finally, Firm C rates ‘Hold regular implementation meetings’ slightly higher than Firm V (2% vs 1%), but in both cases it is not frequently mentioned as a CSF.

Taken together, there are unexpectedly few differences in what the respondents from the two different firms find important when implementing lean in a factory.

4.2 Effect of factory size on the perceived CSFs for implementing lean

The second research question asks whether the size of the plant has an impact on which factors managers suggest as critical (see Table 2, columns H through K). The analysis differentiates small- and medium-sized plants, large plants and huge plants. Only two factors are ranked significantly different at the 0.05 confidence interval (‘Educate managers’ and ‘Invest time and money’). This may question the argument in the literature that smaller sized plants require very different lean implementation approaches to larger plants (e.g., Yusof and Aspinwall 2000; Achanga et al. 2006; Kumar et al. 2011).

Educating managers in lean seems to be slightly more emphasised as the plant grows in size (5%, 6% and 10%). Huge plants rank ‘Educate managers’ among the top-three CSFs, while the other sizes rank it among the top-ten. This is not surprising since the larger the plant is, the more dependent it is on managers for coordination. Finally, small- and medium-sized plants emphasise investing time and money slightly more than large and huge plants (3%, 1% and 1%), which could be anticipated because small plants have fewer resources.

4.3 Effect of implementation stage on the perceived CSFs for implementing lean

The third research question asks if there are differences between factories at different stages of implementing lean. It separates ‘low’, ‘intermediate’ and ‘high’ maturity factories. Compared with the general list of CSFs (Table 1), columns L through O in Table 2 show five statistically significant differences, of which three are at the 0.01 confidence interval and two at the 0.05 interval. As such, the stage of implementation appears to be a contingency that to a slight extent moderates the factors effective for implementing lean in a factory.

The higher the lean maturity, the more highly valued ‘Participate personally’ is (5% for low maturity plants, 10% for intermediate maturity plants and 18% for high maturity plants). This can be interpreted in at least two ways. One interpretation of the

increasing critical importance of participation is that managers get *more*, not less, important as lean implementation progresses. This would be an important wake-up call for managers who tend to 'kick off' large programmes and then divert their energy elsewhere as the programme gets implemented. Another interpretation could be that low maturity plants possibly lack the experience necessary to make qualified statements about which factors would be successful; hence, as they become more mature, they learn the critical importance of commitment and involvement. If the latter is the case, the opinions of respondents in high maturity plants are perhaps the most accurate descriptions of CSFs. In any case, it is clear that managers must stay committed to and involved in the implementation for a long time.

Low-maturity plants value the following three factors higher than plants with more experience of implementing lean: 'Use rewards and recognitions' (7%, 3% and 1%), 'Find and share best practices' (4%, 2% and 1%) and 'Use external experts' (3%, 1% and 0%). Using reward and recognition schemes may be more beneficial in the early stages to incentivise change, but such measures run out of steam as implementation matures. It is also logical that identifying and copying best practices is most helpful in the early stages when the potential for easy improvement is at its highest. A final significant difference is that low and medium maturity plants value 'Invest time and money' slightly more than high maturity plants (2%, 4% and 0%).

Although they are not statistically significant, Table 2 also reveals other tendencies in the data related to increasing implementation maturity. For example, 'Lead actively' (14%, 15% and 18%), 'Involve and support employees' (3%, 6% and 8%), 'Use lean tools and methods' (4%, 5% and 6%) and 'Integrate lean in everyday business' (4%, 6% and 6%) seem to increase their relative importance as implementation progresses. The opposite holds for 'Dedicate human resources' (7%, 5% and 3%). There may be good arguments for these priorities. At the beginning of a lean journey, there is a need for lean champions who drive the change within the organisation. Therefore, establishing a dedicated implementation team or hiring external consultants can be effective in the early stages. As more and more employees change and learn, the need for a team of experts diminishes, while the role of all employees and managers increases in importance. The plants in the most advanced implementation stages still think that a small team of dedicated employees is helpful, whereas external resources are not.

4.4 Effect of national culture on the perceived CSFs for implementing lean

The last research question asks whether plants from different national cultures rate the CSFs for implementing lean differently. The analysis differentiates individualistic national cultures from collectivistic national cultures. Only three significant differences are found (all at the 0.05 confidence interval). Plants in collectivistic cultures value 'Use rewards and recognition' (5% vs 2%),'Benchmark others' (3% vs 1%) and 'Use external experts' (2% vs 1%) marginally more highly than individualistic cultures.

The findings indicate that belonging to a particular national culture does not imply important changes to the CSFs. The top-ten CSFs remain top-ten when considering differences in culture, with the exception of 'Use rewards and recognition', which was also valued higher in early-stage factories and in Firm C than in later-stage factories and Firm V. Because Firm C has relatively more plants located in collectivist cultures than Firm V has, it is difficult to analyse the reasons for this finding. Nonetheless, it suggests that the use of rewards and recognition seems to be a factor that is sensitive to contingencies.

5 Discussion

The results offer several implications for managers implementing lean in factories. First, irrespective of contingencies, managers should be aware of which specific factors help to implement lean in a factory. Second, to make their actions even more effective, managers should adjust what they do to fit their specific environment. Based on the preceding analysis, the current section suggests five essential *bundles of actions* for implementing lean production *in any plant*, and discusses how particular contingencies may impact their significance.

To succeed with the implementation of lean, managers should:

1. ...commit to, lead and take an active part in the lean programme.
2. ...provide and attend training and education.
3. ...have a long-term plan and follow it up on a day-to-day basis.
4. ...allocate resources and share the gains.
5. ...apply lean tools and techniques.

5.1 Commit, lead and be involved

It is beyond question that the respondents think that *managerial commitment and involvement* are the most important success factors—irrespective of any contingencies. In Table 2, column C, 'Lead actively' (ranked #1 in Table 2) is considered 50% more important than the second factor on the list, 'Participate personally' (#2), which is also about commitment. Both of these factors are consistent with the existing literature on the CSFs for production improvement, which holds management commitment and involvement as the most critical success factor (e.g., Sila and Ebrahimpour 2003; Liker 2004; Brady and Allen 2006). An interesting observation is that the more mature the plant is in terms of implementing lean, the more it values these two factors. A few respondents, particularly in high maturity plants, also specify that success requires 'Committed global managers' (#24) outside the plant.

The results indicate that active leadership is considered more important than personal participation. Thus, relatively more managerial time should perhaps be allocated to long-term leadership activities than to operational participation—even if both are essential and may be difficult to clearly distinguish from each other. In this regard, 'Communicate, inform and discuss' (#5), that is, talking about the implementation of lean, listening to employees and explaining why it is needed, is of critical importance, regardless of contingencies.

5.2 Train and educate

A second group of factors emphasises *training and education* in lean production. 'Educate employees' (c.f. Table 2, #3) and 'Educate managers' (#4) are both ranked as top-ten CSFs across all contingencies. This is also in accordance with previous literature (e.g., Saraph et al. 1989; Sila and Ebrahimpour 2003; Näslund 2008). Without proper training and education, a plant is not likely to succeed with its lean implementation. Importantly, managers also need training and education. In different situations, particularly in huge plants, the education of managers is reported to be more important than educating employees—but, again, both are essential.

One quick way to learn can be to 'Benchmark others' (#19). In particular, those plants located in countries characterised by a collectivist culture suggest benchmarking as a success factor. Knowledge can also be accessed by 'Using external experts' (#21), either from external consultancy firms or from internal corporate resources. As can be anticipated, it is those plants that are new to lean (low maturity plants) that emphasise

the use of external experts more. Interestingly, among the high maturity plants, there was only a single respondent in one plant who advised the use of external experts. On the whole, it is clear that accumulating local knowledge is considered much more important than the use of consultants. However, in the early stages of the lean journey, external consultants and experts can help build this local knowledge.

5.3 Have a plan and follow it up

A third group of factors is concerned with *having a plan and following it up*. This is also broadly in accordance with the rankings in the existing literature (Table 1). There is a strong belief among the respondents, regardless of contingencies, that 'Set and follow-up targets' (Table 2, #6) is a CSF. To be able to set appropriate and achievable targets, it is often necessary to 'Develop a vision and roadmap' (#11) in the first place. This is also connected to 'Monitor and audit performance' (#13) (for example, through the use of regular implementation assessments), emphasise a 'Stepwise approach' (#16), 'Focus on areas and prioritise activities' (#17) and 'Hold regular meetings' (#22) to follow-up the implementation of specific projects.

Deviation from the plan has consequences, which is why many respondents, especially in larger-sized factories, claim that to 'Standardise and manage discipline' (#14) is of high importance. By the same token, managers should seek to 'Integrate lean in everyday business' (#10) and not run it as a separate, temporary project on the side of operations. The latter point is especially emphasised by factories that are at the more mature stages of lean implementation.

5.4 Allocate resources and share gains

A fourth group of factors involves *allocating the necessary resources to assist implementation, but sharing the gains with all*. Many respondents, especially in early-stage plants, emphasise the importance of 'Dedicating human resources' (c.f. Table 2, #8) in terms of a local lean implementation team or a distributed task force in the organisation. Relatedly, both smaller sized and less mature factories often refer the need to 'Invest time and money' (#18). A lean transformation does not come for free. As the plant matures in its lean implementation, 'Involve and support employees' (#7) is reported as being relatively more important as a CSF.

Gains won through improvements should be shared. A considerable amount of respondents emphasise 'Use reward and recognition' (#12). However, in this sample, it

is particularly the early-stage factories and factories located in collectivist cultures that emphasise rewards. Plants that have already implemented much of lean do not seem to value rewards. A particular finding in this study is that managers should take care when designing reward and recognition schemes because the effects of such schemes seem highly sensitive to contingencies.

5.5 Apply lean tools and methods

A fifth group of highly valued factors involve emphasising the application of *lean tools and methods*. 'Use lean tools and methods' (c.f. Table 2, #9) is a top-ten factor in the total sample, and there are only a few differences among the groups of contingencies. While one of the firms in the sample ranks tools and methods as more important than the other does, there are no noteworthy differences among plants at different stages, different maturity stages or national cultures in the use of tools and methods.

By taking a closer look at the respondents' statements that fall into this category, the specific tools and methods that are most frequently mentioned can be identified: waste reduction, visualisation, problem solving, team concept, continuous improvement, daily management, value stream mapping and 5S. These are all well-known methods from the lean production philosophy (Womack and Jones 1996). Tools and methods are effective and necessary for succeeding with the implementation of lean in a plant, but they are not sufficient on their own; the four other bundles of management actions must complement the tools and methods.

6 Conclusions

This paper addressed a fundamental question for managers who seek to implement lean production in their factories: Given the particular contingencies of a factory, what are the critical success factors for implementing lean? Contingency theory suggests that different environments would require different managerial actions. But, an analysis of data from 432 individual respondents in two multinational companies found only few statistically significant differences among the four investigated contingencies: corporation, size, lean implementation stage and location. On the whole, a generic list of CSFs makes sense, with some minor reservations: Belonging to a certain corporation,

the size of the factory and, in particular, the stage of lean implementation, influence to a minor extent the ranking of some few factors that managers see as critical for success.

In brief, to succeed with implementing a lean programme in a factory, managers must commit to and involve themselves in the activities of implementation. Such active leadership must be sustained—and even intensified—as implementation progresses. Developing lean knowledge and competency by offering continual education and training to *both* managers and employees is critical for success. External resources can be used early on, but they will have a more limited effect when plants reach higher implementation stages. Furthermore, there is a persistent need for proper planning, following-up and funding of the lean programme. In the early stages of implementation, sharing best practices and establishing a dedicated implementation team can be effective. As implementation progresses, these factors become less important and managers should instil plant-wide routines by increasing the empowerment of shop-floor employees. Rewards and recognition schemes must be designed carefully because they are sensitive to contingences (they seem to be less valued in more advanced stages of lean implementation and in individualistic cultures). Finally, lean offers many tools and methods (5S, value stream mapping, etc.) that will assist in its implementation.

6.1 Limitations

The research design has some limitations. First, the opinions of practitioners are not perfect measures of success factors; they reveal what individuals *think* helps rather than what is objectively proven to help. It is, however, reasonable to think that the overlap is substantial. Another critique is that practitioners could be predisposed to what constitutes success factors; there might be a general and shared—but not necessarily correct—understanding of success factors stemming from the literature and consultants.

Second, the categorisation of free-text qualitative statements is a subjective process. The use of free-text qualitative statements is a fresh approach in the literature and has both strengths and weaknesses. One weakness is that other authors may have categorised the statements differently. We mitigated this limitation by using two independent researchers for categorisation and testing for inter-rater reliability. As a strength of the method, practitioners are likely to be well qualified to describe the needs of their factories, as exemplified by the proverb ‘only the wearer knows where the shoe pinches’. A rushed, but weak, criticism could be that if managers knew what to do, they

could just do it; but being able to describe something is not the same as being able to act on it.

A third limitation in the research design is that the possibilities for generalisation are limited due to the inclusion of respondents from only two multinational firms. Additionally, it is hard to compare 'leanness' across industries. This paper uses different measures of lean maturity stage in the two firms. Relative to each other, the automotive firm could perhaps be leaner than the chemical firm on average. However, the firms do not compete with each other but rather with firms in their own industry, which reduce the limitation of using dissimilar measurements. In general, the sample's limited possibility for conducting tests of association and robustness calls for caution when interpreting the results.

6.2 Future research

As demonstrated in the review of the existing literature, the effect of contingencies on CSFs for improvement programmes has largely been ignored. Nonetheless, a main finding of this paper is that, with a few expectations, contingencies do not seem to have a drastic effect on which factors are critical for success. Then, considering the large amount of literature on generic CSFs, managers presumably already know *what* should be done. Hence, failed implementations are likely more connected to *how* managers perform these actions. This is fertile grounds for future research.

Future research should go deeper than just studying CSFs for various programmes. Instead, it could either follow the route in this paper by investigating how other contingency variables (e.g., market climate, market demand, unionisation, etc.) moderate the effect of managerial actions on lean implementation, or, perhaps from a behavioural operations perspective, study how managers should act to implement lean and other improvement programmes with success. Even if challenging to conduct, future research could attempt to use a longitudinal design to study the real effectiveness of certain factors or actions. Both surveys and case research offer promising research methodologies for assisting managers to answer their repeated question: 'What should *we* do to advance our implementation of lean?'

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8 References

Achanga, P., Shehab, E., Roy, R. & Nelder, G. 2006. Critical success factors for lean implementation within SMEs. *Journal of Manufacturing Technology Management,* 17,(4). 460-471.

Ahire, S. L., Golhar, D. Y. & Waller, M. A. 1996. Development and validation of TQM implementation constructs. *Decision Sciences,* 27,(1). 23-56.

Ahlström, P. 1998. Sequences in the implementation of lean production. *European Management Journal,* 16,(3). 327-334.

Ahuja, I. P. S. & Khamba, J. S. 2008. Total productive maintenance: literature review and directions. *International Journal of Quality & Reliability Management,* 25,(7). 709 - 756.

Aiken, C. & Keller, S. 2009. The irrational side of change management. *McKinsey Quarterly,* 2,(June). 100–109.

Antony, J., Antony, F. J., Maneesh, K. & Rae, C. B. 2007. Six sigma in service organisations: Benefits, challenges and difficulties, common myths, empirical observations and success factors. *The International Journal of Quality & Reliability Management,* 24,(3). 294-311.

Balakrishnan, N., Voinov, V. & Nikulin, M. S. 2013. *Chi-squared goodness of fit tests with applications,* Waltham, MA, Academic Press, Elsevier.

Bamber, C. J., Sharp, J. M. & Hides, M. T. 1999. Factors affecting successful implementation of total productive maintenance: A UK manufacturing case study perspective. *Journal of Quality in Maintenance Engineering,* 5,(3). 162 - 181.

Bateman, N. 2005. Sustainability: the elusive element of process improvement. *International Journal of Operations & Production Management,* 25,(3/4). 261-276.

Beer, M. & Nohria, N. 2001. Cracking the code of change. *Harvard Business Review,* 78,(3). 133-141.

Black, J. T. 2007. Design rules for implementing the Toyota Production System. *International Journal of Production Research,* 45,(16). 3639-3664.

Black, S. A. & Porter, L. J. 1996. Identification of the Critical Factors of TQM. *Decision Sciences,* 27,(1). 1-21.

Bortolotti, T., Boscari, S. & Danese, P. 2015. Successful lean implementation: Organizational culture and soft lean practices. *International Journal of Production Economics,* 160,(0). 182-201.

Boynton, A. C. & Zmud, R. W. 1984. An Assessment of Critical Success Factors. *Sloan Management Review,* 25,(4). 17-27.

Brady, J. E. & Allen, T. T. 2006. Six Sigma Literature: A Review and Agenda for Future Research. *Quality and Reliability Engineering International,* 22,(3). 335-367.

Brah, S. A. & Chong, W. K. 2004. Relationship between total productive maintenance and performance. *International Journal of Production Research,* 42,(12). 2383-2401.

Brun, A. 2011. Critical success factors of Six Sigma implementations in Italian companies. *International Journal of Production Economics,* 131,(1). 158-164.

Chang, D. & Lee, S. M. 1996. The impact of critical success factors of JIT implementation on organizational performance. *Production Planning & Control,* 7,(3). 329-338.

Cochran, W. G. 1952. The Chi square test of goodness of fit. *The Annals of Mathematical Statistics,* 23,(3). 315-345.

Coronado, R. B. & Antony, J. 2002. Critical success factors for the successful implementation of six sigma projects in organisations. *The TQM Magazine,* 14,(2). 92-99.

Cotte, P., Farber, A., Merchant, A., Paranikas, P. & Sirkin, H. L. 2008. Getting more from lean. *BCG Publication.* Boston, MA.

Crosby, P. 1979. *Quality is Free: the art of making quality certain,* New York, Mc Graw Hill.

Davies, A. J. & Kochhar, A. K. 2002. Manufacturing best practice and performance studies: A critique. *International Journal of Operations & Production Management,* 22,(3). 289-305.

Dayton, N. A. 2001. Total quality management critical success factors, a comparison: The UK versus the USA. *Total Quality Management,* 12,(3). 293-298.

Deming, W. E. 1986. *Out of the crisis: quality, productivity and competitive position,* Cambridge, Cambridge University Press.

Donaldson, L. 2001. *The contingency theory of organizations,* Thousand Oaks, Calif., Sage.

Easton, G. S. & Rosenzweig, E. D. 2012. The role of experience in six sigma project success: An empirical analysis of improvement projects. *Journal of Operations Management,* 30,(7–8). 481-493.

Furlan, A., Vinelli, A. & Dal Pont, G. 2011. Complementarity and lean manufacturing bundles: an empirical analysis. *International Journal of Operations & Production Management,* 31,(8). 835-850.

Goyal, S. K. & Deshmukh, S. G. 1992. A Critique of the Literature on Just-in-Time Manufacturing. *International Journal of Operations & Production Management,* 12,(1). 18-28.

Gwet, K. L. 2012. *Handbook of inter-rater reliability: The definitive guide to measuring the extent of agreement among raters,* Gaithersburg, MD, Advanced Analytics, LLC.

Henderson, K. M. & Evans, J. R. 2000. Successful implementation of Six Sigma: benchmarking General Electric Company. *Benchmarking: An International Journal,* 7,(4). 260-282.

Hines, P., Found, P., Griffiths, G. & Harrison, R. 2011. *Staying Lean: Thriving, not just surviving,* New York, NY, Productivity Press.

Hofstede, G. & Hofstede, G. J. 2005. *Cultures and organizations: software of the mind,* New York, McGraw-Hill.

Holweg, M. 2007. The genealogy of lean production. *Journal of Operations Management,* 25,(2). 420-437.

Ishikawa, K. 1985. *What is total quality control? : the Japanese way,* Englewood Cliffs, N.J., Prentice-Hall.
Jasti, N. V. K. & Kodali, R. 2015. Lean production: literature review and trends. *International Journal of Production Research,* 53,(3). 867-885.
Jayaram, J., Ahire, S. L. & Dreyfus, P. 2010. Contingency relationships of firm size, TQM duration, unionization, and industry context on TQM implementation--A focus on total effects. *Journal of Operations Management,* 28,(4). 345-356.
Juran, J. M. 1988. *Juran on planning for quality,* New York, Free Press.
Karuppusami, G. & Gandhinathan, R. 2006. Pareto analysis of critical success factors of total quality management: A literature review and analysis. *The TQM Magazine,* 18,(4). 372-385.
Kotter, J. P. 1995. Leading Change: Why Transformation Efforts Fail. *Harvard Business Review,* 73,(2). 59-67.
Krafcik, J. F. 1988. Triumph Of The Lean Production System. *Sloan Management Review,* 30,(1). 41-51.
Kull, T. J. & Wacker, J. G. 2010. Quality management effectiveness in Asia: The influence of culture. *Journal of Operations Management,* 28,(3). 223-239.
Kumar, M., Antony, J. & Tiwari, M. K. 2011. Six Sigma implementation framework for SMEs – a roadmap to manage and sustain the change. *International Journal of Production Research,* 49,(18). 5449-5467.
Kwak, Y. H. & Anbari, F. T. 2006. Benefits, obstacles, and future of six sigma approach. *Technovation,* 26,(5-6). 708-715.
Lagrosen, S. 2003. Exploring the impact of culture on quality management. *International Journal of Quality & Reliability Management,* 20,(4). 473 - 487.
Liker, J. K. 2004. *The Toyota way: 14 management principles from the world's greatest manufacturer,* New York, McGraw-Hill.
Liker, J. K. & Hoseus, M. 2008. *Toyota culture: the heart and soul of the Toyota way,* New York, McGraw-Hill.
Losonci, D., Demeter, K. & Jenei, I. 2011. Factors influencing employee perceptions in lean transformations. *International Journal of Production Economics,* 131,(1). 30-43.
Lucey, J., Bateman, N. & Hines, P. 2005. Why major lean transitions have not been sustained. *Management Services,* 49,(2). 9-13.
Mackelprang, A. W. & Nair, A. 2010. Relationship between just-in-time manufacturing practices and performance: A meta-analytic investigation. *Journal of Operations Management,* 28,(4). 283-302.
Manville, G., Greatbanks, R., Krishnasam, R. & Parker, D. W. 2012. Critical success factors for Lean Six Sigma programmes: a view from middle management. *International Journal of Quality & Reliability Management,* 29,(1). 7-20.
Marodin, G. A. & Saurin, T. A. 2013. Implementing lean production systems: research areas and opportunities for future studies. *International Journal of Production Research,* 51,(22). 6663-6680.
Marodin, G. A. & Saurin, T. A. 2015. Managing barriers to lean production implementation: context matters. *International Journal of Production Research,* 53,(13). 3947-3962.
Mehra, S. & Inman, R. A. 1992. Determining the critical elements of just-in-time implementation. *Decision Sciences,* 23,(1). 160-174.
Motwani, J. 2001. Critical factors and performance measures of TQM. *The TQM Magazine,* 13,(4). 292-300.

Naor, M., Linderman, K. & Schroeder, R. 2010. The globalization of operations in Eastern and Western countries: Unpacking the relationship between national and organizational culture and its impact on manufacturing performance. *Journal of Operations Management,* 28,(3). 194-205.

Netland, T. & Ferdows, K. 2014. What to expect from a corporate lean program. *MIT Sloan Management Review,* 55,(3, Summer). 83-89.

Netland, T. H. 2013. Exploring the phenomenon of company-specific production systems: One-best-way or own-best-way? *International Journal of Production Research,* 51,(4). 1084-1097.

Netland, T. H. & Aspelund, A. 2014. Multi-plant improvement programmes: A literature review and research agenda. *International Journal of Operations & Production Management,* 34,(3). 390-418.

Newman, K. L. & Nollen, S. D. 1996. Culture and Congruence: The Fit between Management Practices and National Culture. *Journal of International Business Studies,* 27,(4). 753-779.

Nitin, S., Dinesh, K. & Paul, S. T. 2011. TQM for manufacturing excellence: Factors critical to success. *Journal of Applied Engineering Research, Dindigul* 2,(1). 219-233.

Näslund, D. 2008. Lean, six sigma and lean sigma: fads or real process improvement methods? *Business Process Management Journal,* 14,(3). 269 - 287.

Näslund, D. 2013. Lean and six sigma – critical success factors revisited. *International Journal of Quality and Service Sciences,* 5,(1). 86-100.

Pay, R. 2008. Everybody's Jumping on the Lean Bandwagon, But Many Are Being Taken for a Ride. *Industry Week*, 01-03-2008.

Porter, L. J. & Parker, A. J. 1993. Total quality management—the critical success factors. *Total Quality Management,* 4,(1). 13-22.

Powell, D., Riezebos, J. & Strandhagen, J. O. 2012. Lean production and ERP systems in small- and medium-sized enterprises: ERP support for pull production. *International Journal of Production Research,* 51,(2). 395-409.

Power, D., Schoenherr, T. & Samson, D. 2010. The cultural characteristic of individualism/collectivism: A comparative study of implications for investment in operations between emerging Asian and industrialized Western countries. *Journal of Operations Management,* 28,(3). 206-222.

Ramarapu, N. K., Mehra, S. & Frolick, M. N. 1995. A comparative analysis and review of JIT "implementation" research. *International Journal of Operations & Production Management,* 15,(1). 38-49.

Saraph, J. V., Benson, P. G. & Schroeder, R. G. 1989. An Instrument for Measuring the Critical Factors of Quality Management. *Decision Sciences,* 20,(4). 810-829.

Scherrer-Rathje, M., Boyle, T. A. & Deflorin, P. 2009. Lean, take two! Reflections from the second attempt at lean implementation. *Business Horizons,* 52,(1). 79-88.

Schonberger, R. 2008. *Best practices in lean six sigma process improvement: a deeper look,* Hoboken, N.J., John Wiley & Sons.

Schroeder, R. G., Linderman, K., Liedtke, C. & Choo, A. S. 2008. Six Sigma: Definition and underlying theory. *Journal of Operations Management,* 26,(4). 536-554.

Shah, R. & Ward, P. T. 2003. Lean manufacturing: context, practice bundles, and performance. *Journal of Operations Management,* 21,(2). 129-149.

Sharp, V. F. 1979. *Statistics for the social sciences* Boston, MA, Little, Brown.

Sila, I. & Ebrahimpour, M. 2003. Examination and comparison of the critical factors of total quality management (TQM) across countries. *International Journal of Production Research,* 41,(2). 235-268.
Sousa, R. & Voss, C. A. 2001. Quality management: Universal or context dependent? *Production and Operations Management,* 10,(4). 383-404.
Sousa, R. & Voss, C. A. 2008. Contingency Research in Operations Management Practices. *Journal of Operations Management,* 26,(6). 697-713.
Swamidass, P. M. 2007. The effect of TPS on US manufacturing during 1981-1998: inventory increased or decreased as a function of plant performance. *International Journal of Production Research,* 45,(16). 3763-3778.
Swink, M. & Jacobs, B. W. 2012. Six Sigma adoption: Operating performance impacts and contextual drivers of success. *Journal of Operations Management,* 30,(6). 437-453.
Taylor, W. A. & Wright, G. H. 2003. A longitudinal study of TQM implementation: factors influencing success and failure. *Omega,* 31,(2). 97-111.
Trkman, P. 2010. The critical success factors of business process management. *International Journal of Information Management,* 30,(2). 125-134.
Vecchi, A. & Brennan, L. 2011. Quality management: a cross-cultural perspective based on the GLOBE framework. *International Journal of Operations & Production Management,* 31,(5). 527-553.
Vinodh, S. & Joy, D. 2011. Structural Equation Modelling of lean manufacturing practices. *International Journal of Production Research,* 50,(6). 1598-1607.
Wali, A. A., Deshmukh, S. G. & Gupta, A. D. 2003. Critical success factors of TQM: A select study of Indian organizations. *Production Planning & Control,* 14,(1). 3-14.
White, R. E., Pearson, J. N. & Wilson, J. R. 1999. JIT Manufacturing: A Survey of Implementations in Small and Large U.S. Manufacturers. *Management Science,* 45,(1). 1-15.
Wiengarten, F., Fynes, B., Pagell, M. & De Búrca, S. 2011. Exploring the impact of national culture on investments in manufacturing practices and performance. *International Journal of Operations & Production Management,* 31,(5). 554-578.
Womack, J. P. & Jones, D. T. 1996. *Lean thinking: banish waste and create wealth in your corporation,* New York, Free Press.
Womack, J. P., Jones, D. T. & Roos, D. 1990. *The machine that changed the world,* New York, Rawson Associates.
Yusof, S. R. M. & Aspinwall, E. 1999. Critical success factors for total quality management implementation in small and medium enterprises. *Total Quality Management,* 10,(4-5). 803-809.
Yusof, S. R. M. & Aspinwall, E. 2000. A conceptual framework for TQM implementation for SMEs. *The TQM Magazine,* 12,(1). 31-37.

Attachment A

Table A-1 Critical success factors for implementing lean programmes: Examples of statements within each CSF category.

Rank	***Action***	***Examples of statements from survey respondents***	***Total %***
1	Lead actively	'Personal commitment and time spent with his co-workers to influence behaviour' 'Take initiatives and drive it with passion' 'Lead by example'	15.8 %
2	Participate personally	'Participate visibly in lean implementations' 'Participate in the day-to-day work (go to Gemba)' 'Demonstrate power of lean by doing sample projects with teams (walk the talk)'	9.0 %
3	Educate employees	'Train and teach people regarding lean tools and method' 'Managers holds formal training in lean for its shop-floor personnel' 'Teaching the lean principles to employees'	7.7 %
4	Educate managers	'To have the lean knowledge in order to be a coach' 'Additional training and theoretical education within lean production' 'Learn the philosophy behind the lean programme before start of implementation'	6.7 %
5	Communicate, inform and discuss	'Regularly inform people and communicate about vision, strategy, targets, performance data, etc.' 'To be a good communicator on the shop floor' 'Maintain a permanent dialogue'	6.3 %
6	Set targets and follow-up	'Fix clear targets on lean programme and review and link to performance' 'Communicate clear targets to the factory' 'Set lean KPI for all employees. Example: One kaizen/month'	6.2 %
7	Involve and support employees	'Working with the employees to solve problems' 'To support the initiatives of employees regarding hard and soft savings' 'Listen to employees'	5.5 %
8	Dedicate human resources	'Secure resources to develop an implementation team' 'A Lean Production System organization for lean implementation' 'Regular strong governance (e.g., Lean Production System Day, Lean Production System council)'	5.4 %
9	Use lean tools and methods	'Perform kaizen events is a good way to show what you can gain with use the different lean tools' 'Visualise the flow by using 5S to make deviations easy to see' 'Starting to use root-cause analysis tools based on results'	5.0 %
10	Integrate lean in everyday business	'Live up to the lean programme on a daily basis' 'Show more interest for the lean programme as a systematic improvement system' 'The lean production system is the way we work, not a special project'	4.9 %
11	Develop vision and roadmap	'Set the goals and strategy for implementation (long term policy deployment)' 'Managers need to have a road map that describe the transformation' 'Develop a strategy and plan to deliver a sustainable lean programme'	3.6 %
12	Use rewards and recognition	'Motivate (reward) the operators for their good work' 'Incentive programme' 'Define recognition system for the best performers'	3.5 %

13	Monitor and audit implementation	'Regular internal audits' 'Periodic review of the implementation of lean' 'Very frequent follow-up'	3.2 %
14	Standardise and manage discipline	'Set expectation for the lean production system standard in the area' 'Communicate the obligation to execute' 'Disciplinary follow-up'	2.3 %
15	Find and share best practices	'Encourage the best practices and good examples' 'Communicate the really good practices from your team, create friendly competition' 'Sharing the best practise of lean implementation'	2.3 %
16	Stepwise approach	'Enforce and implement improvements step by step systematically' 'Do not move forward until your previous step is secured' 'Effort of work more important than top success. Work on small step success'	2,3 %
17	Focus on areas and prioritise activities	'Focus on maximum of three priorities or areas' 'Some of the weakest modules in our lean production system should be more followed up' 'Reduction of KPIs'	2.1 %
18	Invest time and money	'Fund projects requested by workers' 'Time set aside' 'Allocate time and resource for lean projects'	2.0 %
19	Benchmark others	'Copy and paste the best plants' 'By visiting other factories' 'Benchmark with the best plants on our lean production system'	1.6 %
20	Emphasise team concept	'Team concept introduction' 'Starting goal oriented teams' 'Teamwork spirit: everything is possible to improve'	1.3 %
21	Use external experts	'Lean consultants stay long term and guide rather than visit for short durations' 'Hire consultants from external companies and internally' 'Use external consultants with lean experience'	1.2 %
22	Hold regular implementation meetings	'Managers regularly meet to discuss lean implementation in this plant' 'Weekly updates in the department ' 'Set meeting to share information and review action plan'	1.2 %
23	Emphasise safety and job attractiveness	'Support change that is for greater good versus $-impact' 'Think operator by helping and improving his working place and environment' 'Communication on targets and results in wellbeing (ergonomics, quality)'	0.6 %
24	Commit corporate management	'Lean programme driven by top management (not local management)' 'Global necessity and decision to go in the VPS direction' 'Commitment and resources from external hierarchy'	0.5 %