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Company-specific production systems: Managing production improvement in global firms

Thesis for the degree of Philosophiae Doctor

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Summary

How can a firm improve the production of all its plants simultaneously? Many multinational firms have suggested they can do so by developing strategic *production improvement programmes* and implementing them in their dispersed network of plants. Instead of leaving every subsidiary to solve their own improvement issues, they offer a company-specific production system: an XPS. The 'X' stands for the company's name, and 'PS' stands for *production system* or an equivalent. A few good examples include the Bosch Production System, Caterpillar Production System, Jotun Operations System, Nissan Production Way and—the main case of my research—the Volvo Production System (VPS).

When developing an XPS, a firm adapts principles from available production improvement templates, such as total quality management (Deming, 1982), just-in-time production (Ohno, 1988), theory of constraints (Goldratt and Cox, 1984), world class manufacturing (Schonberger, 1986), mass customisation (Pine, 1993), six sigma (Pande *et al.*, 2000) and, most notably, lean production (Womack *et al.*, 1990). The famous Toyota Production System has been a particular inspiration for other firms (Hofman, 2000; Feggeler and Neuhaus, 2002).

However, considering the large amount of investments that are required to establish and manage these systems, it is puzzling that apparently little is known about how to implement them with success. Chakravorty (2010) reported that 60% of all six sigma programmes were unsuccessful, and Pay (2008) suggested the same for 74% of lean production projects. In general, two-thirds of all corporate change programmes tend to fail (Kotter, 1995; Beer and Nohria, 2001; Aiken and Keller, 2009). In particular, a main challenge is to *sustain* the improvements over time (Bateman, 2005; Schonberger, 2007). Can a corporate multi-plant improvement programme in the form of an XPS deliver the promised results?

This dissertation provides answers to this question. The research method has primarily been qualitative case studies, which hold many advantages when studying emergent and less codified phenomena (Voss *et al.*, 2002), such as the XPS. With the exception of a literature synthesis (Paper 2), the research is empirical and based on close interactions with practitioners, for the most part in the Volvo Group (Papers 3-5). For example, to collect data for the fifth paper included in this thesis, I visited 40 Volvo plants on five continents,

interviewed 200 managers at Volvo, administered a questionnaire survey that received 312 responses and had full access to Volvo's own audit data for VPS implementation in the plants.

This dissertation consists of two parts: The first is a summary and discussion of the five papers included in this thesis. The second part is a collection of the papers, each answering a general research question:

- What is the phenomenon of 'XPS'? (Paper 1)
- What does the literature say about XPSs? (Paper 2)
- Strategically, do XPSs make sense? (Paper 3)
- Empirically, does an XPS improve performance? (Paper 4)
- In what pattern does an XPS affect performance? (Paper 5)

Paper 1 analyses the XPSs of 30 renowned multinational companies and found that the XPS is a strategic production improvement programme tailored to the specific needs of a company.

In the literature synthesis in Paper 2, only 30 papers that explicitly studied improvement programmes in an international, multi-plant setting were discovered. Whereas the literature on production improvement and international management are both mature, their union is much less studied. The results in Paper 3 suggest that any firm can attain a competitive advantage if it implements an XPS with a good strategic fit and does so faster than its competitors do.

Paper 4 presents evidence that an XPS can significantly improve operational performance.

Finally, Paper 5 concludes that the implementation of an XPS seems to affect the performance of a plant in an S-curve pattern: performance first improves slowly, then rapidly, then less rapidly and finally slowly again.

These findings have important implications for practice. A general recommendation is that an XPS can be an effective way to improve the production in multiple plants. I balance this advice with a thorough discussion of problematic issues: both methodological and practical. This thesis strives to be helpful to those who either manage or study production improvement, today and in the future.

Sammendrag

Hvordan kan en bedrift forbedre produksjonen i alle sine fabrikker samtidig? Mange multinasjonale selskaper mener at det kan gjøres gjennom et strategisk *produksjonsforbedringsprogram* som implementeres i deres globale produksjonsnettverk. Istedenfor å la hver fabrikk selv finne ut av hvordan man best forbedrer produksjonen, tilbyr morselskapet et *bedriftsspesifikt produksjonssystem*: et XPS. “X”-en står for bedriftens navn, mens “PS” er en forkortelse for “produksjonssystem”, eller tilsvarende. Noen få gode eksempler inkluderer Bosch Production System, Caterpillar Production System, Jotun Operations System, Nissan Production Way og—hovedcaset i min egen forskning—Volvo Production System (VPS).

Når man utvikler et XPS tilpasser bedriften prinsipper fra alle tilgjengelige oppskrifter for produksjonsforbedring, slik som for eksempel “total kvalitetsledelse” (Deming, 1982), “just-in-time produksjon” (Ohno, 1988), “flaskehalsstyring” (Goldratt and Cox, 1984), “world class manufacturing” (Schonberger, 1986), “masseprodusert skreddersøm” (Pine, 1993), “six sigma” (Pande *et al.*, 2000) og, trolig mest kjent, “lean produksjon” (Womack *et al.*, 1990). Det berømte produksjonssystemet til Toyota har utvilsomt vært en spesiell inspirasjonskilde for andre bedrifter (Hofman, 2000; Feggeler and Neuhaus, 2002).

Men, med tanke på de betydelige investeringene som gjøres i disse systemene, er det overraskende at vi tilsynelatende vet lite om hvordan vi skal lykkes med å implementere dem. Chakravorty (2010) rapporterte at 60 % av alle six sigma programmer feiler. Pay (2008) fant det samme for 74 % av alle lean prosjekter. Generelt mislykkes to tredjedeler av alle endringsprogrammer i bedrifter (Kotter, 1995; Beer and Nohria, 2001; Aiken and Keller, 2009). En hovedutfordring er å opprettholde forbedringsarbeidet over tid (Bateman, 2005; Schonberger, 2007). Kan et globalt produksjonsforbedringsprogram i form av et XPS levere bedre og vedvarende resultater?

Denne avhandlingen søker svar på dette spørsmålet gjennom fem artikler og en diskusjon av dem. Forskningsmetoden er først og fremst kvalitative casestudier, som har mange fordeler når man studerer et fremvoksende og ubeskrevet fenomen (Voss *et al.*, 2002)—slik som XPS. Med unntak av litteratur-sammenskrivningen (Artikkel 2) er all min forskning empirisk og basert på tett interaksjon med industribedrifter, for det meste i Volvo Gruppen (Artikkel 3-5). For eksempel, for å samle data til den femte artikkelen besøkte jeg 40 fabrikker på fem

kontinenter, intervjuet mer enn 200 ansatte, samlet 312 svar til en spørreundersøkelse og fikk full tilgang til Volvos egne revisjonsdata på implementering av VPS i fabrikkene.

Denne avhandlingen består av to deler: Den første delen er en sammenfatning og diskusjon av forskningsdesignet og funnene i de fem artiklene. Den andre delen er en samling av artiklene, hvor hver av dem svarer på et generelt forskningsspørsmål:

1. Hva er fenomenet “XPS”? (Artikkel 1)
2. Hva sier litteraturen om XPS? (Artikkel 2)
3. Strategisk sett, er det fornuftig å utvikle og innføre et XPS? (Artikkel 3)
4. Forbedrer et XPS ytelsen til en fabrikk? (Artikkel 4)
5. I hvilket mønster forbedrer et XPS ytelsen til en fabrikk? (Artikkel 5)

Den første artikkelen analyserer innholdet i 30 XPSer tilhørende kjente multinasjonale selskaper og konkluderer at et XPS er et strategisk produksjonsforbedringsprogram som er skreddersydd til den spesifikke bedriften. Artikkel 2 avdekker bare 30 artikler som eksplisitt studerer implementeringen av produksjonsforbedringsprogrammer i internasjonale fabrikknettverk. Mens litteraturen på “produksjonsforbedring” og “internasjonal ledelse” er modne på hver sin side, er foreningen av dem mye mindre studert. Artikkel 3 foreslår at enhver bedrift kan skaffe seg en konkurransefordel dersom den implementerer et XPS som har en god strategisk tilpasning til bedriften, og gjør det raskere enn sine konkurrenter. Artikkel 4 presenterer statistisk signifikante funn som viser at et XPS kan forbedre produktiviteten i en fabrikk. Avslutningsvis, konkluderer Artikkel 5 at implementeringen av et XPS påvirker en fabrikkens produktivitet i et S-kurve-mønster: ytelsen forbedres først langsomt, så raskt og økende, så raskt men avtagende og til slutt langsomt igjen.

Disse funnene har viktige implikasjoner for praksis. Et generelt råd er at et XPS kan være en effektiv måte å forbedre produksjonen på i mange fabrikker samtidig. Men jeg avveier dette konkrete rådet med en grundig diskusjon av både forskningsmetodiske og praktiske utfordringer. Forhåpentligvis vil denne avhandlingen være til hjelp for dem som enten leder eller forsker på produksjonsforbedring, i dag og i fremtiden.

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This dissertation is the result of swarms of inspiration, critique and support given to me from countless people. Many deserve explicit acknowledgement.

However trivial it might sound, I want to send my first thanks to the Norwegian taxpayers: without you, this project would never see daylight. We are lucky to have one of the world's most attractive education systems in Norway, but we often seem to forget exactly that. In my biased opinion, NTNU and the Norwegian Research Council administer your tax money well. Thanking the taxpayers is also as far as I will go in thanking myself. I owe you.

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I hope my supervisor will not feel disappointed coming in at third place in my round of giving thanks. Arild Aspelund has been exactly the supervisor I wanted. Apparently, he holds a professorship in the art of giving simple but effective advice 'just-in-time'. His assistance in two of the included papers was pivotal for their acceptance in the *International Journal of Production and Operations Management*. Thanks also to my co-supervisor Luitzen de Boer, who has been more important than he expectedly thinks himself.

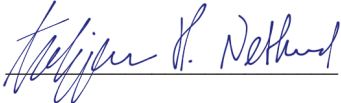
If my colleagues had suggested four years ago that I would be lucky enough to work with the world's foremost capacity on global production strategy, I would thank them for their trust but naivety. Their prediction would have been right, though. I am extremely grateful for the

mentorship and friendship of Kasra Ferdows at Georgetown University. You have challenged me and shared your experience and wisdom in a remarkably kind way. During my visit to McDonough School of Business at Georgetown University, Washington, D.C. (2011-2012), I became a vigorous academic. I send many thanks to all my friends across the sea, and, of course, to the U.S.-Norway Fulbright Foundation that granted me the prestigious Fulbright scholarship for the year at Georgetown.

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I dedicate this dissertation to my wife, Julia. I am sorry to say that after giving me endless amounts of support, inspiration and joy, all you get back is this book... and me. I love you.

Trondheim, June 2013



Halvar H. Nethund

Abbreviations

4A	Adopt; Adapt; Act; Avoid
5S	Sort; Set in order; Shine; Standardise; Sustain
AMJ	<i>Academy of Management Journal</i>
AMR	<i>Academy of Management Review</i> (a journal)
AMT	Advanced manufacturing technology
APS	Advanced Planning and Scheduling (business software)
ASQ	<i>Administrative Science Quarterly</i> (a journal)
BiQ	Built-in-quality (a VPS principle)
BPR	Business process reengineering
BRIC	Brazil; Russia; India; China
CC	Customer complaints (a KPI)
CEO	Chief Executive Officer
CI	Continuous improvement
CS	Customer satisfaction (a KPI)
ERP	Enterprise Resource Planning (business software)
FTT	First-time-through (a KPI)
HRM	Human Resource Management
HSE	Health; Safety; Environment
IBR	<i>International Business Review</i> (a journal)
ICT	Information and Communication Technology
IJOPM	<i>International Journal of Operations and Production Management</i>
IJPE	<i>Journal of Production Economics</i>
IJPR	<i>International Journal of Production Research</i>
IMR	<i>International Marketing Review</i> (a journal)
IMS	Integrated Management System
ISO	International Standards Organization
JIBS	<i>Journal of International Business Studies</i>
JIT	Just-in-time
JOM	<i>Journal of Operations Management</i>
JWB	<i>Journal of World Business</i>
KPI	Key performance indicator
LOESS	Locally weighted regression
MES	Manufacturing Execution System (business software)
MIR	<i>Management International Review</i> (a journal)
MNC	Multinational corporation
MS	<i>Management Science</i> (a journal)
OD	Operational Development (a Volvo concept)

OEE	Overall equipment effectiveness (a KPI)
OM	Operations Management
OS	<i>Organization Science</i> (a journal)
OtD	Order-to-delivery
PLC	Product life-cycle
POM	<i>Production and Operations Management</i> (a journal)
RBV	Resource-based view of the firm
SMED	Single-minute exchange of die
SMJ	<i>Strategic Management Journal</i>
SQDCEP	Safety; Quality; Delivery, Cost, Environment; People
TOC	Theory of constraints
TPM	Total productive maintenance
TPS	Toyota Production System
TQM	Total quality management
VPS	Volvo Production System
VPSA	Volvo Production System Academy
VRIO	Valuable; Rare; Inimitable; Organisationally exploitable
VRIS	Valuable; Rare; Inimitable; Non-substitutable
WCM	World class manufacturing
XPS	Company-specific production system

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Netland, T.H. (2012) Exploring the phenomenon of company-specific production systems: One-best-way or own-best-way? *International Journal of Production Research*, Vol. 51, Iss. 4, pp. 1084-1097.

Paper 2 | page 73

Netland, T.H., Aspelund, A. (2013) Multi-plant improvement programmes: A literature review and research agenda. *International Journal of Operations & Production Management*, Vol. 34, Iss. 3. Forthcoming.

A draft version of the paper was presented at the 18th EurOMA Conference in Cambridge, UK, 3-6 July 2011.

Paper 3 | page 111

Netland, T.H., Aspelund, A. (2013) Company-specific production systems and competitive advantage: A resource-based view on the Volvo Production System. *International Journal of Operations & Production Management*, Vol. 33, Iss. 11/12. Forthcoming.

A draft version was presented at the 17th EurOMA Conference in Porto, Portugal, 6-9 June 2010. It will appear in the *IJOPM* special issue on ‘Trends in modern operations management’, edited by Ben Clegg, Prasanta Dey and Jill MacBryde.

Paper 4 | page 139

Netland, T.H., Sanchez, E. (2014) Investigating the effects of a corporate improvement programme on global quality performance: The case of the Volvo Production System. *The TQM Journal*, Vol. 26, Iss. 2. Forthcoming.

A draft version was presented at the 4th Swedish Production Symposium, in Lund, Sweden, 3-5 May 2011.

Paper 5 | page 159

Netland, T.H., Ferdows, K. (2013) How do company-specific production systems affect plant performance? *Working paper. NTNU, Trondheim/Georgetown University, Washington, D.C.*

A draft version was presented at the 24th POMS Annual Meeting in Denver, Co, USA, 3-6 May 2013, and at the 20th EurOMA Conference in Dublin, Ireland, 9-12 June 2013. The paper has been submitted to the *Journal of Operations Management* for a second first-time review.

Part I – Main report

1 Introduction

How can manufacturing companies sustain and progress the productivity of their plants? This question is fundamental to the operations management literature. Since the days of Frederick Taylor (1911) and Henry Ford (1922), research has suggested an array of production improvement philosophies, methods and tools (Hayes and Wheelwright, 1984; Schonberger, 1986; Ohno, 1988; Womack *et al.*, 1990). One particular company has had an exceptional position in this stream of research: the Toyota Motor Corporation. The continued success of Toyota has inspired many other companies to develop their own company-specific variants of the Toyota Production System (TPS) over the last two decades (Deming, 1982; Hofman, 2000; Lee and Jo, 2007; Neuhaus, 2009). Companies are spending enormous amounts of resources developing, implementing and managing such *company-specific production systems* (XPSs).

An XPS is a production improvement programme tailored to a specific company. The ‘X’ stands for the company’s name, and ‘PS’ is an abbreviation for ‘production system’ or something similar (e.g. business system, operations system, manufacturing system). A few typical examples include the Audi Production System, Boeing Production System, Bosch Production System, Caterpillar Production System, Electrolux Manufacturing System, Elkem Business System, Hydro’s Aluminium Metal Production System, Jotun Operations System, Nissan Production Way, Rolls Royce Production System, Scania Production System and—the main case of my research—the Volvo Production System (VPS).

However, having an XPS is only the beginning for companies; to actually improve their operations, and to do so over time, is a challenging task (Bateman, 2005; Schonberger, 2007). It has been suggested that two-thirds of all corporate change programmes fail (Kotter, 1995; Beer and Nohria, 2001; Aiken and Keller, 2009). According to an article in the *Wall Street Journal* (Chakravorty, 2010), 60% of all six sigma programmes are unsuccessful. In 2007, *Industry Week* reported that 70% of all manufacturing plants in the United States employed some form of a lean production project, but only 24% of them were satisfied with the outcome (Pay, 2008). New (2007, p. 3547) makes 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’. In this thesis, I investigate whether global companies can achieve and sustain the improvement of production by using XPSs.

1.1 Why study XPSs?

Before starting my PhD, I led a three-year collaborative research project ('Ideal Factory') among SINTEF, Volvo Aero Norway and Kongsberg Defence Systems. At the Volvo plant, I learned how 'VPS was rolled in on pallets as heaps of books from Sweden in 2008' (quote from the technical director, Gunnar Adolfsen). The plant, which produces parts for aircraft jet engines, struggled to deal with the system and all its requirements. An early external assessment of the VPS implementation at the plant scored low. Sceptics at the plant typically claimed that 'VPS had been developed for Volvo's truck division, and would not fit the special requirements of aero production'. Nonetheless, the implementation of the VPS was a requirement from the Swedish owners, and the managers in Norway were serious about it. This insight spurred my interest into systems such as the VPS.

The first natural question was 'what is VPS?' Volvo launched the VPS in 2007 after two years of careful development. A VPS pre-study report concluded, 'The benefits of a common Volvo Production System would be maximum use of resources, better communication within the company group, sharing of best practices, industrial and personnel mobility and reduced duplication of efforts' (Hill, 2006). Figure 1 shows the basic design of the system. It consists of six core principles: the Volvo Way, teamwork, process stability, built-in quality, continuous improvement and just-in-time; all geared towards meeting the demand of the customer. These principles are further described in 22 modules that contain a number of tools and techniques beneficial for implementation of the system. The VPS is Volvo's 'way to operational excellence'. (Note that Papers 3, 4 and 5 include further descriptions of the VPS).

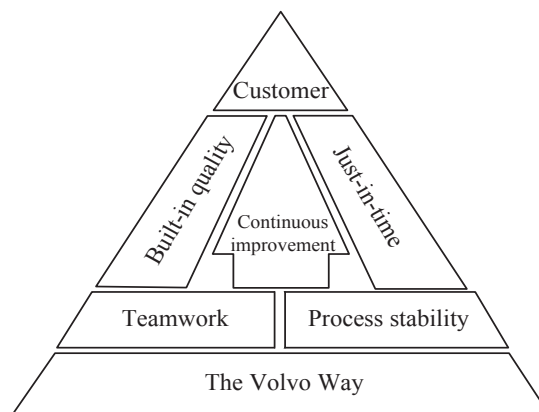


Figure 1. The Volvo Production System pyramid with principles (Source: Volvo AB).

A number of new questions arose from this first inquiry into Volvo's XPS: Is the VPS special, or are other companies also doing this? If so, are the systems different or alike? How do such systems depart from other production improvement systems such as *lean*, *six sigma* and *total quality management* (TQM)? Why do firms develop XPSs in the first place? Answering these questions became the motivation for my first investigation (Paper 1): what is XPS? To investigate this question, I started collecting XPSs through web searches. I quickly collected more than 100 XPSs. It became clear that developing such global production improvement programmes was an ongoing phenomenon in the industry that deserved more elucidation.

Companies evidently use billions of dollars to develop, manage and maintain multi-plant production improvement programmes. Surprisingly, I found that the corresponding academic literature on XPSs was scarce (see Paper 2 for a full review of the literature). Except for a few German books on *Ganzheitliche Produktionssysteme* (e.g. Hofman, 2000; Feggeler and Neuhaus, 2002; MTM, 2004; Clarke, 2005; Lay and Neuhaus, 2005; Dombrowski *et al.*, 2009; Westkämper *et al.*, 2009), a few scattered journal publications (e.g. Wallace, 2004; Lee and Jo, 2007) and many articles in the popular press, the phenomenon of the XPS seemed to lack an accepted codification and stream of literature. This left an intriguing opportunity for me to conduct this research on XPSs.

1.2 Research objectives

The ultimate objective of this thesis is to provide advice on how practitioners can succeed in improving production by incorporating XPSs. To achieve this aim, I suggested and sought to answer the following research questions:

1. What is the phenomenon of XPS?
 - a) What are the characteristics of global companies' XPSs?
 - b) What does the literature say about multi-plant improvement programmes?
2. What is the relationship between implementation of an XPS and performance?
 - a) Does an XPS contribute to a firm's competitive advantage?
 - b) In what pattern does an XPS affect plant performance?
3. What should managers do to succeed with the implementation of an XPS?

The first set of questions aim to codify what an XPS is and how it relates to current business practices and the literature. The second set of questions examines how the implementation of

an XPS affects the performance of the firm, both from theoretical and empirical perspectives. The answers to these questions have important implications for how managers should perform the improvement work in their companies, which is the third proposed question.

2 Research design

The research setting and nature of the research questions set requirements for what type of data collection methods were preferable. Multinational companies are challenging research objects because they are influenced by an array of complicating contingency variables: market characteristics, national cultures, politics and trade agreements, corporate strategies, organisational cultures and production characteristics such as volume, size, variability, product mix and use of technology, to mention a few. Thus, to single out the effects of the multifaceted XPS and, hence, control for all the other impacting variables, is difficult, if not impossible. In such situations, in-depth case studies and triangulation can improve the reliability and validity of the results considerably (Jick, 1979; Eisenhardt, 1989; Barratt *et al.*, 2011). Moreover, case research is a suitable choice for young and emerging fields (Voss *et al.*, 2002). Four of the included papers are case studies: Paper 1 is an explorative multiple-case study, and Papers 3, 4 and 5 report from in-depth case studies about the Volvo Group. Paper 2 is a literature review.

In the following section, the methods used for each paper are briefly presented. For a full account, please see the method sections in each of the papers in Part II of the thesis. In Section 2.6, the methodological limitations of the research design are discussed.

2.1 Method in Paper 1: Explorative multiple-case study

The objective of the first study was to explore the phenomenon of XPS; more specifically, it was to compare differences and similarities across XPSs concerning their main principles. Practically, this could be done in two ways: either through a large-scaled survey sent to a sufficient selection of manufacturing companies or through a multiple-case study. Both methods have strengths and weaknesses. I chose a comparative multiple-case study design, following the advice of Voss (2009, p. 165), who said, ‘Case research provides an excellent means of studying emergent practices’. The alternative, a survey, would have many advantages (e.g. sample size and statistical analysis), but it would also be prone to many disadvantages (e.g. lack of in-depth understanding, survey administration, access to

companies and respondent bias). The multiple-case approach allowed for much deeper insight into each specific case than a quantitative survey would have allowed (Yin, 2003). In the early stages of my research, that benefit became decisive.

The research method followed Yin's (2003) recommended approach for multiple-case studies. First, propositions about the phenomenon were developed from the literature. Then, I acquired access to information about the XPSs of 30 renowned multinational companies. I did so by writing to approximately 60 persons in manufacturing companies identified through an internet search for XPSs. In the invitation e-mail, I explained the intention of the research and offered to return a brief benchmark report for all companies that would participate. As a result, 15 companies sent me detailed information about their improvement systems. I added 15 other XPSs that were satisfactorily described either in corporate white papers or in the literature. The principles of the 30 XPSs were compared against a literature-based framework of principles (as recommended by Miles and Huberman, 1994; Yin, 2003), which was developed from four seminal references in the lean/TPS literature: Ohno (1988), Womack and Jones (1996), Liker (2004) and Shah and Ward (2003). Finally, I discussed the propositions in reference to the findings. Section 3.1 provides a brief outline of the main findings.

2.2 Method in Paper 2: Systematic literature review

Reviewing the literature informs the researcher about the most current knowledge and helps identify promising possibilities for further research (Baumeister and Leary, 1997). Because XPS is not an established term, Professor Arild Aspelund and I performed a review of the literature on the broader topic of 'multi-plant improvement programmes'. Starting where Prasad and Babbar (2000) ended their 1986–1997 review on 'international operations management', our review covered the relevant papers published in 15 top management journals between 1998 and 2011.

There are several methodological considerations that must be made when conducting literature reviews: They should be systematic, explicit, comprehensible and reproducible (Fink, 2010). We took several actions to adhere to these requirements. Note that keyword searches failed early on because of the numerous terms that describe similar concepts to both 'improvement programme' and 'multi-plant'. Instead, we embarked on a manual search in the selected journals. We used acknowledged journal rankings to decide which journals to

include. Throughout this process, I manually scanned more than 20,500 paper titles and abstracts when needed. All relevant papers were stored in a research database and were subject to several iterations of reading and considerations for inclusion. Thus, the paper selection method resembled that used by Prasad and colleagues (Prasad and Babbar, 2000; Prasad *et al.*, 2000; Prasad *et al.*, 2001). Out of an initial sample of 531 potentially relevant papers, we identified only 30 that explicitly dealt with ‘multi-plant production improvement programmes in an international setting’.

2.3 Method in Paper 3: Explorative single-case study

The objective of the third paper was to explore, from theoretical and empirical points of view, whether an XPS makes sense or not. In this paper, which I co-authored with my supervisor, we investigated the competitiveness implications of the VPS using the resource-based view of the firm (RBV). The RBV is an established and well-regarded theory of how companies can build and maintain competitiveness (Peteraf, 1993; Barney, 2011). Specifically, we used Jay Barney’s VRIO model (Barney, 1997, 2011), which explained that a sustained competitive advantage can only be gained from a resource that is *valuable* (V), *rare* (R) and *inimitable* (I) and that the *organisation is able to exploit* (O).

Because of my established contact with Volvo Aero Norway, we chose the Volvo plant in Norway as ‘a convenience case’ (Stake, 1994). This was my first in-depth investigation of the implementation of an XPS in a plant. Although starting with the ideas of Yin (2003) that a conceptual pre-defined and thought-through methodological process is the right way to proceed, the development of this paper followed an iterative research process (Eisenhardt, 1989; Andersen, 1997). At this early stage of the project, this explorative approach to the case was useful (Voss, 2009).

In addition to the data collected from the Norwegian Volvo plant, I added a corporate perspective by travelling to Volvo’s headquarters in Gothenburg, Sweden. In short, I collected two types of data from Volvo: interviews and documents. I interviewed 11 managers at Volvo: five in the Volvo Aero plant in Kongsberg and six in the corporate VPS office in Gothenburg. The interviews were carefully prepared, taped and transcribed in full. The transcribed interviews were sent to the interviewees for quality assurance. We searched more than 100 pages of transcribed raw text and additional documents for confirmative and

contradictive statements to the VRIO framework. The discussion resulted in a proposed enhancement to the VRIO framework for competitive advantage.

2.4 Method in Paper 4: Case study and survey

In the fourth paper, my co-author Eby Sanchez (VPS Director for Volvo Trucks North America) and I set out to investigate the relationship between the implementation of an XPS and its impact on global quality performance. There is an abundance of literature that examined the relationship between various production improvement programmes and performance, most of which used large-scale industry surveys and reported positive relationships (Sousa and Voss, 2002; Nair, 2006). Although often used, surveys like these have a few limitations (Davies and Kochhar, 2002; Forza, 2002). For example, surveys are prone to respondent bias because a single individual in a firm often responds to the questionnaire. In addition, the respondent reports subjective perceptions to (ambiguous) questions, which may lead to construct errors. Furthermore, comparing heterogeneous groups and controlling for all confounding factors is challenging. We also used survey research to investigate our hypotheses in this paper, but we did so in a single-case environment (the Volvo Group) and triangulated the results with longitudinal performance data from three factories in Volvo.

We used data from Volvo's implementation of the VPS to investigate a simple question: Does the implementation of the VPS improve the quality performance of manufacturing plants in the global network? We hypothesised that it does. Specifically, we investigated if the implementation of quality practices, as described by the VPS, positively affects *process quality* (measured by first-time-through) and *product quality* (measured inversely by customer complaints). Instead of relying on a self-reported measure of the independent variable (the degree of VPS implementation), we measured it using the VPS assessment scores, which one can argue is a more robust method (Schloetzer, 2012). Independent Volvo teams are regularly collecting these data through a standardised audit of the implementation of VPS in all Volvo plants (see Papers 4 and 5 for details). For the dependent variables—process and product quality—we used single-item measures from a survey with 305 responses from 56 plants. We used the mean of the multiple responses from managers in the plants as the plant's measure of quality performance. This reduces the risk of single-respondent bias (Flynn *et al.*, 1995).

The quantitative analyses were basic and uncomplicated. First, we used correlation and linear regression analyses to investigate the relationship between implementation and the resulting performance. Second, we visited and collected actual longitudinal performance data from three different plants for the years 2007-2012. We used these three detailed case studies to determine if they would confirm or invalidate the results from the quantitative analysis. Our method is not without limitations, which I will address in Section 2.6. However, this paper's strength lies in its simplicity and use of triangulation with real performance metrics.

2.5 Method in Paper 5: Theory-building and -testing case study

The last paper included in my thesis investigates *the pattern of the relationship* between XPS implementation and plant performance. I started this investigation during my research visit at Georgetown University in Washington, D.C. With the help of Professor Kasra Ferdows, I embarked on an in-depth study of the global implementation of the VPS.

In short, we hypothesised that the implementation of an XPS affects the performance of a plant in an S-shaped pattern. As in Paper 4, we measured the independent variable with the VPS assessment score. We tested our hypothesis using four different measurements for the dependent variable (plant performance). These were collected from (1) a quantitative survey, (2) Volvo's own performance audit of the plants, (3) changes in the VPS assessment score (used as a proxy for performance development) and (4) qualitative observations and interviews from 40 of Volvo's plants all over the world. We drew scatter plots of the independent variable and four different dependent variables, and used locally weighted regression (LOESS) to reveal the relationship between them (Cleveland, 1979; Jacoby, 2000). An advantage of LOESS is that it does not need a priori specification of a fit function; it discovers the pattern from the data. Finally, we compared the results of the four tests.

Admittedly, our method is rather unusual. For example, one anonymous reviewer made the following remark about our first-round submission to the *Journal of Operations Management*: 'I would like to commend the authors for carrying out such a unique study. To my mind, this is a very unusual study, the likes of which I have not seen earlier (from a methodological standpoint, as well as from a research question and hypotheses testing standpoint)' (JOM Reviewer 2 on Paper 5, March 2013). Whereas case studies have traditionally been inductive and used for building propositions for future research (Eisenhardt, 1989; Meredith, 1998; Yin,

2003), Barratt *et al.* (2011) suggested that using case studies to test a theory has an untapped potential. In our paper, we proposed the S-curve theory and tested it. This method also has its strengths and weaknesses, which we thoroughly address in Paper 5.

2.6 Methodological limitations and countermeasures

As with all social science research, this research design is not without flaws. Five major limitations of the chosen research methods are:

- The complexity of the unit of analysis: the XPS.
- The difficulty of isolating causal relationships in context-rich environments.
- The limited possibility of generalising from case-study research.
- The need for longitudinal data over many years to judge the sustainability and effectiveness of XPS as a new phenomenon.
- The limited ability of the researcher to master a variety of theories and literature that contributes to the understanding of the subject.

The first limitation is that an XPS is not a clear-cut unit of analysis. What exactly does it represent? The 30 XPSs I investigated in Paper 1 proved similar enough to codify an XPS as a company-specific variant of the Toyota Production System. This perspective finds solid support in the German literature on XPS (e.g. Feggeler and Neuhaus, 2002; Lay and Neuhaus, 2005; Dombrowski *et al.*, 2009) and in most of the different companies' own descriptions of their systems (in fact, I did not come across one company that had not looked into Toyota's TPS). Even Volvo, a rare historical opponent to the standardisation and just-in-time thinking of TPS (Nilssen and Skorstad, 1986; Lohr, 1987; Berggren, 1993; Ellegård, 1995), admits that the VPS is heavily influenced by the TPS (Hill, 2006).

However, if we accept that a key characteristic of an XPS is exactly that it is *specific* to the company, XPSs that are very different from the TPS should exist. How much can an XPS deviate from the TPS and lean templates and still be an XPS? Modig and Ahlström (2012) share the same concern for the term *lean*: 'If lean is everything that is good, and everything good is lean, what is then the alternative?' (p. 93). I do not have the complete answers to these questions. Therefore, future research must assist the further codification of the field.

A second inevitable challenge in doing research like this is the embedment of an XPS in a complex social organisation and environment. It is hard to single out causal relationships between implementation of an improvement programme and, for example, performance. Many other factors are in play, such as market characteristics, national and organisational cultures, strategic decisions and leadership styles, strength of unions, competence levels, supply chain dynamics, product mix and volumes, technology characteristics and the size and history of the plant. It is not possible to do laboratory experiments or mathematical modelling on XPS implementation. All production improvement literature shares this limitation; however, for research on XPSs, it is amplified by the multi-plant and international settings. To account for all contingency factors is very hard, if not impossible. My main strategy to reduce these factors' impact has been to undertake a single-case study of the VPS in the global Volvo Group. A case-study approach holds many contingency factors at nearly constant and allows an in-depth understanding of the unit of analysis. Nonetheless, the controlling for confounding factors remains a limitation of the research.

Ironically, the countermeasure for the second limitation results in the third limitation: the possibility of generalisation from one or a few case studies is limited. I share this restriction with all case-based empirical research. Whereas the first paper included 30 companies, the third, fourth and fifth papers focused on the implementation of VPS in the Volvo Group. I cannot confirm whether the results from Volvo apply to other companies. However, as discussed, I have confirmed that XPSs are 'largely variants of the same system' in the first paper. The VPS is a typical XPS. Because of this, it is not a far-fetched argument that the results I found in Volvo most probably also apply to other multinational companies implementing similar XPSs. I hope future research will test if this assumption is true.

The fourth limitation is concerned with access to longitudinal data. To analyse an alleged new organisational system, such as an XPS, data must be tracked over several years. We still do not know if XPSs will remain in the future in the way that the TPS has stayed with Toyota or if it will fade away as a faddish phenomenon, like Business Process Reengineering (BPR), or end up as dead stock, like ISO certification binders in many companies. The key to the first alternative is that it sustains its positive impact on performance over years. It is very hard to judge the effects on performance without having longitudinal and comparable data. Luckily, I had access to performance data over a period of 2-5 years from Volvo, but it is not clear whether this is a sufficient timeframe. More longitudinal performance research is required.

The fifth limitation is the bounded scope of the literature included in my papers. The literature review in the second paper concluded there is much written that is relevant to this topic. In particular, the tremendous amount of production improvement literature that has been written over 100 years of operations management history clearly relates to programmes like the XPS. However, an XPS is more than a traditional improvement project in a plant. Several other theories contribute to our understanding of the complex and social phenomenon of the XPS. A few of these theories have been used in this thesis (institutional theory, RBV, learning curve, performance frontier and organisational inertia). Future research should explore the further potential of other fields in explaining the phenomenon of the XPS.

3 Presentation of main findings

In this section, I present the main findings from the five included papers.

3.1 Paper 1: What is the phenomenon of XPS?

The first study set out to explore the phenomenon of XPS. I found that having an XPS seems to be an ongoing trend among multinational manufacturers. An XPS is a production improvement programme developed specifically for the company. For multinational companies, it is a shared system for all plants. Importantly, it differs from improvement *projects* in its intention of being permanent. The use of the company's name and corporate design signify the company-specific elements. A graphical model often summarises the chosen principles (e.g. a house at Toyota, a temple at Chrysler or a pyramid at Volvo). This paper focuses on one of the arguably most important components of the XPS: the content.

The main conclusion of the comparative analysis of the content of XPSs from the 30 multinational companies was that 'XPSs represent an own-best-way approach to the one-best-way paradigm'. This means two things. First, multinational companies largely choose the same principles—the one-best way—when they develop their own production improvement programmes. Second, the systems, however, contain company-specific elements—the own-best way—, which makes the XPS more tailored to the firm than generic improvement philosophies. Figure 2 lists the ten most common principles among the 30 companies in the study (see Paper 1 for the complete list).

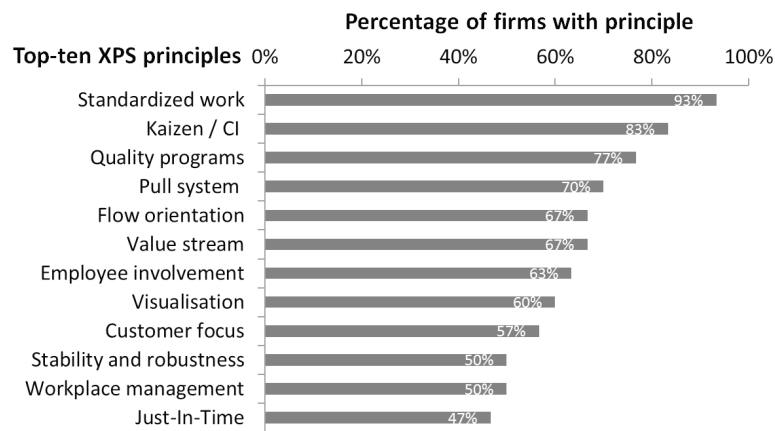


Figure 2. Top 10 XPS principles among 30 multinational firms (Source: Paper 1).

The analysis confirms that the principles of TPS and lean production are common for all the included XPSs. This finding has support in the limited existing research on XPSs (Hofman, 2000; Feggeler and Neuhaus, 2002; Clarke, 2005; Lay and Neuhaus, 2005; Lee and Jo, 2007). Furthermore, many companies explicitly state that the TPS and lean production heavily influenced their own XPS development. Companies seem to develop their XPSs by choosing the principles that best suit their needs from a broad pallet of proven lean production principles. Having already established that XPSs are company-specific ‘mutations of the TPS’ (Lee and Jo, 2007), the analysis of how XPS *departs* from the TPS blueprint is more interesting.

No two of the 30 analysed XPSs contained the exact same principles. A company’s XPS is the result of a strategic selection of principles. Therefore, even if the principles stem from the same templates, a tailoring to the unique needs of the firm takes place in the development process of the XPS. The argument is that not all lean principles suit all companies, as suggested by the *contingency perspective* in operations management (Sousa and Voss, 2008). Olhager and Prajago (2012), for example, found that lean production has a better impact on the performance of make-to-stock companies than it has for make-to-order companies. The strength of the XPS is that it allows for this specific adaptation. Instead of simply adopting the one-best-way approach, a company can strategically choose from all proven production improvement philosophies, such as just-in-time production (Sugimori *et al.*, 1977; Ohno, 1988), TQM (Deming, 1982; Powell, 1995), world class manufacturing (Schonberger, 1986), theory of constraints (Goldratt and Cox, 1984), BPR (Hammer and Champy, 1995), mass

customisation (Pine, 1993), six sigma (Pande *et al.*, 2000) and, still most significantly, lean production (Womack *et al.*, 1990).

In fact, one concern is that companies tailor their systems to a too limited extent. Using arguments from the resource-based view of strategy (Barney, 2011), I warn against a too path-dependent development from the TPS. The reason for this is the scarcity of non-lean principles among the XPSs. For example, principles related to the use of information technology and automation, which are two central elements of modern production improvement, are hardly represented. Another concern is the bias toward the technical side of the TPS for the average XPS. The original TPS balances the technical with social principles (Ohno, 1988; Liker, 2004). In contrast, I found that principles such as leadership, teamwork and employee involvement have much less thrust in the average XPSs than recommended by the literature. In the discussion in Section 4.3, challenges such as these are explored further.

3.2 Paper 2: What does the literature say about XPSs?

The answer to the section headline is ‘not much’. There is, indeed, a substantial amount of literature that is relevant, but the phenomenon of XPS per se is not well documented in academic journals. Because of this, the literature synthesis was organised into two parts: The first reviewed theoretical work in the international business and operations management literature, which we used to suggest a literature-based framework for how subsidiaries might respond to the requirement of implementing an XPS. In the second part, using the framework as a backdrop, we discussed the 30 papers we found that explicitly studied multi-plant improvement programmes.

When we reviewed the theoretical contributions, we found that two dimensions were of notable importance for the implementation of a multi-plant improvement programme in a subsidiary: First, to what extent should the plant conform to the global standards (or, alternatively, adapt the standards to fit local contingencies)? Second, to what extent should the plant institutionalise the standards (that is, to what level should implementation reach)? Using these two questions as axes, we suggested a framework for how subsidiaries might respond to the improvement programme or sub-sections of it (Figure 3).

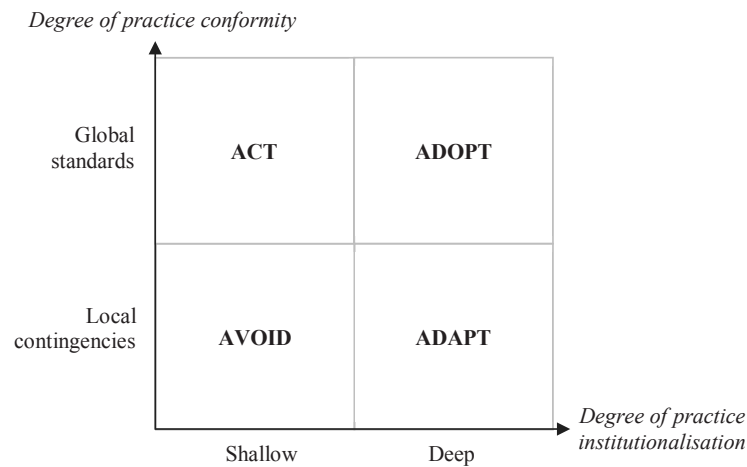


Figure 3. The 4A framework for subsidiary response to a multi-plant improvement programme (Paper 2).

The 4A framework suggests that subsidiaries *adopt*, *adapt*, *act* or *avoid* the multi-plant improvement programme, as well as its sub-elements and practices. ‘Adopting’ means that the subsidiary implements the practices prescribed by the global XPS in full. The logic behind this response is provided by the best practice paradigm of operations strategy, which argues that some ultimate practices have universal applicability (Womack *et al.*, 1990; Voss, 1995). ‘Adapting’ happens when the subsidiary alters the practice to achieve a better fit with the local contingencies. This is supported by the contingency theory (Ghoshal and Nohira, 1989; Sousa and Voss, 2001). The third response, ‘acting’, happens when the subsidiary pretends to have implemented the practice, but in reality, it is mostly superficial. The institutional theory explains that this behaviour is rational because it relates to institutional pressure from headquarters, or the market, to implement the practice (Oliver, 1991; Kostova and Roth, 2002). Finally, the institutional theory also explains why subsidiaries sometimes choose to ‘avoid’ the programme or its practices altogether and continue with ‘business as usual’.

We sorted the 30 papers according to the 4A framework. Several papers gave good reasons for companies to develop a multi-plant improvement programme and seek institutionalised adoption of practices across the plants (e.g. Colotla *et al.*, 2003; Goel and Chen, 2008). Most papers argued for adapting the practices to the local contingencies (e.g. Wallace, 2004; Browning and Heath, 2009) but not all (Jensen and Szulanski, 2007; Yu and Zaheer, 2010). A few studies found that plants do engage in acting behaviour, only implementing the system to a shallow degree (Kostova and Roth, 2002; Baxter and Hirschhauser, 2004).

The main conclusion was that the academic research in the field—despite the broad and still growing dissemination of such programmes in practice—is scarce and underdeveloped. This provides an excellent opportunity to add to the literature. We proposed that future research should seek answers to four fundamental questions:

- When should firms deploy multi-plant improvement programmes?
- How should firms balance adoption and adaptation of the programme?
- How can firms avoid superficial implementation and achieve real change?
- How should firms manage the multi-plant improvement programme per se?

The first and last questions stemmed from an apparent lack in the literature, and the second and third questions from areas where the literature was inconclusive. These questions are addressed further in Section 4.3. We also provided a recommendation on what research methods to use, encouraging empirical research. Because of the presence of many contingencies, longitudinal case studies are especially promising. Given the popularity of XPSs in the industry, researchers should have rich access to empirical cases. Quantitative surveys are efficient for data collection, but mere reliance on such data should be cautioned because they do not capture the institutionalisation of the XPSs (a problem of validity). As a minimum, triangulation with audit or performance data is encouraged when surveys are used.

3.3 Paper 3: Do XPSs make sense?

Papers 1 and 2 established that XPSs are popular in the industry. Popularity is a good litmus test of utility. However, as the institutional theory suggests, companies might implement XPSs for reasons other than performance improvement (Tolbert and Zucker, 1996; Kostova and Roth, 2002). In the third paper, the first case study concerning the VPS was used to discuss the *strategic rationale* for an XPS. The purpose of this study was to explore the circumstances under which an XPS can provide a competitive advantage. To do so, we used the previously described VRIO model of Barney (2011), which explain how firms grow and sustain competitive advantages.

The results suggested that XPSs indeed make sense. As a minimum, it can provide competitive parity. However—contrary to what the VRIO model suggests—we propose that an XPS can also lead to both temporary and sustainable competitive advantages, even if the content of the XPS is neither rare nor inimitable. We suggest that the value of an XPS is

dependent on the implementation *speed* and its strategic *fit* within the firm’s business strategy. Based on these results, we proposed an updated VRIO model, which, according to Paper 3, is better suited to understand how composite and time-dependent resources such as an XPS can provide competitive advantages (Figure 4).

XPS content: Is the resource...?	Valuable	Rare	Inimitable
XPS process: Do the capabilities provide...?			
Organisational Exploitation Traditional VRIO	Competitive parity	Temporary competitive advantage	Sustained competitive advantage
Superior Speed Better process efficiency and/or effectiveness resulting in higher speed than among competitors	Temporary competitive advantage	Temporary competitive advantage	Sustained competitive advantage
Superior Fit Better fit and interplay with existing resources than among competitors	Sustained competitive advantage	Sustained competitive advantage	Sustained competitive advantage

Figure 4. XPS and competitive advantage: an extended VRIO model (Source: Paper 3).

We summarised the implications of the extended VRIO model in four propositions on how an XPS affects the competitiveness of the firm:

- First, in industries with widespread XPS implementation, an XPS is a necessary resource for achieving competitive parity (P1).
- Second, early-starters get an instant temporary competitive advantage (P2a).
- Third, late-starters can achieve a temporary competitive advantage if they implement an XPS at a faster speed than their competitors (P2b).
- Finally, an XPS can provide a sustainable competitive advantage if it has a superior fit with other path-dependent resources in the organisation (P3).

3.4 Paper 4: Does an XPS improve global quality performance?

The most fundamental question for all companies implementing an XPS, or considering launching one, is ‘Does its implementation positively affect the performance of the plants?’ Although the literature is full of inquiries into the performance effects of implementing different types of production improvement programmes (lean, TQM, six sigma, BPR, etc.),

few have investigated the performance effects of a global XPS approach (see for example the meta-reviews of Sousa and Voss (2002), Nair (2006) and Mackelprang and Nair (2010)). Using data from Volvo, we applied an uncomplicated analysis to a simple question. We chose to focus explicitly on quality performance because quality is believed to be the most fundamental capability to invest in (Crosby, 1979; Ferdows and De Meyer, 1990). Because quality is multidimensional (Garvin, 1984), we distinguished between *product quality* and *process quality* (Taguchi, 1986) and investigated the effect of the VPS on both dimensions.

We found a strong and positive effect of implementing the quality practices prescribed by the VPS and the resulting quality performance. Our results from comparing audit data with survey data showed that the plant's level of VPS implementation explained approximately 20% of the improvement in quality performance. The positive relationships were significant and considered strong. Longitudinal quality performance data from three different plants gave additional support for the hypothesised effects. All three plants had implemented more quality practices and experienced improved quality performance, as measured by developments in real performance metrics, during the years 2007-2012. On average, the three plants improved their VPS built-in-quality score by 11% annually, whereas the first-time-through score improved by 6% and customer complaints decreased by 28% annually. Furthermore, managers from all the plants we visited credited much of the quality improvements to the implementation of the VPS. We concluded that a tailored production improvement programme has clear positive effects on global quality performance.

3.5 Paper 5: In what pattern does an XPS affect performance?

The fifth paper empirically investigated how an XPS affects plant performance while the plant is implementing it. Building on the learning curve theory (Wright, 1936; Yelle, 1979), the theory of performance frontier (Schmenner and Swink, 1998), the notion of organisational inertia (Hannan and Freeman, 1977) and the epidemiology theory of the spread of infectious diseases in bounded environments (Omran, 1971), we hypothesised that the implementation of an XPS affects the plant's performance in an S-shaped pattern.

As previously explained, we triangulated four different tests using four separate data sources. The results from all the tests supported our hypothesis. Thus, when implementing an XPS in a plant, performance first improves slowly in the early stages of implementation, then improves rapidly and eventually returns to a slow rate of improvement (Figure 5).

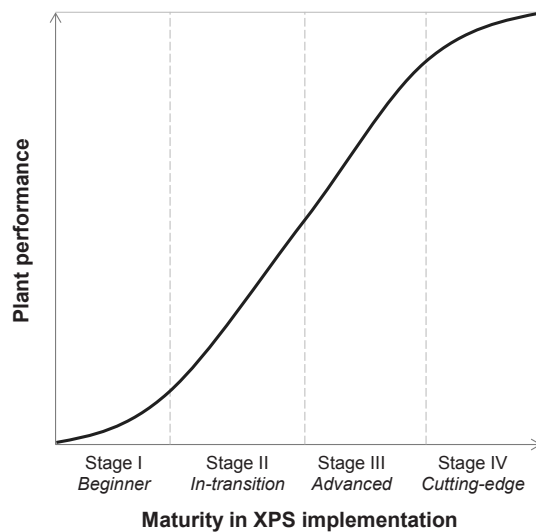


Figure 5. The S-shaped performance effect of XPS implementation (Source: Paper 5).

The theoretical reasoning is as follows: The performance effect is principally explained by the learning curve that suggests learning is more prevalent in the early stages and then decreases as the plant moves closer to the performance frontier (Yelle, 1979; Schmenner and Swink, 1998; Zangwill and Kantor, 1998). In practical terms, there are ‘low hanging fruits’ that can be reaped early on. However, this effect of learning is moderated by the extent to which the XPS has spread in the plant (i.e., the number of areas that are learning). The spread can be explained using an analogy to the epidemiology theory (Omran, 1971)—even if we by no means consider XPS to be a disease (!): In the first stage, only a few areas are ‘infected’ by the XPS because it usually starts in limited pilot areas. Success in these areas infects other susceptible areas. The notion of organisational inertia—the tendency of an organisation to continue on its current trajectory and resist change (Hannan and Freeman, 1977)—explains why some areas are more susceptible (or resistant) to change than others. In the second stage, many susceptible areas catch the infection, making the spread exponential and extensive. In the third stage, whereas still rapid, the growth starts to slow down because there are fewer new areas to infect, and the ones remaining are more resistant to change. In the fourth stage, almost the whole plant is infected and learning decelerates. Together, the effect of learning and the spread of an XPS in a plant constitute a reasonable explanation for the S-curve.

The S-curve theory provides novel insights into the benefits of an XPS. For example, two plants, equally focused on implementing the system, may experience different rates of

improvement if they are at different stages in their implementation journey. Both *beginners* and plants that are *cutting-edge* are likely to experience a slower rate of performance improvement than those that are *in-transition* or *advanced*. The S-curve has important implications for theory and practice, which I will return to in the next section.

4 Discussion

In this section, I discuss the implications of the five papers for research and practice. To recapitulate, Table 1 offers a brief account of the included papers.

Table 1. A brief summary of the five included papers.

#	Title	Research question	Method	Key finding
1	Exploring the phenomenon of company-specific production systems: One-best-way or own-best-way?	What are the characteristics of global companies' XPSs?	Explorative multiple-case study of XPSs in 30 MNCs. Comparing XPS principles.	Different XPSs tend to be similar in content. XPSs are variants of the TPS, tailored to the specific firm.
2	Multi-plant improvement programmes: A literature review and research agenda.	What is the state of the literature on multi-plant improvement programmes?	Systematic review of the literature in 15 top journals from 1998 to 2011.	The discovery of only 30 papers indicates a research gap on multi-plant improvement programmes.
3	Company-specific production systems and competitive advantage: A resource-based view on the Volvo Production System.	Does an XPS contribute to a firm's competitive advantage?	Explorative case study of Volvo Aero Norway. Document studies and 11 interviews in the corporate VPS Academy and in one Volvo plant.	An XPS can provide a competitive advantage, but it depends on the XPS-maturity in the industry, speed of implementation and its strategic fit.
4	Investigating the effects of a corporate improvement programme on global quality performance: The case of the Volvo Production System.	Does the implementation of an XPS improve the quality performance in a network of plants?	Case study of Volvo AB. 305 survey responses, 48 plant audits and KPI data from 3 plant cases.	The implementation of VPS in Volvo has delivered a significantly positive improvement in quality performance across plants.
5	How do company-specific production systems affect plant performance?	In what pattern does the implementation of an XPS affect plant performance?	Case study of Volvo AB. 312 survey responses, 49 plant audits, 40 plant visits and 200 interviews.	As a plant implements an XPS, its performance improves in an S-curve pattern: slow, fast, slow.

4.1 Contribution to research

Table 2 provides an overview of the key contributions from the papers.

Table 2. Summary of key contributions from the five included papers.

Key contribution	Paper	# 1	# 2	# 3	# 4	# 5
1. Codification of the phenomenon ‘company-specific production system’ (XPS)		X	X	X	X	X
2. A list of the most common XPS principles		X				
3. Establishing a positive relationship between implementation of an XPS and plant performance				X	X	X
4. The 4A framework for possible subsidiary responses to a corporate multi-plant improvement programme			X			
5. The updated VRIO model for how an XPS can contribute to sustained competitive advantage: the notions of fit and speed				X		
6. The theory of the S-curve: the effect on performance from implementing an XPS in a plant						X
7. Methodological innovation on conducting empirical research in context-rich environments						X
8. A suggested research agenda for future research on XPS			X			

The first contribution of the thesis is the common thread in all the five papers: describing and explaining the phenomenon of XPS as a distinctive—and potentially successful—strategy for organising production improvement. This contributes to the vast literature on production and process improvement, which Voss (1995) labels the ‘best practice paradigm of operations strategy’. The first two papers revealed the popularity of multi-plant improvement programmes in the industry. Since the 1990s, companies in the automotive and related industries have developed their company-specific variants of the TPS. During the last 10 years, the trend of developing XPSs has spread to all manufacturing industries, and beyond. Moreover, the systems have evolved from plant-specific initiatives to broad corporate systems; the XPS is common for all plants in the company’s global production network.

Second, Paper 1 summarised a list of the most common XPS principles among 30 multinational companies and confirmed that the link with TPS and lean production remains

strong. Hence, the phenomenon of XPSs adds to our knowledge on lean production (e.g. Womack *et al.*, 1990; Holweg, 2007) and adjacent production improvement templates (e.g. Powell, 1995; Pande *et al.*, 2000; Schonberger, 2007).

Third, in Paper 4, a positive effect on quality performance was seen with the implementation of the VPS in Volvo's global network. Papers 3 and 5 gave further support to this positive effect of seriously implementing an XPS. If our conclusions in Volvo relate to other companies' XPSs, then the esteem for these systems in the industry is not strange. The established positive effect of a production improvement programme on performance adds to the concurrent literature (Sousa and Voss, 2002; Nair, 2006; Mackelprang and Nair, 2010). One explanation for why some studies continue to report opposite effects or insignificant results from improvement programmes (Beer and Nohria, 2001; Schonberger, 2007; Pay, 2008; Aiken and Keller, 2009) might be attributable to companies making half-hearted attempts at implementing the programme, which will be further discussed in Section 4.3.

Fourth, in Paper 2, Aspelund and I suggested the 4A framework (see Figure 3) based on theories from international management. This framework explains four different and plausible responses for a subsidiary when the headquarters require conformity to a corporate XPS. Founded in theories regarding multinational corporations (vertical axis) and the institutional theory (horizontal axis), the 4A framework can help us understand the patterns of implementation of an XPS in a multi-plant network.

Fifth, in Paper 3, we proposed an updated VRIO model for analysing competitive advantage of composite and organisational resources such as an XPS. This model contributes to the theories on the resources-based view of the firm (Barney, 1991; Peteraf, 1993; Barney, 2011) by questioning the underlying logic of Barney's model. The proposed new model suggested that a company could gain a sustainable (or temporary) competitive advantage from implementing an XPS, even if an XPS, as a resource, is neither rare (second requirement in Barney's model) nor inimitable (third requirement). If the XPS has a superior fit with the company's strategy, or the firm implements it with superior speed relative to their competitors, the XPS can provide a competitive advantage (see Figure 4).

Sixth, in Paper 5, empirical support was found for the hypothesised S-curved relationship between the implementation of an XPS and plant performance. In brief, the learning curve

and performance frontier theories explain the effects on performance as the plant gains more maturity in implementing an XPS, and the organisational inertia and epidemiology theories explain how the XPS spreads throughout a plant, which moderates the effect of the plant's total learning. The total effect is the S-curve with four suggested maturity stages of implementation. The concept of the S-curve potentially constitutes a theory on its own. As argued in Table 3, it fulfils the five qualifying criteria for a theory in operations management proposed by Schmenner and Swink (1998, p. 100).

Table 3. Does the 'S-curve' qualify as a theory?

Criteria for a theory in operations management (Schmenner and Swink, 1998, p. 100)	The proposed theory of the S-curve (Paper 5)
1. Is the phenomenon for which an explanation is sought clearly defined?	Our case in the paper—the VPS—is clearly defined. Admittedly, however, an XPS may take different forms across companies and lacks a generally accepted definition. Paper 1 helps in this regard and establishes that XPSs tend to be very similar to each other.
2. Is the description of the phenomenon centred on some observed regularities that have been derived either logically or empirically?	The S-curve is an empirically observed phenomenon, backed up with theoretical explanations of why it occurs.
3. Are there one or more precise statements of these regularities (laws)?	The laws of the S-curve are explained by the four underlying theories.
4. Does it indicate a mechanism or tell a story that explains why the laws work as they do and how, and in which ways the laws may be subject to limitations?	The underlying mechanisms of the S-curve are explained by the combined effect of depth of XPS implementation and the spread of implementation in a plant. The mechanisms are presented in the paper.
5. Does it unify various laws and generate predictions or implications that can be tested with data? Can different methods be used to test the theory?	The S-curve can easily be tested using longitudinal data of implementation and performance in empirical cases. It can be tested with different methods (as our four triangulated ways show).

Although generalising from a single case study is challenging, it is reasonable to believe that our findings about the S-curve also apply to other production improvement philosophies. Therefore, this paper contributes to the rich body of process improvement literature in general, including lean production, six sigma and TQM, among others. We suggest that research in these related areas should recognise the *stage* of implementation, because it likely affects the implementation dynamics and resultant performance effects of the programmes.

I suggest that the seventh contribution of the thesis is that our research approach in Paper 5 can serve as an example of how to conduct robust empirical research on context-rich phenomena, such as an XPS. The difficulty of observing and measuring many complex variables is a big challenge in conducting empirical research on the effect of improvement programmes on plant performance. We showed that by gathering data from four different sources, analysing them separately and together and using a regression technique that does not need designation of a fit function (LOESS), one can mitigate this challenge.

Finally, an eighth contribution is the presented overview of the current research and recommendations for further studies—particularly provided by Paper 2. How to improve the performance of a plant remains one of the most fundamental research issues in operations management. How to do it in multiple plants simultaneously is a new problem. The synthesis of the research in the field helps inform researchers about the current research frontier and provides readers with a quick introduction without having to undertake a full review themselves. In the review paper, we suggest a research agenda on multi-plant improvement programmes that can guide future research on XPSs. I expand on that list in Section 4.3.

4.2 Implications for practitioners

For practitioners, the first implication that may be of benefit from this research is the general recommendation of organising production improvement in form of an XPS. The first paper established that many companies do so—and for good reasons. The second paper summarised the literature on the topic and found strong arguments for why multinational companies develop multi-plant improvement programmes. In the third paper, we suggested that an XPS has the ability not only to create competitive parity, but also competitive advantage. The fourth and fifth papers found empirical support that an XPS has a positive impact on plant performance. In conclusion, there is good indication that deploying an XPS can be a potent source for increased competitiveness in many industries.

4.2.1 Why XPS is a recommended improvement strategy

What are the characteristics of an XPS that make it a successful strategy for improving performance? There is an abundance of literature that has established a positive link between various improvement programmes and performance (Kaynak, 2003; Shah and Ward, 2003; Olhager and Prajogo, 2012; Shafer and Moeller, 2012), but there is also a considerable

amount of research that elucidated how companies struggle to sustain the benefits of those programmes over a long period (Bateman, 2005; Schonberger, 2007; Pay, 2008). Can an XPS help sustain the improvement work? In my related normative work (based on the insight acquired in my research), I have suggested that it can—and that it is due to the following three characteristics (Netland and Andersen, 2011; Netland, 2012a; Netland, 2012b):

- An XPS is company-specific, not general.
- An XPS is a strategic programme, not a project.
- An XPS is unifying, not isolating.

In the first place, the ‘X-factor’ of an XPS is the adaptation of the improvement work to the specific conditions and needs of a company. The company strategically chooses the principles that are most relevant to its operations, rather than photocopying the principles from other systems, such as the TPS (Liker, 2004), the five lean principles (Womack and Jones, 1996) and six sigma guidelines (Pande *et al.*, 2000). For example, the process industry companies tended to prioritise *production levelling*, equipment manufacturers tended to prioritise *design-for-manufacturing* and the heavy-vehicle industry tended to prioritise the reduction of *batch size* more than other industries. These are sensible choices for these industries. Moreover, the company often uses its own name and design in its XPS. This serious choice symbolises sincerity and commitment. It presumably increases employees’ ownership of the programme. Off-the-shelf improvement philosophies do not have these advantages.

Second, an XPS is a strategic improvement programme, not a project like many other improvement initiatives. The XPS brings consistency and durability to the improvement work. I explored this dimension in a paper where I investigated how the *programme management literature* can be applied to XPS (Netland, 2012b) (note that the paper is not included as one of the five papers in Part 2 of the thesis). The programme management literature is still in an early phase (Vereecke *et al.*, 2003; Milosevic *et al.*, 2007; Pellegrinelli *et al.*, 2007), and there are few contributions that deal with these types of strategic multi-plant improvement programmes. Thiry (2002) and Pellegrinelli *et al.* (2007) suggested that strategic programmes are proceeding, dynamic, emergent and people-oriented. Strategic programmes are proceeding because they do not have an intended end point or end date: the aim is continuous improvement. They are dynamic in that they should continuously adapt to changes in the environment and in the system they aim to improve. They are emergent in that they are not precisely defined or designed before the implementation process begins. They are people-

oriented because they target deep cultural changes that require all employees to be included in the programme. These characteristics are different from stand-alone and isolated improvement projects, sometimes characterised as managerial fads and fashions (Abrahamson and Fairchild, 1999).

Finally, an XPS is a shared and systematic approach for all plants and employees in a firm. It creates a common improvement language, which leads to easier transfer of experiences, principles and practices between units. This aspect makes the most sense for companies that have several plants because it eliminates the need for each plant to develop and maintain their own improvement programme. International business scholars have argued that leveraging knowledge in the global network is one of the prime reasons for the existence of multinational companies in the first place (Kogut and Zander, 1993; Buckley and Casson, 1998). This advantage of an XPS may be more important for multinational companies with sprawling networks of plants than it is for small- and medium-sized enterprises.

4.2.2 Implications of the S-curve for managing the XPS

The S-curved effect from implementing an XPS has some particular implications for practitioners. Because we thoroughly presented the implications in the paper, I only include a short discussion here.

The literature on critical success factors for production improvement lists sustained top-management commitment as the most important factor for success (e.g. Saraph *et al.*, 1989; Dayton, 2001; Sila and Ebrahimpour, 2003; Trkman, 2010; Brun, 2011). It is, therefore, important for managers in the corporate headquarters and in the plants to be aware of the S-curve—it can help them set appropriate targets, take suitable actions and sustain their commitment over long periods.

Managers must be aware that two plants may experience different rates of improvement if they are at different stages in their implementation of the XPS. They must be patient with the plants that are *beginners* in the implementation because those plants are not likely to show rapid improvement in their performance. An accelerated pace of improvement for plants that are *in-transition* should be expected. At the later stages of a plant's XPS implementation, the managers should reduce their expectations once again because when the plants reach the *advanced* or *cutting-edge* stages, improvement rates decrease again.

Importantly, we suggest that managers should not reduce their attention to the XPS for plants that are cutting-edge even if the effects decelerate. A reduction in commitment can quickly lead to programme termination, and the plant will have to start again at a lower level in the future: if you stop improving, at one point, you will stop being good.

4.3 Problematic issues

The preceding section argued why the XPS is an advisable strategy for firms in all industries. However, problematic issues concerning its application, management and future development still warrant discussion and further research. Based on my three years of inquiry into XPSs—including numerous discussions with practitioners and academics—I find the following 10 problems to be especially interesting:

- 1) When is an XPS needed? (the boundary conditions for an XPS)
- 2) Can an XPS be right for every part of the firm? (the adoption-adaptation balance)
- 3) Do national cultures matter? (the recurring question of the role of national culture)
- 4) What really is the return on investment? (the difficulty of measuring total effects)
- 5) Why are the XPSs of different firms so similar? (the path-dependency from the TPS)
- 6) How can a firm spread the XPS beyond production? (the constraint of the ‘P’ in XPS)
- 7) How can a firm codify the people-side of an XPS? (the seductive tools and techniques)
- 8) Does an XPS impede innovation? (the risk of organisational inertia)
- 9) How can a firm achieve a dynamic XPS? (the improvement of the XPS itself)
- 10) How can a firm sustain interest in its XPS over time? (the risk of concept fatigue)

4.3.1 When is an XPS needed?

The first question in the proposed research agenda in Paper 2 reads: ‘When should firms deploy multi-plant improvement programmes?’ I do not propose that the XPS is a panacea for all companies, always. If it was, it is likely that it would already be a well-codified phenomenon. An XPS is a programme for improving production continuously and systematically over a long time. Therefore, the advantages of having an XPS is likely to increase with increasing stability of both the production network and the environment of a firm (Benner and Tushman, 2003). For example, if the production network of a firm is constantly changing, as in IKEA’s ‘footloose strategy’ (Ferdows, 2008), the XPS would naturally have a more time-limited effect (in fact, the S-curve in Paper 5 would argue against investment in an XPS if the firm shifts plants rapidly). Likewise, in industries characterised

by rapid and disruptive innovations in technology, the relative effects of implementing an XPS can be marginal; hence, other improvement strategies might be superior (e.g. Intel's successful 'copy exactly strategy').

Unfortunately, my data does not allow for analyses into issues like these. Moreover, I have not investigated whether multi-site improvement programmes are, or should be, used in service industries. My thesis focused on manufacturing firms in relatively mature and stable industries (c.f. the 30 companies included in Paper 1). Thus, further research is required to investigate the boundary conditions of XPSs.

4.3.2 Can an XPS be right for every part of a firm?

If it is assumed that an XPS is a suitable strategy for a firm, the next question that naturally follows is 'Can it be right for every part of the firm?' Should a subsidiary plant fully adopt the principles of the XPS, or should it adapt (or even ignore) them? This discussion is well alive in all Volvo plants worldwide: 'Is VPS really applicable to us? Should we implement all of it—everywhere?'

Let us take the extreme example of a highly diversified company, where different plants in the global network produce different products (and services) for different markets using different technologies and skills. In this case, the benefits of a common XPS are likely to be limited. This touches on a logical fallacy of the XPS: if we argue that a firm should adapt generic principles (from lean and TPS) to its unique conditions, then each division of the firm, each plant and each line and cell on the shop floor could use the same logic to argue for its own tailored XPS. In fact, the key argument of the control model methodology developed at SINTEF/NTNU (Strandhagen and Skarlo, 1995; Alfnes and Strandhagen, 2000; Alfnes, 2005) is that companies should use different principles even within the plants: they argue that companies must mix and tailor principles to strategically fit the different parts of a plant.

At which organisational level a firm should define its XPS or XPSs is a trade-off. It depends on the situation, of course, but in most cases, it is likely to be at the corporate level. One reason is that if a firm deploys more than one XPS, it misses other advantages, which were explained previously in Section 4.2.1 (e.g. a common improvement language). Another reason is the added expense, bureaucracy and complexity that result from maintaining several systems. A practical solution to this problem is for plants to choose a pragmatic approach to

the XPS: for example, in Volvo's plant in Durban, South Africa, the general manager explained, 'We will never fully implement all of the modules in the VPS; instead, we identify a few that are good for us.' The pragmatic approach sees an XPS as a useful guideline rather than a silver bullet. Examining the right balance between adoption and adaptation of the XPS within a firm remains a promising area for research.

4.3.3 Do national cultures matter?

Can the same XPS fit all the national cultures of the world? This question has been asked at most conferences where I have presented this research. According to Hofstede and Hofstede (2005), national culture is the 'collective programming of the mind' that makes one nation distinctively different from another. Such national cultures are extremely hard to change because they are deeply ingrained in their societies. A lot of research has been conducted on the impact of national culture on different improvement programmes, but the results are often contradictory to each other or inconclusive (e.g. Newman and Nollen, 1996; Lagrosen, 2003; Kull and Wacker, 2010; Vecchi and Brennan, 2011).

In my experience, the discussion on the role of national cultures remains interesting and prevalent, but it is a digression away from what really matters. Based on my visits to Volvo plants in Norway, Sweden, Belgium, Germany, France, Spain, the USA, Brazil, South Africa, India, China and Japan, I propose that national culture is not a big issue when it comes to implementing the VPS. It matters in some specific areas (e.g. the use of rewards and competitions to motivate improvement suggestions will likely have different effects in different cultures) but not for the bulk of the modules and principles in the VPS. In a bookshop in Bangalore, India, I saw the same books on operations management that we use at NTNU. The manufacturing processes of heavy vehicles are the same all over world. In fact, the only moments where I experienced an obvious difference among the national cultures at the Volvo plants were during lunch...

In a conference paper, Dr Miguel Mediavilla from Bosch Siemens Haushaltsgeräte GmbH and I investigated the role of national culture statistically using data from both the implementations of the VPS and BSH Production System (Netland *et al.*, 2013) (this paper is not included as one of the five in the thesis). We concluded that cultural differences, as operationalised by the Hofstede model (Hofstede, 1980), are insignificant for explaining differences in XPS implementation across countries. Advocates of lean production would

likely support this and argue that this discussion was muted in the 1980s when the TPS was implemented with success in Western automobile plants (Krafcik, 1988; Womack *et al.*, 1990). I would agree that implementing the same XPS with success in all corners of the world is much more of a challenge regarding general leadership than managing cultural traits.

4.3.4 What really is the return on investment of an XPS?

A difficult question repeatedly presented to managers of XPSs concerns its real effect on firm performance. In Papers 4 and 5, I found a positive effect on performance with the VPS, but I did not consider the costs of managing the programme. It is reasonable to assume that the improvements in operational performance, as considerable as the ones shown in the three case plants in Paper 4, easily trump the programme costs. Nevertheless, to quantify the total effects is extremely hard. Corporate finance managers are the first to ask for the value of the programme. Furthermore, it is often not sufficient to show positive returns if the investments could generate larger returns elsewhere (i.e., investing in new technology, product development or business model innovation). In their study of implementing lean in two Lockheed Martin factories, Browning and Heath (2009) actually found negative returns in the early stages of implementation. If managers are aware of the S-curve (Paper 5) and are able to be patient and wait for the returns to begin, such findings are not necessarily jeopardising the commitment to an XPS. However, telling business managers to ‘wait and believe’ is a challenging task.

A practical solution used in the Powertrain division of Volvo has been the cost deployment technique adapted from Fiat’s XPS: the World Class Manufacturing programme. Cost deployment is an accounting method for calculating the potential cost savings of all suggested improvement projects in the plant. However, the method is not without flaws, and its technical complexity makes it hard to disseminate. The difficulty of calculating the real return on the investment of an XPS, or any other production improvement programme, is a persistent issue confronting managers and future researchers.

4.3.5 Why are the XPSs of different firms so similar?

Most XPSs, as previously stated, are close adaptations of the TPS (Feggeler and Neuhaus, 2002; Lee and Jo, 2007) and firms frequently refer to their XPSs as ‘lean programmes’ (Lay and Neuhaus, 2005). I thoroughly discussed the universal versus contingent approaches in Paper 1 and concluded that XPSs tend to be variants of the same system. This similarity is not

a problem if ‘the principles of lean production can be applied equally in every industry across the globe’ (Womack *et al.*, 1990, p. 6). However, if lean is *not* a one-size-fit-all remedy, then what? Obviously, this scenario would result in many firms struggling to fit a wrong-sized lean programme to its non-lean conditions.

How XPSs spread among firms would be an interesting study on its own. Let us consider a brief example: When Jotun now develops its Jotun Operations System (JOS), it adapts heavily from the XPS of a major shareholder: the Orkla Business System (OBS). Orkla, on the other hand, developed the Orkla Production System (OPS) in the early 2000s, and updated it to the OBS when Elkem was acquired in 2005. Elkem had developed the Elkem Business System (EBS) in the late 90s, using input from Alcoa, a prior major shareholder. The Alcoa Business System (ABS), dating back to 1995, was Alcoa’s version of Toyota’s TPS. (Going even further back, Ohno (1988) made it clear that the TPS is a development of Ford’s mass production system.) Companies heavily influence each other, and it happens in a detectable pattern. Nonetheless, there is no guarantee that the influence is optimal for the firms.

The institutional theory provides theoretical explanations for why companies copy each other. Best-performing firms, like Toyota, become celebrated benchmarks, and copying them becomes a source for legitimacy in the market (DiMaggio and Powell, 1983). Learning from the actions of other firms (‘vicarious learning’) is a low-risk, low-investment approach to changing quickly (Terlaak and Gong, 2008). A senior manager in a cutting-edge Japanese Volvo plant admitted that ‘copying best practices from others is the quickest and easiest way to improve performance—visiting other firms and stealing with the eyes’. This makes sense at the level of the firm, but it is not without problems. Over time, this behaviour results in *mimetic isomorphism* (DiMaggio and Powell, 1983), where the firms have copied the exact same practices. However, imitators seldom have full access to the non-codified aspects of their benchmarks, resulting in sub-optimal copies (Ketokivi and Jokinen, 2006; Yu and Zaheer, 2010).

In Paper 1, I cautioned that the observed path-dependency from the TPS might be a limiting factor for many firms. For example, among the 30 XPSs in the sample, only a few suggested the following three principles: use of automation, Enterprise Resource Planning system (ERP) and real-time response. Considering the prominence of these technology-driven improvement principles in modern manufacturing, their scarce visibility is interesting. In their study of the

Hyundai Production System, Lee and Jo (2007) concluded that Hyundai deviated from the TPS exactly in its use of ERP as a planning engine. While visiting Volvo in Japan, I learned in the former Nissan Diesel plants that the ‘synchronised production system’ of Nissan is principally different from Toyota’s card-based supply system (*kanban*): Nissan’s system depends on the use of advanced information technology to achieve just-in-time deliveries. Compared with the TPS, Nissan’s synchronisation system is geared more towards lower-volume, higher-variety and more high-tech manufacturing, which is exactly the characteristics Western economies claim to have and need to build (European Commission, 2010). When firms apply both ERP and lean production (Powell *et al.*, 2013), as all modern multinational companies tend to do, it is likely that they can learn just as much from Hyundai or Nissan as from Toyota. The spread and imitation of XPSs among firms warrants further research.

4.3.6 How can a firm spread the XPS beyond production?

All major textbooks on lean production emphasise the need for a *lean enterprise* (e.g. Womack *et al.*, 1990; Womack and Jones, 1996; Liker, 2004). In Volvo, Ebly Sanchez stresses the need for ‘end-to-end integration’, arguing that it is not possible to achieve a lean transformation without the whole organisation and supply-chain taking part. However, such lean enterprises are rare. The ‘P’ in XPS symbolises the emphasis on production. Authorities like Ohno (1988) and Womack *et al.* (1990) claim that production is what matters; all other functions are supportive functions to production. Unfortunately, the ‘P’ then carries the risk of alienating the people working in marketing, sales, finance, purchasing, logistics and human resources.

To move towards the lean enterprise, Volvo has developed separate VPS models for its product development and business services processes. The VPS pyramid (see Figure 1) and its main principles are the same from all perspectives, but the modules and key elements vary. Still, the implementation of the VPS is most prominent in production (order-to-delivery processes) and lagging in the other support functions. The general manager in an American Volvo plant complained that ‘the corporate purchasing and product development departments are not lean at all, making it impossible for us to succeed with a just-in-time system at the production line.’ How to spread the XPS beyond production remains a headache for many managers, and reduces its effect on actual performance improvement.

4.3.7 How can a firm codify the people-side of an XPS?

Similar to the previous concern about spread; how can a firm move beyond a superficial implementation of tools and techniques to change the organisational culture in a plant? A usual critique to XPSs is that they have attempted to learn from Toyota but missed the most essential part: the human side. Instead of balancing the social and technical aspects (Sugimori *et al.*, 1977; Ohno, 1988), companies get seduced by the practical tools and techniques (Liker, 2004; Liker and Hoseus, 2008; Modig and Åhlström, 2012). My investigation into the 30 XPSs in Paper 1 found similar notions. A reason for this is that the human side is far less codified than the technical side. One risk is that the implementation of the XPS in a plant never develops into more than new and visible technical solutions on the production floor (e.g. 5S, team boards, Kanban and Andon lights) (Baxter and Hirschhauser, 2004). In Paper 2, I termed such superficial implementation of an XPS as *acting*, as in a spectacle. Obviously, a real cultural change cannot happen without changing how people think and behave.

There is a lot we do not know about the underlying managerial processes that lead to successful production improvement (Bititci *et al.*, 2011). The emergence of a special focus on behavioural operations management over the past few years (Loch and Wu, 2007) shows the potential of doing research in this area in the future.

4.3.8 Does an XPS impede innovation?

Another concern is that an XPS, as a uniform way of creating continuous and incremental improvements in all parts of the firm, stifles creativity and out-of-the-box thinking. Proponents of this critique tend to emphasise a strong focus on standardisation in XPSs (note that ‘standardisation’ came out as the most common principle in my analysis of 30 XPSs in Paper 1). A much cited study by Benner and Tushman (2002) concluded that investing in ‘exploitation’ programmes (like an XPS) returns incremental improvements, but on the expenses of ‘exploration’ activities such as technological innovation. However, the implementation of production improvement programmes has shown a strong and significant effect on firm innovation in other studies (Prajogo and Sohal, 2003; Hung *et al.*, 2011). Toyota provides a good example: the recognised Bloomberg Business Week annual ranking of the world’s most innovative firms ranked Toyota 12th in 2012 (BCG, 2012).

Whether an XPS increases organisational inertia or not is a timely question. My position is that an XPS, per se, does not impede innovation. Its primary objective is relentless

incremental improvement over long periods (based on the continuous perfection of standards). However, it can presumably also be a catalyst for radical innovation as the firm moves towards a learning organisation, where all employees contribute with their creativity and intellect. Firms that regularly and systematically handle improvement suggestions are likely to be more effective in managing the radical suggestions as well. Importantly, an XPS is not designed to drive radical innovation; for that purpose, a firm must also invest in exploration programmes (i.e., technology trend monitoring, external knowledge alliances and research and development activities). To achieve a good balance between incremental and radical improvement (i.e., becoming ‘ambidextrous’) (Benner and Tushman, 2003), firms must balance their investments in several programmes. Admittedly, my research contributes only to the literature on exploitation.

4.3.9 How can a firm achieve a dynamic XPS?

Related to the discussion on innovation, how can a firm achieve a dynamic XPS, which is always up-to-date with the latest developments in the market, technology and resource-base of the firm? When establishing an XPS, the firm essentially creates a bureaucracy to enable systematic production improvement. The idea is that a bureaucratic approach will outperform other ways to organise improvement (Weber, 1947). Fundamentally, building a bureaucracy to ‘reduce waste’ in an organisation is a paradoxical strategy. Furthermore, bureaucracies have been criticised for being slow and inflexible (Crozier, 1964). The XPS of course requires improvement itself as conditions change. These processes tie up additional resources and time, but failure to do so quickly cause the system to become out of date.

Since the launch of the VPS in Volvo in 2007, the model, and especially the assessment method, has been updated incrementally approximately every other year. Of course, Volvo has discovered what seems to work and what does not, and has taken appropriate action. However, the frequent updates of the assessment method also result in considerable frustration in plants that are preparing for the assessments. One American plant manager expressed this sentiment, ‘People went nuts around here; they changed the assessment guidelines a few days before the audit’. Managing the development and maintenance of XPSs are important tasks, but they were not investigated in this thesis. I encourage investigations in this area in the future.

4.3.10 How can a firm sustain interest in its XPS over time?

When Volvo launched the VPS, the chief executive officer (CEO) at the time, Leif Johansson, convincingly announced, ‘The work with VPS is never finished. This is not a new campaign that will lose focus after a while; it is a way of thinking—a programme that will continue at all times’ (Volvo Group, 2009, Annual Report, p. 23). The present CEO, Olof Persson, also emphasises the strategic importance of the VPS, but will the same commitment continue under the second, third and fourth successors of Johansson? The literature has suggested that sustainability is the difficult part of production improvement (Bateman, 2005; Schonberger, 2007) and that programmes like these are ‘fads and fashions’ (Abrahamson, 1991) and the results of ‘the tyranny of trends’ (Rolfson, 2000). There is an evident risk of concept fatigue. New managers have a legit need to establish territory, and one effective way to do so is to discontinue previous improvement programmes.

However, due to the reasons suggested in Section 4.2.1, I will argue that an XPS has several advantages over other production improvement templates, such as BPR (arguably expired as a term), TQM (expiring), world class manufacturing (scattered use), six sigma (trending) and lean production (trending). It becomes a career boost for managers to succeed in implementing the XPS. Over time, more and more corporate managers are XPS advocates, strengthening the position of the XPS. An implemented XPS is like a mushroom with a myriad of roots in all plants; if it dies in one plant, it is alive in others and might eventually pop up again in the original plant. However, after a while, the XPS will inevitably become an old concept and lose the attraction that it had while it was new. The future will tell if companies, also other than Toyota, are able to sustain their XPSs for decades.

5 Conclusions

How can manufacturing companies simultaneously improve the production of all their plants? In this doctoral thesis, I have thoroughly investigated the phenomenon of multi-plant improvement programmes, or, more specifically, company-specific production systems (XPSs). To develop and deploy such systems seems to be an ongoing trend in manufacturing industries, and has started to spread beyond manufacturing to engineering, services and administration industries, as well. Huge amounts of resources go into developing and managing such programmes all over the world, yet it appears to be a poorly codified phenomenon in the literature. This thesis contributes in this regard.

An XPS is a strategic production improvement programme tailored to the specific company. It is *not* a general production philosophy in the manner that TQM, TPM, six sigma or lean production are. Rather, it is a firm's collocation of carefully selected principles from each of the established philosophies and other production concepts. Because firms tailor the composition of principles to fit their different needs and strategies, XPSs are not identical. It is clear, however, that the success of the Toyota Production System (TPS) has been the greatest motivational force for developing such systems. An XPS is not a temporary project but a permanent programme for building and sustaining a culture of continuous improvement in all the firm's divisions and plants.

Assessing the effects of the Volvo Production System (VPS) on plant performance in Volvo's global production network was a particular focus in the thesis. The empirical analyses show a significant and strong relationship between implementation of the VPS and plant performance. I found additional support for the positive effects of the VPS in my visits to 40 Volvo plants all over the world and in the interviews with roughly 200 Volvo employees. Interestingly, my analysis suggests that the plants improve in an S-curved pattern when implementing the VPS. It takes some time before the implementation starts to show results, but then the plant improves rapidly before it improves slowly again at the later stages of implementation. There are many reasons to believe that the S-curve also relates to other XPSs. The proposed 'theory of the S-curve' (explained by four established theories) is a novel contribution to the literature. It also has important implications for how managers should implement production improvement programmes in their plants.

Despite the evidence that an XPS has good potential to improve productivity, developing one should not be a hasty decision. It requires a long-term commitment and considerable investments in resources and capital. Therefore, having knowledge about the S-curve and the pros and cons of the phenomenon is likely to improve the chances of success radically. Due to its high practical interest and value—and many questions that remain unanswered scientifically—this field should be very attractive for future research.

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Part II – The papers

**Paper 1: Exploring the phenomenon of company-specific
Production Systems: One-best-way or own-best-way?**

Paper 1

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

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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 its 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 *jidoka 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.

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Paper 2: Multi-plant improvement programmes: A literature review and research agenda

Paper 2

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Multi-plant improvement programmes: A literature review and research agenda

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Abstract

Purpose: To advance the productivity of all plants in the network, multinational corporations develop and deploy multi-plant improvement programmes. In this paper, we systematically review and synthesise the emerging literature on multi-plant improvement programmes.

Methodology: Through a systematic manual search, we examine fifteen top journals from operations management, general management and international business literature in the time span between 1998 and 2011.

Findings: We found 30 papers that specifically deal with operational improvement programmes in a multi-plant international setting, of which only nine take a headquarter perspective. This low number contrasts sharply with the magnitude and importance of such programmes in industry. We discuss key dimensions that explain how multi-plant improvement programmes result in the *adopting*, *adapting*, *acting* or *avoiding* of programme practices in subsidiaries and propose a related research agenda.

Research implications: We affirm that a new field is in the making, with *IJOPM* as the leading professional journal. Further empirical research is called for, but particular methodological caution must be paid to the phenomenon of acting in subsidiaries.

Originality: No coherent stream of research has addressed multi-plant improvement programmes. This paper represents a focused review that supports the field's development.

Keywords: improvement program; production system; process improvement; global operations management; knowledge transfer; literature review

1 Introduction

Many multinational corporations (MNCs) have strategically used the steeply increasing globalisation of the past two decades to grow internationally through acquisitions, mergers and green field establishments in foreign markets. As economic conditions tighten and competition gets tougher, many MNCs find themselves struggling with a dispersed, heterogeneous and low-performing network of plants. Experiencing a legitimate need for continuous process improvement in all plants in the network, corporations seek to improve operational capabilities and, hence, increase the competitiveness of the MNC as a whole. With the knowledge that the ability to learn within international networks offers a potent source of competitive advantage (Shi and Gregory, 1998), the latest trend for process improvement sees MNCs going from plant-specific improvement projects to *multi-plant improvement programmes* (Netland, 2013).

Despite the magnitude and popularity in industry, however, there is yet no established stream of literature for such programmes. A review by Prasad and Babbar (2000) of the international operations literature up to 1998 affirmed a need for more research that investigates (1) international operations in general, (2) practices in international operations and (3) the effects of specific global strategic initiatives. The field of multi-plant improvement programmes, which we review in this paper, spans all three of these issues. Other authors have also found a limited body of research on intra-firm knowledge and practice transfers (Anakwe *et al.*, 2000; Gupta and Govindarajan, 2000; Maritan and Brush, 2003; Ansari *et al.*, 2010), which remain central to the implementation of multi-plant improvement programmes.

This study contributes to research and practice by offering the first full review of the recent literature on multi-plant improvement programmes. We cover the literature over the last fourteen years from fifteen top journals in three research streams: operations management, international business and general management. We aim to

1. review the research in the field according to its methodologies, themes and key conclusions;
2. summarise the body of research into key dimensions that explain how multi-plant improvement programmes play out in subsidiaries; and
3. suggest a research agenda for multi-plant improvement programmes based on the current research frontier.

In the section that follows, we define the scope of this review. In Section 3, we shape the discussion on improvement programmes in intra-firm manufacturing networks by presenting a framework drawn from seminal contributions in the broader field of international practice transfer. The proposed theoretical framework later guides the presentation and analysis of the relevant work that has been published in the selected journals. In Section 4, we outline the research method applied. Section 5 summarises the included papers. In Section 6, we derive a suggested research agenda for further research. We conclude and address implications for practice and limitations of the study in Section 7.

2 Theoretical Background and Definition of Scope

We are investigating the union of multi-plant coordination literature and process improvement literature. In order to define our scope, these two topics are now introduced.

2.1 Multi-plant coordination

Research on international business distinguishes between *configuration* and *coordination* (Porter, 1986). Configuration is about the global set-up of the corporation; with what resources to innovate, source, produce and sell what for which markets where and when. Coordination is about the management of the network; how to most effectively and efficiently share resources and knowledge between the dispersed plants. Seminal research in the field of international business even suggests that the ability to share knowledge in the intra-firm network efficiently is the prime reason for the existence of MNCs in the first place (Kogut and Zander, 1993; Buckley and Casson, 1998).

With more units to manage and more complexity to handle, a tempting strategy for MNCs has been to rely more on standardised best practices when deciding how to operate production (Jensen and Szulanski, 2004). Consequently, they seek to continuously develop and share best practices in the intra-firm network (Kostova, 1999). For this purpose, many manufacturing MNCs are developing firm-wide process improvement programmes (Netland, 2013). This paper deals with this specific type of multi-plant coordination.

2.2 Process improvement programmes

As for the content of the practice programmes, MNCs turn to proven production philosophies including, for example, total quality management (TQM) (Deming, 1986), the Toyota Production System (TPS) (Ohno, 1988), just-in-time production (JIT) (Monden, 2010), lean thinking (Womack and Jones, 1996), continuous improvement (CI) (Zangwill and Kantor, 1998), time-based manufacturing practices (Koufteros *et al.*, 1998), six sigma (Schroeder *et al.*, 2008), business process reengineering (BPR) (Hammer and Champy, 1995) and world class manufacturing (WCM) (Schonberger, 1986).

In the big picture, programmes that are based on one or a combination of these philosophies retain the same purpose under different names: They focus on making the most out of the *existing* resources and capabilities of a plant (Repenning and Sterman, 2002), and share a common goal of improving the productivity of manufacturing operations through improving the processes. Holweg (2007) establishes the close relationship between TPS, JIT and lean; Andersson *et al.* (2006) find that TQM, lean and six sigma share origin, methodologies, tools and effects; Koufteros *et al.* (1998) argue that time-based practices follow from TPS and JIT; and Schonberger (2007) describes how TQM, TPS, JIT, lean, CI, BPR and WCM are all evolutionary offspring of Japanese production management rooted in process improvement.

As collective terms, programmes like these have been called *meta-routines* (Feldman and Pentland, 2003) and *strategic organisational practices* (Kostova, 1999). They are vehicles for how organisations update what they do. Therefore, at the general level, the core challenge is to update and share *procedural knowledge* or *know-how* in the network of plants—most often standardised in what has been called *best practices* (Voss, 1995).

2.3 Defining multi-plant improvement programmes

Drawn from the literature above, we define a multi-plant improvement programme as *the systematic process of creating, formalising and diffusing better operational practices in the intra-firm production network with the aim of increasing competitiveness*. In other words, this describes an MNC's effort to implement and share a process improvement programme in more than one plant simultaneously.

3 Conceptual Background

The multi-disciplinary nature of the topic becomes apparent when reviewing influential theoretical studies in the broader field of knowledge and practice transfer in MNCs. This literature unveils two explanatory axes for how *wide* and *deep* multi-plant improvement programmes play out in subsidiaries—one stems primarily from international business and the other primarily from organisation science:

- First, when designing and implementing multi-plant improvement programmes, corporations must manage trade-offs between *global conformity and local contingencies* carefully. This refers to the *width* of practice transfer.
- Second, corporations face challenges they must manage between *superficial and profound implementation* in subsidiaries. This refers to the *depth* of practice transfer.

3.1 Global conformity versus local contingencies

Top management of MNCs establishes incentive schemes that motivate subordinates to work according to group-optimising behaviour (Agrell *et al.*, 2002); however, intra-firm practice diffusion presents challenges and often fails (Kostova, 1999; Prasad *et al.*, 2001; Ferdows, 2006). MNCs are heterogeneous because subsidiaries have developed under different historical conditions and are embedded in different national environments (Ghoshal and Nohira, 1989). Because the pressure for globalisation and the pressure for local responsiveness represent two competing forces (Miltenburg, 2009), we can expect a differentiated implementation of even standardised practices (Jensen and Szulanski, 2004). This variation can be presented on a continuum from *adoption* to *adaptation*, which corresponds to the two ideal types of strategies for transplantation of work practices identified by Mefford and Bruun (1998)—respectively, the minimal-modification model and the culture-adaptive model—and to the replication and adaptation perspectives of Winter *et al.* (2011). The extreme case of adoption is full acceptance of the practice in all its aspects. The extreme case of adaptation is full rejection.

Researchers have often used *contingency theory* to investigate the adaptation processes (Ghoshal and Nohira, 1989; Sousa and Voss, 2001). Ansari *et al.* (2010) define *adaptation* as ‘the process by which an adopter strikes to create a better fit between an external practice and the adopter’s particular needs to increase its zone of acceptance during implementation’ (p. 71), whereas they define *fit* as ‘the degree to which the characteristics of a practice are

consistent with the (perceived) needs, objectives, and structure of an adopting organisation' (p. 68). Successful knowledge transfer requires some degree of adaptation (Prahalad and Doz, 1987; Bartlett and Ghoshal, 1998) and the degree of adaptation depends on the strength and mix of contingencies. A core idea of institutional theory, *isomorphism*, suggests that units that share the same environment will also share the same practices (Kostova and Roth, 2002). A low degree of adaptation will most likely occur if the practices sought transferred are isomorphic; it thus resembles existing practices in place (DiMaggio and Powell, 1983).

Paradoxically, the required adaptation of practices significantly increases the stickiness of cross-border knowledge transfer and, hence, makes the transfer process more difficult (Jensen and Szulanski, 2004). Two generic practice-sharing mechanisms exist: sharing codified manuals for explicit practices and sharing people for tacit practices. Either way, formalisation of practices is needed to render possible their easier diffusion (Kostova, 1999). This formalisation, or *standardisation*, on a group level contradicts a high degree of local adaptation. Zaheer (1995) finds that companies must adapt with care because the local environment might present difficulties when interpreting information. Thus, she argues, following the original template might prove a more risk-free way to proceed than to embark on full adaptation to the local environment from the outset—a standpoint empirically supported by Winter *et al.* (2011). This debate on the balance between global integration and local adaptation rests at the heart of any multi-plant improvement programme.

3.2 Superficial versus profound implementation

Theory gives both economic and social explanations for the diffusion of improvement programmes. Economic models of practice diffusion tend to argue for the value of the practice as its reason for diffusion, whereas social models in general argue for the reputational reasons for practice adaptation (Ketokivi and Schroeder, 2004; Terlaak and Gong, 2008; Ansari *et al.*, 2010). Tolbert and Zucker (1983) suggest that early-movers follow economic rationales seeking value, whereas late-movers generally follow social arguments seeking legitimacy.

The successful transfer of a strategic practice goes beyond the mere transfer of a written rule to include the underlying values and beliefs of the specific practice (Ferdows, 2006). Such normative integration of common goals and values represents the single most important activity for successful implementation of improvement programmes in multinational

enterprises (Ghoshal and Bartlett, 1988). Kostova (1999) argues that companies can measure the success of a practice transfer by its degree of *institutionalisation* at the recipient unit, where ‘To institutionalise is to infuse with value beyond the technical requirements of the task at hand’ (Selznick, 1957, p. 17). Institutionalised practices are profoundly implemented.

However, some critics of improvement programmes point to a superficial, insubstantial and fake adoption of practices that often takes place (Oliver, 1991; Baxter and Hirschhauser, 2004), and others refer to them as ‘fads and fashions’ (Dale *et al.*, 2001; Abrahamson and Eisenman, 2008). Practices regarded as superior by the parent company are not always easily institutionalised in subsidiaries due to *institutional duality* (Kostova and Roth, 2002), which means that subsidiaries have to cope with partly competing institutional pressures from both the mother company and the local culture and environment. Even if the corporation regards a particular practice as technically superior and therefore wants to diffuse it to its subsidiaries worldwide, it does not follow that the practice will prove efficient in all locations. To comply with the institutional pressure of implementation from the mother, subsidiaries might engage in a symbolic or *ceremonial adoption* of the practice that disguises nonconformity (Oliver, 1991). Kostova and Roth (2002, p. 220) describe such ceremonial adoption as ‘the formal adoption of a practice on the part of a recipient unit’s employees for legitimacy reasons, without their believing in its real value for the organisation’.

3.3 Theoretical framework

Multi-plant improvement programmes are by logic designed to seek institutionalised adoption of the same operational practices in all subsidiaries. They seek a certain amount of global standardisation, but they must not standardise to such a degree that they nullify location advantages. To achieve this, the corporation must carefully manage any legitimacy-seeking pitfall that leads to shallow implementation of practices and the trade-off between adoption and adaptation. Figure 1 summarises how subsidiaries can respond to multi-plant improvement programmes. This theoretical framework sums all the work discussed above but has particular similarities with the ‘dimensions of practice variability and adaptation’ of Ansari *et al.* (2010, p. 72) and the ‘strategic responses to institutional processes’ of Oliver (1991, p. 152). Our model differs, however, from Ansari *et al.*’s model with the added perspectives that follow from avoidance and acting in subsidiaries—aspects well described by Oliver as escaping and concealing.

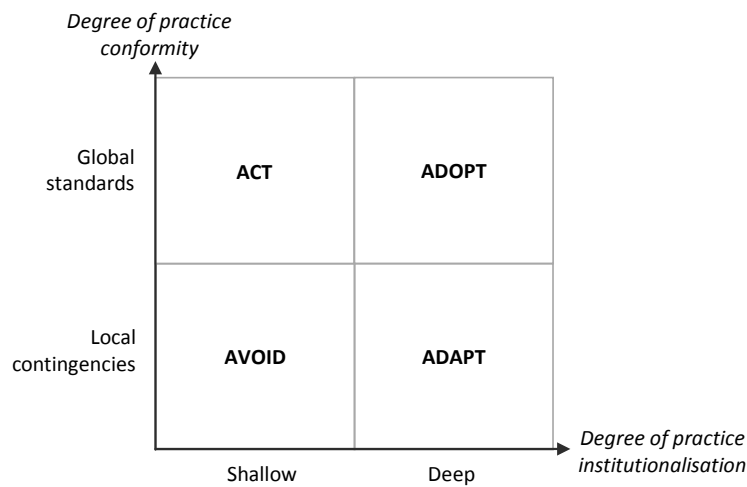


Figure 1. The 4A framework for subsidiary response to a multi-plant improvement programme.

The two axes in Figure 1 leave four quadrants as typologies for ways subsidiaries might respond to multi-plant improvement programmes, subsets of the programme or even specific practices in the programme. Because multinational companies operate under multiple and often conflicting institutional pressures (Oliver, 1991; Fenton-O’Creevy et al., 2008), subsidiaries can arguably fall into any of the four quadrants.

- The upper right quadrant, ‘Adopt’, represents the theoretical ideal of an improvement programme. Adoption means that the subsidiary embraces and implements the transferred improvement practice in full. This is not to say that it is the desired outcome for all practices in all subsidiaries, however.
- The lower right quadrant, ‘Adapt’, means that the practice—while profoundly implemented—has been adjusted to better fit the local contingencies. This also increases the stickiness of the practice and thus complicates the management of multi-plant improvement programmes.
- The upper left quadrant, ‘Act’, describes how subsidiaries engage in pretending behaviour to comply with institutional pressures to implement the improvement programme. From the perspective of multi-plant improvement programmes, such ceremonial adoption must be regarded as undesirable because it does not realise the sought-after operational improvement.
- The lower left quadrant, ‘Avoid’, describes how subsidiaries seek to sidestep the corporate improvement programme or sub-practice altogether and continue with the

practices and routines they already have in place. If the subsidiary has not achieved world-class status, this ‘business-as-usual’ behaviour fails to increase competitiveness, and we consider it undesirable.

We will return to the framework in Section 6, where we discuss the papers reviewed.

4 Research Method

A research synthesis summarises and cumulates the findings of different studies on a topic (Tranfield *et al.*, 2003). To synthesise the state of the art on multi-plant improvement programmes, we undertook a systematic literature review. Starting where Prasad and Babbar (2000) ended their 1986–1997 review on international operations management, this review spans the fourteen years from 1998 to 2011.

4.1 Academic journals included

We cover fifteen top journals from three areas: (1) operations management, (2) international business and (3) general management. Acknowledged journal rankings (Soteriou *et al.*, 1999; DuBois and Reeb, 2000; Mingers and Harzing, 2007; Segalla, 2008) were used to decide which journals to include. Table 1 presents the fifteen journals we examined.

Table 1. The fifteen included journals in the 1998–2010 review (ranked according to sources).

Area (Source)	Abbrev.	Journal title
Operations management (Soteriou <i>et al.</i> , 1999)	JOM	Journal of Operations Management
	IJOPM	International Journal of Operations and Production Management
	POM	Production and Operations Management
	IJPR	International Journal of Production Research
	IJPE	International Journal of Production Economics
International business (DuBois and Reeb, 2000)	JIBS	Journal of International Business Studies
	MIR	Management International Review
	JWB	Journal of World Business
	IMR	International Marketing Review
	IBR	International Business Review
General business (Mingers and Harzing, 2007; Segalla, 2008) ¹	AMJ	Academy of Management Journal
	AMR	Academy of Management Review
	ASQ	Administrative Science Quarterly
	SMJ	Strategic Management Journal
	MS	Management Science

¹ Segalla (2008, p. 127) points to the five top general management journals as AMR, AMJ, ASQ, Organization Science (OS) and SMJ, based on the University of Texas at Dallas Database. We have included Management Science (MS) instead of OS because MS ranks well above OS in Mingers and Harzing’s (2007) ranking.

4.2 Inclusion and exclusion criteria

The unit of analysis is the multi-plant improvement programme in an MNC. To be included, a paper simultaneously had to match (1) the improvement programme criteria and (2) the MNC multi-plant criteria, with the following clarifications:

First, for the purposes of this review, we operationalise an ‘improvement programme’ as a *systematic improvement initiative in the production area that spans more than a single improvement practice and targets several competitive priorities (safety, cost, quality, delivery, flexibility, people and environment)*. The papers must study the multi-plant implementation of practice programmes such as those mentioned in Section 2.2 or the intra-firm transfer of procedural operational knowledge between plants. In line with this definition, the literature review omits papers focusing on single practice programmes (e.g., statistical process control, single minute exchange of die, 5S, etc.). In addition, topics such as multi-plant configuration and planning and control were not included. Similarly, we excluded the many articles dealing with ISO programmes and certification because ISO represents a meta-company standardisation that firms can only influence in a limited manner (the argument to exclude ISO programmes is similar to Power et al., 2010, who argues that ISO is a structural issue). We also excluded papers dealing with practice programmes within human resource management (HRM) because of their broader focus on union issues, leadership, wage agreements, etc., and given their indirect tie to manufacturing operations only. For the same reason, we excluded papers studying environmental impact programmes.

Second, with the criterion ‘MNC multi-plant’, we limit the selection to articles that we understand as *dealing either with a corporation’s global, multinational or international manufacturing operations, or the operations of subsidiaries where the link to foreign mother or sister companies is explicitly stated and part of the research*. The implementation of multi-plant improvement programmes presents greater challenges for MNCs because they also need to overcome multiple barriers related to differences in language, culture, business practices and legislation. Following the definitions, the literature review omits practice programmes in multi-firm supply chains, joint ventures and inter-firm networks. Finally, because we focus on manufacturing MNCs, papers concerning service industries, governmental organisations, not-for-profit organisations and small- and medium-sized enterprises, were all excluded.

4.3 Literature search

Several attempts to perform key word searches on the topic failed because of the extremely broad variety of terms used to describe research on improvement programmes (e.g. best practice, knowledge, know-how, routines and different practice programme names such as those mentioned in Section 2.2) and the same held true for multinational enterprises (international, multinational, global, multi-plant or not explicitly stated). Instead, we found it necessary to undertake a structured and manual search of articles in the fifteen selected journals. This involved reading and considering a total of approximately 20,500 titles as well as the corresponding abstracts, when necessary, for inclusion in the review. Thus, the paper selection method resembles that used by Prasad and colleagues (Prasad and Babbar, 2000; Prasad *et al.*, 2000; Prasad *et al.*, 2001).

To ensure conformity and validity in the search process, we employed a two-step funnel strategy: First, the first author systematically scanned issue by issue in journal by journal with the sole task of keeping all articles that could *potentially* be included. The time-consuming search process resulted in a first sample of 531 potentially related papers. A literature review database was established and continuously updated. Second, we considered this first sample in light of the inclusion criteria explained in Section 4.2. This resulted in 80 articles subject to full reading. We made several iterations of consideration and discussion, which finally resulted in 30 papers that complied with our strict inclusion criteria.

5 Presentation of Findings

The review found 30 papers that explicitly address multi-plant improvement programmes in MNCs. The papers are summarised in Appendix 1, which provides a short description of all the included papers in terms of publication channel and year, type of improvement programmes studied, methodological approach and research focus, and main finding.

5.1 Publication year and channels

Figure 2 shows a fairly stable rate of publication over the years.² The majority of articles (21) appeared in operations management journals. This journal, the *International Journal of Production and Operations Management (IJOPM)* is a dominant vehicle and included one

² We controlled for the effect of special issues and found that only five of the papers appeared in special issues and only two belonged to the same special issue (*IJOPM*, 1999, Vol. 19, Iss. 11).

third of the articles (12). Contributions also stem from general management (6) and international business (3) journals, adding important perspectives to operations management research (and vice versa). Of the fifteen investigated, the final sample includes ten journals, which points to a scattered academic interest that spans several disciplines and academic societies. This comes as no surprise considering the complex and multifaceted environment in which multi-plant improvement programmes play out.

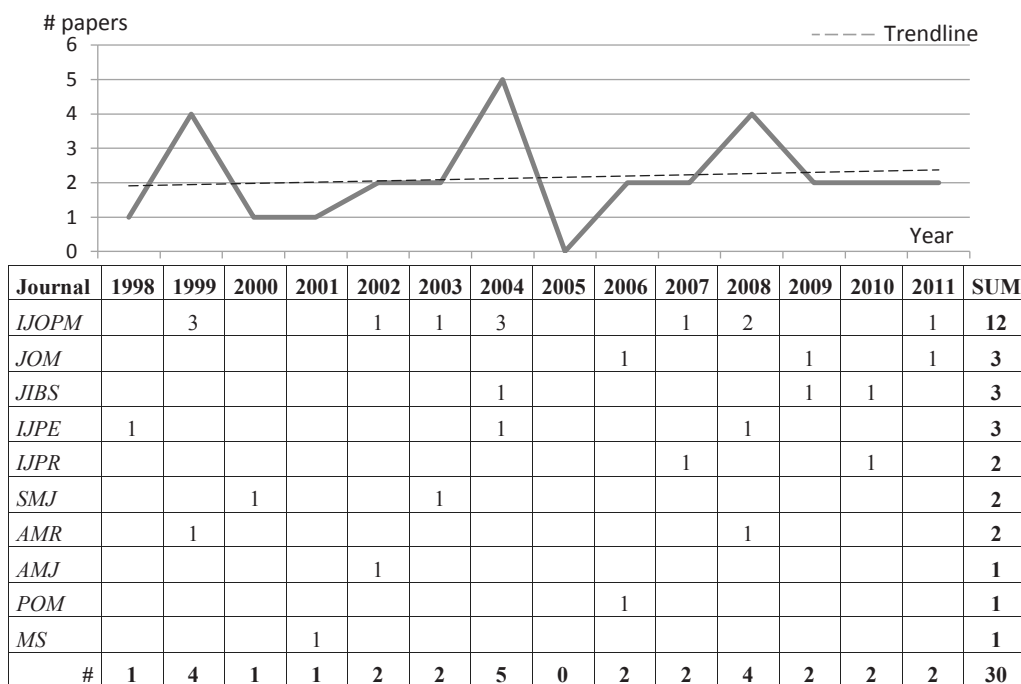


Figure 2. Number of included papers per year and journal.

5.2 Methodological approaches

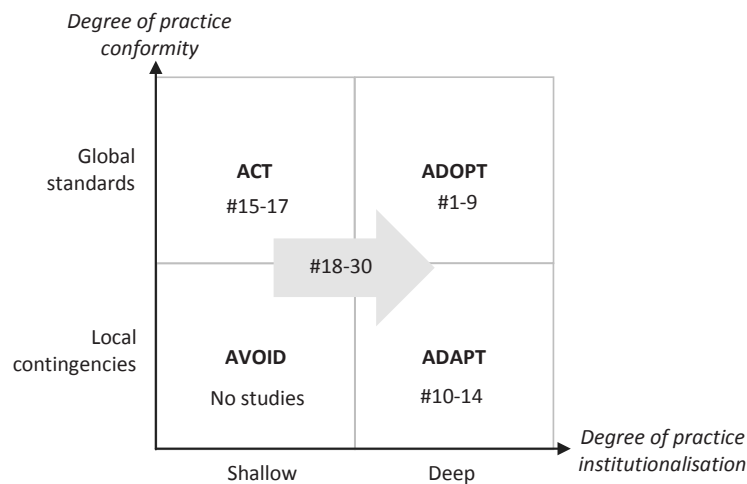
Most of the research takes a qualitative approach, but quantitative and conceptual studies are also represented. Single-case studies dominate the sample. This could be expected as a result of the multi-plant inclusion criteria. Most likely, the complexity of the topic makes it hard to model and test relationships through survey data, so researchers prefer in-depth studies of one or a few entities. Moreover, in general, emerging fields of research are predominantly conceptual and qualitative as researchers in this phase try to establish a common vocabulary, define concepts and explore the phenomenon for causal relationships. Table 2 shows the distribution of methodologies applied in the papers.

Table 2. Research methods among the included 30 papers.

Qualitative			Mixed methods	Quantitative surveys	Conceptual / Theoretical
Single-case	Multiple-cases	Action Research			
11	4	2	4	5	4

5.3 Key empirical findings and propositions

It makes sense to categorise the papers according to their main contribution to the proposed 4A framework in Figure 1. One group of papers is mainly concerned with the multi-plant improvement programme from an MNC-perspective, generally exploring the possibility for adoption across plants. The second and the third groups take an explicitly subsidiary perspective and focus on adaptation and acting respectively. The fourth group of papers focuses mainly on the practice transfer and implementation perspective that takes subsidiaries toward the two right A-quadrants. We found no papers studying avoidance in subsidiaries per se. Figure 3 categorises the papers accordingly.



MNC perspective	Subsidiary perspective	Transfer perspective
¹ Bessant & Francis (1999) ² Colotla <i>et al.</i> (2003) ³ Delbridge & Barton (2002) ⁴ Ferdows & Thurnheer (2011) ⁵ Freknel (2008) ⁶ Goel & Chen (2008) ⁷ Lee & Jo (2007) ⁸ Maritan & Brush (2003) ⁹ Mefford & Bruun (1998)	<i>Adaptation</i> ¹⁰ Aoki (2008) ¹¹ Browning & Heath (2009) ¹² Nair <i>et al.</i> (2011) ¹³ Wallace (2004) ¹⁴ Yu & Zaheer (2010)	¹⁸ Bond (1999) ¹⁹ Bruun & Mefford (2004) ²⁰ Collins & Schmenner (2007) ²¹ Ferdows (2006) ²² Gupta & Govindarajan (2000) ²³ Henriksen & Rolstadås (2010) ²⁴ Jensen & Szulanski (2004) ²⁵ Kerrin (1999) ²⁶ Kostova (1999) ²⁷ Lapré & Wassenhove (2001) ²⁸ McAdam & Lafferty (2004) ²⁹ Noorderhaven & Harzing (2009) ³⁰ Witcher <i>et al.</i> (2008)
	<i>Acting</i> ¹⁵ Baxter & Hirschhauser (2004) ¹⁶ Jun <i>et al.</i> (2006) ¹⁷ Kostova & Roth (2002)	

Figure 3. Categorisation of the papers in the 4A framework.

We now discuss the papers in accordance with the suggested classification:

1. Building global capabilities with multi-plant improvement programmes
2. Adaptation of practices to local contingencies
3. The phenomenon of acting in subsidiaries
4. How to succeed with practice transfer and institutionalisation

5.3.1 Building global capabilities with multi-plant improvement programmes

This category of studies deals with strategic use of globally standardised multi-plant improvement programmes with the intention of building global strategic capabilities through profound implementation. Goel and Chen (2008) discuss how General Electric Wind Energy aimed to move away from ‘operating functionally as a holding company for multiple and autonomous units’ to a globally integrated MNC. Similarly, Lee and Jo (2007) describe how Hyundai Motor Company have adopted and adapted the TPS into their own Hyundai Production System with the purpose of improving Hyundai’s global competitiveness. Other studies show how improvement programmes can add to plant level competitiveness. For example, Colotla *et al.* (2003) find that multinational companies can develop specific capabilities on the network level that add to the factory-level capabilities.

Referring to the same motivation, Maritan and Brush (2003) show that this is a challenging task. They study the multi-plant implementation of flow manufacturing in a US MNC and find that subsidiaries may have different strategic priorities at different times and thus different aims with the shared programme. Their key finding is that heterogeneity in history, culture, managerial beliefs, physical attributes, current performance, strategic priorities and the transfer process itself strongly influence the implementation route and results of the improvement programme in the different subsidiaries, and hence provide challenges for a firm-wide lean programme. Likewise, Delbridge and Barton (2002) found little evidence of substantial learning among sister plants. Bessant and Francis (1999) found that a majority of UK manufacturers pursue CI, but most of them still operate on a suboptimal level where the continuous improvement programme has not developed into a strategic competitive advantage given by a learning organisation. The study by Mefford and Bruun (1998) describes the general intention among global improvement programmes and shows several obstacles to make this transition a reality. Freknel (2008) warns that global managers should not make the ‘colonisation mistake’ of pushing their domestic management practices and thereby not taking advantage of local cultural knowledge in the network.

Escaping this pitfall, Ferdows and Thurnheer (2011) suggest a slightly different approach to multi-plant improvement programmes. Using a longitudinal case study of Hydro Aluminium's worldwide network of extrusion plants, they argue that a cumulative capability building approach is a better choice than a typical lean production programme; where lean programmes focus on 'reducing fat', the proposed *factory fitness programme* focuses on 'building core muscles'. The approach successfully used by the case company was to relentlessly balance subsidiaries' KPI reporting for the strategic capabilities safety, process stability, sharing of know-how and responsiveness with the ones traditionally used for costs—in that specific cumulative order.

These studies show us the main objective of multi-plant improvement programmes: to create competitive strength by turning a dispersed production network into a symphony of world-class competitive plants. The means to achieve this is the shared improvement programme—centrally managed by the headquarters of the MNC and shared by all plants. The papers indicate the importance of multi-plant improvement programmes in industry and that it is a far from trivial topic.

5.3.2 Adaptation of practices to local contingencies

The literature has abundantly investigated the question of adaptation to local contingencies of a global improvement programme. Most authors argue in favour of strong adaptation (Maritan and Brush, 2003; Wallace, 2004; Jun *et al.*, 2006; Aoki, 2008; Nair *et al.*, 2011) and thus support traditional theories in the field of international business (e.g. Prahalad and Doz, 1987; Ghoshal and Bartlett, 1988; Kostova, 1999). Studies across different programme types, such as lean, TQM, CI and six sigma, argue for adaptation using contingency arguments. Jensen and Szulanski (2004) conclude differently; they find that adaptation of practices significantly increases the stickiness of cross-border knowledge transfer and, hence, makes the transfer process more difficult. Yu and Zaheer (2010) find that adaptation may better suit practices that hold strong social dimensions, such as quality management and HRM practices, whereas practices that hold strong technical dimensions better suit conformity and adoption.

Aoki (2008) points to two successful examples of *kaizen* transfer at Chinese plants where the foreign plants outperformed their Japanese sister plants. The study concludes that the success results from adaptation based on team-based implementation, cross training and management presence on the shop floor rather than a copy-exactly approach. Similarly, Wallace's (2004)

case study of how Volvo succeeded with the implementation of a hybrid Volvo-Toyota system in the Curitiba plant in Brazil argues strongly for adaptation of the global system to the local setting. He finds such ‘hybridisation’ of production systems to the local culture to be of pivotal importance for success. Browning and Heath (2009) make the argument that a lean programme has a different impact depending on different market and product characteristics in subsidiaries. These studies confirm that the balance between adaptation and adoption of the practice is essential. Thus, companies must understand and respect heterogeneity in the balance to achieve the maximum competitive advantage in the global network. This view is supported by Nair *et al.* (2011), who propose that adaptations of standardised six sigma methods better allow for openness, curiosity and learning in the process, which again lead to greater psychological safety and success.

These studies highlight one of the most central discussions in the multi-plant improvement programme literature: the role of adaptation. While the fundamental rationale for company-wide improvement programmes is based on cross-plant sharing of uniform best practices, most authors—but not all—would argue that adaptation is required for institutionalised implementation. The literature to date suggests two solutions to this: either, as Yu and Zaheer (2010) advocate, companies should carefully select programme practices that easily render themselves to standardisation or, as Nair *et al.* (2011) encourage, companies should allow wide adaptations from the local business environment. Both solutions will complicate the management of multi-plant improvement programmes. We can only conclude that the extent of adaptation remains disputed in the literature and need further investigation in future research.

5.3.3 The phenomenon of acting in subsidiaries

In this third category, we include studies that discuss the phenomenon of superficial adoption of multi-plant improvement programmes. This category includes three significant contributions. Baxter and Hirschhauser (2004) performed a longitudinal study of an improvement programme in a multi-plant network of an automobile supplier. They found a hollow management exercise of sustaining and communicating on-going improvement programmes that were fully detached from actual operations on the shop floor: ‘The dominant community of practice was not that of performance improvement but creating the impression of doing so’ (p. 207). They label such sites ‘pink factories’ (in reference to the expression of seeing the world through rose-tinted glasses). According to the authors, a pink factory has

four main characteristics: first, it emphasises visual effects in the factory more than actual improvements; second, it makes superficial use of simple standard tools and techniques; third, it reorganises into new teams to show the world that the company ‘operates teamwork’; and fourth, it engages in training that does not really transfer into real improvement on the shop floor. The authors strongly recommend that corporations drop the ‘pink factory community of practice’, but they recognise that apparent implementation—even if superficial—can (1) boost managers’ internal careers and (2) create the perception of a quality product or service to customers.

Kostova and Roth (2002) suggest that multinational enterprises run a particular risk of ceremonial adoption of practices in subsidiaries because of considerable uncertainty about the real value of the practice alongside institutional pressure from the MNC headquarters to implement the practice. Because social and cultural understandings differ across the world, some in the subsidiary might well consider such practices non-value adding, inefficient and faddish, while those in the parent company consider the practices to be of superior worth. Still, the subsidiary will superficially adopt the practice—leading to ceremonial adoption—to achieve legitimacy with the parent. In a similar vein, Jun *et al.* (2006) discuss TQM as a source of legitimacy in the market using institutional theory. Thus, *acting* TQM has value because customers perceive the adopters to be high-quality suppliers and this may influence them to place orders or pay a premium. However, in practice, it has none or even negative effects on operational competitive priorities.

This phenomenon of acting is interesting in itself because we need to understand why it occurs and how to minimise it. Of course, all programme managers have a strong bias towards reporting programme success. Acting therefore presents difficulty from a practical point of view because it is difficult to uncover when plant managers celebrate the programme in public settings. It seems reasonable to explain the occurrence of acting from under-communication of programme benefits, as Kostova and Roth (2002) do, but as Jun *et al.* (2006) argue, any number of other explanations can arise. The studies mentioned above hint to a prevalence of ceremonial adoption in reality but more research is required to measure how widespread the phenomenon is and why it occurs.

5.3.4 How to succeed with practice transfer and institutionalisation

In this fourth and final category, we summarise what the reviewed literature suggests corporations do to avoid ‘business as usual’ in subsidiaries. Hence, we do not discuss the avoidance in subsidiaries per se—which is very rarely studied—but rather what managers should do to succeed with the multi-plant improvement programme. Most authors provide guidelines for how to successfully implement and manage improvement programmes (e.g. Bessant and Francis, 1999; Kostova, 1999; Gupta and Govindarajan, 2000; Lapré and Wassenhove, 2001; Kostova and Roth, 2002; Maritan and Brush, 2003; Jun *et al.*, 2006; Collins and Schmenner, 2007; Aoki, 2008). Common grounds for the roadmaps involve urging the following four key strategies:

1. Fostering a dedicated management.
2. Building a deeply rooted improvement culture.
3. Creating suitable channels for knowledge and practice transfer.
4. Involving empowered teams in the on-going improvement process.

First, management support, leadership and active policy deployment is absolutely critical for any success of the improvement programme (Bessant and Francis, 1999; Bond, 1999; Kostova and Roth, 2002; Maritan and Brush, 2003; Collins and Schmenner, 2007; Aoki, 2008; Witcher *et al.*, 2008). Describing the six sigma programmes of LG, Samsung, POSCO, 3M, GE and Honeywell, Yu and Zaheer (2010) argue that the cases confirm that change requires commitment and endurance over time. Kerrin (1999) found CI to be a top-down management-led process in the case company, as opposed to the involvement strategy that the literature strongly depicts.

Second, all studies emphasise the importance of culture- and mindset-building mechanisms rather than heavy reliance on technical tools and techniques. However, industry does not necessarily understand this (McAdam and Lafferty, 2004). The key conclusion of Collins and Schmenner (2007) is that ‘system’ initiatives, such as improvement programmes, automation and technology, have far less impact on performance than soft issues, such as mentality and morale. Most authors would argue, however, that improvement programmes are exactly about building a deeply rooted CI culture where everybody takes part (Witcher *et al.*, 2008).

Third, successful knowledge and practice transfer remains essential to multi-plant improvement programmes. In her seminal paper on practice transfer, Kostova (1999) proposes

an analytical model for the successful transfer and institutionalisation of strategic organisational practices, emphasising that the transfer is embedded in contextual elements at the individual, organisational and cultural levels. Ferdows (2006) discusses how different types of know-how require different modes of transfer. He suggests that CI initiatives are best transferred 'fast and codified', meaning that proven process improvements should quickly be put into updated standards and shared with sister plants. Codification of written rules into manuals does not exclude the need for people to travel and share related tacit knowledge. In support of this, Kostova and Roth (2002) advise managers of multinational enterprises to create an appropriate relational context for the transfer of practices. Moreover, Noorderhaven and Harzing (2009) find that social interaction represents more than just a transfer mechanism; it also produces knowledge. Other authors express the importance of ICT and the Internet as modern channels for efficient knowledge storage and transfer of lean practices (Delbridge and Barton, 2002; Bruun and Mefford, 2004; Henriksen and Rolstadås, 2010). The case study of Henriksen and Rolstadås (2010) warns, however, that ICT is necessary but not sufficient, because it overemphasises codified knowledge.

Fourth, establishing and empowering shop floor teams is essential for successful internalisation of a practice according to the following studies: the case study of Seagate Technology of McAdam and Lafferty's (2004), the study of *kaizen* transfer to Chinese plants of Aoki (2008), the Baekert case described by Lapré and van Wassenhove (2001), and the study of TQM transfer to Mexican maquiladoras of Jun *et al.* (2006). McAdam and Lafferty (2004) suggest that the early involvement of the human resources department in communication, empowerment and involvement—not just training—is a success factor for six sigma implementation.

This final category assesses a broad range of factors that facilitates the implementation of multi-plant improvement programmes. The studies present managerial implications very well through different proposed roadmaps. A gap in this literature appears to involve its limited focus on the international multi-plant perspective: typical factors from international management, such as communication barriers and differences in culture, local management practices, politics and law, are rarely addressed. These are factors are often brought forward as major hurdles in the popular literature.

6 Discussion and Research Agenda

This study has reviewed the recent literature on multi-plant improvement programmes. It seems clear from the covered literature that a new field is in the making and will establish itself with a continuous flow of high-quality studies, in high-level journals, using a variety of methodological approaches and theoretical perspectives. Future research should address the several gaps and shortcomings in the literature.

We identified only 30 studies over a fourteen-year period, and just nine of these took the MNC headquarters perspective. This is in stark contrast to the abundant attention and investment that goes into such programmes in industry (Netland, 2013). From this perspective, the current scholarly literature largely fails to fulfil its role to synthesise and guide practitioners who implement and manage such programmes. This, in general, calls for much more research on multi-plant improvement programmes, which echoes the general call for more research on international aspects of operations strategy (Barnes, 2008; Ferdows, 2008).

Here we propose an agenda for future research on multi-plant improvement programmes by summarising (1) what the current research has insufficiently addressed and (2) what it inconclusively answers. We derive the first and the fourth topics from apparent gaps in the current literature. The second and the third topics are directly linked to the two axes of the proposed 4A model. We call for more research addressing the following four topics:

- First, we find a lack of studies exploring and explaining when and where a multi-plant improvement programme is useful at all.
- Second, the literature is inconclusive about where an MNC should seek adaptation and where it should enforce adoption.
- Third, there is clearly inadequate knowledge about the phenomenon of acting.
- Fourth, there is a lack of research on how to manage multi-plant programmes from a headquarters perspective.

6.1 When should firms use multi-plant improvement programmes?

The first question we recommend for further exploration deals with the overarching objective of building global capabilities with multi-plant improvement programmes: Under what circumstances should managers invest in multi-plant improvement programmes and when

should they allow complete local plant autonomy? Our literature review reveals that very little research effort has gone into investigating this fundamental question. In general, we do not know much about managing *multi-plant* improvement programmes specifically.

The literature largely remains inconclusive in the debate between the universalistic and contingent approaches (Rungtusanatham *et al.*, 2005; Jayaram *et al.*, 2010). What appears to be a powerful managerial tool to build competitiveness through global production capabilities stands at risk of becoming a managerial fad due to widespread implementation that includes instances where no such programme is needed—or where the associated costs exceed the expected benefits. This discussion ties directly to the broader theme of multi-plant coordination (Porter, 1986; Buckley and Casson, 1998), in which the existing literature has affirmed that using global resources to support or manage local operations can improve the competitiveness of the MNC as a whole. However, to what extent it is rational remains an open question. As multinationals continue to consolidate and coordinate their increasingly global operations, we expect to see far more research within this stream in the future.

A specific question for research will be what the actual performance gains of improvement programmes are. Even though some studies establish positive links between improvement programmes and performance, their calculations rarely include the cost of establishing and managing such a programme. Recently, we have seen a few attempts to address this question (Anand *et al.*, 2009; Ferdows and Thurnheer, 2011; Swink and Jacobs, 2012; Netland and Aspelund, 2013), but we still find a scarcity of empirical studies to determine when integration through multi-plant improvement programmes outcompetes local autonomy. The design and implementation of multi-plant improvement programmes are indeed expensive because they require human, organisational and financial investments over a long period before and while they provide significant benefits. Hence, cost considerations remain important. While often demanding from a methodological point of view, researchers should not shun performance research that use real company data.

6.2 How should firms balance adoption and adaptation?

Our second question regards when and where one should encourage adaptation and where one should enforce full adoption of the multi-plant improvement programme. The balance between adaptation and adoption is not clear-cut. While most researchers stress the

advantages of adaptation, some argue that adaptation increases stickiness and complicates the global management of a multi-plant improvement programme. Pursuing research similar to the in-depth case study of multi-plant improvement programme implementation by Maritan *et al.* (2004), could provide better answers to this unsolved contradiction.

A related issue that also needs further investigation is whether different types of process improvement programmes, such as lean, six sigma and TQM, have different requirements for adaptation, as suggested by Yu and Zaheer (2010). Answers to this question will be a good contribution to the on-going discussion on best practices (Voss, 1995; Schonberger, 2007) in operations management research. In this respect, the concept from Winter and Szulanski (2000) of an ‘arrow core’—a subset of practices within a practice that constitute the heart and soul of the practice—may offer a promising perspective. As long as the arrow core is transferred, they argue, a partial transfer of practices will give the anticipated and desirable results.

6.3 How can firms avoid superficial implementation?

The third question we raise deals with acting. Most researchers neglect this phenomenon. The few existing studies establish that such behaviour occurs and give theoretical reasons for why it occurs (Kostova and Roth, 2002; Ketokivi and Schroeder, 2004). Ceremonial adoption undermines the overall objectives and function of the multi-plant improvement programme, and research should be able to predict when and where it will occur so that appropriate action can be taken before costs are incurred. Total avoidance, as described by the fourth quadrant in our theoretical framework in Figure 1, is not a desired state either. In contrast to acting, however, it does not cause the subsidiary unproductive costs and it is far easier to observe and, hence, manage. From an operational point of view, acting should be avoided, but it is largely unclear how this can be achieved because acting also brings along positive market effects for individual managers and plants. This is a major weakness of the research field, and the answers to this question might provide us with better answers about how to achieve institutionalised adoption.

The best strategy to avoid superficial implementation is arguably to take managerial actions that lead to a profound implementation of the multi-plant improvement programme. Our review shows an abundance of roadmaps and advices, but most of these are at such a high-

level description that practitioners find them useless. For example, one critical success factor commonly referred to as ‘management commitment’ often carries no further explanation of what that commitment actually involve. Hence, we see a need to better assist global managers in their efforts to bring about change through multi-plant improvement programmes. It is not a given that the critical success factors that apply to process improvement in single factories apply to networks of factories. The reviewed literature is inconclusive on the best way to achieve change; while some authors argue for a top-down, management-led approach, others argue for a more subtle communities-of-practice approach with focus on socialisation mechanisms.

In addition, the manufacturing industry has arguably become far more international than at the time of writing of Prasad and Babbar’s review in the year 2000. The importance of understanding global and cultural factors has only increased and continues to do so—especially as we witness the rise of the BRIC countries as major players in the international business arena. We would therefore like to see more research studying the link between multi-plant improvement programmes and international aspects such as politics, economics and culture.

6.4 How should firms manage the programme per se?

Our final question—and one becoming increasingly important for modern managers of MNCs—involves the capacity for change in an increasingly competitive environment. We can view a multi-plant improvement programme as a strategic tool for building capabilities to exploit the firm’s resources. If the programme remains static, however, it can become a liability in itself, leading to organisational inertia at times when the firm needs to respond to rapid changes in the environment. A number of questions arise: How does one design multi-plant improvement programmes so that they do not turn into competitive liabilities in the long term? How does one improve the improvement programme itself? Who is responsible for this and what is the best way to do it? These are fundamental questions that global managers face; unfortunately, they find little guidance in the scholarly literature to date. These questions are far from trivial and deserve attention in future research.

6.5 What research methods work best?

It remains to discuss what methodologies to employ in future research on multi-plant improvement programmes. In general, we find that the maturity level of this research has evolved beyond its infancy. Definitions and concepts now describe the phenomenon, and as the field moves to a more mature phase, we believe it will profit from further empirical tests of earlier proposed theories, roadmaps and models regarding design and implementation of the programmes. An impressive amount of research has gone into the development of these roadmaps, and they deserve thorough empirical testing to determine their applicability from both theoretical and managerial perspectives. Given the popularity of the phenomenon in industry, researchers should have access to an abundant supply of empirical cases to investigate.

We would hence like to see the ratio of qualitative versus quantitative research become more balanced—especially in the operations management literature, which is predominantly populated by qualitative research. We call for more quantitative cross-industry studies and more longitudinal case studies focusing on performance indicators. Researchers should be extremely careful when undertaking quantitative survey research using perceptual data so as not to reinforce an overly positive picture of improvement programmes. A major weakness with perception-based surveys is that they fall victim to acting: it is very difficult to measure institutionalisation of practices correctly. Therefore, as far as possible, quantitative research should rely on factual data, such as rigid audits, operational performance indicators and financial results. When these numbers are hard to obtain—which unfortunately they often are—qualitative research based on longitudinal case studies offers a good alternative. Due to limited generalisability, however, we would need a high number of such contributions to answer—with certainty—the questions outlined above.

7 Conclusions

The past decade has seen an on-going trend among multinational manufacturing companies to implement multi-plant improvement programmes. Despite the evident popularity of such programmes among practitioners, the corresponding literature remains scarce and no coherent stream of literature has emerged to this date on this widespread phenomenon. Instead, research from several areas offers theoretical explanations and normative roadmaps for aspects of such efforts. This paper has brought together this research on multi-plant

improvement programmes from fifteen leading management journals to describe the current research frontier and suggest a research agenda for the future. We found a scattered interest across journals, where *IJOPM* still stands out as a primary professional journal for research on multi-plant improvement programmes.

7.1 Contribution to research

By synthesising the current conceptual and empirical literature, this review provides an original and better understanding of the phenomenon of multi-plant improvement programmes and its potential outcome in different subsidiaries. Appendix 1 offers a full overview and summary of the reviewed papers. We suggest four research topics that deserve further attention—two derived from inconclusive research to date and two derived from apparent gaps in the research.

We argue that multi-plant improvement programmes aim to build dynamic isomorphism into a global network, where best practices are continuously updated, shared and *adopted* in all plants. Importantly, heterogeneity of local contingencies in the network enforces a degree of local *adaptation* of the practices that improve institutionalisation and, hence, value creation but hampers sharing of the practice to sister plants. The unwanted effect of *acting* characterises a superficial and rhetoric-based implementation without institutionalisation of the practice. This effect continues to prevail in industry despite the many normative roadmaps offered by research. A further alternative, and one that is much easier to relate to, is the total *avoidance* of the programme in a subsidiary, leading to business as usual and no substantial change. These four possible outcomes are summarised in the proposed 4A framework for subsidiary response to a multi-plant improvement programme.

7.2 Contribution to practice

This literature review offers a quick introduction and overview of the current research frontier in the specific field of multi-plant improvement programmes. As in the case of all literature reviews, this is helpful for time-conscious managers who do not have the time to track down all the available literature themselves. In particular, practitioners might find the proposed 4A framework in Section 3.3 useful when considering programme implementation in their own global production networks. In addition, the summary of the four critical success factors for

programme implementation in Section 5.3.4 should be of interest. It is our hope that the scholarly literature will provide even better managerial advice as the field matures.

7.3 Limitations

The much focused literature review of this paper has evident strengths and weaknesses. First, the inevitable manual search runs the risk of excluding papers that could be included; in any such case, the researchers have not intended this. Second, the authors acknowledge that the low number of articles (30) focusing on multi-plant improvement programmes is not ideal when general conclusions are being drawn. The low number corresponds well, however, to the numbers of Prasad and colleagues (Prasad *et al.*, 2000; Prasad *et al.*, 2001), who found 91 articles within the larger scope of international operations strategy between 1986 and 1997.

The main reason for the relatively low number of studies we found stems from our requirement for the papers to deal specifically with *multi-plant* improvement programmes in international settings. The literature on single-plant improvement projects is far richer and more mature. Multi-plant programmes are much more exposed to the challenges of balancing global standardisation versus local adaptation and ceremonial adoption versus profound implementation, however, which in our view justifies their study as a separate field. Undoubtedly, much single-plant research also applies to multi-plant improvement programmes, but not all. Moreover, the literature on coordination in supply chain management and international business literature can contribute to our understanding of multi-plant improvement programmes. Future research should confront the task of exploring these interfaces.

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Appendix 1: Papers included in the review (sorted alphabetically)

Reference	Improvement programme	Method and research focus	Key empirical finding and/or proposition
Aoki (2008) IJOPM	Continuous Improvement	Uses a multiple-case study to examine the transfer of kaizen from Japanese companies to nine overseas Chinese plants.	Successful kaizen transfer to Chinese plants does not occur based on a copy-exactly approach but on a balanced implementation of three types of kaizen capabilities: (1) team-based suggestion schemes, (2) supportive human resource practices, and (3) daily management shop-floor visits.
Baxter & Hirschhauser (2004) IJOPM	TQM	Uses a longitudinal case to explore the degree of superficiality in implementing improving programmes	Improvement programme implementations might be symbolic actions characterised by reification and representation. Main characteristics of such “pink factories” are: (1) emphasis on visual effects in the factory more than actual improvements, (2) superficial use of standard tools and techniques, (3) reorganisation into new teams and (4) untapped training.
Bessant & Francis (1999) IJOPM	Continuous Improvement	Uses a single-case study to explore the experiences with CI policy deployment through a Western MNC case compared to three anecdotal Japanese cases.	Most UK manufacturers pursue CI, but most often on a suboptimal stage where CI is not a strategic competitive advantage. The key enablers for the highest level of CI (double-loop learning stage) include (1) structured policy deployment, (2) measurement, (3) idea management and (4) reward and recognition systems.
Bond (1999) IJOPM	Continuous Improvement, BPR	Uses a single-case study to examine the role of performance measurement in fostering both a kaizen programme and a process reengineering project.	Undergoing improvement means going through four distinctive phases of the process life cycle where each stage requires a different approach to performance measurement and management.
Browning & Heath (2009) JOM	Lean	Uses a case study of two Lockheed Martin factories in the F22-jet airplane programme to explore the effects of lean on production cost in a high-tech production environment characterised by a high-degree of novelty and complexity.	Eleven research propositions for further research suggest that implementation of lean production costs more in high-tech environments characterised by complexity and novelty, and that contingencies in such firms lead to radical differences in subsidiaries’ lean journeys.
Bruun & Mefford (2004) IJPE	Lean	Uses case studies to explore whether internet facilitates the implementation of lean or if it serves as a substitute for lean.	There are synergies between lean and ICT, and the Internet can be a facilitator to lean implementation (“e-lean”). This potential is especially large beyond the company’s border when building the lean supply chain.
Collins & Schmenner (2007) IJOPM	Practices (e.g. Lean, WCM, Theory of Constraints)	Uses mixed methods (survey and interviews) to examine the reasons for differences in relative performance between sister plants occurring over time.	“System” initiatives such as improvement programmes, benchmarking, automation and technology have far less impact on performance than soft issues such as mentality, culture and morale. Management support is absolutely critical for any success of improvement.

Reference	Improvement programme	Method and research focus	Key empirical finding and/or proposition
Colotla, Shi & Gregory (2003) IJOPM	Lean, TPS, JIT	Uses a case study in two MNCs to study how capabilities dispersed in multi-plant manufacturing networks interplay, are managed and impact performance.	Interdependence between factory capabilities and multi-plant networks capabilities mutually affects the overall performance of both the plant and the network. Propose the Factory-Network Capability Matrix.
Delbridge & Barton (2002) IJOPM	Continuous Improvement	Uses mixed methods (survey and 18 case studies) to study the management of CI towards the learning factory among first-tier automotive suppliers in the US and UK.	A trend toward the learning factory: Managers seek to empower cross-functional shop-floor teams in problem-solving and CI and facilitate intra-firm knowledge sharing. However, mostly non-substantial data on products, quality and cost are shared today.
Ferdows (2006) POM	Procedural knowledge	Conceptually proposes a framework for the sharing of changing production know-how in production networks, and illustrates with the four case examples McDonalds, Club Med, Intel and AOL.	Four classification zones for sharing production know-how are suggested based on the speed and tacitness of the practice. For each zone a primary sharing mechanism and an absorptive capacity template is suggested. The “fast and codified” zone is best suited for continuous improvement.
Ferdows & Thurnheer (2011) IJOPM	Factory fitness programme	Uses a single-case study of Hydro Aluminium to investigate the effects of a factory fitness programme as something different than a lean production programme.	A factory fitness programme—aiming at building cumulative capabilities in line with the sandcone model—showed above industry-average rates of return in the case company. A muscle-building factory fitness regimen is conceptually different from a fat-reducing lean production programme.
Freknel (2008) AMR	Best practice	Conceptually builds on Homi Bhabha's theories of post-colonization to propose a new analytical perspective to study power-relations between the HQ colonizer and the colonized subsidiary in an MNC.	The current international management literature is blind for geo-political forces that characterise and influence the practice transfer process in multinationals. To make use of all global resources, managers should not be limited by their own national, ethnic or racial systems of beliefs.
Goel & Chen (2008) IJPE	BPR	Uses action research at GE Wind Energy to study the risk of maintaining information security associated with implementing a global six sigma programme.	Security issues should be sought integrated in the business redesign process rather than as a patchwork of security fixes after problems occur. Proposes a three-step model for successful BPR implementation.
Gupta & Govindarajan (2000) SMJ	Procedural knowledge	Uses a survey to study the transfer of procedural knowledge in an MNC network and the factors influencing successful transfer.	Five major hindrances to knowledge transfer are: (1) value of source unit's knowledge stock, (2) motivation of the source unit, (3) existence and richness of transmission channels, (4) motivational disposition of the target unit, and (5) absorptive capacity of the target unit.
Henriksen & Rolstadås (2010) IJPR	Lean, Mass production	Uses a single-case study to explore the different knowledge transfer mechanisms between lean and mass production.	Different manufacturing strategies have different implicit knowledge transfer mechanisms. ICT is necessary but overemphasises explicit knowledge. Efficient transfer requires social mechanisms such as communities of practice, rotation of personnel and knowledge brokers.

Reference	Improvement programme	Method and research focus	Key empirical finding and/or proposition
Jensen & Szulanski (2004) JIBS	Best practice	Uses a survey to explore the stickiness of organisational best practices as they are adapted and sought transferred to other units.	Adaptation of practices significantly increases the stickiness of cross-border knowledge transfer and, hence, makes the transfer process more difficult.
Jun, Cai & Shin (2006) JOM	TQM	Uses a survey to investigate the transfer of TQM practice programmes to two Mexican maquiladora production plants.	Employee empowerment, teamwork and employee compensation positively influence employee satisfaction, and higher satisfaction leads to higher loyalty. In addition, sufficient employee training is needed.
Kerrin (1999) IJOPM	Continuous Improvement	Uses a single-case study to examine the application of Bessant and Caffyn's framework for implementation of CI in one UK company with a Japanese parent.	Bessant and Caffyn's five-stage implementation framework has explanatory power for CI implementation in the case company. CI was found to be a top-down management-led process in the case company.
Kostova (1999) AMR	Strategic organisational practices	Conceptually theorises around the transnational transfer of strategic organisational practices and proposes a model for the successful transfer and institutionalisation of such practices.	The success of a practice transfer can be measured by its degree of institutionalisation at the recipient unit, and is dependent on the country-level social context, the company-level organisational context and the individual-level relational context.
Kostova & Roth (2002) AMJ	Quality management	Uses a survey to examine the forces at play in the transfer and adoption of organisational practices in a subsidiary of an MNC using institutional theory.	Diffusion of practices regarded superior by the parent company is not easily institutionalised in subsidiaries due to partly competing institutional pressures from both the MNC and the host country environments. The result is often "ceremonial adoption".
Lapr�e & Wassenhove (2001) MS	Productivity improvement practice	Uses mixed methods (mathematical modelling and case study) to explore the transfer of a formal learning and experiment concept to three other plants in the same firm.	Lasting improvements and learning require both know-why and know-how. Management buy-in and cross-functional teams possessing knowledge diversity are two success factors for intra-firm transfer of learning by doing.
Lee & Jo (2007) IJPR	TPS, Hyundai Production System	Uses a single-case study of Hyundai in Korea to examine the mutation of the Toyota Production System into the Hyundai Production System.	The Hyundai Production System is a mutation of the TPS stemming from adaptation of TPS to Hyundai's unique setting. Such company-specific systems can differ sustainably from TPS and give positive results.
Maritan & Brush (2003) SMJ	Lean	Use a case study to examine differences in intra-firm sharing and implementation of flow manufacturing or lean in four US locations.	The implementation process of lean in multiple locations follows a process life-cycle model, where heterogeneity in context lead to important differences in a plant's starting point, strongly influencing the result.
McAdam & Lafferty (2004) IJOPM	Six sigma, TQM	Uses mixed methods (survey and interviews) to study the implementation of six sigma in a large organisation and to explore the role of organisation and people.	For six sigma to become embedded in the factory, people and organisational involvement and development play a critical role. This contrasts with the practice where six sigma usually takes a mechanistic top-down, technology-based approach.

Reference	Improvement programme	Method and research focus	Key empirical finding and/or proposition
Mefford & Bruun (1998) IJPE	Continuous Improvement	Conceptually discusses how multinational companies can turn their subsidiary plants in developing countries into world-class plants.	Proposes a conceptual roadmap for the selection of both hard and soft production technologies for facilities in developing countries based on a socio-technical systems perspective.
Nair, Malhotra & Ahire (2011) JOM	Six sigma	Uses an action research approach to explore and build a theory on how to manage local context in six sigma projects.	Twelve research propositions together suggest that a balance must be struck between structured known methods and local adaptations to complexity and uncertainty in six sigma projects.
Noorderhaven & Harzing (2009) JIBS	Procedural knowledge	Uses a survey to investigate the role social interaction plays in MNCs to support the transfer of procedural knowledge between units in the network.	(1) Social interaction positively influences knowledge transfer in MNCs and in fact also produces new knowledge and (2) subsidiary autonomy negatively affects knowledge transfer.
Wallace (2004) IJOPM	Lean	Uses a case study to investigate innovation tied to the implementation of lean manufacturing and Swedish work principles in a Brazilian Volvo plant.	Hybridisation of production systems to the local culture is pivotal for success. Success stems from an iterative process of implementation and learning that leads to hybridisation of the local and external systems.
Witcher, Chau & Harding (2008) IJOPM	Policy management	Uses a single-case study to examine the role and effects of the organisational practices of top-executive audits and policy management (Hoshin Kanri) at Nissan South Africa.	Management skills such as active listening, questioning, probing, coaching and visible involvement prove absolutely crucial for the success of a policy management programme and, hence, for the organisation's ability to continuously improve overall.
Yu & Zaheer (2010) JIBS	Six sigma	Uses case studies and a grounded theory approach to look at the adaptation process of Western six sigma practices into local settings in Koran and US firm.	A sequential and cascading adaptation model of the conceptual, social and technical dimensions of six sigma is suggested. Adaptation may be more suitable for practices with strong social dimensions such as quality management and HR practices than for technical practices.

**Paper 3: Company-specific Production Systems and
Competitive Advantage: A resource-based view on the
Volvo Production System**

Paper 3

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Company-specific Production Systems and Competitive Advantage: A resource-based view on the Volvo Production System

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Abstract

Purpose: In order to improve competitiveness on a global scale, multinational enterprises increasingly develop a company-specific production system (XPS) and deploy it in their worldwide operations. An XPS is synonymous with a tailored corporate-wide improvement programme. The purpose of this paper is to explore the circumstances under which an XPS can provide a competitive advantage.

Methodology: We use an explorative case study methodology to investigate the link between the establishment of an XPS and competitive advantage. Specifically we investigate the part of the Volvo Group's globally implemented Volvo Production System (VPS) that aim to improve the manufacturing processes worldwide. Due to its historical trajectories, Volvo constitutes a unique case for studying the trend and effects of XPS. The resource-based view of the firm provides the theoretical foundation for our analysis.

Findings: We conclude with four research propositions. P1: In industries with widespread XPS implementation, an XPS is a necessary resource for achieving competitive parity; P2a: Early-starters get an instant temporary competitive advantage; P2b: Late-starters can achieve a temporary competitive advantage if they implement an XPS at a faster speed than competitors; and P3: An XPS can provide a sustainable competitive advantage if it has a superior fit with other path-dependent resources in the organisation.

Research implications and limitations: We propose an updated VRIO model, which is better suited for understanding the relations between an XPS and competitive advantage. The major limitation of the study is the single-case design, which complicates generalisation from the VPS to an XPS of the propositions set forward.

Originality: Despite the significant trend in modern operations management, XPSs have received remarkably limited attention from academia except for the Toyota Production System. Presumably, this is the first paper to discuss the recent trend of XPS and its contribution to competitive advantage.

Keywords: production systems; competitive advantage; global operations management; resource-based view; lean; VRIO model

1 Introduction

There is a strong and intensifying trend among manufacturers to develop and deploy company-specific production systems. Inspired from the success of the Toyota Production System (TPS), and armed with a massive body of literature suggesting a positive relationship between improvement programmes and operational performance, corporate managers firmly believe that having a similar but tailored system in place will strengthen their firm's competitiveness. Such a system is often labelled the '*company name*' *production system*, here abbreviated to XPSⁱ.

XPSs seem particularly popular among multinational enterprises that have undergone rapid global growth over the last decades. They now face the challenge of operating a globally dispersed manufacturing network effectively and efficiently (Colotla *et al.*, 2003) and seek inspiration from the broad literature that suggests sharing organisational practices among multiple locations as a fundamental strategy for seeking competitive advantage in multinational enterprises (e.g. Birkinshaw and Hood, 1998; Maritan and Brush, 2003; Jensen and Szulanski, 2004). Thus, a recent innovation is that companies consolidate their earlier plant-specific local improvement programmes into corporate-wide global improvement programmes. Companies as varied as Mercedes, Caterpillar, John Deere, Scania, Bosch, Du Pont, Jotun, Hydro, Siemens, Ecco, Whirlpool, Swedwood, Lego and Volvo have all

implemented an XPS in recent years. A shared ultimate goal is to build dynamic capabilities that provide sustained competitive advantage (Anand *et al.*, 2009).

Despite this evident trend in industry, only a few dedicated studies of firm-specific improvement programmes in international manufacturing networks have been published, with the notable exception of the TPS (Witcher *et al.*, 2008). Even though the TPS is a convincing example of an XPS that has rendered its mother company with a durable competitive advantage, it is questionable that the implementation of an XPS would become a competitive advantage for any company to the same extent that it has for Toyota. Under what circumstances an XPS contributes to competitive advantage is not well understood, and at first glance the increased adoption of such systems tends to be based on conviction rather than research-based evidence. This study seeks to investigate the general conditions under which the global deployment of XPSs can provide a sustainable competitive advantage, outside of the Toyota case.

We will answer this question by adopting an intrinsic case study using the Volvo Production System (VPS)ⁱⁱ as our case and the resource-based view of the firm as the theoretical background. The paper is structured as follows: Next we introduce Jay Barney's VRIO model of competitive advantage, and relate it to the phenomenon of XPS and TPS in particular. The VRIO model explains that sustained competitive advantage can only be gained from resources that are 'valuable' (V), 'rare' (R) and 'inimitable' (I), and presupposes that the firm can 'organisationally exploit' the resource (O). The methodology and the Volvo case are then described, before we apply the VRIO model to our empirical data from the VPS. Thereafter, we discuss the findings and propose research propositions and implications for practitioners. Finally, we conclude and discuss limitations and further research.

2 Competitive advantage of the Toyota Production System

In terms of competitive analysis, the resource-based view of the firm has been widely used in the strategic management literature in general (Conner, 1991; Barney, 2001) and has shown great potential in operation management research in particular (Coates and McDermott, 2002; Schroeder *et al.*, 2002). The essence of the resource-based view lies in its conceptualisation of the firm as a 'bundle of resources' (Penrose, 1959; Wernerfelt, 1984). In this paper we view an XPS as a firm-specific resource.

2.1 The VRIO model of competitive advantage

The central goal of the resource-based view is to build and maintain competitive advantage (Teece *et al.*, 1997). In this regard, Jay Barney's (1991) VRIS model is often referred to as the most influential contribution of the resource-based view (e.g. Eisenhardt and Martin, 2000; Priem and Butler, 2001; Foss, 2005). Figure 1 shows Barney's (1991) original VRIS model. Barney's core argument is that a firm that possesses valuable (V) and rare (R) resources has the potential to gain competitive advantage, and when such resources in addition are imperfectly imitable (I) and non-substitutable (S), the resources have the potential of building sustained competitive advantage.

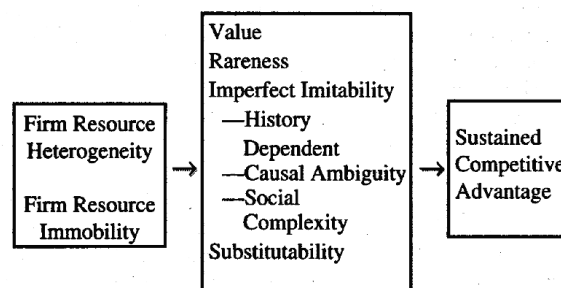


Figure 1. The VRIS attributes of resources (from Barney, 1991, Fig. 2, p. 112).

According to Barney (1991, p. 102), 'a firm is said to have a sustained competitive advantage when it is implementing a value creating strategy not simultaneously being implemented by any current or potential competitors and when these other firms are unable to duplicate the benefits of this strategy'. To be *valuable*, the resource must give positive rents when deployed. *Rarity* requires that the same resource is not available to competitors, and *non-substitutability* requires that the same effects cannot be obtained by other types of resources (Barney, 1991). Thus, according to the resource-based view, heterogeneity is the mother of competitive advantage (Peteraf, 1993).

The resource-based view is based on the assumption that most resources are tradable. However, some resources and capabilities are firm-specific and 'sticky' (Barney, 1991); that is, they cannot be transferred easily between firms without significant costs. Such *imperfect imitability* is obtained either through one or a combination of the following reasons (Barney, 1991): (1) The resource has grown over time through the company's unique historical development. Dierickx *et al.* (1989) stress that critical strategic resources must be

accumulated over a certain time period and cannot be instantly bought in strategic factor markets, i.e. being path-dependent; (2) The resource is of tacit nature, skill-based or people-intensive, and thus causally ambiguous, making it extremely hard to understand the true source of competitive advantage; and (3) The resource is socially complex, meaning it resides in the collective actions of people and teams.

Although the main originator of the resource-based theory, Edith Penrose (1959), emphasised dynamic concepts and change over time, much of the subsequent literature was static in nature (Priem and Butler, 2001). Teece *et al.* (1997) expanded the resource-based view into dynamic markets again, when introducing the dynamic capabilities perspective. *Capabilities* 'refer to a firm's capacity to deploy resources' (Amit and Schoemaker, 1993, p. 35), and are characterised by 'information-based, tangible or intangible processes that are firm-specific and are developed over time through complex interactions among the firm's resources'. Teece *et al.* (1997) argue that *dynamic capabilities* are more important to the firm than other resources, because they build new forms of routines, while other resources only replicate existing routines. The term 'dynamic' refers to the changing environments, which require the firm to change its capabilities as 'time, competition and change erode their value' (Rumelt, 1984, p. 557). Prahalad and Hamel (1990, p. 82) refer to such capabilities as core competencies, which denote the 'collective learning in the organisation, especially how to coordinate diverse production skills and integrate multiple streams of technologies'. They argue that the ability to integrate and grow competencies across the corporation's architecture is dependent on processes such as communication, involvement and commitment.

To incorporate this insight in the VRIS model, Barney argued in 1997 for enhancing the VRIS model with an 'O' for 'organisational exploitation'. He further argued that the 'S' is covered by the 'I', and the organisation's ability to effectively utilise the resources should be part of a complete model. According to Barney (1997, 2011), complementary resources and capabilities such as reporting structures, management systems, control systems and compensation policies must be in place in order to be able to exploit the VRIS attributes of a resource. Thus, organisational exploitation is basically about having the processes in place to realise the content of the resource. In this sense one can argue that, whereas the VRIS attributes address resource development, the O-attribute addresses resource deployment, i.e. capabilities. Figure 2 shows the VRIO model of competitive advantage, where we have

specified that VRIS attributes are tied to the content of a resource, while the O-attribute is concerned with process capabilities of deploying the resource.

Content (resources)			Process (capabilities)	Competitive implications
Valuable	Rare	Inimitable / Non- substitutable	Organisational exploitation	
No	-	-	No/Yes	Competitive disadvantage
Yes	No	-	Yes	Competitive parity
Yes	Yes	No	Yes	Temporary competitive advantage
Yes	Yes	Yes	Yes	Sustained competitive advantage

Figure 2. The VRIO attributes and competitive advantage (based on Barney, 1997, p. 163).

It follows from this that the XPS must be a resource both in content and process that holds all the four VRIO attributes in order to provide sustainable competitive advantage according to the resource-based view.

2.2 The VRIO model of competitive advantage applied to TPS

In his book *Toyota Production System*, Taiichi Ohno (1988) described the step-by-step development of Toyota's super efficient production concept during the years 1945 to 1975. The TPS enhanced the mass production paradigm of Fredrick Taylor and Henry Ford by adding an invariable customer perspective to all operations through the principles of just-in-time, jidoka and waste elimination (Sugimori *et al.*, 1977; Ohno, 1988). The core ideas of the TPS were transferred to Europe and the US in the 1980s as bits and pieces of just-in-time production (JIT), total productive maintenance (TPM) and total quality management (TQM) (Schonberger, 2007). In 1990, the International Motor Vehicle Program summarised its findings in the book *The Machine that changed the World* (Womack *et al.*, 1990), and concluded that the TPS was superior to Western automobile production concepts. What became known as lean production (Krafcik, 1988; Womack and Jones, 1996) has become the dominant manufacturing paradigm of modern times (Holweg, 2007), and manufacturers all over the world have spared no efforts in trying to imitate it—with variable results.

There is little doubt that the TPS has, over time, rendered Toyota with a sustainable competitive advantage and contributed significantly to Toyota's success and growth (e.g. Womack *et al.*, 1990; Vastag, 2000; Liker, 2004). With the TPS, Toyota has been able to develop more automobile models faster, with significantly less defects and at a lower cost than its Western competitors (Womack *et al.*, 1990). In 2008, it became the world's largest automobile manufacturer. This shows the potential value of an XPS as a firm resource. The TPS has proven *valuable* both for Toyota and many of its followers.

But is the TPS fundamentally *rare* and *inimitable*? At the time of its introduction, Toyota's heavy investments in innovative soft infrastructural factors were new and rare in the industry. In the 1980s there was a general myth that TPS was inimitable because its success resided in cultural-specific characteristics of Japan. This contemporary debate about the transferability of the TPS to Western cultures finally ended when Toyota proved the success of introducing TPS to its NUMMI and Georgetown plants in the USA (Krafcik, 1988). During the last three decades, the content of the TPS has become public property through extensive codified documentation. Toyota has never been reluctant to share what they do with competitors. Today, XPS content across companies and industries largely consists of well-known practices heavily inspired from the TPS and the lean production paradigm (Lehr and Springer, 2000; Clarke, 2005; Dombrowski *et al.*, 2009). Moreover, numerous empirical studies serve as proof of the positive effects that successful lean production or XPS improvement programme implementation can give across various companies and industries (e.g. Womack and Jones, 1996; Lewis, 2000; Barthel and Korge, 2002). Thus, in 2011 it is difficult to argue for the fundamental rarity and inimitability of the *content* of the TPS.

Despite the limited rarity and inimitability, companies still find it extremely hard to replicate Toyota's competitive advantage: 'After 30 years, we can now be reasonably certain that whatever Toyota have got, it isn't a trivial task to bottle it and sell it on' (New, 2007, p. 3547). Toyota's key to sustained competitive advantage is a deeply rooted and subtle organisational culture (Liker and Hoseus, 2008) that allows a superior *organisational exploitation* of TPS (Spear and Bowen, 1999). Organisational exploitation will always vary between companies (Teece *et al.*, 1997); thus, the companies that are able to do 'superior resource deployment' (Makadok, 2001) can gain competitive advantage. 'In order for a continuous improvement initiative to serve as a dynamic capability, continuous improvement infrastructure should provide an organisational context that enables organisations to

coordinate and sustain their organisational learning efforts towards systematically improving processes' (Anand *et al.*, 2009, p. 446).

The example of Toyota proves that an XPS can be a source of durable competitive advantage. The question remains if this trend will continue. We investigate this question by looking more closely at an ambitious case with long historical manufacturing traditions—the Volvo Group.

3 Method

This paper explores if and how XPSs can provide sustainable competitive advantage. The main research question is a 'how' question and, according to Yin (2003), is suitable for a case study research design. Case studies are well suited for explorative theory-building research because they allow the development of in-depth insight into and understanding of the case (Meredith, 1998; Voss *et al.*, 2002). We chose the VPS as our case study. Volvo is a global manufacturer that is currently implementing the VPS in its plants worldwide, with the aim of making it a source of competitive advantage. The VPS is the unit of analysis in the study, which is interpreted as a firm-specific resource that must hold all the VRIO attributes to provide a sustainable competitive advantage. Volvo is also a suitable case due to its long and well documented dedication to developing world-class production.

The Volvo Group, the largest Swedish multinational manufacturing company, develops and produces trucks, buses, components for aircraft engines, construction equipment and drive systems for marine and industrial applications. Volvo is a global company with about 90,000 employees, facilities in 19 countries and sales operations in more than 180 countries. Volvo has since its founding in 1927 always represented a special case within manufacturing industries, attracting and supporting research from many varied fields, Operations Management (OM) and Human Resource Management (HRM) in particular. This journal, for example, published in 2004 a special issue on work organisation and lean production in Volvo (IJOPM, Vol. 24, Iss. 8). Known in particular for its work organisation experiments in the Kalmar and Uddevalla plants in the 1970s and 1980s, Volvo has become synonymous with a democratic team-based production system with a high level of shop-floor autonomy that has contrasted other companies' approaches to manufacturing. The question 'What does Volvo do?' continues to attract special interest from industry and academia.

Case studies are suitable for developing hypotheses or propositions, i.e. generating or extending theories (Meredith, 1998). Yin (2003, p. 10) stressed that ‘case studies are generalisable to theoretical propositions and not to populations or universes’. Accordingly, this explorative paper’s contribution to research corresponds to Eisenhardt’s (1989) midrange-theory building, as it proposes an update to the VRIO model to better suit resources such as an XPS, and develops a set of propositions for further research. Case studies ‘can and often do go beyond the original model, particularly if there is a need to explain anomalies or unexpected results’ (Meredith, 1998, p. 445). The developed propositions can be subject to further testing in studies using other research designs.

The analysis of qualitative in-depth interviews is the most often applied methodology for firm-level international business research (Sinkovics *et al.*, 2008). In this study, 11 interviews are included. In order to get varied and multiple views on the VPS, we chose five respondents from a Volvo subsidiary adopting the VPS outside Sweden and six from the central Volvo Production System Academy (VPSA) in Gothenburg. A case study protocol was used to guide the research process. To increase the reliability of the study an interview guide was carefully developed as part of the preparation process (Kvale, 1996; Yin, 2003). The interview guide was pre-tested with a relevant interviewee at the Volvo subsidiary. All interviewees received the interview guide one week before the interview, and the fully transcribed interviews were sent to the interviewees afterwards for their review and additional comments (Kvale, 1996). The interviews ranged from 45 minutes to 1 hour and 20 minutes. All interviews were tape recorded and transcribed in full length, resulting in more than 100 A4-pages of raw data.

In order to add triangulation validity to the case study (Eisenhardt, 1989; Voss *et al.*, 2002) document studies were added as sources of empirical evidence. The documentation included both internal Volvo material and a comprehensive review of external literature on Volvo. Volvo gave us full access to all material about its VPS on the internal VPS intranet page.

The measurements in this study are qualitative written and oral statements about the perceived competitive advantage held up against the VRIO model. The transcribed interviews, VPS databases and external literature were carefully searched for support or apparent contradictions with the VRIO attributes, which constituted the categories for data coding (Sinkovics *et al.*, 2008). Representative data with potential explanatory power for each of the VRIO attributes from interviews, databases and literature are included in the paper.

4 VRIO-analysis of the Volvo Production System

In the following section the VPS is presented and its potential contribution to sustainable competitive advantage is discussed through the resource-based view's four VRIO attributes; valuable, rare, inimitable and organisational exploitation.

4.1 Valuable

The first prerequisite for the VPS to provide competitive advantage according to Barney (1991; 1997) is that it must be *valuable* to the organisation. The VPS must bring along a positive return on investments. The broad range of literature on the TPS and lean production indicates that an XPS is perceived as a valuable asset. The 2008 annual report for Volvo introduces the VPS in this way:

More colleagues, more facilities and a broader cultural diversity strengthen the need for common values and goals to pursue. (...) with the stiff competition in the market place a continuous work with productivity-increasing measures is needed to further increase competitiveness. (Volvo Group, 2009, p. 20)

Volvo explains the VPS initiative with a need to consolidate and jointly improve an increasingly dispersed and diversified global group of business units. Since the sale of Volvo Cars to Ford in 1999, the remaining Volvo Group has grown considerably worldwide. In 2001, Renault Trucks and Mack Trucks were acquired, and between 2006 and 2007 Nissan Diesel, Ingersoll Rand's road development division and parts of Lingong were acquired. Clearly Volvo's global operations and corporate culture has become more diverse and dynamic over the last decade. Due to this, the Volvo Group decided in 2005 to carry out a group-wide production system initiative (Hill and Svenningstorp, 2006). A pre-study by the internal Volvo Technology department concluded in 2005 that 'the benefits of a common VPS would be maximum use of resources, better communication within the company group, sharing of the best practices, industrial and personnel mobility and reduced duplication of effort' (Hill, 2006, p. 1). The main purpose with the VPS is to increase competitiveness:

VPS provides the vision and framework of principles and tools designed to guide us in to creating value for our customers by increasing the quality, securing the delivery and lowering the cost of the products we produce. (VPS on Violin, Volvo's Intranet, 2010)

Even though it is hard to establish empirical evidence that directly links the VPS implementation to improved financial results, there exist reports of positive results such as considerable quality improvement, increased uptime and safety improvement following the VPS implementation. For example, Netland and Sanchez (2011) found indication of a positive relationship between VPS implementation and quality performance in ten globally dispersed Volvo plants. All interviews confirmed a common opinion within the company that the VPS contributes to increased competitiveness, and that it does so by first and foremost ensuring a more systemised profitable production. The following quotations from the VPS Director and a VPS recipient at the subsidiary are representative of a common understanding at Volvo:

From a safety perspective, for example, we see that more and more have zero accidents so far per year. We are getting cost reductions amounting to millions of Swedish Kronor everywhere. We are moving from approximately 50 % machine breakdown in 2008 to zero breakdowns now. (VPS Director)

I think that being customer-focused, and delivering good quality at the right price, at the same time as we reduce our costs so that our profitability improves, absolutely increases our competitiveness. (VPS Recipient)

Because the effects of successfully applying the VPS are *valuable*, the VPS can be a potential source of competitive advantage as anticipated. If competitors are successfully implementing an XPS and Volvo does not, Volvo would likely end up with a competitive disadvantage, according to the resource-based view.

4.2 Rare

In order to provide competitive advantage, valuable resources must be rare. That is, if all actors in a market have access to the same homogeneous resource it cannot serve as a source for competitive advantage, according to Barney (1991). Intentionally, the VPS is intended to be company-specific, and hence one-of-a-kind, as the following quotation from corporate management illustrates:

It is not about taking over someone else's way of working. It is all about us using all the knowledge and experience from other companies and within the Group to create something even better. (Volvo Group, 2009 p. 22)

Despite the corporate rhetoric, the degree of rarity is disputed and deserves closer investigation. The VPS started as an internal pre-study project at Volvo Technology in 2005 (Hill and Svenningstorp, 2006). A project group collected available information on existing production systems and best practices within Volvo. Most business units had or had started developing their own type of production system at that time. Other XPSs (e.g. Toyota, Renault, Nissan, Ford, Tritec) and in particular other Swedish initiatives (e.g. Scania, Volvo Cars), were analysed closely as benchmarks either through studies of documents and/or study trips. During 2005 seven local workshops were held, and a self assessment questionnaire with 26 lean production items received 57 responses from selected respondents in the Volvo Group. Based on all the input, the pre-study concluded in early 2006. The project group suggested that the VPS should be customer-focused, based on Volvo’s corporate values, and contain the following main principles: ‘goal oriented teams’; ‘cross-functional teams’; ‘built-in-quality’; ‘just-in-time manufacturing’; and ‘continuous improvement’ (Hill and Svenningstorp, 2006, p. 24). The VPS was globally launched in 2007.

Today, after some minor adjustments, the VPS model for the order-to-delivery process is a pyramid with seven main categories. The foundation wall contains the corporate values, culture and leadership described in The Volvo Way. The main focus, value for the customer, is found at the top of the pyramid. Between are the five main VPS principles: Teamwork; Process-stability; Built-in-quality; Continuous improvement; and Just-in-time. The VPS pyramid is shown in Figure 3:

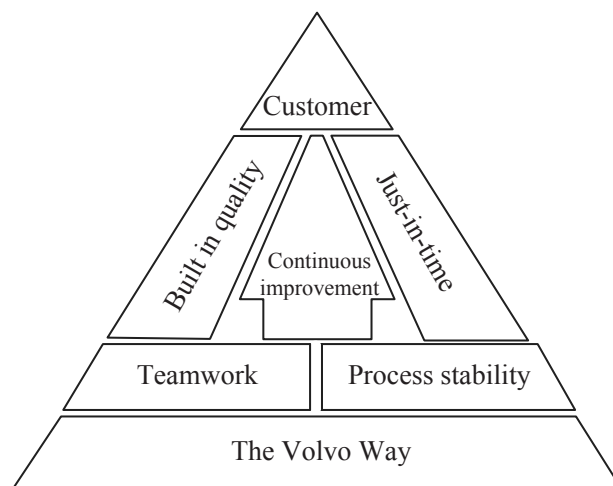


Figure 3. The Volvo Production System pyramid for the order-to-delivery process (Source: Volvo AB).

The Volvo Way and the VPS principles are extensively described in documents in the VPS information portal on Volvo’s intranet. The five VPS principles each consist of three to five modules (detailed in Table 1), which again hold a number of practical tools and techniques that support the implementation of the module.

Table 1. VPS’ five main order-to-delivery process principles with modules.

Teamwork	Process stability	Built-in-quality	Just-in-time	Continuous improvement
Organisational design	5S	Product & process quality planning	Material supply	Prioritising
Goal-oriented teams	Maintenance systems	Quality assurance	Continuous flow processing	Problem solving methodology
Cross-functional work	Production levelling	Zero defect	Takt time	Design of improvement org.
	Standardised work		Pull systems	Improvement approach
			Flexible manpower	

Considering the content of the VPS, it must be considered as Volvo’s worldwide lean programme. This argument is also strongly reflected in the interviews and document analyses. Hill (2006) explicitly states that the TPS worked as the boundaries for the development of the VPS. The goals of the VPS, as shown in the next quotation, have an almost identical overlap with the goals of lean manufacturing (e.g. Womack *et al.*, 1990; Liker, 2004), and the subsequent representative quotation also confirms a tight relationship between the VPS and lean production.

VPS involves a common approach to reduce production costs and increase quality through identifying what creates customer value, doing it even better and avoiding unnecessary work. (Volvo Group, 2009, p. 20)

VPS does not have patents on its ideas. Volvo has taken well-known knowledge that there exists abundance of documentation on, and then chosen parts, maybe with exception of the Volvo Way which is unique. (VPS Recipient)

Evidently, the main VPS principles, except the Volvo Way, are largely lean principles and, hence, not *rare*. If the VPS principles are similar to those of all other XPSs in content, the

content of the VPS can at best provide competitive parity. Thus, the VPS becomes a necessary order-qualifier (c.f. Hill, 1995).

4.3 Inimitable

Arguably, a strategic resource can only provide a durable competitive advantage if it cannot be easily imitated by competitors. So far, the analysis indicates that the main content of VPS, except the Volvo Way, can only provide competitive parity. Because the five principles of the VPS are not fundamentally rare, they can by logic not be *inimitable* either. It remains to investigate the inimitability of the Volvo Way. In order to understand the path-dependency of the VPS and its relationship with the Volvo Way, a brief historical outline of the development of Volvo is needed.

4.3.1 Volvo's trajectory to the Toyota Production System

Volvo visited Toyota to learn the 'new Japanese management' already in the end of the 1970s (Berggren, 1993). In the early 1980s, Volvo Cars made several successful efforts to change the Torslanda plant into a just-in-time plant, with three main principles: increase through-put time, reduce waste and create pull production (Nilssen and Skorstad, 1986, 1994). Thus, contrary to a common impression that Volvo rejected lean production, Volvo was in fact a Western pioneer in lean production. What Volvo did, however, was to acknowledge the negative effects of line production on work attractiveness and aim to improve the working conditions while building on, not rejecting, lean production. Following the Scandinavian tradition of work-place democracy, worker participation and flat organisational hierarchies, reflected in the Socio-Technical System research (Trist and Bamforth, 1951; Emery and Thorsrud, 1969), Volvo developed and deployed a new trajectory to TPS and lean manufacturing in the automobile industry (Gyllenhammar, 1977; Berggren, 1992). This is known today as human-centred production (Wallace, 2004), or the reflective production system (Ellegård, 1995), which was implemented at the dedicated plants in Kalmar and Uddevalla, opened respectively in 1972 and 1989.

The human-centred production philosophy did not result in a clash with the main lean principles, but required an adaptation of them to the local setting (Berggren, 1993; Nilssen and Skorstad, 1994). In practice, the moving assembly line and the limited interpretation of teamwork were replaced with a dock assemblyⁱⁱⁱ performed by more autonomous teams that

had greater responsibility and joint decision power for the complete product from subassembly to final product. Volvo's CEO at that time, Peer Gyllenhammar, stressed that a key principle was that all employees in the assembly plant should have ownership of the final product (Gyllenhammar, 1977). Another key feature was the cooperative role of the union, contrasting the otherwise conflict-based relationship between employer and union traditional in other countries (Wallace, 2004). Moreover, Volvo allowed possibilities for the ambitious individual to quickly have a career in a dynamic organisation with a low hierarchy. This resulted in a broad competence raise across the organisation that again allowed for multi-skilled teams where employees could rotate in team positions as leaders, production planners, mentors, quality engineers or operators when needed (Wallace, 2004).

Despite the short-term positive effects (Berggren, 1993), the Uddevalla and Kalmar plants were closed down in 1993 and 1994 respectively, and the Volvo experiments were generally judged as failures (e.g. Womack *et al.*, 1990; Adler and Cole, 1993). Less known, however, is that the Volvo Trucks department also introduced dock-assembly in the Tuve and Arendal plants and exported the concept to the new plants in the USA and Brazil, and Volvo Buses established dock assembly in the Borås plant and in the UK plant (Berggren, 1992). Even if Volvo has left dock assembly and adopted line assembly in most of its facilities today, many of the principles of the humanisation approach are successfully kept alive within the Group.

4.3.2 Inimitability of Volvo Production System

Barney (1991) argued that an inimitable resource is either historically path-dependent, causal ambiguous and/or socially complex. The Volvo Group clearly has a unique historical trajectory, which was developed with great efforts over a long time, and is explicitly or subtly part of the VPS today. This inherent Volvo culture, labelled the Volvo Way, influences the organisational exploitation capabilities of the leadership, work organisation and teamwork principles of today's VPS. This feature is, in Barney's words, historically path dependent, causal ambiguous and socially complex and, hence, difficult to imitate for any competitor.

4.4 Organisational exploitation

The last but inevitable VRIO-requirement is organisational exploitation. Without organisational exploitation capabilities, the company will gain no effects from its valuable, rare and/or inimitable resources (Barney, 1997). Barney's (1997, 2011) requirements for

organisational exploitation are established reporting structures, management systems, control systems and compensation policies. Alongside the development of the VPS content, Volvo has put much effort into developing complementary resources and capabilities for successful VPS deployment and management.

Since 2007, VPS has been a part of Volvo's corporate strategy, supported by an organisational VPS *structure* and broad *management commitment*. With the launch in 2007, a new department called VPS Academy was established with a mission to be responsible for the initiation and support of the VPS globally. Volvo also built a worldwide VPS organisation, where each business unit has a VPS Global Coordinator and each plant has an appointed VPS Coordinator and in some occurrences a plant-internal VPS department. As the following quotation from corporate management promises, the VPS is an ever-lasting programme with unlimited top-management support:

The work with VPS is never finished. This is not a new campaign that will lose focus after a while. It's a way of thinking. A programme that will continue at all time. (Volvo Group, 2009, p. 23)

A VPS assessment regime acts as a *control system*, with belonging *compensation policies*. A complete methodology and tool for assessment have been developed (for a detailed description of the assessment methodology see Harlin *et al.*, 2008). The objective of the assessment is to measure each plant's maturity in the execution of the VPS principles and thereby drive performance. Today, the business units and plants engaging in the VPS typically go through an annual or bi-annual VPS assessment, and most plants in the global network have been assessed twice since 2007. Implementation of the VPS that leads to assessable results is compensated with praise. Besides the increased profits anticipated from the successful VPS implementation, there is no central remuneration-scheme at Volvo. The interviewees underlined that the business units still have a choice whether or not to implement the VPS, which is in line with Volvo's historically decentralised strategy. They argue that the VPS must be organically grown within the unit to take foothold and prosper. A main goal with the VPS is to build a learning organisation that is able to learn faster than its competitors, and move beyond competitive parity to competitive advantage, as illustrated by the quotation:

If we continue working with VPS, building the grounds, building a change culture and a learning organisation, then we can have competitive advantage. Others might be in front of us, but we can have a change-tact that is higher. (VPS Consultant)

5 Discussion

The aim of this paper was to explore if and how XPSs can contribute to sustainable competitive advantage also outside the Toyota case. Analysing the case of the VPS through the VRIO model of competitive advantage has led to some potential answers to these questions that we now discuss further. Our analysis has theoretical implications for the VRIO model that challenge the fundamental logic of the role of rarity and inimitability in the model. In the remainder of the paper, we develop research propositions describing the conditions under which an XPS can provide competitive parity, temporary competitive advantage and sustainable competitive advantage.

5.1 Extending the VRIO model

Our analysis shows that the VRIO model is a well-suited analytical framework for discussing XPS' contribution to competitive advantage. But our findings also support the criticism of the resource-based view that it is too static (Priem and Butler, 2001) and does not sufficiently encompass the time-dependent process factors that strongly affect XPS-type resources. The XPS as a resource is particular in two ways. First, because its value is time dependent, an XPS is based on continuous improvement and hence the value of the output is dependent on the time it has been deployed. This also means that its value is dependent on the speed and dedication in which it is implemented in the organisation. Secondly, its value is dependent on the strategic fit with the firm's business strategy.

The consequence is that even though the XPS *content* is hardly rare (R) and inimitable (I), it can still provide temporary or sustainable competitive advantage. If the organisational exploitation (O) of a valuable (V) XPS is characterised by the attributes 'superior speed' and/or 'superior fit' relative to the competitors, the XPS can move beyond giving competitive parity. This is illustrated in Figure 4 where we propose an extended VRIO analysis better suited to understand how XPSs can provide competitive advantage.

XPS content: Is the resource...? XPS process: Do the capabilities provide...?	Valuable	Rare	Inimitable
Organisational Exploitation Traditional VRIO	Competitive parity	Temporary competitive advantage	Sustained competitive advantage
Superior Speed Better process efficiency and/or effectiveness resulting in higher speed than among competitors	Temporary competitive advantage	Temporary competitive advantage	Sustained competitive advantage
Superior Fit Better fit and interplay with existing resources than among competitors	Sustained competitive advantage	Sustained competitive advantage	Sustained competitive advantage

Figure 4. XPS and competitive advantage – an extended VRIO model.

5.2 XPS and competitive parity

XPSs can increase competitiveness because they contain well-proven operational principles that bring along valuable results, given that the organisation has the capability to efficiently exploit the resource. As more and more companies develop and implement an XPS globally, the XPS becomes a necessary resource for maintaining competitive parity. This is in line with the original VRIO model (Barney, 1997). Thus, in industries where an XPS is widespread, the co-existence of V and O in the VRIO model leads to the following proposition:

- Proposition 1: *In industries where the use of an XPS is commonplace, the adoption of an XPS is a necessary resource to achieve competitive parity.*

5.3 XPS, time advantages and temporary competitive advantage

The contents of XPSs are heavily inspired by the TPS, lean production and benchmarking studies of other companies' XPSs. It is, therefore, hard to argue for fundamental rarity and inimitability among the content of most XPSs. According to the VRIO model, an XPS cannot provide competitive advantage if the resource is not rare and inimitable (Barney, 1997). However, our explorative study of the VPS indicates that there are exceptions to this rule. Because there is heterogeneity in the organisational exploitation of an XPS, as argued by the dynamic capabilities perspective (Teece *et al.*, 1997), companies can potentially enjoy a

competitive advantage if the resource adaptation process enjoys an absolute or relative time-advantage compared with competitors.

An XPS is a type of resource that increases in value over time. This is a feature that we know from the TPS, have seen in the discussion of the VPS, and is generally acknowledged in the literature on XPSs. The rationale is that an XPS brings along continuous improvement in competitive priorities such as costs, quality, delivery and flexibility. The return of investment on an XPS follows a path-dependent logic as described by Dierickx *et al.* (1989). This means that early adopters can enjoy a temporary competitive advantage. Hence, we propose:

- Proposition 2a: *An XPS can become a source of temporary competitive advantage if it is adopted ahead of competitors in the same industry, even if the XPS content is not rare and inimitable.*

XPS-followers can also move beyond competitive parity. Given that the organisation either has the ability to implement the XPS content faster (process efficiency), or reap more benefits from its XPS content (process effectiveness), it can render the organisation with a temporary competitive advantage. For the latter to hold true it is absolutely necessary that the XPS process is fuelled by organisational commitment and dedication, leading to rooted implementation and not only skin-deep rhetoric. This argument has support in the dynamic capability perspective of superior resource deployment (Teece *et al.*, 1997; Makadok, 2001). Thus, higher implementation speed, either as process efficiency or process effectiveness, can provide temporary competitive advantage even if the XPS is a non-rare and imitable world standard:

- Proposition 2b: *If the speed of the XPS implementation in terms of process efficiency and/or process effectiveness is superior to that of its competitors, the XPS can provide temporary competitive advantage even if the XPS content is not rare and inimitable.*

5.4 XPS, uniqueness and sustainable competitive advantage

The VPS case upholds that an XPS can provide sustainable competitive advantage under the condition that its implementation process has a superior fit with the organisation's history, culture and strategies, compared to a competitor's XPS. We argue that this holds true even if the XPS content is publicly available and well-known, hence non-rare and imitable. No company can become better than Toyota on the TPS because Toyota's organisational

exploitation of the TPS fits perfectly with Toyota's current strategy and historical capability and development. Similarly, Volvo can turn its VPS into a sustainable competitive advantage if it is designed to enhance the long developed strategic capabilities that form the basis for its current business strategy. Specifically, we have seen this in the Volvo case, where the human-centred production philosophy provides Volvo with a competitive advantage on mass customised, medium-volume and high-tech products. If the XPS is bundled with existing valuable, rare and inimitable resources it could enhance the overall competitiveness of the firm and turn the XPS into a sustainable competitive advantage. Hence, we propose:

- Proposition 3: *An XPS can provide a sustainable competitive advantage if it has a superior fit with existing valuable, rare and inimitable strategic operational resources and capabilities that form the basis of the firm's current and future business strategy.*

5.5 Implications for practitioners

Implications for practitioners follow directly from the propositions. First-movers can extract a sustainable competitive advantage from the implementation of XPSs, but only if competitors in the industry hesitate to do the same. However, with the development trend of XPSs that we see today, it is unlikely that early-movers will enjoy more than a temporary advantage. Rather, in the long run the implementation of an XPS becomes a necessary move in order to achieve competitive parity as such systems become commonplace. Likewise, a rapid and dedicated implementation of an XPS can provide the company with a temporary competitive advantage and even a way to catch up with early movers, but it is not likely to provide the firm with durable advantages.

It is, rather, in terms of implementation and organisational exploitation that we find the most interesting implications for competitiveness. We know from previous studies that an XPS can provide a firm with operational excellence in cost reductions, increased quality, innovation and sales, but our findings also suggest that an XPS could be a valuable tool to refine and enhance current core strategic operational resources and capabilities. If applied in this manner, an XPS could provide the company with sustainable competitive advantage.

Managers must be aware of the joint optimisation of content and process needed for an XPS to give the desired effects. If competitive parity is the goal, one can probably achieve it by introducing off-the-shelf practices for lean production, TQM, six sigma or similar

programmes by copying another XPS. On the other hand, if one seeks sustainable competitive advantage, the XPS process and content must be rooted in the path-dependent strategic process of the firm and uniquely designed to strengthen the existing strategic resources of the firm.

6 Conclusions

The growth and importance of company-specific production systems (XPSs) in multinational companies is indisputable. Companies continue to use large amounts of financial and human resources for developing, deploying and maintaining their XPS. However, the true costs and pay-offs of such corporate-wide improvement programmes are not well understood. Applying the resource-based view's VRIO model to an XPS, this paper has investigated if and how XPSs could provide companies with a sustained competitive advantage.

We argue that even though the VRIO model is well suited for analysis, it cannot fully explain the potential for achieving competitive advantage through resources such as an XPS. Contrary to what the VRIO model suggests, the process of deploying XPSs can lead to temporary and sustainable competitive advantage, even if its content is not rare and inimitable. We propose expanding the O-attribute of the VRIO model to include process attributes of speed and fit (c.f. Figure 4). The updated VRIO model better explains the process side of a time-dependent composite resource such as an XPS.

In industries with widespread XPS implementation, an XPS becomes a necessary resource for sustaining competitive parity. Early-starters get an instant, temporary competitive advantage. If the deployment of the XPS in late-starters happens faster than among competitors, the XPS can provide a temporary competitive advantage. Finally, an XPS can potentially provide sustainable competitive advantage if the XPS has a unique fit with other strategic resources that are rooted in the company's path-dependent history, organisation and environment.

6.1 Limitations and further research

This explorative study has limitations both in its theoretical foundation and methodology. The paper positions itself within Voss' (1995) best practice paradigm of operations strategy, taking an implicit assumption that some operations practices are superior to others. If a variety of operational practices can lead to the same performance, then our propositions do not hold.

Thus, the implications of violating the original S-attribute (non-substitutability) of Barney's (1991) VRIS model have not been discussed much in this paper.

A major methodological limitation of the study is the single case study design, which makes it difficult to argue for a general validity from the VPS to an XPS of the propositions set forward. We have also limited the study to the part of the VPS that aim to improve Volvo's globally dispersed *manufacturing* operations, and hence not investigated the effects of Volvo's recent efforts in expanding the VPS-thinking to the product development processes and aftermarket and support processes. In this respect we underline that the paper set out to be explorative and theory-generating, and, hence, not theory-testing.

To test the validity of the enhanced VRIO model, its implications and the propositions, we encourage quantitative studies of industries where XPSs are widespread and longitudinal single-case studies of the effects of an XPS outside Toyota.

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Notes

ⁱ Company-specific production systems (XPSs) are corporate improvement programmes that aim to raise the operational performance level throughout the global production network by sharing, using and improving a standardised set of corporate values and operational practices. By the term XPS we include similar labeling variants, such as 'Business System' (e.g. Alcoa, Danfoss), 'Manufacturing System' (e.g. Electrolux, Airbus), 'Production Way' (Nissan) or unique labels such as 'cLEAN' by Novo Nordisk or 'Synchro' by Trumf. Because 'company name' production system is by far the most common label (e.g. Toyota, Boeing, Volvo, Mercedes, Borsch, Scania, Cummins, etc.), the abbreviation XPS is chosen to cover all these variants of corporate-wide improvement programmes.

ⁱⁱ Note that this paper is concerned with the Volvo Production System's 'order-to-delivery process' (VPS OtD). This was the first VPS launched within the Volvo Group in 2007, and aimed mainly to improve the manufacturing operations of the Volvo Group. In the last years the VPS has expanded to also include models for the 'product development process' and it is in the process of expanding to the 'aftermarket and support processes' as well. When we refer to VPS in this paper we refer solely to the VPS OtD content and process.

ⁱⁱⁱ In dock-assembly the vehicle is moving on a docking station rather than on a conventional production line. The docking station is moved sequentially between sub-assembly teams that complete several assembly operations. This is in contrast to single-operation stations at a constantly moving assembly line. In effect the tact time increases, whereas more flexibility and humanisation of work is gained.

Paper 4: The effects of a production improvement programme on global quality performance: The case of the Volvo Production System

Paper 4

Effects of a production improvement programme on global quality performance: The case of the Volvo Production System

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Abstract

Purpose: How can multinational companies become more productive on a global scale? This paper investigates whether a production improvement programme can improve quality performance in a global network of factories. Specifically, we analyse the effects of the Volvo Group's production improvement programme on global quality performance.

Methodology: Our research approach is a case study of the Volvo Production System. We analyse the effects of the programme on global quality performance, using data from an implementation audit and a questionnaire survey. We triangulate the analysis with longitudinal quality performance data from three different plants.

Findings: We find a significant and strong positive relationship between implementation of the Volvo Production System and improvements in both process quality and product quality. Hence, we suggest that tailored production improvement programmes have clear positive effects on global quality performance.

Research limitations: As with all case studies, we should use caution when generalising beyond the specific case. However, the Volvo Group is a broad and diversified corporation, which mitigates this limitation.

Originality: While many studies have investigated the effect of production improvement programmes on performance, very few have looked at the effect of a corporate multi-plant

programme. This study represents one of the first attempts to do so. We also provide a case description of the Volvo Production System that readers might find valuable in its own right.

Keywords: improvement programme; quality management; quality performance; production system; global operations management; lean production; Volvo

1 Introduction

As a result of the increasing globalisation of firms, it has become a trend to roll out group-wide production improvement programmes. Inspired by the success of the Toyota Production System (TPS), such a programme is often labelled ‘your-company-name-here’ production system (XPS). By implementing an XPS, a corporation aims to adopt, synthesise and adapt well-known production philosophies, such as total quality management (TQM), just-in-time (JIT), six sigma, lean production and so on, in view of its specific environment, characteristics and needs.

Even though a positive link between different types of improvement programmes and resulting performance is well established in the literature, there is surprisingly limited knowledge about the performance effects of a global, group-wide approach. In this paper, we contribute to the on-going debate about the effectiveness of production improvement programmes by investigating the Volvo Group’s global implementation of the Volvo Production System (VPS).

Launched in 2007, the VPS provides principles, tools and guidelines for how all units in Volvo’s global production network should work to reach operational excellence. The overall aim of implementing and sustaining the VPS is to reach world-class performance in six defined competitive priorities: safety, quality, delivery, cost, environment and people (abbreviated to SQDCEP) (Volvo Group, 2010a). As illustrated in Figure 1, VPS is a never-ending endeavour to improve SQDCEP. To support this effort, Volvo uses *VPS assessments* in which gap-analyses identify what practical tools and techniques to deploy in each plant.

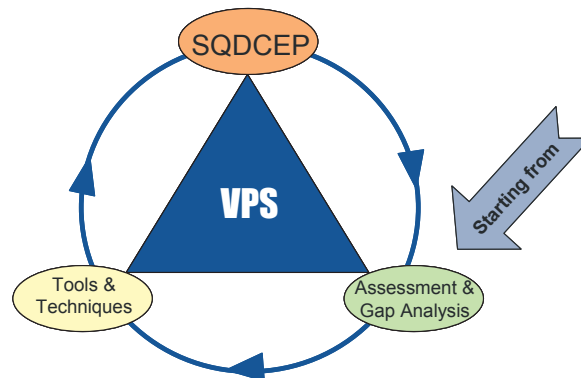


Figure 1. The never-ending VPS implementation loop (source: Volvo AB).

In this paper, we focus on the system’s effect on global quality performance (the ‘Q’ in SQDCEP). We investigate the association between implementation of the VPS and quality improvement in Volvo’s global production network. We choose to focus explicitly on quality because it is considered the most fundamental capability to build (Ferdows and De Meyer, 1990). Improving quality performance has always been a common objective of all improvement philosophies (Schonberger, 2007). We therefore ask: does an XPS deliver the promised quality improvement across plants in a global production network?

2 Background

To improve productivity on a global scale, many multinational companies have developed their own company-specific production systems (XPSs) (Neuhaus, 2009; Netland, 2013). For example, Honnef *et al.* (2000) described how the XPSs of Ford, Opel, Audi, Daimler Chrysler and Mercedes-Benz were developed. Lee and Jo (2007) showed how the TPS was ‘mutated’ into a similar, yet distinctive, Hyundai Production System. Netland (2013) analysed the content across 30 such systems—including the Alfa Laval Production System, Bosch Production System, John Deere Quality and Production System and Scania Production System, to mention only a few.

The guiding objective of an XPS is that the corporation as a whole operates in alignment with the same set of principles and improves according to the same system. This way, XPSs can be seen as an advancement of *integrated management systems* (IMSs) (Khanna *et al.*, 2010; Leopoulos *et al.*, 2010; Casadesús *et al.*, 2011). IMSs emphasise the need for a holistic improvement system that has a broader scope than ISO certification¹ (Asif *et al.*, 2010). The

aim is to reuse proven operational practices in multiple locations to leverage knowledge and ultimately increase competitiveness (Netland and Aspelund, 2013).

For Deming (1986), competitiveness starts with *quality*. It makes sense to distinguish between *process quality* and *product quality* (Taguchi, 1986; Garvin, 1988). Process quality describes the quality of the manufacturing processes, whereas product quality specifies the quality of the result. It is possible to achieve good process quality without good product quality and to achieve good product quality without good process quality. The first would be the result of an ineffective—but efficient—production system based on a poor understanding of the customer’s need. The latter would be the result of an inefficient—but effective—production system characterised by wasteful processes. Both, of course, are undesirable: the intention of an XPS is to improve process quality and product quality simultaneously.

The literature suggests that implementation of quality practices leads to improved quality performance—both in terms of product quality (e.g. Forza and Filippini, 1998; Cua *et al.*, 2001; McKone *et al.*, 2001) and process quality (e.g. Flynn *et al.*, 1995; Shah and Ward, 2003). Positive associations with improvements in quality performance have been established for various improvement programmes, such as TQM (e.g. Fotopoulos and Psomas, 2010), JIT (e.g. Fullerton and McWatters, 2001), total productive maintenance (TPM) (e.g. McKone *et al.*, 2001), six sigma (e.g. Swink and Jacobs, 2012), IMS (e.g. Casadesús *et al.*, 2011), high-involvement work practices (Wickramasinghe and Gamage, 2011) and lean production (e.g. Shah and Ward, 2003). Also, meta-reviews of the literature have found convincing support for the positive relationship (e.g. Sousa and Voss, 2002; Nair, 2006; Mackelprang and Nair, 2010).

This is why ‘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’ (Sousa and Voss, 2008, p. 697). We investigate whether the same set of quality practices, packaged together with other practices in an XPS, can be effective if deployed simultaneously in a global network of plants. A contingency perspective would suggest a limited effect. Considering the existing literature on single-plant implementation, however, we hypothesise that it is an effective strategy:

- Hypothesis 1: *The implementation of an XPS will be positively associated with process quality performance in the plants.*

- Hypothesis 2: *The implementation of an XPS will be positively associated with product quality performance in the plants.*

3 Methodology

In order to test our hypotheses, we employed a case study methodology (Stake, 1994; Yin, 2003). A case study can be defined as ‘empirical research that primarily uses contextually rich data from bounded real-world settings to investigate a focused phenomenon’ (Barratt *et al.*, 2011, p. 329). Specifically, we investigated the worldwide implementation of VPS in the Volvo Group. The research was performed in close cooperation between Volvo Group practitioners and the first author, in line with the Scandinavian research tradition in operations management (Karlsson, 2009). We used multiple sources of data—both quantitative and qualitative—to triangulate our analyses and hence improve the validity of the results (Voss, 2009).

3.1 The Volvo Group and the Volvo Production System

The Swedish Volvo Group develops and produces high-tech products in the transportation industry. With its more than 100.000 employees, sales operations in 185 countries and plants in 20 countries, it is a truly global company. As a growing and increasingly dispersed and fragmented company, the Volvo Group decided in 2005 to carry out a group-wide XPS initiative. Many Volvo plants experienced extensive price competition from new economies such as China, and needed to embark on lean production projects in order to lower production costs while improving quality and reducing delivery times. An internal pre-study concluded in 2005 that ‘the benefits of a common Volvo Production System would be maximum use of resources, better communication within the company group, sharing of the best practices, industrial and personnel mobility and reduced duplication of effort’ (Hill, 2006, p. 1).

The VPSⁱⁱ was launched in 2007. Its key difference from earlier improvement projects is that it was designed to function as a never-ending programme: ‘The work with VPS is never finished. This is not a new campaign that will lose focus after a while. It’s a way of thinking. A programme that will continue at all times’ (Volvo Group, 2009, p. 23). In other words, implementing the VPS is a continuous process. The VPS is intended to instil a more unified Volvo culture. The VPS provides ‘the vision and framework of principles and tools designed to guide us in creating value for our customers by increasing the quality, securing the

delivery, and lowering the cost of the products we produce' (Volvo Group, 2010a). The VPS model is shown in Figure 2. It consists of five main principles: teamwork, process stability, built-in-quality, continuous improvement and just-in-time. At the foundation are the corporate values (the Volvo Way), and the inherent customer orientation is represented at the top of the pyramid. The VPS comprises 22 modules, including a range of tools and techniques.

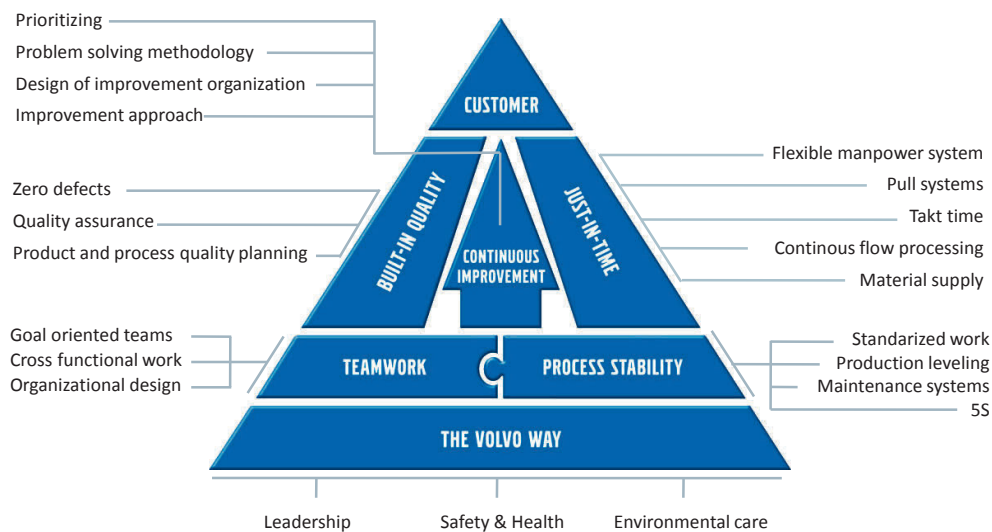


Figure 2. The Volvo Production System pyramid (Source: Volvo AB).

3.2 Independent variable: Implementation of VPS quality practices

In order to measure the level of implementation of the VPS in the plants, we took advantage of full access to original VPS assessment data. These data have been qualitatively collected through a standardised VPS assessment led by employees from the centralised VPS Academy. The assessments are carried out through a physical plant visit over three to four days, led by two VPS assessors from the Academy together with assessors from other Volvo plants. The assessments follow a standard procedure. A clearly defined assessment score scheme is used, in which the plants are assessed according to their implementation of the 22 VPS modules.

The assessments determine whether the system is in place and whether business results are improving in the correct order for continuous improvement (cf. SQDCEP): 'The assessments should be seen as one source that will help the plants to prioritise the efforts on the most urgent and beneficial areas. The objective of the plant assessment is also to stimulate the

discussion around deepened capabilities and create renewed motivation to improve. The assessments are also a way to create transparency of the use of VPS principles across all plants within the Volvo Group, and a way to follow the development of each individual plant over time. The assessments help the VPS Academy to collect best practices and then share them within the Volvo Group' (Volvo Group, 2010b). For all VPS principles, a continuous scale from 0 to 5 is used to assess implementation (0 = nothing, 1 = basic initiatives, 2 = structured approach, 3 = established, 4 = outstanding, 5 = perfection). For a thorough discussion of the VPS assessment, see Harlin *et al.* (2008).

Because we focus on the quality dimension, we used the plant assessment scores for the built-in-quality (BiQ) principle (see the VPS pyramid in Figure 2). The BiQ principle consists of four modules with approximately 100 itemsⁱⁱⁱ to assess. The four modules are quality culture, zero defects, quality assurance and quality planning. A lower BiQ score suggests a poorer implementation of quality tools and techniques in the plant (but not necessarily poorer quality performance). Correspondingly, a higher BiQ score indicates that a better quality system is in place. Because the BiQ score is a composite quality measure, we maintain that it represents a robust and valid measure of the plant's overall implementation of quality practices. We have assessment data for 48 plants in Volvo's network. For the purpose of eliminating the bias of different assessment versions, we normalised all the data within the different versions when we compared the plants.

3.3 Dependent variables: Process and product quality performance

To measure the dependent variable, we chose key performance indicators (KPIs) that represent process- and product quality performance, respectively. A suitable measure for *process quality* is *first-time-through* (FTT)^{iv}. FTT measures the percentage of units that are produced correctly—without flaws or need for rework—the first time they pass through the process or value stream. If products are produced correctly the first time, it signifies a good process quality. We measured *product quality* with the KPI *customer satisfaction* (CS). CS is typically measured inversely as 'number of customer complaints' (CC) in parts per million (ppm) for all orders delivered. Customers are expected to be satisfied with the product quality only if it meets or exceeds their expectations. For triangulation purposes, we collected the data from two different sources: a questionnaire survey administered in all Volvo plants and longitudinal KPI data collected from three in-depth case studies of plants.

First, the survey directly asked the following questions: ‘How has VPS affected the FTT in the last two years?’ and ‘How has VPS affected the CS in the last two years?’ Both questions were measured on a five-point Likert scale from ‘significant negative impact’ to ‘significant positive impact’. In order to control for moderating factors, we included measures for *plant size* (current number of employees), *plant age* (decade of start-up) and *unionisation* (degree of union membership). The survey was distributed to contact persons in Volvo’s 60 plants on all six continents. We asked for three to eight respondents drawn from managers at different hierarchical levels in each plant, depending on the size of the plant. After several iterations of reminders, we received 305 responses from 56 plants. On average, 5.5 managers in each participating plant responded to the survey. Responses from each plant were merged into a single average score for that plant.

Second, we collected longitudinal performance data from a few representative plants to triangulate the results from the survey analysis. We chose three different plants, each located in a different part of the world and representing a different product group: a South American truck powertrain plant, a Scandinavian construction equipment plant and a European truck assembly plant. All plants had records of FTT performance (the calculations differ among the plants). Whereas two plants measured CC as complaints in ppm, the third plant measured CC as the number of claims from the customer after first month of use (‘fault frequency first month’).

4 Analysis

We first investigate the two hypotheses quantitatively, using data from the global survey and the VPS assessments. Thereafter, we analyse longitudinal performance data from three plants that have worked seriously with the implementation of VPS since 2007. Triangulating the results from these different analyses, we explore the effects of VPS implementation on both types of quality performance.

4.1 Global survey data

A correlation analysis shows a significant and strong positive correlation between VPS implementation and the two dependent variables: Pearson’s r is 0.41 for FTT and 0.46 for CS, both at a 0.01 significance level. We included plant size, plant age and degree of unionisation as control variables. However, as we found non-significant and weak correlations between the

control variables and both independent variables, we did not include them in the subsequent regression models. In Figures 3 and 4 we have plotted the two hypothesised relationships for the 45 plants in the sample and added the corresponding linear regression models.

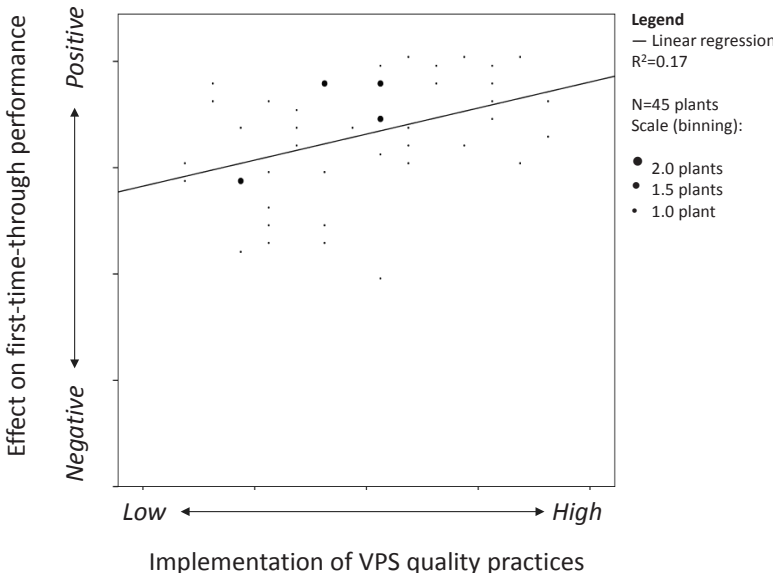


Figure 3. The effect of VPS implementation on FTT performance (Hypothesis 1).

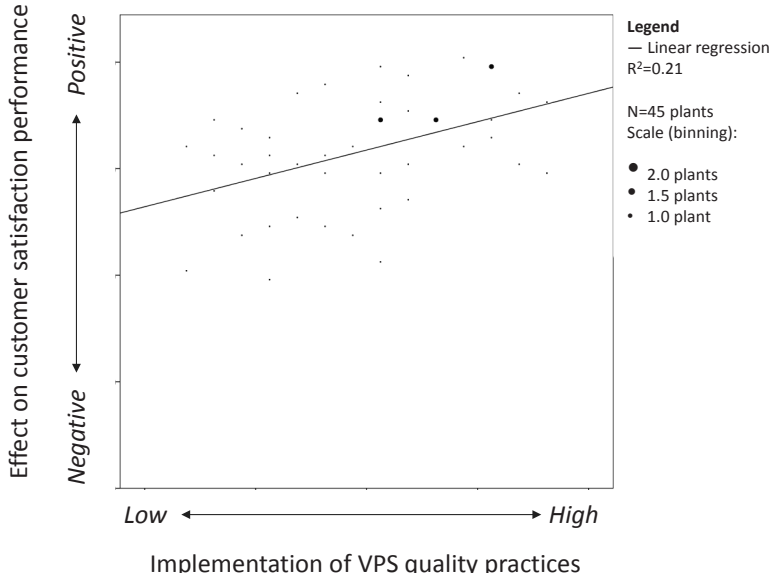


Figure 4. The effect of VPS implementation on CS performance (Hypothesis 2).

The linear regression models support the causality we hypothesised. We find that the implementation of VPS quality practices explains 17% of the variation in FTT performance (the coefficient of determination, R^2 , is 0.17). Similarly, implementation of the same practices explains 21% of the variation in CS performance (R^2 is 0.21). Both are significant at a 0.01 significance level. Thus, this analysis lends support to both hypotheses.

4.2 Case 1: Powertrain plant in South America

The first plant we choose to investigate is one of the few plants that have been subject to four VPS assessments. The plant manufactures transmissions and cylinder blocks and assembles truck engines. It employs 400 people. The method used for implementing the VPS in the plant is the *world-class manufacturing* (WCM) method developed by Professor Hajime Yamashina at Kyoto University in Japan. Despite a challenging 2011 with several new start-ups, it was ‘the plant’s best year ever’. The VPS manager convincingly claims: ‘I can assure you; this comes from our VPS work using the WCM method’. Table 1 shows the development of BiQ scores, FTT and CC from 2007 to 2011.

Table 1. Longitudinal KPI data for truck powertrain plant in South America (2007-2011).

Year KPI	2007	2008	2009	2010	2011	Average annual improvement
BiQ score	2,0	2,5	2,4	n/a	2,9	10%
First-time-through	78,5%	88%	94,2%	95,5%	96,1%	5%
Customer complaints	12.100 ppm	2465 ppm	1466 ppm	1221 ppm	905 ppm	41%

Since the introduction of VPS in 2007, the plant has shown rapid improvements. Whereas the implementation of quality practices, on average, has increased by 10% annually, FTT has improved by 5% annually, and the number of customer complaints has decreased by 41% annually. The data from this plant support both our hypotheses.

4.3 Case 2: Construction equipment plant in Scandinavia

The second plant employs approximately 900 people. It manufactures powertrain parts for heavy construction equipment. In this plant, the journey to lean production started with an extensive reengineering project in 2007. Before that, there had been isolated attempts at TPM, work place organisation (5S) and so on, none of which were sustained for a significant period. As a result of the reengineering, the plant changed from a traditional layout, where machining

was done in functional cells and operators built complete transmissions and axles on stations, to a flow orientation, where machining is done in flow-oriented cells and assembly is performed on small lines. The transformations were carried out cell station after cell station, with three proceeding transformation projects at a time lasting 12 weeks each. Ten VPS coaches supported and led the transformations from 2007 to 2010. Since then, the plant has worked relentlessly to implement VPS in daily work and throughout the organisation. Table 2 shows the development of BiQ scores, FTT and CC from 2007 to 2012.

Table 2. Longitudinal KPI data for construction equipment plant in Scandinavia (2007-2012).

KPI	Year						Average annual improvement
	2007	2008	2009	2010	2011	2012	
BiQ score	0,67	n/a	0,94	n/a	1,61	n/a	22%
First-time-through	n/a	n/a	n/a	n/a	94,2%	95,4%	1,3%
Customer complaints	n/a	9414 ppm	8683 ppm	3068 ppm	1995 ppm	1889 ppm	28%

Because this plant started with less practices implemented than the previously discussed plant (cf. BiQ scores), it has been relatively easier for it to implement more practices faster than for the first plant. We only have FTT data for the last two years, but we believe that since 2007 the process quality has improved much more rapidly than the suggested annual improvement of 1.3%. As demonstrated by the 28% annual decrease in CC, product quality has been gradually improving at the plant. Again, the data from this plant lends support to both hypotheses.

4.4 Case 3: Truck assembly plant in Continental Europe

The third plant we investigate is a truck plant in Europe. More than 2000 people are employed at the site, which consists of several factories in a truck-building supply chain. The plant launched its own XPS already in 2005. However, the VPS manager explains that ‘before 2007 there were no big improvements’. Then, in 2007, there was a top-management requirement to restart the programme as VPS. With helpful coaching from Japanese Volvo employees, the plant has since made significant improvements in productivity. The VPS manager stresses the following: ‘VPS is a success. It makes us work on all processes simultaneously, and not in isolation. Before we did not have a common culture, but today, we have a common language, and all work in the same way. It is almost like a religion’. Table 3 shows the development of BiQ scores, FTT and CC from 2007 to 2012.

Table 3. Longitudinal KPI data for truck assembly plant in Europe (2007-2012).

KPI	Year						Average annual improvement
	2007	2008	2009	2010	2011	2012	
BiQ score	n/a	2,33	n/a	2,48	2,43	n/a	1%
First-time-through	47%	65%	73%	74%	76%	75%	10,7%
Customer complaints*	n/a	0,18	0,15	0,17	0,14	0,08	16%

* Measured as claims from the customer after one month of use ('fault frequency first month')

This plant has made considerable strides in implementing the VPS. It is highly regarded in its region for its operational excellence. By 2008, the plant had already reached a relatively high level of VPS implementation. The 1% improvement in VPS implementation is better than it seems, as the requirements for a high score in the assessment have intensified a great deal over the years. Both the process quality (measured by FTT) and the product quality (for this plant, measured by 'fault frequency first month') have improved considerably since 2007. Again, the performance data and the stories of managers leave minimal reason to doubt that VPS implementation has had a positive effect on the plant.

5 Discussion

The analyses of the survey data and case data establish a positive association between implementation of VPS quality practices and aggregate quality performance. Hence, our paper supports the literature that claims positive links between quality improvement programmes and quality performance. An original insight of our study is that quality practices seem effective also when they are packaged with other improvement practices in an XPS and deployed simultaneously in a global network of plants (also outside the Toyota case). Based on our data and in-depth knowledge of the Volvo plants, we suggest and discuss three plausible explanations for why XPSs prove effective in improving quality performance:

- Some quality practices are universally effective.
- A holistic XPS approach to improvement is effective.
- External pressure for implementing an XPS in a plant is effective.

One explanation for the positive relationship might simply be the universal validity of some superior quality practices. Nair (2006, p. 948) writes that 'it is now widely believed that the underlying practices in quality management are fundamental and essential for effective management and competitive survival of organisations'. The considerable amount of

empirical research that finds a positive effect of various quality practices lends strong support to this explanation. Thus, even if contingencies matter, they might not matter much for quality practices such as those in the VPS. After half a century of research on quality practices—from quality circles to total quality management, six sigma and lean production—we know what works.

A second potential explanation for the positive results is that an XPS represents a *holistic* approach to improvement. In an XPS, the ‘best of’ JIT, six sigma, TQM, lean production and so on can be strategically selected by the firm. It might be that quality practices are effective, precisely because they are packaged with complimentary practices in the XPS. Researchers like Cua *et al.* (2001) and Flynn *et al.* (1995) suggest that the *concurrent* implementation of TQM and JIT yields synergies that go beyond the sum of their individual effects. This argument finds further support in the literature on IMS that suggests a holistic approach to improvement (e.g. Khanna *et al.*, 2010) and in the contingency perspective that suggests that improvement programmes should be tailored to individual corporate strategies (e.g. Sousa and Voss, 2008).

A third explanation is that the XPS—in contrast to many other temporary improvement *projects*—is a serious and lasting improvement *programme*. For the plants, the XPS comes with lasting pressure and support from the headquarters to implement the system. Abundant research has established that management commitment is the most important critical success factor (e.g. Crosby, 1979; Deming, 1986; Garvin, 1988; Brady and Allen, 2006). Because embarking on an XPS is a costly decision, top management ensures that the necessary management commitment is sustained over time in the dispersed network of plants. Volvo’s assessment scheme for VPS implementation is a good example of how this commitment manifests itself in both requirements and assistance over time. Such external pressure to implement an XPS is effective in improving performance.

Of course, a combination of the three explanations is most likely taking place. As the contingency perspective suggests—and our analysis of three different Volvo plants shows—different plants have different needs and motivations for the implementation of an XPS. This is also a likely explanation for why the plants experience different levels of quality improvement. Nevertheless, the XPS appears effective for all plants.

6 Conclusions

In this paper, we investigated the effects on global quality performance of deploying a corporate production improvement programme in a multinational company. We distinguished between process quality (measured by first-time-through) and product quality (measured by customer satisfaction) and hypothesised that the implementation of an XPS in a worldwide network of plants would improve both. The results of a survey questionnaire, administered in all Volvo plants worldwide, indicated strong and significant support for our hypotheses. We controlled for the moderating effects of plant size, plant age and degree of unionisation, but found that these factors could not explain the differences in performance. Three longitudinal cases affirmed that greater implementation of quality practices—as described by the VPS—co-occurred with increased factual quality performance in both dimensions for the plants. To the best of our knowledge, this is the first study to investigate the relationship between the implementation of an XPS and the associated quality improvement in a global production network.

Considering the importance and magnitude of XPSs in industry, we call for more research in this area. Research should elaborate on the effects of XPSs on *all* competitive priorities (SQDCEP) and ultimately aim to demonstrate the implications for overall costs and profits. Interestingly, we found that different plants follow different implementation routes and that they all tend to maintain that *their* roadmap is the right one. Hence, we encourage researchers to test and describe normative roadmaps that help multinational corporations to develop, deploy, manage and sustain better XPSs. As business continues to globalise, topics similar to the one discussed in this paper will only become more important.

7 Acknowledgements

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Notes

ⁱ International Organization for Standardization (ISO) is responsible for the ISO 9000 quality management standards, ISO 14000 environmental care management standards and other international standards (www.iso.org).

ⁱⁱ In this paper, we are concerned with the Order-to-Delivery processes (OtD). VPS OtD shall improve the manufacturing operations in all Volvo plants. Volvo has also developed similar, but separate, VPS models for the product development processes and for the business services processes.

ⁱⁱⁱ Number of items vary slightly for different versions of the VPS assessment (version 2.0 had 99 items).

^{iv} FTT is also known as first-pass-yield; first time quality; direct runners; direct OK; and direct green tag. The FTT score depends on the number of quality control gates in the process (the more gates, the harder to get a good score).

**Paper 5: How do company-specific production systems
affect plant performance?**

Paper 5

Is not included due to copyright

Make it simple, but significant.

(Don Draper, Mad Men, Season 4, Episode 6)