From Successful to Sustainable Lean Production: The Case of a Lean Prize Award Winner

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From successful to sustainable Lean production – the case of a Lean Prize Award Winner

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Many improvement programmes often fail to sustain over an extended period of time. Previous research suggests that a similar set of factors influence the success and sustainability of an improvement programme. The purpose of this paper is to make a distinction between the success and sustainability of improvement programmes, and to identify mechanisms that specifically contribute to the sustainability. In this paper, we study a sustainable improvement programme from the perspective of complexity theories that stress the importance of studying change as a dynamic process of interacting elements and events unfolding in time. We conducted a longitudinal, in-depth case study of a Swedish Lean Prize Award Winner where a Lean improvement programme was studied over 9 years. An improvement programme is successful if goals are achieved and the targeted problems are resolved. Furthermore, the first-order sustainability means the ability to sustain results and the second-order sustainability means the ability to keep an improvement programme alive. The lessons identified from complexity theories, such as destabilising the organisation, ensuring novelty and constant flow of change or self-organisation at the team level, are examples of mechanisms important to achieve the sustainability of the improvement programme.

\textbf{Keywords:} improvement programmes; sustainable change; Lean production

\section{Introduction}

Although several studies have reported that working with Lean production can lead to substantial improvements in quality and productivity (Fullerton, Mcwatters, & Fawson, 2003; Huson & Nanda, 1995), implementing Lean production seems to be associated with difficulties, mainly sustainability problems (Chakravorty & Hales, 2016; Hines, Found, Griffiths, & Harrison, 2008; Mann, 2005). Many Lean initiatives begin with great promise but slowly regress back to the ‘old ways’ (Brown, Schmitt, & Schonberger, 2015). Keating, Oliva, Repenning, Rockart, and Sterman (1999) referred to this as the improvement paradox, wherein companies find it difficult to sustain even initially successful improvement programmes. Even more puzzling, improvement programmes sometimes worsen business performance, trigger layoffs, lower morale and collapse employee commitment (Dervitisiotis, 2001; Hicks & Matthews, 2010; Keating et al., 1999).

A number of prescriptions on how to manage improvement programmes exist, such as creating understanding and motivation, establishing and communicating a vision and strategy, committed leadership, involving employees in change activities, creating short-term wins and
alignment with the value system (e.g. Appelbaum, Habashy, Malo, & Shafiq, 2012; Beer & Nohria, 2000; Benson, Kimmel, & Lawler, 2013; Burnes, 2011; Canning & Found, 2015; Higgs & Rowland, 2011; Kettinger & Grover, 1995; Kotter, 1995). In the literature, these prescriptions are often presented as general recommendations for any particular organisational change initiative. Despite so many change success factor studies, improvement programmes still have a high failure rate (Alvesson & Sveningsson, 2016; Burnes, 2011). Why is it so hard to sustain an initially successful improvement programme? We believe that the problem lies in how we view and study improvement programmes. Change processes are often seen as single and isolated events (Meyer & Stensaker, 2006), a view that assumes that improvement programmes have a clear beginning and end with a specific objective. Improvement programmes, however, assume change process continuity where the development of one element builds on another (Graetz & Smith, 2010). Studying an improvement programme as a single and isolated event might be able to identify a set of factors that are important for its success but not necessarily for its sustainability (Brulin & Svensson, 2016; Meyer & Stensaker, 2006). We believe that improvement programme sustainability can be studied only by seeing organisational change as a dynamic process that is continuously shaped through complex social interactions. Improvement programme sustainability cannot be explained by studying the individual elements but needs to be considered as a system of interrelated and interacting elements evolving over time.

The differences between successful and sustainable change are not clearly discussed in the literature: terms are often used interchangeably and authors who specifically study improvement programme sustainability propose a similar set of prescriptions as the authors focusing on successful improvement programmes (e.g. Bateman & David, 2002; Brännmark & Benn, 2012; Buchanan, FitzGerald, & Ketley, 2007; Dale, Boaden, Wilcox, & McQuater, 1997; Hayes, 2014; Kaye & Anderson, 1999). In this paper, we study a sustainable Lean programme from the perspective of complexity theories that stress the importance of studying change as a dynamic process of interacting elements and events unfolding in time (Anderson, Crabtree, Steele, & McDaniel, 2005).

The purpose of this paper is to make a distinction between the success and sustainability of improvement programmes, and to identify mechanisms that specifically contribute to the sustainability. We conducted a longitudinal, in-depth case study of AstraZeneca’s Turbuhalers production unit, which is a case of a sustainable Lean production implementation.

Theoretical background

**Lean production as an improvement programme**

Organisations often initiate an improvement programme, which is an induced change effort focused on improving the effectiveness of an organisation’s existing processes (Raja Sreedharan, Raju, & Srivatsa Srinivas, 2017; Repenning, 2002). It is itself an unending process whose aim is, ‘to design and implement a system whose natural equilibrium is constant improvement and change’ (Schroeder & Robinson, 2002, p. 230). Independent of the improvement programme’s content and origin, the basic goal has been the same: to make changes in how business is conducted in order to cope with a new, more challenging market environment (Maes & Van Hootegem, 2011).

Lean production is one of the most popular contemporary improvement programmes. It originated in the Toyota Production System (TPS), which was developed by Toyota managers in the 1940s (Holweg, 2007; Sugimori, Kusunoki, Cho, & Uchikawa, 1977). NIST (2000) defined Lean production as ‘a systematic approach to identifying and eliminating waste through continuous improvement, flowing the product at the pull of the customer in pursuit of perfection’. Lean production evolved over a long period of time and there
is a lack of agreement on what constitutes the improvement programme (Bhamu & Singh Sangwan, 2014; Shah & Ward, 2007). Lean production is generally described from two perspectives: the practical and the philosophical (Pettersen, 2009; Shah & Ward, 2007; Womack & Jones, 1996). The practical perspective is related to a set of tools and techniques that are used for waste reduction. The philosophical perspective includes guiding principles, values and organisational behaviours, such as cultivating ‘respect for people’ or long-term relationships with suppliers (Hines et al., 2008; Liker, 2004; Piercy & Rich, 2015; Snyder, Ingelsson, & Bäckström, 2016).

**Complexity theories and organisational change**

Complexity theories originated from the natural sciences, but are increasingly seen as a way of understanding change (Burnes, 2005; Grobman, 2005; Norberg & Cumming, 2013). Organisations are seen as complex, nonlinear, self-organising systems that are able to learn and change only when they operate at the edge of chaos, that means between stable and unstable state (Anderson, 1999). If systems become too stable, they do not develop. If they become too unstable, they may get out of control (Eisenhardt & Piezunka, 2011; Frederick, 1998). Complex systems consist of agents that interact with each other and their environment. The behaviour of agents is guided by ‘order-generating rules’ (Burnes, 2004), or ‘semistructures’ (Brown & Eisenhardt, 1997), such as policies and procedures or cultural norms and values. Order-generating rules permit limited chaos while providing relative order and keeping the organisation at the edge of instability (Brown & Eisenhardt, 1997; Burnes, 2005). A key to understanding complex systems is contained in patterns of relationships and interactions among agents (Eisenhardt & Piezunka, 2011). Furthermore, the pattern, nature and strength of relationships as well as interactions between agents may change over time and should therefore be studied in a longer perspective (Anderson et al., 2005). The key principles of complexity theories applied to organisations and change are presented in Table 1.

**Methodology**

To gain a comprehensive understanding of change processes and system properties, we carried out a case study of a company that succeeded in turning its initially successful

<table>
<thead>
<tr>
<th>Edge of chaos</th>
<th>Managers promote bringing their organisations to the state between order and disorder to make them the most creative and open to change (Frederick, 1998)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-organisation</td>
<td>Complex systems tend to exhibit ‘self-organizing’ behaviour: starting in a random state, they usually evolve toward order instead of disorder (Anderson, 1999)</td>
</tr>
<tr>
<td>Non-linearity</td>
<td>Complex systems are constantly changing, where the laws of cause and effect appear not to apply (Burnes, 2005). Managers can only roughly foresee what behaviours will emerge when some elements are changed (Anderson, 1999).</td>
</tr>
<tr>
<td>Agents and interconnections</td>
<td>Complex systems consist of agents that interact with each other and demonstrate certain behaviours according to order-generating rules (Anderson, 1999)</td>
</tr>
<tr>
<td>Order-generating rules</td>
<td>In achieving effective change, order-generating rules have the potential to overcome the limitations of rational, linear, top-down, strategy-driven approaches (Burnes, 2005; Styhre, 2002)</td>
</tr>
</tbody>
</table>
improvement programme into a sustainable one. Anderson et al. (2005) described how case studies can be used in combination with complexity theories for studying organisations. The case study methodology was considered suitable since it allows studying both the system as a whole and the interdependencies and interactions among the elements (Eisenhardt, 1989). Since complexity theories require prolonged case study engagement with the system (Anderson et al., 2005), the case study is longitudinal and involved data collection over 9 years.

**The case company**

AstraZeneca is a global biopharmaceutical company, which was formed in 1999. The business scope includes research, development, manufacturing and marketing of pharmaceuticals. The company is active in over 100 countries with a growing presence in markets such as China, Brazil, India and Russia and it has more than 62,000 employees.

The factory for Turbuhaler that has been studied belongs to the Sweden Operations and is the largest manufacturing and product supply unit within the group. AstraZeneca Turbuhaler received the Swedish Lean Award in 2008. One of the motivations for the award was the strong commitment and involvement of management and employees as well as simple and pragmatic applications of Lean thinking and practices. Especially prominent was the continuous improvement system, visual control of production, as well as support function development. To mention some results, Turbuhaler increased its productivity by 150% and decreased quality deviations by 90% between 2001 and 2016.

**Data collection**

Figure 1 presents a timeline showing the timeline of the study. The first data collection was performed in 2009 after the case company received the Lean Award and was a retrospective study looking back over the previous 7 years.

The data collection methods included semi-structured interviews \((n = 24)\), observations \((n = 34)\), document studies (Bryman, 2001) and shadowing managers (4 managers during 2 days). An overview of the data collection is presented in Table 2.

The interviews were conducted with three levels of management (top, middle and first-line managers) and focused primarily on how and what changes were made over the years. Participant observations were made at several meetings, such as daily stand-up meetings, team and cross-functional improvement meetings, management and project meetings. The empirical data from the meetings were collected using structured field notes (DeWalt & DeWalt, 2002). The researchers used an observational template that contained a number of questions, such as who is leading the meeting, who is participating, what is the agenda, what meeting artefacts are used, who is making decisions, and what performance

![Figure 1. Timeline of the study.](image-url)
measures are used. If a phenomenon appeared that could not be coded by using the template, additional notes were taken.

In 2011, to gain in-depth understanding of behaviour patterns and interactions between managers and employees, we used the method of shadowing (McDonald, 2005). Four managers (factory manager, production manager, two first-line managers) were followed over two consecutive working days. This method involved shadowing a person from the moment she/he began the working day until she/he left for home. During the shadowing, researchers asked clarification questions and wrote field notes to document the answers and observations. At the end of the shadowing period, structured interviews with questions around the observations were conducted (McDonald, 2005).

Finally, several company documents, such as strategy documents, implementation plans, historical meeting minutes and performance reports were studied using qualitative analysis (Bryman, 2001). This approach comprised a searching-out of underlying themes in the documents being analysed.

In 2017, a meeting with a Lean manager was arranged to confirm Lean improvement programme sustainability. Performance data were reviewed and the future visions with the improvement programme were discussed.

Data collection and analysis were carried out by a research team in order to achieve complementary insights (Eisenhardt, 1989). The combination of data from interviews, observations, shadowing and internal documents, represents data source triangulation (Gibbert, Ruigrok, & Wicki, 2008; Yin, 2003), which adds reliability and construct validity to the research findings. After the data collection stages were completed, a draft summary of the findings was presented at a feedback session with key respondents. The purpose of this session was to validate the results, and it was seen as a possibility to expand our analysis.

Table 2. Overview of the data collection in 2009, 2011, 2015.

<table>
<thead>
<tr>
<th>Year</th>
<th>Interviews (n = 24)</th>
<th>Observations</th>
<th>Other data collection methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>n = 12</td>
<td>n = 6</td>
<td>Documents studies:</td>
</tr>
<tr>
<td></td>
<td>6 operators,</td>
<td>daily stand-up meetings,</td>
<td>strategy documents,</td>
</tr>
<tr>
<td></td>
<td>4 first-line managers,</td>
<td>improvement meetings</td>
<td>implementation plans,</td>
</tr>
<tr>
<td></td>
<td>1 production manager,</td>
<td></td>
<td>historical meeting minutes,</td>
</tr>
<tr>
<td></td>
<td>1 factory manager</td>
<td></td>
<td>performance reports</td>
</tr>
<tr>
<td>2011</td>
<td>n = 6</td>
<td>n = 20</td>
<td>Shadowing managers: 4 managers were shadowed during 2 days</td>
</tr>
<tr>
<td></td>
<td>2 operators,</td>
<td>daily stand-up meetings,</td>
<td>Documents studies:</td>
</tr>
<tr>
<td></td>
<td>2 first-line managers,</td>
<td>improvement meetings</td>
<td>strategy documents and performance reports</td>
</tr>
<tr>
<td></td>
<td>1 production manager,</td>
<td></td>
<td>project meetings,</td>
</tr>
<tr>
<td></td>
<td>1 factory manager</td>
<td></td>
<td>management meetings</td>
</tr>
<tr>
<td>2015</td>
<td>n = 6</td>
<td>n = 8</td>
<td>Documents studies:</td>
</tr>
<tr>
<td></td>
<td>3 operators,</td>
<td>daily stand-up meetings,</td>
<td>strategy documents and</td>
</tr>
<tr>
<td></td>
<td>2 first-line managers,</td>
<td>improvement meetings</td>
<td>performance reports</td>
</tr>
<tr>
<td></td>
<td>1 production manager</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
through collaboration, elaboration, reaction, and developing alternate and multiple interpretations of the findings (Merriam, 1998).

In our data analysis, we paid particular attention to understanding the different improvement programme phases and identifying events, patterns of behaviour, and interdependencies and interactions among the system’s agents that unfold over time (Anderson et al., 2005). We looked at improvement programme implementation as a dynamic process and paid attention to the flow of events and change of behaviours.

Findings
In the following sections, we describe the transformation journey of AstraZeneca. We start with a description of AstraZeneca before Lean production and illustrate then what happened during the four phases of the transformation journey: (1) orientation, (2) preparation, (3) activity and (4) sustaining.

AstraZeneca before Lean production
Before Lean production was launched, AstraZeneca was a highly profitable company, although productivity and efficiency was rather low. The company manufactured and sold a number of very successful drugs, which contributed to higher revenues. There was a profit-sharing system where all employees got a bonus dependent on their individual performance.

You could get so much that you could buy a car with cash without thinking about it. (Operator A, 2009)

At this time the important issue was to keep production capacity up, rather than keeping costs down. The production lines were provided with excess personnel and there was a ‘just in case’ culture:

It was better to hire one person extra just in case we get problems with sick absence. (Production manager, 2009)

Extra personnel were also needed since there were huge demand variations. Some weeks there was a need for personnel working overtime; other weeks the personnel had nothing to do.

Improvement work was organised according to the traditional suggestion box, but activity was rather low. Few suggestions were submitted and implementation was slow. The implemented ideas were rewarded with bonuses.

We had the classical suggestion box, but it was abolished since there was only a few that made the improvements for their own sake. There was a lot of fuss surrounding the suggestion box since the rewards could be substantial, especially for process improvements, several tens of thousands of Swedish kronor. (Factory manager, 2009)

The orientation phase
The orientation phase was a pre-study where the concept of Lean production was investigated and different ways to implement the improvement programme were considered. In 2001, AstraZeneca was still in a good financial situation, but the profits were endangered and the production unit faced being outsourced to low-wage countries. Inefficient production and high costs were an incentive to initiate a Lean-based improvement programme.

The reason we started with Lean was simply that we were so bad. (Factory manager, 2009)
The orientation phase, in which only managers were involved, implied creating formal and informal networks and questioning current thinking. To get improvements on the agenda and increase Lean production competence, new managers were recruited externally. Two managers were recruited from Scania, an exemplary company in Lean production, and one was recruited from Volvo. A formal network of managers was created to learn and discuss about Lean production and plan the implementation. The externally recruited managers had a key role in this period since they had the know-how and positive experience of the Lean concept and were convinced that the improvement programme would work at AstraZeneca. Several study visits and internal and external Lean training sessions were organised.

We received a lot of training. I participated in several seminars, lectures, courses and study visits. Endless discussion about what Lean can do for our company... But it was very useful... I completely changed my mind. I started to see the great potential with Lean. I needed to be strongly convinced that Lean is good for us. My role was then to convince my employees that it is worthwhile to work with Lean. Not just me. All managers were out in production and preaching for Lean. (First-line manager A, 2009)

The primary outcome from the orientation phase was the change of mental models, which managers used to make sense of their work situation. These changes included shifts in beliefs, attitudes and values, which in turn influenced their on-the-job-behaviour.

The preparation phase

The purpose of the preparation phase was to make the organisation ready for Lean production in terms of motivation, support and education. The process started top-down with the factory managers and spread via the first-line managers to the operators.

All employees were involved in education days or, using AstraZeneca’s language, ‘mobilizing days’, which included different kinds of seminars and exercises about Lean production. The employees were organised in cross-functional and cross-department teams and discussed how Lean could be implemented and what benefits it would provide. The managers were educated in transformative leadership and requested to focus on coaching employees and using participative leadership styles.

Improvement programme goals were set and the strategy and implementation plans were developed at different organisation levels. The emphasis was to communicate Lean production as a long-term improvement programme, which will not fade away like previous programmes. The management also highlighted that Lean production was not just an improvement programme, but a new way of thinking and behaving.

In summary, the preparation phase focused on influencing the mental models of employees that gradually changed their attitudes and values and were willing to improve their way of working.

The activity phase

In the beginning, the activity level was low and focused on measuring waste. The idea was to involve employees and increase their awareness of different types of waste. The activity level increased with time and several Lean tools and techniques were implemented in parallel. Some changes went smooth, while others were faced with some difficulties.

An example of successful improvement was setup time reduction by single minute exchange of dies (SMED). The SMED project was performed by a group of operators and their leader who jointly had the authority to question the changeover procedure as...
long as the result was satisfactory. The result from the project was remarkable: the setup time was reduced from 600 minutes to 83 minutes.

In contrast, the implementation of standardised work was faced with some difficulties. The first version of standardised work was a conference room product with little operator involvement. The management wanted to have quick results and hired consultants who developed new standard operating procedures based on those of the automotive industry. The group implementing standardised work quickly realised that this approach would not work:

When standardized work was implemented and everybody had to follow the given procedures there was fierce resistance among the operators. People were furious. (Operator B, 2009)

The managers learned from these mistakes and let the operators decide on the improvements of their working methods. New procedures were developed, tested and gradually refined. All the work was basically performed by operators themselves, which ensured strong adherence.

Other important changes were setting supporting structure for employee empowerment. Teams became the primary operational working unit and received the responsibility for the daily work management and improvement. Individually submitted improvement ideas were discussed in weekly improvement meetings with the team itself approving and planning the realisation of ideas. Ideas were implemented by the individual who submitted the idea. If needed, other operators, managers, or supporting functions could be involved in the implementation. Individual bonuses based on the number of submitted ideas and active participation in improvements were introduced. In contrast to previous reward systems the activity phase reward system aimed to encourage participation and initiative-taking. Daily stand-up meetings in front of a whiteboard were introduced to involve employees in planning and managing daily operations. The agenda included planning daily production, checking the conditions to meet the day’s demands, reviewing objectives and reviewing nonconformities. One of the important objectives of stand-up meetings was to increase two-way communication and establish information flow from bottom-up to top-down.

The implementation of Lean tools and techniques was accompanied by changes in the management. The managers described that their role changed radically from managing processes to developing and coaching people.

There is a huge difference in management compared to when I started. I became team leader in 2005 and then we were more like project managers. I was principally never out in production. I only managed projects; the operators more or less took care of themselves. (First-line manager B, 2009)

The primary managerial task became to support and coach operators. There was an increased focus on the operators as individuals.

It is so much more important than one might think that we actually know the names of operators’ children or the dog or something. It is important to have small conversations and see them as individuals and not always in their job! (First-line manager A, 2009)

By communicating objectives and sharing values, the managers influenced operators’ attitudes toward Lean production and encouraged appropriate behaviours. The focus was on turning operators from passive work performers to active contributors that take responsibility for the daily work.

The sustainability phase

In this phase, the focus was not on making new changes, but on sustaining and improving the Lean practices already implemented. Some changes introduced and considered as
successful in the activity phase were questioned and new, improved working methods were introduced. In the sustainability phase, it was evident that thinking and behaviour patterns changed. Several employees described that they changed their behaviour not only at work but also transferred their on-the-job experience to free-time behaviour. The interviewees share several stories of Lean applications in their private sphere, such as 5S in the garage or kitchen or applying the Kanban system to weekly shopping routines.

My husband is also working at Astra. So we are both Lean-damaged [laughter]. He made a list in Excel of groceries in the order we walk in the ICA supermarket. We always buy food there. Yes, vegetables first, bread next and so on. Now when I make a shopping list I just put down numbers. How many cans of tomatoes do I have? I have one and I need three, the minimal inventory. It is really easy! (Operator D, 2011)

The improvement capability increased as employee’s attitudes and values changed and their competencies developed. Changes could be implemented that seemed to be impossible in the early phases of the improvement programme. The sustainability phase was also about constantly setting new challenges and influencing social interactions in the company. Below follow some examples.

In the activity phase, employees submitted improvement ideas individually, but in the sustainability phase team-based submissions were promoted and preferred. The reward system was changed from individual bonuses to team-based bonuses to foster collaboration and learning. Since commitment to teamwork was not strong enough, these kinds of solutions were first possible in the sustainability phase. The character of the improvement ideas also changed. In the activity phase, all kinds of ideas were counted and mostly concerned physical workplace improvements, whereas the sustainability phase focused on specific process improvement goals. Furthermore, the arrangement for the cross-functional improvement work was changed. In the activity phase, every process had an improvement team that took care of ideas that were more complex, included several processes, or required more resources. This structure was replaced by one cross-functional team, which worked with improvements in all processes. As the improvement work matured, more ideas could be directly realised by operators and the need for process-level improvement teams decreased. The idea was also to increase cooperation between different organisational units and to avoid sub-optimisation.

In the activity phase, operators received the responsibility for improvements but were not mature to take the responsibility for managing daily operations. In the sustainability phase, the teams were responsible for planning and performing tasks in their part of the flow and were the focal point of problem-solving and improvement. This change was a long-term process, which required sustained managerial efforts. Increased responsibility for daily tasks and involvement in decision-making were used to realise participation, empowerment and better utilisation of employees’ skills. The managers focused more on individual employee’s skills, experience, and abilities and set challenges that would nurture and encourage growth. Several new employee development opportunities were created and involved taking new roles in the organisation. For example, operators received special roles, such as spec operator (operator who partly took over team leader’s role, that is, became internal team leader), quality operator, safety operator, etc.

Finally, changes were constantly introduced in the work organisation and management structure, which influenced the social interactions between employees. As the operational teams developed the improvement work and daily management required less push from management and became independent from managers’ support and encouragement. The number of first-line managers was halved. The managers, who led the activity phase, were moved to implement Lean in other business areas. The operational teams were
frequently reorganised and operators were encouraged to change jobs. The salary was set based on the number of competence certificates, which could be achieved when working in different operational teams.

Discussion
In the introduction, we mentioned several factors associated with the success and sustainability of the improvement programmes, including creating understanding and motivation, establishing and communicating a vision and strategy, committed leadership, involving employees in change activities, creating short-term wins and alignment with the value system (e.g. Appelbaum et al., 2012; Beer & Nohria, 2000; Benson et al., 2013; Burns, 2011; Kettinger & Grover, 1995; Kotter, 1995). We were able to identify all the factors mentioned above in our present case study. We were however able to identify more factors when we researched the transformation journey in a longitudinal study and applied the perspective of complexity theory. What did we learn?

Lessons from the complexity theories perspective
Destabilising the organisation is seen as a state to awaken people to the need for change (Boyatzis, 2006). An important means in this respect was influencing the current social structures and create new interconnections between employees. Forming networks, cross-functional educational days, re-organising operational teams influenced the patterns of relationships and interactions and thereby caused people to think differently and operate in new constellations. An organisation can be moved to an unstable state by altering a system’s distribution of agents (Anderson, 1999). Recruiting managers from outside and moving employees between operational teams contributed to destabilising the organisation, where the current behaviour and thinking was questioned and new goals and challenges brought to the attention of employees.

Ensuring novelty and constant flow of change. We could observe that AstraZeneca constantly introduced changes into their operations, which was one of the ways of keeping the organisation at the edge of chaos. If novelty and change are not introduced, organisations become too ordered and stable, and the improvement programme dies (Frederick, 1998). Brown and Eisenhardt (1997) drew a similar conclusion from their research and stated that continuous innovation is necessary for the improvement programme sustainability. Consequently, a constant pace of change is important. However, the failure to sustain a programme lies not only in the fact that organisations try to change too little, but also that they try change too much (Stacey, 1995). This was the case when the wrong standardisation approach was implemented and caused strong employee resistance. This situation endangered programme sustainability and required considerable efforts to stabilise the organisation and then move again at the edge of chaos.

Setting order-generating rules that balance stability and flexibility. We could observe that new order-generating rules were introduced through all phases of the transformation journey. The reorganisation of the daily improvement work is a clear example of setting new order-generating rules. Brown and Eisenhardt (1997, p. 29) referred to order-generating rules as ‘semistructures’ and stated that they need to be, ‘sufficiently rigid so that change can be organized, but not so rigid that it cannot occur’. In order to achieve stable, but flexible order-generating rules, responsibility and decision-making must move from managers to employees (Grobman, 2005). This is exactly what was observed at AstraZeneca. Before the improvement programme was launched, the managers were invisible and only...
supervised whether employees were fulfilling the production goals. The changed management style involved managers delegating responsibilities and coaching employees in ways that nurtured their growth and brought out their creativity. Employees were empowered and received more responsibility for managing and improving daily operations.

*Self-organisation at the team level.* In order to sustain change, a number of complexity researchers have argued that large-scale, top-down transformational change and small-scale, incremental change need to be replaced with a combination of the two that is based on team-level self-organisation (Brown & Eisenhardt, 1997; Burnes, 2004). This is again what we observed at AstraZeneca. Teams became the primary operational unit of the company. In order to promote change through self-organisation, there is ‘a need for much greater democracy and power equalization in all aspects of organizational life, instead of just narrow employee participation in change’ (Burnes, 2004, p. 162).

As stated before, management responsibility was gradually passed to teams that could influence their work to a greater extent. A similar mechanism was observed by Shiba, Graham, Walden, Lee, and Stata (1993), researchers outside the complexity field. The authors distinguished between two sources of improvement programme commitment: managerial push and employee pull. Managerial push refers to activities that promote an improvement programme, such as communicating with employees, demonstrating support, setting goals, or providing training. However, to achieve sustainability, managerial push needs to be replaced by employee pull. An improvement programme will persist if employees continue with the improvement independent of management actions, support and attention. Shiba et al. (1993) emphasised that managerial push needs to be replaced by employee pull, but the authors do not explicitly explain how this can be achieved. Our results show that this shift can be achieved if managers create supporting structures, give responsibility and authority to teams and promote self-organising processes.

*Influencing thinking and behaviour by learning, communicating and reward systems.* To promote self-organisation the mental models and patterns of behaviour need to be changed (Grobman, 2005). At AstraZeneca, the operators’ behaviour changed from being passive and hesitant to self-driven and active in the improvement activities. This shift was so far-reaching that it influenced operators’ free-time behaviour. According to complexity theories, thinking and behaviour change can be achieved by introducing new agents, changing order-generating rules, or influencing patterns of relationship and agent interconnections (Anderson, 1999). Several of these aspects were observed at AstraZeneca. One of the examples was a changed perspective on learning and knowledge sharing, which enabled individuals to understand and redefine the perceptions of the world around them (Burnes, 2004).

The management at AstraZeneca approached the traditional practice of guarding information and skills and promoted teamwork and collaboration. Several new opportunities for interactions between employees, such as cross-functional training, working in different operational teams, collaboration on improvements, formation of formal and informal networks, and daily management meetings were created. Brown and Eisenhardt (1997) pointed specifically to intensive, real-time communication, which, at AstraZeneca, was realised by daily stand-up meetings, as the factor contributing to sustainability. In the initiation and preparation phase, employees interacted in networks and shared ideas and knowledge on implementing Lean production. In the activity and sustainability phases, the changed patterns of relationships and interactions enabled learning, sharing best practices and jointly developing new practices and processes. Knowledge-sharing occurred not only within the teams but also across functional areas.

Altering the reward system is another way in which managers influenced employee behaviour and thinking. The reward system was changed several times to achieve the desired
behaviour pattern. In the activity phase, an individual-based reward system was implemented to involve an employee in the improvement work. In the sustainability phase, a team-based reward system was introduced to promote collaboration and teamwork. The salary was set based on the competence certificates to work in different areas.

**New insights on the sustainability of improvement programmes**

The current research does not make a clear distinction between the success and sustainability of improvement programmes, nor does it propose a similar set of best practice guidelines. In our view, an improvement programme is successful if goals are achieved and the targeted problems are resolved. Since improvement programmes assume change process continuity, achieving goals only means that new goals need to be set and worked towards. In other words, a sustainable improvement programme consists of several successful change phases. But what mechanisms make an organisation move between the different phases of successful change?

Complexity theories opened our eyes to the importance of not only differentiating between successful and sustainable change but also between first-order and second-order sustainability. We define first-order sustainability as improvement persistence. Most of the research focuses on the first-order sustainability. One example is the NHS Modernisation Agency definition provided by Buchanan et al. (2005, p. 23):

"Sustainability is when new ways of working and improved outcomes become the norm. Not only have the process and outcome changed, but the thinking and attitudes behind them are fundamentally altered and the systems surrounding them are transformed in support."

Second-order sustainability is achieved when the improvement programme itself persists and continues to develop over time. A successful improvement programme can, but does not necessarily, reach first-order sustainability, while a sustainable improvement programme reach both first- and second-order sustainability. In the case of AstraZeneca, both first- and second-order sustainability has been achieved. First-order sustainability was reached since the new way of working became the standard and employees changed their thinking and behaviour accordingly. The improvement programme persists and generates a constant improvement and change.

**Conclusions**

Despite substantial knowledge in the form of best practice guidelines, the mechanisms behind sustainable improvement programmes are still subject of research. By applying the perspective of complexity theories to a longitudinal in-depth case study, we were able to elicit several theoretical and practical implications.

**Theoretical implications**

Our research provides new insights on the success and sustainability of improvement programmes by making a distinction between the success and first- and second-order sustainability. Many improvement programmes can be called successful since the planned changes are implemented and the desired goals are achieved. There are, however, two major frustrations that are often encountered: the first is the inability to sustain the results (first-order sustainability), and the second is the failure to keep the improvement programme alive (second-order sustainability). Initial success can be achieved without achieving either first- or second-order sustainability, but then the effect is probably short term and the
Improvement programme risks being terminated. If first-order sustainability is achieved, then the effect will be long term, but the programme is likely to be abandoned. A sustainable improvement programme consists of several phases of successful and first-order sustainable changes. The lessons identified from complexity theories, such as destabilising the organisation, ensuring novelty and constant flow of change or self-organisation at the team level, are mechanisms that enable an organisation to move between phases and sustain the improvement programme itself (second-order sustainability). These mechanisms were not previously discussed by other studies aiming to explain the sustainability of improvement programmes.

**Practical implications**

We identified the following mechanisms contributing to second-order sustainability:

1. Organisations need to operate at the edge of chaos, that is, the state between order and disorder where the organisation is most creative and open to change. An important means in this respect is influencing the social structures by creating new employee interactions.
2. In order to stay at the edge of chaos, there must be a constant flow of novelty and change followed by the development of new order-generating rules that provide relative stability while permit flexibility.
3. Managers need to rethink the nature of hierarchy and control and change their roles from command and control to supporting and coaching employees.
4. The organisational structure should develop toward self-organisation, in this study teams that take responsibility for managing and improving daily operations. This implies that teams need to be given authority to take decisions and make changes on their work processes.
5. To achieve self-organisation, there must be a change in employee thinking and behaviour. The management can stimulate this change by enabling learning and knowledge sharing, fostering real-time communication, creating opportunities for collaboration and interactions between people, and introducing a reward system that supports teamwork.

**Limitations**

This study was performed in the context of Lean production. The studies of other improvement programmes may provide slightly different forms of self-organisation.

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