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Monica Rolfsen: A blueprint paradox: Successful but unintended cross-national translation of total productive maintenance

Introduction

There is a growing tendency for firms in the manufacturing industry to move or re-establish parts of their production facilities abroad (Blinder, 2006), due to other countries having lower wages than the host country (Farrell, 2005), or in order to be closer to customers (Rutherford & Holmes, 2007). A closely related issue is the overall tendency for implementation of standardized management concepts. The concept of Total Quality Management (TQM) has been thoroughly studied, but contextual factors have been largely been overlooked, and a perspective of universal application has dominated (Sila & Ebrahimpour, 2003). In addition, other concepts share the same challenges when being copied to different contexts. This paper focuses on an attempt to copy the concept Total Productive Maintenance (TPM) from one plant to another within the same company, but on different continents. The two plants have similar technology, production equipment, owners, customers and products, so the conditions for copying should be as favourable as they can possibly be. Our research question is: *Can TPM bw successfully copied from one location to another, and what are the reasons for any potential differences?*

TPM, implementation and transfer to a new context

The objective with TPM is to attain maximum efficiency, prevent losses and reach "zero accidents", "zero defects" and "zero breakdowns" in the manufacturing process. The workforce is intended to be integrated “from bottom to top” (McKone, Schroeder, & Cua, 1999), and the aim is to obtain “zero losses” by integrating team activities into the production system (Panneerselvam, 2006). According to Wireman (2004), TPM was introduced in Japan in 1971 in order to increase the productivity of manufacturing equipment; in other words, to facilitate “productive maintenance activities implemented by employees” (Wireman, 2004). Bamber and colleagues (1999), in a literature review, focused on the difference between Japanese and Western approaches to TPM. Several Japanese authors regard Siiechi Nakajima as “the father” of TPM: he defines the concept as involving total participation, maximizing equipment effectiveness and establishing a thorough system of preventive maintenance (Nakajima, 1989b). While Western authors such as Willmott (1997), Wireman (2004) and Hartmann (1992) have focused mainly on equipment and efficiency, Nakajika was more concerned with involvement and teamwork (Bamber, et al., 1999, p. 165; Nakajima, 1989a).

A third perspective is to include close collaboration between manufacturing, maintenance and engineering (Ahuja & Khamba, 2008a). In addition, improvement activities are suggested by some authors to be included as essential elements of TPM (Ahuja & Kumar, 2009; Lycke, 2003).

There seem to be three distinctive perspectives in the literature between a technological focus on equipment, the inclusion of organizational aspects such as teamwork, and finally multidisciplinary cooperation and improvement. This article will apply a broad approach to TPM, including above-identified aspects, which can be summarized as:

1. A system for optimizing the productivity of equipment
2. Inclusion of all employees; empowerment
3. Extended use of teamwork
4. Continuous improvement activities
5. Close collaboration between manufacturing, maintenance and engineering

Why is TPM becoming increasingly popular? Several studies report TPM to be beneficial for manufacturing performance, and quality in general (Banker, Field, Schroeder, & Sinha, 1996). However, the concept is closely connected to lean production (Womack, Jones, & Roos, 1990) and TQM (Brah & Chong, 2004; Cua, McKone, & Schroeder, 2001), which have both increased in popularity. In addition, including TPM can be interpreted as a means by which to achieve lean production, especially within industries with a high level of automation, and TPM can in itself be interpreted as a management concept (Noon, Jenkins, & Lucio, 2000), that is seen as a potential source of improvement and a next step to improving the benefits of lean production and TQM.

Another recurring theme in the literature is how performance maintenance should be measured, and there are several available methods by which to do this. Muchiri and colleagues (2010) divided performance measurements into two main categories: effort indications and result indicators, and termed them “leading” and “lagging” indicators, depending on whether it is the maintenance in itself that is being measured, or the results. According to Muchiri and colleagues’ empirical investigation, result indicators are more commonly used – especially the number of safety, health and environmental incidents - while Overall Equipment Effectiveness (OEE) was used by 85 percent of the informants in their study (Muchiri, et al., 2010). OEE was the most widely used measurement on a daily basis, and was introduced by the “father” of TPM, Nakajima (Muchiri & Pintelon, 2008; Nakajima, 1989b). One explanation for OEE’s popularity is that it integrates different elements of equipment productivity, and thus managers have a high interest in analysing effectiveness (Muchiri, et al., 2010, p. 5916). A common way to define OEE is as a function of availability, performance and quality rate, and thus to integrate different important aspects of manufacturing into a single measurement tool (Muchiri & Pintelon, 2008). The company that will serve as the basis for our empirical data uses OEE as its overall performance indicator.

Thorough descriptions of TPM *implementation* are lacking in the existing literature, which mostly describes companies following a detailed procedure of techniques, and implicitly treats the concept as pure technology, assuming that it is possible to copy it within different contexts (e.g.Ahuja & Khamba, 2007; Ahuja & Kumar, 2009; Ireland & Dale, 2001). Ahuja and Khamba (2008b), identified a 12-step implementation procedure, three distinct phases, a five-phase roadmap, a three-phase, nine-step plan, eight fundamental development activities, and seven broad elements while other researchers have taken certain organizational aspects into consideration (Hansson, Backlund, & Lycke, 2003; Lycke, 2003), however, the content of TPM and the implementation process is taken for granted, implying that it is possible and preferable to copy a practice from one location to another.

Taking the management literature into consideration, this perspective can be said to be oversimplified. The increased globalization process and spreading of management concepts have resulted in increased diffusion of standardized models of organization (Meyer, 2002). There are different views in the literature relating to whether such concepts are universal or if a contingency approach is required (Sila & Ebrahimpour, 2003).

In the 1970s and early 1980s, many authors considered the Toyota production system to be so inherent to the Japanese local context that it was hard to implement elsewhere (Dohse, Jürgens, & Malsch, 1985). When several Japanese manufacturers started to establish factories in the US, the question changed to *how* to make transfer possible. One approach perceives that the transfer of concepts leads to such a high degree og standardization that cultural differences will decrease (Ritzer, 1996). Boyer et al (1998) offered an alternative perspective, presenting transfer as a continuum from imitation to innovation, with “hybridization” in between. In a hybrid transformation, parts of the original concept are influenced by local context. Transfer and adaptation will necessarily require change processes in the organization. Huy (2001)identified four generic change strategies: engineering to change work processes, teaching to change belief systems, socializing to change social relationships and commanding to change the formal structures.

Instead of transfer, the term “translation” describes how management ideas “travel” from one location or context to another (Czarniawska & Sevon, 2005). An important point is that "a thing moved from one place to another cannot emerge unchanged, to set something in a new place is to construct it anew" (Czarniawska & Sevon, 2005, p. 8). The possibility to change and adapt a certain concept to "fit" into new circumstances has been the subject of a variety of research projects (e.g.Boyer, et al., 1998; Morris & Lancaster, 2006; Rolfsen, 2011; Rolfsen & Knutstad, 2007; Sahlin-Andersson & Engwall, 2002; Özen & Berkman, 2007).

A framework for the transfer of management concepts was developed by Lillrank (1995), who divided the content of management concepts into three categories with different "abstraction levels" and thus abilities to be transferred. Abstraction goes beyond observable practice and includes the meanings and interpretation of the practice, which is culturally and institutionally embedded. Lillrank uses an example from a Japanese company, where workers start their daily work routine by singing a company song. The symbol of the singing practice is the building of organizational cohesion through face-to-face interaction, and is rooted in Buddhist cosmology (Lillrank, 1995). Transferring the pure practice (the song) to a German or American company would probably be unsuccessful because the cultural interpretation is missing. Transferring a pure technique such as statistical process control with low abstraction is considered to be much easier (Lillrank, 1995).

Lillrank divided possible practices into three groups. *Management principles* are related to the specification of success factors. For TPM, this will be the productivity of manufacturing equipment and levels of OEE as a measurement of overall performance. Management principles can be expressed on various levels of abstraction. For example "quality first" is a principle with low abstraction, while "customer satisfaction" will be more context-dependent. The second category, *organizational vehicles*, is defined as the structures required to carry a strategy, such as the labour market, incentive structures, level of education, management authority and cultural dispositions. Participation, involvement and teamwork can serve as practical examples; all of these have a high level of abstraction. This category is not clearly identified in the TPM literature, and will be further developed in our analysis. The last category is labelled *generic management techniques and tools*, and focuses on practical elements such as statistical process control and problem-solving techniques (Lillrank, 1995, p. 979) and with a low level of abstraction.

Lillrank's point is that tools can easily be transferred; however, the results are dependent on the connection with organizational vehicles and the interpretation within a wider context. A typical example is the transfer of quality circles to the US as a pure technique, without taking the context in which it was developed seriously. Transferring elements with high abstraction is harder to transfer and less likely to be successful, depending on the distance, both geographically and culturally. The larger the distance, the more that is lost due to misunderstandings, incomplete information and essential parts of the original context which is missed (Lillrank, 1995, p. 974). Distance as a metaphor is also used by Kostova (1999), who focuses on organizational practices that are *infused with meaning*, which is the case when a practice becomes a basis for organizational identification. In the example above, wherein employees sing a company song, it will be "infused with meaning" within its original context, but not necessarily when transferred to a context with different values and norms. Kostova's concept of *institutional distance* serves as an alternative to focusing mainly on culture, as it takes into account institutional practices as well. The greater the institutional distance the harder it is to transfer a practice without changing it. When pure techniques are transferred, they may not fit with the local environment and will be interpreted differently (Kostova, 1999, p. 314). The "distance" is further divided into regulatory, cognitive and normative elements as norms and values. Lillrank's (1995) point is that the three components need to be combined, it is not possible to simply transfer a practice out of the original context without changing it. As Kostova points out; the practice needs to be "infused with meaning" in order to be successful.

In the following, a case study of a company with the intention to make a "blueprint" of their Norwegian plant in Canada – that is, copying all aspects of the production and organizational system – is presented. The company's technological equipment, production process, products and customers were identical in the two countries, making the circumstances for copying as apparently favourable as possible.

Methodology

In order to answer the research question, a qualitative research methodology was employed since the study aims is to explore and understand a social phenomenon without having clear-cut hypotheses which can be tested. The research approach is case-study based, involving an in-depth qualitative case study of the two plants. This approach was chosen in order to provide a deeper description and understanding of the TPM-practice. The approach is especially appropriate in new topic areas (Eisenhardt, 1989). Further, a single-case approach is particularly fruitful when the aim is to get as close as possible to the phenomenon described. The goal is to provide a rich description of the social scene so as to describe the context in which events occur (Eisenhardt & Graebner, 2007).

This particular case was chosen because it is unique; involving a novel technological solution for the production of wheel suspension with fully automated equipment developed in the home country, and a blue-print of the factory built on another continent. This provided an opportunity to study potential differences that are not due to technology, products or market. Following Starbuck (1993) we suggest that the extraordinary nature of this case will contribute to important perspectives on and novel understanding of transferring organizational practices in a general sense.

Data was collected using different techniques: structured interviews, semi-structured interviews, semi-structured group discussions, written documentation, and non-participant observation. The informants came from both plants in Norway and Canada. Both plants were visited several times as a part of a larger research project. The interviews covered several issues of the transfer process, including teamwork, maintenance, participation and technology. The first interviews were quite open, while those that followed contained more specific questions.

Details of the data sources are presented in Table 1.

Table 1: Sources of data		
Interviews	**Number of informants**	**Number of interviews with each informant**
Interviews; top managers, Canada and Norway	3	2-3
Interviews; middle managers, Norway and Canada	5	2-3
Interviews; shop stewards, Norway and Canada	2	3
Semi-structured interviews; blue collar workers, Norway and Canada	10	1-2
Open and semi-structured interviews; maintenance staff, Norway and Canada	4	5-6
Non-participant observation of maintenance practice, Norway and Canada	4	

The interview informants were chosen according to guidelines for “purposeful sampling” (Lincoln & Guba, 1985). The research process involved an iterative process of collecting empirical material, analyzing it and looking for new informants on the basis of information determined as being important during previous interviews. This strategy made it possible to continuously improve the focus of research and the quality of the empirical material collected.

Additionally, extended participatory observations were used, and reading of strategy documents, key performance indicators, planning systems, management documents and policy documents were read.

Empirical findings

The case company has production plants in Norway and Canada. This particular story started when the company signed a new contract that required it to build an automated production line. The new technological solutions were developed in Norway; such a high level of automation had never previously been implemented anywhere.

One of the main challenges for highly automated manufacturing systems is equipment maintenance, and thus TPM became important for the firm. The maintenance requirement depends on how much strain the equipment is running under. During the start up stage in Norway, huge problems arose on the forge line due to issues relating to the temperature, structure, lubrication and transportation in a furnace with unstable temperature. By using metallurgical experts, and tooling and maintenance staff, these problems were solved. On the assembly line, totally new concepts had been developed for building the advanced automated line. The assembly line workers were low-skilled and used to working manually. They knew the product, but felt alienated by the new, advanced machinery. “I still do not understand anything, and I don’t think I ever will,” was a repeated statement during interviews. However, after extended training, the assembly line began working according to plan, after months of trial end error.

Simultaneously a new plant was planned. According to the contract, it had to be built somewhere in North America, due to the fact that most OEMs expect a global presence from their main suppliers (Rutherford & Holmes, 2007). The ambition was to use identical equipment, maintenance, routines and concepts; “we are building a blueprint of the factory” (Interview, Global CEO).

A factory building was bought, and infrastructure and equipment installed according to the blueprint intentions. However, with such advanced equipment, minor differences can have tremendous consequences, and here the new infrastructure also played a part, in Norway, electric power is relatively cheap, while in Canada, gas ovens were economically feasible. This difference became problematic; because the temperature was less stable, which had consequences for the metallurgical structure of the products, with in turn changed the demands in the machining line. As a consequence, increased local expertise was required for the metallurgy, automation and industrial tools in order to ensure process stability. In the industrial area in Norway, a high level of metallurgical competence was available in the industrial surroundings, while in Canada three experts were hired. The level of expertise and knowledge of each of these individuals had to be extremely high, and the company hired an extraordinarily competent engineering group within the plant.

The next adjustment concerned the level of automation on the assembly line. The labour cost was 60 percent cheaper in Canada compared to Norway, and on this background a less automated, less expensive and less complicated solution was chosen, with seven operators instead of three. An unexpected consequence was more defective components; the quality turned out to more dependent on the operators, who in turn were less experienced than the Norwegian operators. Thus, an effort had to be made to increase their knowledge and systematic work procedures through education and training.

For training purpose, the maintenance planning and work order flow was carried out manually, instead of using computers as was the protocol in Norway. The manual maintenance system proved to have several advantages: the manual work order flow could be modified, corrected and improved, and employees were able to easily learn about the ideas behind the system, and thereby take more initiative. The flow of paper work orders also made the maintenance and improvement processes more visual. Figure 2 shows an illustration of the planning framework for maintenance:

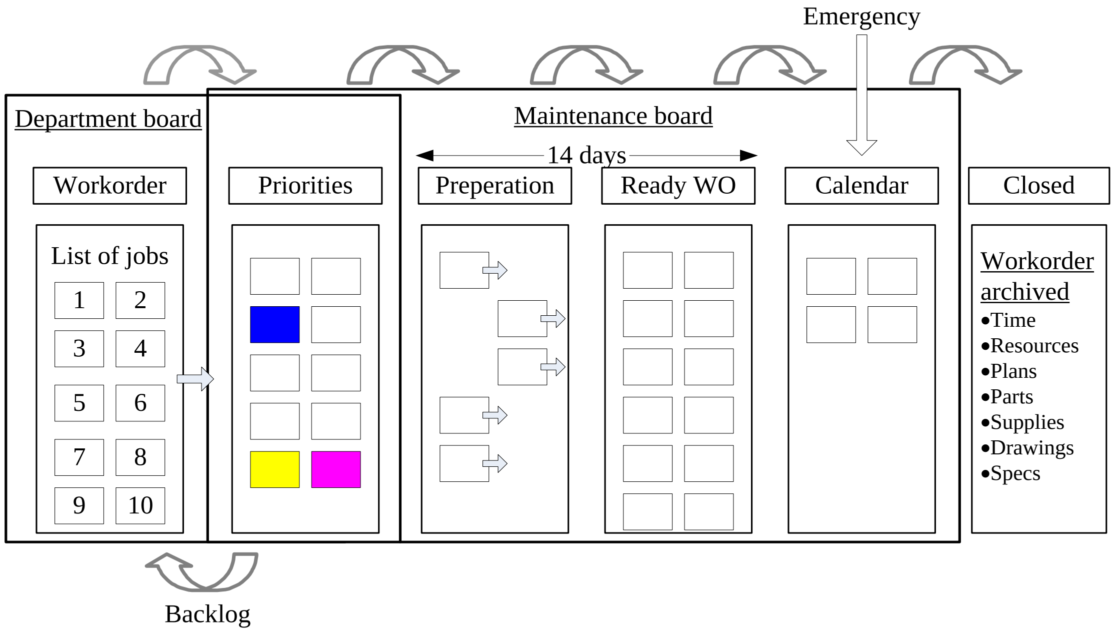

Figure 1: Planning framework for maintenance

Maintenance and production have different roles in the work order process. The production role is illustrated under the department board while the maintenance role is illustrated under the maintenance board (Figure 2).

The operators propose maintenance work orders. The suggestions are written on paper, and each production department has a priority board; the same method is used regarding maintenance proposals. The number of work orders for each department is defined according to specific requirements. The maintenance planner picks these work orders in terms of their priority.

Figure 2: Maintenance board

Each specific order is evaluated, and the procedure is attached, brought to preparation and assigned to a maintenance employee, and all required parts are provided in a blue box with documents describing the procedure to be followed, as well as an evaluation scheme. If documents are missing, a yellow Post-it is attached to the work order; if parts are missing, a pink Post-it is attached. The maintenance planner tracks all Post-its and resolves the issues. In the Norwegian plant, these procedures are conducted using a computer system, and the involvement of operators and maintenance staff is absent.

Going back to the definition of TPM, each of the five elements will be examined and compared between the two plants. The first element *system for optimizing the productivity of equipment* is quite similar across both plants. The second, *inclusion of all employees* has turned out to be more extensive in the Canadian plant, through the manual maintenance system and extended training. The third element of TPM *extended use of teamwork*, is higher in Canada. In Norway, the specialized operators have worked on a more individual basis. In addition for the fourth element, *continuous improvement activities*, the Canadian plant had more systematic routines. Scheduled team meetings were held to enable improvement activities on a regular basis. The final element is defined as *close collaboration between manufacturing, maintenance and engineering*. In the Norwegian plant the competence level is very high, with about 50 engineers, among which are the engineers who invented the production line in the first place. However, the tool and engineering department was outsourced to a separate company serving different plants in the industrial area. There are many advantages of this approach, but the day-to-day collaboration between production and maintenance will necessarily suffer. In Canada, technical experts were hired within the company; these work together with the production operators.

The overall picture is that the Canadian plant has implemented TPM to a higher degree, according to the five elements identified. Although they started with the intention of following a blueprint, the company ended up with a higher performance level in Canada than in Norway. The result was that the Canadian plant received a prize from one of its customers for being the highest-quality supplier that year.

Discussion

As presented above, the company did not succeed in following its blueprint as intended, but improved the practices to a higher performance level. The translation process, in connection with the analytical framework will be discussed further below.

The adjustment to using gas instead of electrical power led to unexpected changes on the forge line, thus the tools on the machining line thus needed to be adjusted, which increased the need for maintenance competence. A technological adjustment (gas instead of electric power) led to organizational consequences (increased engineering competence) *within* the company. The result was a higher level of collaboration between production and maintenance. Using Lillrank's (1995) framework, the company increased two of its organizational vehicles; the educational level and the level of collaboration between production and maintenance.

Reducing the amount of automation on the assembly line led to a greater number of less-experienced operators, resulting in a stronger focus on systematic training. A technological adjustment (level of automation) led to an organizational change (more operators), resulting in extended use of teamwork, since this was chosen as an arena for training, and also to continuous improvement. The result was a higher level of two of the TPM-elements - teamwork and continuous improvement.

The third adjustment was to choose manual instead of computerized solutions to organize maintenance work. This was a technological adjustment with an intentional organizational change in practice (more manual work in improvement activities), leading to a closer collaboration between production and maintenance personnel, and also to higher involvement of employees. In the beginning, the Canadian plant started using the same computer system as in Norway, in line with the intention of copying. After a while, however, the Canadian plant discovered that it did not fit the intention of being transparent and visible and creating potential for participation. The TPM-organizational elements, and the connection to Lillranks's framework, are summarized in Table 2:

Table 2: TPM elements adjusted in the translation process

TPM element	**Content**	**Norway**	**Canada**
A system for optimizing productivity	Management principle Low abstraction	Goals set in strategy	Goals set in strategy
Inclusion of all employees	Organizational vehicle High abstraction	High on individual level	High on team level
Teamwork	Organizational vehicle High abstraction	Low level, working individually	High level due to changes
Continuous improvement	Organizational vehicle High abstraction	Medium level	High level due to changes
Collaboration maintenance – production	Organizational vehicle High abstraction	Low, maintenance outsourced	High level due to changes

The first element has a low abstraction level, and was easily transferred; goals were set, and subsequently implemented. There was some struggle in terms of reaching the goals, but these were related to technological reasons and were not connected to the transfer process. The next element, involvement of employees, was found to be higher in Canada than in the original plant, as explained above. One reason for their increased involvement was the translation of maintenance and work order flows from a computerized system into a manual one. In the Norwegian plant, which had highly competent engineers, the system was just a tool for the maintenance experts, while for the less experienced Canadian production maintenance work force, the system was translated into an organizational vehicle for training. Thus, the work order flow became infused with meaning that differed from the original: it was "reborn" as an educational vehicle. The consequence was a higher level of involvement due to a more transparent system combined with extended training.

The third element, teamwork, also became stronger in the new plant than in the original, as the content and interpretation of teamwork changed when it moved abroad. In Norway, where there were highly competent and experienced operators, teamwork was perceived as a vehicle for job rotation, and was not appreciated among workers. The jobs are quite comprehensive and operators used to have a high level of individual autonomy, which can be described as a craftsman culture. Job rotation, at least on a systematic level, was not a part of that culture. Starting in Canada with inexperienced personnel and advanced machinery, teamwork became a vehicle for mutual learning, which again was infused with different meaning than originally intended. An additional explanation for this is that the Canadian plant had more operators due to the lower automation level, and so teamwork became more feasible.

The fourth element, *continuous improvement*, also increased: this was closely connected to the expanding learning and training culture that emerged. Because of the adjustment to a higher number of operators, the quality became more dependent on people, and thus improvement activities were perceived as more important. Combined with the inexperienced personnel who needed and wanted to increase their technological knowledge, improvement activities were seen as much more important than in the Norwegian plant.

The last element, close collaboration between maintenance and production has already been examined. Several factors contributed to the outcome in relation to this: the maintenance expert was hired within the company, the personnel were inexperienced and had to opt for mutual learning, the production was more depended on operators due to the lower automation level, and also the fact that the staff did not carry with them decades of a culture in which maintenance experts work independently, have a high status and do not interfere with production on a regular basis. During the experiment, one important work method was to perform “Equipment Preventive Predictive” analyses on the most critical production equipment. The analyses were conducted by cross-functional teams consisting of a mechanical engineer, an electrician and an operator, in order to increase the maintenance procedures and productivity. In “old” factories, this goes against traditional working methods in which departments are traditionally are structurally and culturally separate. The collaboration was infused with new meaning: instead of symbolizing reduced power and status it came to symbolize mutual learning and improvement.

An additional point relates to the managers at the Canadian plant, in line with several other findings (Chan, Lau, Ip, Chan, & Kong, 2005; McKone, et al., 1999), wherein committed local management is the most important part of successful implementation of TPM. When asked why they had been able to perform as a world-class supplier, the first thing managers mentioned was participation among workers; this was also confirmed by the union representatives and the workers themselves. Some managers were not comfortable with the practice, and some had quit because of the high level of participation.

The framework by Lillrank (1995) was developed to explain, using import of quality circles from Japan to the US as an example, why attempts to transfer pure techniques and tools are seldom successful. In our case, we have expanded the framework to analyse why a copy proved to be more successful than the original, due to several engineering and some teaching changes that were implemented. The various changes in practical processes developed into new organizational vehicles that were more complementary to the TPM tools - a necessary connection in order for a successful transfer process (Lillrank, 1995, p. 979). According to Lillrank, organizational vehicles are hard to transfer due to a high abstraction level. In the present analysis, it becomes obvious that the vehicles were not transferred, but rather were translated into new ones. The practices such as teamwork and improvement activities were moved and became more successful than in the original plant, but as organizational vehicles they were changed and infused with new meaning, and came to represent other values and norms than in the original plant. As described by Czarniawska and Sevon (1996, 2005), a thing or practice that is moved from one place to another will be constructed anew, in order to fit into the new circumstances.

Conclusion

The research question in this paper addressed whether management concepts can be copied from one location to another, and the reason for potential differences. The attempt to implement TPM across different locations within the same company was thus examined. With similar technology, equipment, products and consumers as a starting point, the potential for creating a copy should be sufficient. The technical aspects of the two factories were almost identical, while the aim was to implement TPM, which is defined as consisting of five main elements, however, our study shows that TPM was implemented to a higher degree in Canada than in the original Norwegian plant.

Earlier statements (Czarniawska & Sevon, 2005) that a pure copy of any practice is hardly possible, even with the favourable circumstances presented, were confirmed. As demonstrated in this paper; minor technological adjustments led to organizational changes that influenced the level of TPM practice, leading it to become infused with different meaning that differed to that in the original plant. When a “blueprint” of an organizational system is impossible in this particular case, it is hard to image it being possible in others. The attempt to copy should then be exchanged by a willingness to adapt to the local context. Within the field of TPM, more research on organizational aspects is needed, and the focus should move from following detailed implementation schemes to understanding the local context in order to increase performance.

The main contribution of the article is to develop an understanding of translation processes, which differ from copying. In this case, the copy proved to be better than the original due to the factors explained in the paper. This provides valuable insight for operation managers when transferring concepts from one location to the other. The theoretical contribution of the paper is that it expands models of change and transfer from a purely planned change perspective to also explaining success through the change of the organizational vehicles.

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