Post-print. This is an Author's Original Manuscript of an article published in the *International Journal of Production Research*, Vol. 51 (2012), Iss. 4, pp. 1084-1097. For the final version and citation data, please visit http://www.tandfonline.com/doi/abs/10.1080/00207543.2012.676686.

Exploring the phenomenon of company-specific Production Systems: One-best-way or own-best-way?

Torbjørn H. Netland

NTNU, Industrial Economics and Technology Management, Trondheim, Norway

Georgetown University, McDonough School of Business, Washington, D.C., USA

Abstract

This explorative study investigates the phenomenon of the company-specific production system (XPS). It has been a strong and recent trend across many manufacturing industries to develop and deploy such corporate improvement programmes. Five propositions regarding the uniqueness of XPSs are derived from universalistic versus contingent perspectives on improvement programmes. The main XPS principles of thirty renowned multinationals are analysed for similarities and differences. In conclusion, XPSs largely represent variants of the same in content. They represent an own-best-way approach to the one-best-way paradigm. Even though a tight relationship to the Toyota Production System (TPS) and lean production is established, the findings raise a red flag that XPSs might suffer under a too rigid, path-dependent development process from what has become an overly technical understanding of the TPS. This study also questions whether modern manufacturers have sufficiently integrated other essential elements of modern operations such as the use of ERP, automation and real-time response technologies in their XPSs. These findings have direct implications for practitioners and provide interesting opportunities for further research.

Keywords: company-specific production systems; global manufacturing; lean manufacturing; Toyota Production System; continuous improvement

1 Introduction

Since the early days of industrial production companies have sought to systematically improve their operations. *Scientific Management* (Taylor, 1911) introduced scientific methods into shop-floor work processes to discover, develop and continuously improve the one-best-way to operate. Popularly known as *best practises,* companies continue to seek to develop, codify and copy recipes for how to operate. We know this generic strategy as the *best-practice paradigm* of manufacturing strategy (Voss, 1995; 2005), and it spans an array of different but related production concepts such as total quality management, just-in-time production, theory of constraints, world class manufacturing, business process reengineering, six sigma and, most significantly, lean production.

For a majority of companies, alternating projects of implementing the latest production concepts and best practices have characterised the last three decades. Many companies have consequently found it hard to sustain the effects of process improvement over time (Jorgansen *et al.*, 2003; Bateman, 2005; Towill, 2007). Trial and error have led to the realisation that sustained success of improvement efforts demands a higher degree of systematisation and adaptation of the best practices to a company's own unique characteristics and environment. Inspired by the persistent success of Toyota and its Toyota Production System (TPS), many companies now firmly believe that having a similar, but tailored, approach in place will strengthen their own competitiveness (Wu *et al.*, 2000; Black, 2007). Instead of embarking on single 'one-best-way' improvement projects, companies now aim for group-wide 'own-best-way' improvement programmes.

Companies in the automobile industry have, since the mid-1990s, led the trend of developing improvement programmes in the form of a company-specific production system (XPS). Chrysler's introduction of the Chrysler Operating System in 1994 represents one of the earliest occurrences of this form of company-wide systematisation of lean production outside Toyota (Clarke, 2005). Other examples include the Mercedes-Benz Production System, the Opel Production System, the Audi Production System, the Volkswagen Production System, the Ford Production System, and the Hyundai Production System (e.g. Barthel and Korge, 2002; Lee and Jo, 2007; Neuhaus, 2009). Following in the footsteps of the Original Equipment Manufacturers is a crowd of upstream n-tier suppliers to the automobile industry. Automotive suppliers such as Benteler, Bosch, Cummins, Danaher, Haldex, Hella, Valeo and

ZF, to mention only a very few, have all developed their variant of an XPS. Furthermore, heavy vehicle manufacturers such as Caterpillar, MAN, Scania, Terex and Volvo have, in the last decade, started following XPS strategies.

Recently, even non-automotive manufacturing industries from all over the world have joined the growing trend; the US agricultural machinery manufacturer Deere and Company launched their John Deere Production System in 2002. Electrolux, the Swedish producer of household appliances, implemented the Electrolux Manufacturing System in 2005. The Norwegian aluminium giant Hydro developed the Aluminium Metal Production System in 2007. Siemens, the German electronics and electrical engineering conglomerate, introduced the Siemens Production System in 2008. The same year, the largest food and nutrition company in the world, the Swiss-based Nestlé Group, introduced the Nestlé Continuous Excellence programme. In Denmark, an iconic toy producer launched the Lego Production System in 2010. These few examples of multinational companies among the many available give evidence of a phenomenon that continues to spread globally across all types of manufacturing industries. This paper will refer to this phenomenon by using the common label *XPS*.

Disappointingly, academic research has neither kept up with nor echoed industry's enormous interest in the XPS. Despite the rich body of improvement literature studying the effects of the TPS and lean production on performance (Adam *et al.*, 2001; Brox and Fader, 2002; Swamidass, 2007; Thun *et al.*, 2010), the XPS phenomenon has received less attention. In their case study of the Hyundai Production System, Lee and Jo (2007, p. 3677) explicitly call for more research studies that 'examine commonalities and differences between various lean production models among firms emulating TPS'. In a similar vein, Ansari *et al.* (2010) call for more comparative cross-company analysis of the diffusion and adaptation of practices. From a *programme management theory* perspective, Pellegrinelli *et al.* (2007, p. 41) argue that 'the widespread use of programme management has outpaced our ability to grasp and codify a complex and subtle phenomenon'. To what extent improvement programmes are in fact specific to different companies remain relatively unexamined questions (Cagliano and Spina, 2000). The purpose of this study is to address this void by investigating the phenomenon of the XPS, analysing differences and commonalities in the content of XPSs.

The paper is structured as follows: Section 2 develops research propositions drawing upon the tension between universalistic versus contingent approaches found in the continuous

improvement, operations strategy, and strategic management literature. Section 3 presents the applied multiple-case methodology. That section includes a reference framework of principles from lean production and its precursor TPS, summarised for the purpose to support the comparison of different XPSs. Section 4 presents and discusses empirical data from the thirty XPSs. Finally, Section 5 discusses the conclusions and limitations of this study.

2 Literature review

A fundamental question for a company deploying a corporate-wide improvement programme asks: Should a company blindly mimic the proven successful work principles of others or should it develop its own principles tailored to it specific needs and environment? Two contrasting academic viewpoints have kept this discussion alive and thriving (Voss, 2005; Lee and Jo, 2007). On one side we have those who argue for a universalistic approach of best principles, and on the other we have those who argue for the need to adapt principles to contingencies. This paper now turns to a discussion of these two strands of research and their implications for the XPS.

2.1 Universalistic approaches to XPS

The best-practice paradigm assumes the superiority of some principles over others (Voss, 1995) and that such practices should be shared in the intra-firm network. Traditionally, the improvement literature that campaigns for such best practices has been universalistic. Since the early mass-production principles of Henry Ford and the scientific management principles of Frederick Taylor, authors and proponents of different production principles have claimed the superiority of their own solutions to that of others. The underlying assumption holds that a one-best-way of organising—the most competitive—does exist as a world-class standard.

Yu and Zaheer (2010, p. 475) remarked that ‘one popular approach for a firm to catch up with world-class standards is to benchmark and adopt organizational practices already proven effective by global market leaders’. By being attentive to the failures and successes of others, through ‘vicarious learning’, companies can reach the world’s performance frontier (Terlaak and Gong, 2008). Due to this belief, proven manufacturing principles tend to spread around the world by *mimicry* (Ketokivi and Schroeder, 2004) in a faddish manner (Abrahamson, 1991). According to this line of thought, the following proposition might hold true:

- Proposition 1a: Companies share the same principles in their XPSs.

Many companies have tried to mimic one global market leader: Toyota. More than two decades have passed since John Krafcik (1988) wrote his seminal article 'The triumph of the lean production system' and Womack *et al.* (1990) wrote and published the book *The Machine that Changed the World* as part of the International Motor Vehicle Program. These publications demonstrated the superiority of the TPS over Western automobile-production concepts and introduced the world to *lean.* Since then, the term *lean production* has prevailed and grasped a foothold as one of the most dominant production paradigms of modern times (Voss, 2005; Holweg, 2007; Towill, 2007).

Proponents of the best-practice paradigm argue for the universal validity of the principles of the TPS and lean production and urge all companies who want to increase the competitiveness of their manufacturing operations to copy them (Adler and Cole, 1993; Womack and Jones, 1996). Womack *et al.* (1990, p. 278) affirm that lean will become 'the standard global production system of the twenty-first century'. This viewpoint has gained support from numerous empirical studies that prove the positive effects of a successful lean improvement programme (e.g. Womack and Jones, 1996; Barthel and Korge, 2002; Shah *et al.*, 2008; Thun *et al.*, 2010). If we accept the universal validity of lean production principles, we can propose:

- Proposition 1b: XPS principles resemble the principles of the TPS and lean production.

2.2 Contingent approaches to XPS

Sousa and Voss (2008) state that 'research on practices has begun to shift its interest from the justification of the value of those practices to the understanding of the contextual conditions under which they are effective'. The *contingency perspective* radically conflicts with the universalistic perspective (Sousa and Voss, 2001). The authors argue that principles must fit the unique path-dependent characteristics of a firm and the dynamic environment under which it operates. The contingency perspective shares common ground with the *resource-based view of the firm* that argues for company-specific principles to achieve a competitive advantage (Wernerfelt, 1984; Barney, 1991; Barney, 2011). These arguments have been further enhanced by those who view improvement programmes as structures for building *dynamic capabilities* (Teece *et al.*, 1997; Witcher *et al.*, 2008; Anand *et al.*, 2009). This perspective holds that a company finds its recipe for success in uniqueness rather than in mimicry, as in:

- Proposition 2a: Companies develop unique company-specific principles in their XPSs.

New (2007, p. 3547) makes it clear that: 'After 30 years, we can now be reasonably certain that whatever Toyota got, it isn't a trivial task to bottle it and sell it on'. Within the best-practice paradigm of operations strategy, the contingency perspective recognises the superiority of the TPS, but at the same time it argues strongly for the need to adapt to differing environments (Lee and Jo, 2007). Nelson and Winter (1982) stress the difficulty in trying to copy other companies' routines because of limited access to them, which leads to imperfectly copying of observed elements. Routines do not just appear; they grow over time based on cumulative knowledge in specific contexts. Toyota, for example, needed 30 years to develop and implement the routines described by the principles in the TPS (Ohno, 1988). 'The existing routines serve as a template for the new ones' (Nelson and Winter, 1982, p. 120), meaning that different contexts grow different routines in a path-dependent manner (Wagner *et al.*, 2010). Though the contingent approach does not disqualify learning from the TPS, it implies a departure from the TPS blueprint. Hence, it can be proposed:

- Proposition 2b: Contemporary XPSs contain company-specific mutations of the principles of the TPS and lean production.

Cooney (2002) questions the universality of lean production principles by arguing that they represent a *supplement to* rather than a *replacement for* other principles such as the radically different *push principles* found in batch production. In industries with lower volume and more unpredictable demand than the automobile industry, batch production continues to be a sound operating principle (Cooney, 2002). Other 'best principles' such as the use of Enterprise Resource Planning systems (ERP) and Advanced Manufacturing Technologies (AMT) also continue to prevail and grow in industry for good reasons (Vonderembse *et al.*, 1997; Voss, 2005). If an XPS aims to be the *one* shared corporate improvement programme that describes a company's main principles for how to operate effectively across multiple locations, the company must expect to incorporate also non-lean elements such as the use of push-based principles, automation and ERP systems in the situations where these apply. If a company's XPS principles merely resemble those of the TPS and lean production, the XPS will not serve the company holistically, leading to the following proposition:

- Proposition 2c: Contemporary XPSs contain non-lean operating principles that reply to the requirements of modern manufacturing.

The next section outlines the multiple-case research design used to investigate the five propositions generated from the two conflicting perspectives.

3 Methodology

As noted, this study undertakes a comparative multiple-case study (Yin, 2003) to investigate the phenomenon of XPSs. Voss (2009, p. 165) states that 'case research provides an excellent means of studying emergent practices', as this paper intends to do by investigating how operation principles vary across firms. Moreover, a multiple-case approach allows much deeper insight into each specific case than a quantitative survey would allow. The research design follows Yin's (2003) recommended method for multiple-case studies.

3.1 Thirty industrial XPSs

This study aims to compare differences and similarities across XPSs in regard to their *content* and, more specifically, to their main principles. Thus, this paper does not investigate the *process* related to implementing and managing the XPS. The first step of this study looked at selecting a number of XPSs for potential inclusion. Two researchers searched for public descriptions of XPSs with a structured search approach: The Internet search engines Google and Yahoo and the academic databases Science Direct, ProQuest and J-Stor were searched for keywords such as 'production system', 'operations system' and 'business system' in English, German and Scandinavian languages. This tedious approach resulted in a list of more than 100 companies that have developed some kind of XPS with a minimum description publicly available that gives evidence of its existence. (The introduction of this paper listed some of the mapped XPSs).

All data was stored in a continuously updated and maintained research database. While academic publications or recent corporate white papers extensively and sufficiently described a few of the XPSs, the majority needed validation. To validate those XPSs with less forthcoming information, 62 companies were contacted asking for additional information and references. In return, they would get access to an anonymous benchmarking study based on the results presented partially in this paper. Fifteen companies offered extensive documentation of their XPSs. Only three companies declined, while the remainder remained silent even after two reminders. The 25% return rate was regarded good for this type of enquiry to industry.

There was a need to include cases based on the same conditions; hence it was decided to compare all the XPSs in regard to their lists of strategically prioritised principles. The online

Oxford Dictionaries describes the usual meaning of the word *principle* as 'a rule or belief governing one's behaviour'. This understanding of the word applies here. This paper adopts the definition of a principle used in the German literature on XPSs (Feggeler and Neuhaus, 2002; Clarke, 2005): Principles are derived from a company's operations strategy and give direction of how to operate in accordance with the overall strategy. Towill (2007) refers to this as *operational guidance*. At a lower level, tools and techniques support the principles.

A majority of companies with an XPS tend to summarise their main list of XPS principles in a holistic XPS model. The analysis is based on the principles that the companies have chosen in their list or holistic models. Typically 8-15 principles are referred to. Evidently, this method has both weaknesses and strengths. In defence of the method, one could argue that the list or visual XPS models are expected to represent the most essential and prioritised elements of an XPS. One criticism would say that the list or visual XPS models do not always cover the most essential principles, and that their wording often becomes too holistic and vague. An alternative method would then be to incorporate all principles, tools and techniques to which the company refers in its XPS documentation. This approach, however, clearly runs the risk of covering too much and making analysis impossible because all XPSs tend to refer to all well-known principles somewhere at some point. By focusing on the content of the visual XPS models or lists, the analysis closes in on the strategic prioritised principles that the companies have chosen as most important for them.

Thirty XPSs were included in the analysis. In addition to the 15 companies that submitted detailed documentation of their XPSs, 15 other XPSs with sufficient public documentation were included to increase the sample size and, hence, the external validity of the study. The number of included cases is based on a replication-logic rather than a sampling logic (Yin, 2003). All 30 XPSs belong to large, renowned, international manufacturing companies from several different industries and countries. The industries range from automotive suppliers to toys and furniture. The overall result does not change much when controlling for type of industry, which justifies the sample size of the study. Table 1 presents the sample details.

Table 1. The 30 examined XPSs.

#	Company	XPS	Main industry	HQ	XPS source
1	Alfa Laval	Alfa Laval Production System (ALPS)	Heating and flow technology	SWE	Direct
2	Audi	Audi Produktionssystem (APS)	Automotive OEM	GER	Direct
3	Bosch	Bosch Production System (BSP)	Electronics	GER	Direct
4	Elkem	Elkem Business System (EBS)	Silicon based materials	NOR	Direct
5	Fomel ZF	Formel ZF Production System	Automotive	GER	Direct
6	Haldex	Haldex Way	Automotive	SWE	Direct
7	Herman Miller	Herman Miller Production System (HMPS)	Furniture	USA	Direct
8	Hydro Aluminium	Aluminium Metal Production System (AMPS)	Aluminium	NOR	Direct
9	John Deere	John Deere Quality and Production System	Heavy vehicle	USA	Direct
10	Novo Nordisk	cLean	Chemical	DEN	Direct
11	REC	REC Production System (RPS)	Solar energy	NOR	Direct
12	Scania	Scania Produktionssystem (SPS)	Heavy vehicle	SWE	Direct
13	Valeo	Valeo Production System (VPS) (part of 5 axes)	Automotive	FRA	Direct
14	Volvo	Volvo Production System (VPS)	Heavy vehicle	SWE	Direct
15	ZF Lemförder	Lemförder Production System (LPS)	Automotive	GER	Direct
16	Almatis	The Almatis Business System (ABS)	Aluminium	GER	(Almatis, 2011)
17	Boeing	Boeing Production System (BPS)	Aerospace	USA	(Boeing, 2008)
18	Caterpillar	Caterpillar Production System (CPS)	Heavy vehicle	USA	(Caterpillar, 2011)
19	Deutsche Edelstahlwerke	Deutsche Edelstahlwerke Produktionssystem (DPS)	Steel	GER	(Deutsche Edelstahlwerke, 2011)
20	Ecco	Ecco Production System (EPS)	Shoes	DEN	(Ecco, 2009)
21	Electrolux	Electrolux Manufacturing System (EMS)	White goods	SWE	(Electrolux, 2009)
22	Gestamp Griwe	Griwe Production System (GPS)	Automotive	GER	(Gestamp Griwe, 2011)
23	Heidelberg	Heidelberg Produktionssystem (HPS)	Machines	GER	(Heidelberg, 2008)
24	JCB	JCB Production System	Heavy vehicle	UK	(JCB, 2008)
25	Knorr Bremse	Knorr-Bremse Production System (KPS)	Automotive	GER	(Knorr-Bremse, 2007)
26	LEGO	Lego Production System (LPS)	Toys	DEN	(LEGO, 2010)
27	Mercedes	Mercedes Production System(MPS)	Automotive OEM	GER	(Clarke, 2005)
28	Trumpf	SYNCHRO	Machines and medical eq.	GER	(TRUMPF, 2011)
29	Viessmann	Viessmann Produktionssystem (ViPS)	Electrical equipment	GER	(Viessmann, 2011)
30	Whirlpool	Whirlpool Production System (WPS)	White goods	USA	(Whirlpool, 2009)

Several actions were taken to test the results for face-validity. First, the results and preliminary conclusions were included in a draft report sent to the 15 participating companies for an industrial review. A few comments and feedback were received from the industry regarding company data in the model and updated the sample, but the main conclusions and analysis were deemed valid. The results from the study have furthermore been subject to a day-long discussion in a workshop on XPSs, where a total of 25 participants from eight multinational companies and two research institutions freely expressed insight and ideas (31.5.2011, NTNU, Trondheim). Three of the participating companies, Volvo, Hydro and Elkem, participated in the original XPS study. These discussions helped steer the conclusions to a more consistent and accurate reflection of the actual experiences of industry.

3.2 Development of a reference framework for XPS principles

Miles and Huberman (1994) and Yin (2003) recommend the use of a theory-based conceptual framework underlying case research. Following this advice, a theoretical reference framework was developed solely for the purpose of the analysis. To compare the content across the XPSs there was a need for a common external reference. Because most existing literature on XPSs found a strong linkage to the TPS and lean production (Hofman, 2000; Clarke, 2005; Lay and Neuhaus, 2005; Lee and Jo, 2007; Westkämper *et al.*, 2009) a list of principles from these sources was developed. The purpose was not that all XPS principles would fit into the reference framework (i.e., resemble principles of the TPS and lean production), but rather to increase the chances that they did so. If they did not fit into the reference framework, as the contingency perspective would suggest, the new principles were added and marked as ‘new’.

Because a vast amount of lean literature has included numerous principles under the lean production umbrella (Shah *et al.*, 2008) and because this literature is far from conclusive on which principles to include or not to include, the reference framework was developed on two premises. First, to secure a representation of principles that few will dispute as genuine TPS principles and of the lean production paradigm, only highly regarded publications in the field were included. Second, the law of diminishing marginal utility was applied; as the coverage of principles representing the TPS and lean production started to repeat with the addition of new studies, the search was terminated. This strategy led to the inclusion of four key contributions: Ohno (1988), Womack and Jones (1996), Shah and Ward (2003) and Liker (2004). Importantly, the aim was not to develop a unison framework of lean production principles but to develop a representative framework with which to compare XPS principles.

Table 2 presents the reference framework. It summarises 32 principles collected from Ohno's monumental *Toyota Production System* (Ohno, 1988), Womack and Jones' international bestseller *Lean Thinking* (Womack and Jones, 1996), Shah and Ward's (2003) seminal article 'Lean manufacturing: Context, bundles, and performance' and Liker's (2004) model of the Toyota Production System House (Fig. 3.3, p. 33) in *The Toyota Way*. (Shah and Ward refer to 'practices', but these do not deviate substantially from what other authors refer to as principles.)

Table 2. Reference framework for XPS principles based on key TPS and lean literature.

TPS / lean principles	Ohno (1988)	Womack & Jones (1996)	Shah & Ward (2003)	Liker (2004)
Jidoka / Autonomation	X			X
Value stream	X	X		X
Performance measurement	X		X	
Flow orientation	X	X	X	
Continuous improvement (CI) / Kaizen	X	X	X	X
Just-in-time (JIT)	X		X	X
Total quality	X		X	X
Leadership / Genchi genbutsu	X			X
Cross functional training	X		X	X
Employee involvement	X			X
Teamwork	X		X	X
Flexibility	X			
Heijunka / Levelled production	X		X	X
Profit-making industrial engineering	X			
New/and effective technology	X		X	
Visualisation	X			X
Communication	X			
Quick change-over / SMED	X		X	X
Reduction of batch size	X		X	
Standardised work	X			X
Inventory management	X			
Takt time	X			X
Maintenance	X		X	
Pull system		X	X	X
Customer focus		X		
Competitive benchmarking			X	
Focused factory production			X	
Order and material planning			X	
Health, Safety and Environment (HSE)			X	
Lean supply chain				X
Stability and robustness				X
Vision, culture and values				X

4 Results and discussion

Table 3 sums up the frequency and percentage of principles in the 30 analysed XPSs. The bulk of XPS principles fit right into the reference framework. However, the reference principles did *not* cover 14 'new' principles, of which only five had more than two occurrences. Asterisks (*) indicate the new principles.

Table 3. Main principles of 30 XPSs.

Rank	Principle	No. of XPSs	% of XPSs	Rank	Principle	No. of XPSs	% of XPSs
1	Standardised work	28	93 %	24	Clear communication	4	13 %
2	CI / Kaizen	25	83 %		Organisational design*	4	13 %
3	Total quality	23	77 %		Quick change-over	4	13 %
4	Pull system	21	70 %	27	Design for manufacturing*	3	10 %
5	Flow orientation	20	67 %		Profit-making	3	10 %
	Value stream	20	67 %		Innovation*	3	10 %
7	Employee involvement	19	63 %		Inventory management	3	10 %
8	Visualisation	18	60 %		Jidoka / Autonomation	3	10 %
9	Customer focus	17	57 %		Product Development*	3	10 %
10	Stability and robustness	15	50 %		Reduction of batch size	3	10 %
	Workplace management*	15	50 %	34	Automation*	2	7 %
12	Just-in-time	14	47 %		New effective technology	2	7 %
13	HSE	13	43 %		OEE*	2	7 %
	Teamwork	13	43 %		Payment*	2	7 %
15	Heijunka	12	40 %		Sales*	2	7 %
	Leadership	12	40 %	39	Competitive benchmarking	1	3 %
	Takt time	12	40 %		ERP*	1	3 %
18	Maintenance	11	37 %		Optimized manning*	1	3 %
19	Lean supply chain	9	30 %		Order & material planning	1	3 %
	Performance measurement	9	30 %		PLC management*	1	3 %
21	Cross functional training	8	27 %		Real-time response*	1	3 %
22	Flexibility	6	20 %		Transport on wheels*	1	3 %
23	Vision, culture and values	5	17 %	46	Focused factory	0	0 %

4.1 How unique is the X in XPS?

The first proposition suggested that companies share the same principles in their XPSs (Proposition 1a), while the third proposition suggested the opposite: that companies develop unique company-specific principles in their XPSs (Proposition 2a). In other words, this questions the uniqueness of the **X** across different XPSs.

None of the analysed XPSs exactly copied any other XPS. However, they still evidently have similarities to each other. A total of 396 principles in the 30 XPSs fit into 32 theory-based plus 14 new principles in the framework. There seems to be evidence for a sort of 'bucket game' that plays out when companies develop their XPS, wherein all the good and well-known principles go into a bucket and make up the sample space of the XPS, before the business selects the ones that fit it best. Thus, it seems companies develop XPSs not by a 'blank paper', bottom-up exercise, but rather the existing best principles in industry influence the companies.

Even though this clearly makes sense from an efficiency perspective, it also results in a similar language and content of the XPSs than should be expected if the company-specific part of the systems received more emphasis as suggested by the contingency perspective. This finding agrees with that of van Iwaarden *et al.* (2008) who found that six sigma implementation across countries follows a fairly similar pattern. In conclusion, while no XPS exactly copies any other, XPSs are all largely variants of the same when it comes to content.

4.2 Relating the XPS to the TPS and lean production

The second proposition suggested that XPS principles largely resemble the principles of the TPS and lean production (Proposition 1b). It becomes clear from the comparison that the overall resemblance of principles from the TPS and lean production paradigm should be considered high. The top-ten principles are represented in 50–93% of the XPSs. Only one literature-based lean principle failed to appear in any of the analysed XPSs: Ohno's (1988) principle of 'focused factory production'. Probably this principle is regarded as more of a strategic decision, as suggested by Skinner (1974), than part of the continuous improvement principles normally addressed by an XPS.

Only five of the fourteen new principles appeared with more than two occurrences among the analysed XPSs. These included 'workplace management' (15 occurrences), 'organisational design' (4), 'design for manufacturing' (3), 'innovation' (3) and 'product development' (3). Only one of these had a significant occurrence among the 30 companies; the principle 'workplace management' occurred as a main principle in half of the sample. 'Workplace management' including 5S, a well-known lean principle, was not included in the reference

framework. Thus, this finding suggests that the lean principle ‘workplace management’ has gained a more important role in industry than in the literature.

The second highest new principle with more than two occurrences, ‘organisational design’, appears in four XPSs. ‘Organisational design’, as described by the companies, points to a flow-oriented organisation with clear roles and responsibilities, i.e., a lean organisation. Also, the three related new principles ‘design for manufacturing’, ‘innovation’ and ‘product development’ (all in three occurrences) are well-known principles within lean production, with the exception of (radical) innovation. Toyota’s success is partly due to rapid product-development based in modular design-for-manufacturing setup of platforms (Morgan and Liker, 2006). Still, none of these has been referred to as a lean principle in the developed reference framework. A potential explanation for this mismatch might be that the literature separates innovation and product-development activities from running lean operations. In any case, relatively few XPSs have these new principles, and most of the companies do not regard them among the most important ones.

Lean production principles either highly influence or actually form the basis of the majority of the XPSs. This, however, does not represent a radical finding, because most companies explicitly state that TPS and lean thinking heavily influenced their XPS development. Moreover, several authors point to a strong similarity in content, a result of the tendency to mimic Toyota’s TPS (e.g. Clarke, 2005; Dombrowski *et al.*, 2009; Westkämper *et al.*, 2009). Thus, this study confirms that XPSs share common ground in the TPS and lean production paradigm. The prioritised list of lean principles in practice in Table 3 is a new contribution to literature.

4.3 Deviation from the TPS template

The fourth proposition suggested that contemporary XPSs contain company-specific *mutations* of the principles of the TPS and lean production. Interestingly, the two pillars of TPS, Just-in-time and jidoka, do not appear among the most important principles of the average XPS. The term *jidoka*, or in Ohno’s (1988) language *autonomation*, is barely represented with only three occurrences. The *jidkoa principle* strongly emphasises soft values relative to people and team development and involvement. It also becomes evident that principles such as ‘leadership’, ‘teamwork’ and ‘employee involvement’ only have medium

occurrence in the analysis. This indicates a development bias toward the technical side of the TPS and a shift away from the soft and people-oriented side of the TPS. Also, as a term, 'Just-in-time' is used by less than half the sample. Further, only five companies incorporate vision, culture and values in their holistic XPS model. This definitely departs from Ohno's (1988), Womack and Jones' (1996) and Liker's (2004) core emphasis on culture building.

The results were controlled for type of industry to see if there were any considerable differences between different industries as one would expect with the contingency perspective. The results appear remarkably similar across industries with only a few expected differences between the clusters:

- The heavy vehicle and aerospace cluster tend to place more emphasis on the 'reduction of batch-size' principle than the average XPS, which one might expect in an industry with relatively lower volume and higher pressure for customisation.
- The process industry cluster has zero occurrences of the 'tact time' principle and tends to put more emphasis on the 'production levelling' principle (*heijunka*) than the average XPS, which one might expect in an industry that operates with relatively longer and variable cycle times.
- The automotive cluster emphasises the 'teamwork' principle somewhat more than the average XPS, which one might expect in an industry known for relatively higher degrees of stressful, assembly line jobs.
- The equipment manufacturers put more emphasis on the 'design-for-manufacturing' principle than the average XPS, which one might expect in an industry with relatively faster product lifecycles and higher technological complexity.

All these sound deviations between industries do not however conflict with the TPS and lean principles. All 30 analysed XPSs share strong commonalities in their relationship to the TPS and lean production. The companies do emphasise slightly different XPS principles, and no two XPSs are alike. This indicates an adaptation process taking place in the companies, resulting in the company-specific element of the systems. It seems like XPSs follow a path-dependent development process rooted in the TPS.

The result is XPS mutations of the TPS (Lee and Jo, 2007). Given that 'the manufacturing function is solved', and lean production provides the template for best-in-class operations

(Womack and Jones, 1996), this development is sound. Authors have long argued for some adaptation of lean production to the company-specific context, and it might be that developing an XPS enhances adaptation and, hence, the success rate of lean production improvements in the company. If, however, lean is not a universally applicable production philosophy, the similarities among XPS represents mere 'fad and fashion' (Abrahamson, 1991) that run the risk of not yielding concrete business improvements across all industrial settings.

4.4 Occurrence of industry-specific non-lean principles

The fifth proposition suggested that contemporary XPSs contain non-lean operating principles that reply to requirements of modern manufacturing (Proposition 2c). The analysis shows that not all of the mapped new principles are traditional lean principles. Most of these have a very low frequency, but their occurrence is nevertheless of vital interest. First, because of their low frequency these principles are by definition more distinctive and company specific than the other practices – a prerequisite for giving sustainable competitive advantage according to the resource-based view (Wernerfelt, 1984; Barney, 1991; Barney, 2011). Second, they represent a departure from the masses and, hence, interesting research opportunities. In particular three principles that were not part of the reference framework reply to the requirements of modern manufacturing:

- Automation (2 cases)
- ERP (1 case)
- Real-time response (1 case)

Automation is often claimed to be the hallmark of the future Western manufacturing industry (Vonderembse *et al.*, 1997). The argument holds that Western companies must automate to offset high wages. However, only two of the companies in the sample have explicitly stated automation as a top operational principle in their XPSs. An explanation for this, which appears likely when studying the supplementary documentation of the analysed XPSs, is that most companies view technology development as a separate function not covered by the XPS. Another explanation is that XPSs are designed to be global improvement programmes that hence do not take into account region-specific challenges. This, however, reduces the XPS to a continuous improvement programme that must co-exist with other equally important programmes. If companies are serious about automation as one of the most important improvement principles, one would expect to see it represented more often in the XPSs.

Manufacturing companies today depend on ERP (Gunasekaran and Ngai, 2007). All manufacturing companies use ERP systems to plan and control production to meet demand, and, thus, ERP serves a vital role in the everyday working routines in companies. Because ERP, and increasingly also Advanced Planning System (APS) and Manufacturing Execution System (MES), has become an integrated part of how modern manufacturing operates, one would expect the XPSs to reflect this alongside the focus on lean principles. In their study of the Hyundai Production System, Lee and Jo (2007) found that one of the two major deviations in Hyundai from TPS was exactly in the use of pull logic; the Hyundai Production System is built on a push logic powered by ERP and APS. In this study, however, only one company in the sample explicitly addresses ERP as a top operating principle (while 70% refer to 'pull' as a principle). This finding indicates that industry is not adapting their XPSs to follow the advice given by Henriksen and Rolstadås (2010), among others, who recommend an integration and balance between the use of ERP-based push principles and lean-based pull principles.

One company emphasises 'responding in real time' as a main XPS principle. 'Real-time response' deviates from just-in-time response when it comes to the time aspect; real-time means that needed information and physical materials are instantly available (Wiklund, 1999). 'Real-time response' requires an advanced use of ICT to overcome any geographical distance. Responding to fluctuating and different demand patterns in real-time is also an area that looks to become a source for competitive advantage as markets become increasingly volatile and personalised. Still, analysis of 30 XPSs indicates that 'real-time response' has yet to become a top operating principle for the majority of firms.

5 Conclusions

Developing and deploying company-specific production systems (XPSs) is a strong and recent trend across many manufacturing industries. This continuing diffusion of XPSs across companies and industries is probably the strongest justification for their existence.

A multiple-case study of the main principles in 30 XPSs concludes that XPSs are largely variants of the same. The investigation of five propositions from two conflicting theoretical perspectives gives the strongest support to the universalistic perspective of best practices; companies do, to a large extent, share the same principles in their XPSs (P1a), and XPS

principles do resemble the principles of the TPS and lean production (P1b). The XPSs from different industries do to some extent reply to industry-specific requirements; but it is the emphasis on different lean principles that varies, not the common roots in lean per se. It seems evident that XPSs are developed in a path-dependent manner from the TPS. There is also an indication that contemporary XPSs represent a shift away from the people-oriented, culture-building emphasis in lean production toward its more technical side.

Still, XPSs do have company-specific characteristics which might facilitate an XPS to succeed where off-the-shelf lean improvement projects earlier have failed. Not two XPSs contain the exact same principles. They often carry the company's name and design and are shared and lasting programmes for all subsidiaries. An XPS represents a company's strategic choice of operating principles most important to it. It can be concluded that an XPS represents an own-best-way to the one-best-way. Very few XPSs contain unique, non-lean principles, as suggested by the contingency perspective and propositions P2a through P2c. The bulk of XPSs does not reply to essential elements of modern manufacturing such as, for example, ERP, automation and real-time response. These anomalies provide especially interesting possibilities for further research.

5.1 Implications for managers

This paper offers several implications for practitioners. The prioritised list of XPS principles in Table 3 can be used as a benchmark in XPS development. Companies must strategically clarify what the XPS should cover and what it should not. If the XPS is intended only for continuous improvement of the production function, other equally important programmes are needed that will compete for resources and management attention. Moreover, companies put less emphasis on culture-building in their XPSs than lean literature advises. The XPSs then run the risk of becoming tool boxes more than systems for sustained improvement. At worst, it makes the XPS a time-limited management fad. The analysis also warns that most XPSs fail to cover some essential principles in modern manufacturing. Among the ones discussed here are the utilisation of technology and automation, the use of ERP systems and pull principles and the use of real-time response strategies.

5.2 Research limitations

A main limitation of this research has been the reliance on the list of main principles and in some cases the visual XPS-model as the main source of data. However, as argued, this selection represents the principles chosen by companies as the most important principles for them and thus gives a fairly good representation of the XPSs studied. It must also be mentioned that XPSs are subject to updates, and, hence, those analysed here might take different forms today in the mentioned multinational companies.

The research findings would have higher external validity if more XPSs were included, which would also allow valid comparison across industries and other factors. This would most likely require a completely different research strategy, giving preferences to a quantitative survey methodology. Such a strategy would raise new challenges in regard to multiple respondents interpreting their XPS principles into the lean framework and run the risk of having low internal validity. The comparative multiple-case approach chosen here would consume too much time if it included enough cases for broad statistical analysis.

Even though this study establishes a strong link between XPSs and lean production, the relationship is not necessarily two-way; not all lean companies have an explicit XPS. This study has investigated the phenomenon of the XPS, which turns out to be a programme strategy to lean implementation, and not lean production per se.

This study took the corporations' perspectives and did not investigate what happens to the XPS as it is implemented by a subsidiary. From a contingency perspective, one could argue that just as corporations argue for adapting the lean principles to their specific characteristics and contexts, subsidiaries of the corporation should argue for adaptation of the XPS to fit their local contingencies. Thus, XPSs might be subject to the exact same propositions as they are implemented locally. The phenomenon of XPS offers many possibilities for future, high-impact research.

6 Acknowledgements

I am grateful for the partial financial support granted from the research project CRI Norman at SINTEF Technology and Society, Trondheim, Norway. Research assistant Alexander Welland deserves a special 'thank you' for the initial mapping of XPSs. I also want to

acknowledge the constructive discussions with colleagues at SINTEF, NTNU and Georgetown University, in addition to the comments from three anonymous reviewers. Last, but not least, I am thankful for the research willingness of the 15 participating multinational companies.

7 References

Abrahamson, E. (1991) Managerial fads and fashions: the diffusion and rejection of innovations. *Academy of Management Review,* Vol. 16, Iss. 3, pp. 586-612.

Adam, E., Flores, B. & Macias, A. (2001) Quality improvement practices and the effect on manufacturing firm performance: evidence from Mexico and the USA *International Journal of Production Research,* Vol. 39, Iss. 1, pp. 43-63.

Adler, P. S. & Cole, R. (1993) Designed for Learning: A Tale of Two Auto Plants. *Sloan Management Review,* Vol. 34, Iss. 3, pp. 85-94.

Almatis (2011) *ABS – Business Excellence the Almatis Way!,* Almatis. http://www.almatis.com/about-us/pdfs/ABS.pdf Accessed 8 February 2011

Anand, G., Ward, P. T., Tatikonda, M. V. & Schilling, D. A. (2009) Dynamic capabilities through continuous improvement infrastructure. *Journal of Operations Management,* Vol. 27, Iss. 6, pp. 444-461.

Ansari, A. M., Fiss, P. C. & Zajac, E. J. (2010) Made to fit: How practices vary as they diffuse. *Academy Management Review,* Vol. 35, Iss. 1, pp. 67-91.

Barney, J. B. (1991) Firm Resources and Sustained Competitive Advantage. *Journal of Management,* Vol. 17, Iss. 1, pp. 99-120.

Barney, J. B. (2011) *Gaining and sustaining competitive advantage,* Boston, Pearson.

Barthel, J. & Korge, A. (2002) Implementierung Ganzheilicher Produktionssysteme als Aufgabe des Managements - Ergebnisse einer Studie in Brownfield-Werken der Automobilindustries. In Feggeler, A. & Neuhaus, R. (Eds.) *Ganzheitliche Produktionssysteme - Gestaltungsprinzipien und deren Verknüpfung.* Köln, Wirtschaftsverlag Bachem.

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

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

Boeing (2008) *Enabling More Proactive IE Support of Factory Efficiency,* Boeing. http://www.iienet.org/uploadedfiles/IIE/Technical_Resources/Conference_Proceedings/Annual/55-pres.pdf Accessed 8 February 2011

Brox, J. A. & Fader, C. (2002) The set of just-in-time management strategies: An assessment of their impact on plant-level productivity and input-factor substitutability using variable cost function estimates. *International Journal of Production Research,* Vol. 40, Iss. 12, pp. 2705-2720.

Cagliano, R. & Spina, G. (2000) How improvement programmes of manufacturing are selected The role of strategic priorities and past experience. *International Journal of Operations & Production Management,* Vol. 20, Iss. 7, pp. 772-791.

Caterpillar (2011) *Caterpillar Production System (CPS),* Caterpillar. http://marine.cat.com/cda/components/fullArticle?m=233421&x=7&id=966559 Accessed 8 February 2011

Clarke, C. (2005) *Automotive production systems and standardisation: from Ford to the case of Mercedes-Benz,* Heidelberg, Physica-Verlag.

Cooney, R. (2002) Is “lean” a universal production system? Batch production in the automotive industry. *International Journal of Operations & Production Management*, Vol. 22, Iss. 9/10, pp. 1130-1147.
Deutsche Edelstahlwerke (2011) *Lean Maintenance als Reaktion auf das Deutsche Edelstahlwerke Produktionssystem*, Berlin, Maintainer 2010. http://www.tacook.de/media/pdf/00155_2.pdf Accessed 8 February 2011
Dombrowski, U., Schulze, S. & Otano, I. C. (2009) Instandhaltungsmanagement als Gestaltungsfeld Ganzheitlicher Produktionssysteme. In Reichel, J., Müller, G. & Mandelartz, J. (Eds.) *Betribliche Instandhaltung.* Berlin Heidelberg, Springer.
Ecco (2009) *Ecco - turning the supply chain into a competitive advantage*, Den Danske Logistikkonference 27.10.2009. http://www.logistikkonferencen.dk/PPDF/ECCO.pdf Accessed 8 February 2011
Electrolux (2009) *Electrolux Manufacturing System fact-sheet*, Electrolux. http://group.electrolux.com/en/wp-content/uploads/2010/07/Electrolux-Fact-Sheet-EMS.pdf Accessed 8 February 2011
Feggeler, A. & Neuhaus, R. (Eds.) (2002) *Ganzheitliche Produktionssysteme - Gestaltungsprinzipien und deren Verknüpfung*, Köln, Wirtschaftsverlag Bachem.
Gestamp Griwe (2011) *Produktionssystem.* http://www.griwe.de/de/unternehmen/produktionssystem.html Accessed 19 March 2011
Gunasekaran, A. & Ngai, E. W. T. (2007) Knowledge management in 21st century manufacturing. *International Journal of Production Research*, Vol. 45, Iss. 11, pp. 2391-2418.
Heidelberg (2008) *Heidelberg Produktionssystem (HPS) - Leitlinie für die Zusammenarbeit mit Lieferanten*, Heidelberg. http://www.heidelberg.com/corp/www/binaries/bin/files/dotcom/de/about_us/procurement/guideline/attachment_05_int.pdf Accessed 8 February 2011
Henriksen, B. & Rolstadås, A. (2010) Knowledge and manufacturing strategy-how different manufacturing paradigms have different requirements to knowledge: Examples from the automotive industry. *International Journal of Production Research*, Vol. 48, Iss. 8, pp. 2413-2430.
Hofman, A. (Ed.) (2000) *Arbeitsorganisation in der Automobilindustrie - Stand und Ausblick*, Köln, Wirtschaftsverlag Bachem.
Holweg, M. (2007) The genealogy of lean production. *Journal of Operations Management*, Vol. 25, Iss. 2, pp. 420-437.
JCB (2008) *Making Manufacturing Pay - Work Practices: Maximising Efficiency*, Cirencester, UK http://www.iagre.org/files/conf08/jcb.pdf Accessed 8 February 2011
Jorgansen, F., Boer, H. & Gertsen, F. (2003) Jump-starting continuous improvements through self-assessment. *International Journal of Operations & Production Management*, Vol. 23, Iss. 10, pp. 1260-1278.
Ketokivi, M. A. & Schroeder, R. G. (2004) Strategic, structural contingency and institutional explanations in the adoption of innovative manufacturing practices. *Journal of Operations Management*, Vol. 22, Iss. 1, pp. 63-89.
Knorr-Bremse (2007) *Knorr-Bremse - Mobilität ist Zukunft. Wir machen sie sicherer*, Berlin, Knorr-Bremse SfS. http://www.q-preis.de/uploads/media/KBB-19_11_07_Vers_02_rkw.pdf Accessed 8 February 2011
Krafcik, J. F. (1988) Triumph Of The Lean Production System. *Sloan Management Review*, Vol. 30, Iss. 1, pp. 41-51.
Lay, G. & Neuhaus, R. (2005) Ganzheitliche Produktionssysteme (GPS) - Fortführung von Lean Production? *Angewandte Arbeitswissenschaft*, Vol. 42, Iss. 185, pp. 32-47.

Lee, B. H. & Jo, H. J. (2007) The mutation of the Toyota Production System: adapting the TPS at Hyundai Motor Company. *International Journal of Production Research,* Vol. 45, Iss. 16, pp. 3665-3679.
Lego (2010) *The LEGO Group - recent years development,* Älvsjö, Plankonferens. http://plan.cust.bluerange.se/2010/Denhardt.pdf Accessed 8 February 2011
Liker, J. K. (2004) *The Toyota way: 14 management principles from the world's greatest manufacturer,* New York, McGraw-Hill.
Miles, H. & Huberman, M. (1994) *Qualitative data analysis: a source book,* Beverly Hills, CA, Sage Publications.
Morgan, J. M. & Liker, J. K. (2006) *The Toyota product development system: integrating people, process, and technology,* New York, Productivity Press.
Nelson, R. R. & Winter, S. G. (1982) *An evolutionary Theory of Economic Change,* Cambridge, MA, Belknap Press of Harvard University Press.
Neuhaus, R. (2009) Produktionssysteme in deutshen Unternehmen - Hintergründe, Nutzen und Kernelemente. *Fachzeitschrift Industrial Engineering.* REFA Bundesverband e.V.
New, S. J. (2007) Celebrating the enigma: the continuing puzzle of the Toyota Production System. *International Journal of Production Research,* Vol. 45, Iss. 16, pp. 3545 - 3554.
Ohno, T. (1988) *Toyota production system: beyond large-scale production,* New York, Productivity Press.
Pellegrinelli, S., Partington, D., Hemingway, C., Mohdzain, Z. & Shah, M. (2007) The importance of context in programme management: An empirical review of programme practices. *International Journal of Project Management,* Vol. 25, Iss. 1, pp. 41-55.
Shah, R., Chandrasekaran, A. & Linderman, K. (2008) In pursuit of implementation patterns: the context of Lean and Six Sigma. *International Journal of Production Research,* Vol. 46, Iss. 23, pp. 6679-6699.
Shah, R. & Ward, P. T. (2003) Lean manufacturing: context, practice bundles, and performance. *Journal of Operations Management,* Vol. 21, Iss. 2, pp. 129-149.
Skinner, W. (1974) The Focused Factory. *Harvard Business Review,* Vol. 52, Iss. 3, pp. 113-121.
Sousa, R. & Voss, C. A. (2001) Quality management: Universal or context dependent? *Production and Operations Management,* Vol. 10, Iss. 4, pp. 383-404.
Sousa, R. & Voss, C. A. (2008) Contingency Research in Operations Management Practices. *Journal of Operations Management,* Vol. 26, Iss. 6, pp. 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,* Vol. 45, Iss. 16, pp. 3763-3778.
Taylor, F. W. (1911) *The Principles of scientific management,* New York, Harper & Brothers.
Teece, D. J., Pisano, G. & Shuen, A. (1997) Dynamic Capabilities and Strategic Management. *Strategic Management Journal,* Vol. 18, Iss. 7, pp. 509-533.
Terlaak, A. & Gong, Y. (2008) Vicarious learning and inferential accuracy in adoption of processes. *Academy Management Review,* Vol. 33, Iss. 4, pp. 846-868.
Thun, J., Drüke, M. & Grübner, A. (2010) Empowering Kanban through TPS-principles - an empirical analysis of the Toyota Production System. *International Journal of Production Research,* Vol. 48, Iss. 23, pp. 7089-7106.
Towill, D. R. (2007) Exploiting the DNA of the Toyota Production System. *International Journal of Production Research,* Vol. 45, Iss. 16, pp. 3619 - 3637.
Trumpf (2011) *Die SYNCHRO Philosophie,* TRUMPF. http://www.trumpf.com/innovation/synchro/synchro-philosophie.html Accessed 8 February 2011

Van Iwaarden, J., Van Der Wiele, T., Dale, B., Williams, R. & Bertsch, B. (2008) The Six Sigma improvement approach: a transnational comparison. *International Journal of Production Research,* Vol. 46, Iss. 23, pp. 6739–6758.

Viessmann (2011) *Viessmann Produktionssystem ViPS,* Viessmann. http://www.viessmann.de/de/portrait/produktionssystem.html Accessed 8 February 2011

Vonderembse, M. A., Raghunathan, T. S. & Subba Rao, S. (1997) A post-industrial paradigm: To integrate and automate manufacturing. *International Journal of Production Research,* Vol. 35, Iss. 9, pp. 2579-2600.

Voss, C. (2009) Case research in operations management. In Karlsson, C. (Ed.) *Researching Operations Management.* New York, Routledge.

Voss, C. A. (1995) Alternative paradigms for manufacturing strategy. *International Journal of Operations & Production Management,* Vol. 15, Iss. 4, pp. 5-16.

Voss, C. A. (2005) Alternative Paradigms for Manufacturing Strategy. *International Journal of Operations and Production Management,* Vol. 25, Iss. 12, pp. 1211-1222.

Wagner, H. T., Morton, S. C., Dainty, A. R. J. & Burns, N. D. (2010) Path dependent constraints on innovation programmes in production and operations management. *International Journal of Production Research,* Vol. 49, Iss. 11, pp. 3069-3085.

Wernerfelt, B. (1984) A Resource-Based View of the Firm. *Strategic Management Journal,* Vol. 5, Iss. 2, pp. 171-180.

Westkämper, E., Hummel, V. & Rönnecke, T. (2009) Ganzheitliche Produktionssysteme. In Westkämper, E. & Zahn, E. (Eds.) *Wandlungsfähige Produktionsunternehmen - Das Stuttgarter Unternehmensmodell.* Berlin/Heidelberg, Springer.

Whirlpool (2009) *Whirlpool corporation: Lean Operations and Supply Chain,* Whirlpool. http://www.sap.com/italy/about/events/2009_7_2_lean_production/pdf/Whirlpool.pdf Accessed 8 February 2011

Wiklund, H. (1999) A statistical approach to real-time quality control. *International Journal of Production Research,* Vol. 37, Iss. 18, pp. 4141-4155.

Witcher, B. J., Chau, V. S. & Harding, P. (2008) Dynamic capabilities: top executive audits and hoshin kanri at Nissan South Africa. *International Journal of Operations & Production Management,* Vol. 28, Iss. 6, pp. 540-561.

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.

Wu, B., Kay, J. M., Looks, V. & Bennett, M. (2000) The design of business processes within manufacturing systems management. *International Journal of Production Research,* Vol. 38, Iss. 17, pp. 4097-4111.

Yin, R. K. (2003) *Case study research: design and methods,* Thousand Oaks, CA, Sage.

Yu, J. & Zaheer, S. (2010) Building a process model of local adaptation of practices: A study of Six Sigma implementation in Korean and US firms. *Journal of International Business Studies,* Vol. 41, Iss. 3, pp. 475-499.