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Implementing Information Technologies and Operational Excellence: Planning, emergence and randomness in the survival of adaptive manufacturing systems

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ABSTRACT

We explore the why and how of synergies and dysfunctions between Information Technologies (IT) and Operational Excellence (OE). Moving away from the type of analyses that focus on the starting-point and the final stage, we address the evolution of the complex factors involved in the joint deployment of IT and OE that try to transform manufacturing systems. Evidence stems from a longitudinal case study over a period of 11 years (2003–2014) in one of the world's largest canning factories. Combining quasi-experiments at the systems level with time series data, we compare the evolution of IT implementation in a Lean environment with 17 different assembly lines and 1,100 workers. Thus, building on an evolutionary framework, the paper highlights the simultaneity of planned, random and emergent components in mutations; the influence of the rhythm and sequence of reforms in the construction of capabilities; and the effect of environmental evolution on the type of mutations passed on over time.

1. INTRODUCTION

We explore the synergies and dysfunctions between Information Technologies (IT) and Operational Excellence (OE) in a Lean environment, delving into how changes come about in a complex system through evolving interactions of individuals, technologies and departments.

In principle, the introduction of IT in business seems perfectly in line with OE objectives. However, ever since the invention of the transistor in 1947 and its consequent influence on the dissemination of IT in industrial environments, many authors have been wary of how IT might affect the relevance of the human factor. Sugimori et al. [1] and Ohno [2] stated that the use of IT implied a certain dehumanization of processes and, more importantly, gave rise to unnecessary costs associated with surplus information. Along the same lines, Toyoda [3] stated that the fact that it was possible to receive a huge amount of information "just by pressing a single button" could damage workers' capacity to think and, therefore, their problem-solving skills.

IT has nevertheless developed in its benefits and ease of use and the digitalization of society has led the gradual incorporation of these technologies into manufacturing environments [4]. Today many young workers in any sector are better at using a tablet PC than writing with a pen. It is perhaps for these reasons that the management and operations literature has gradually moved toward positions that show a greater acceptance of IT deployment. Liker [5], for example, claimed that using IT was justified considering it is a reliable, proven technology, whereas Riezebos et al. [6] suggested that introducing IT could add great value to production planning or the maintenance management and business aspects, promoting principles such as JIT. More recent studies go a step further and show that IT is a key factor for improving efficiency [7]. In fact, although Lean Manufacturing (LM) can be implemented conceptually without IT, under current market conditions, the leaner an organisation aims to be, the higher the level of IT required. Actually, there are more and more studies that analyze Lean-IT initiatives in any area of organization: from the business area [8], to production [9,10], maintenance [6] and even associated to the New Product Development (NPD) process [11].

All of these analyses have undoubtedly been very useful for considering the potential synergies between IT and organizational tools for optimizing operations. Few doubts are raised today, in fact, about the capacity of IT to maximize the speed with which information can be exchanged, for facilitating data processing and

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analysis and for improving the quality of in-company communication [12,13]. It is less clear, however, how such benefits are produced, at what rhythm and in what sequence [14]. Thus, to understand the complex factors involved in the joint deployment of IT and OE, it is insufficient to solely analyze the starting-point or the final goal, as most of these studies suggest. We have to observe evolution in the process of transformation, step-by-step.

In order to do so, the analyses cannot be based exclusively on descriptions of good practices from a strictly empirical point of view and based on anecdotal evidence. In the absence of theory, such approximations often lead to specific tools (sub-routines) to be identified as the essence of OE, or many of these tools may be presented as different alternatives when they are really just different packaging covering up a lack of novelty in many concepts. The organizational solutions featured in academic analyses and in much of the more general literature should not be confused with the development of a theory of the meaning of OE, the process of organizational transformation needed to pursue it, and the role IT can play in this context. The theory we need is therefore eclectic, at the intersection of numerous bodies of literature to clarify the nature of causal relations among variables necessarily related to IT implementation, Operations Management and routine dynamics. Our goal is to identify which elements come first and when.

Against this background, the following section presents an evolutionary interpretation of OE. Although different strategies exist (Six Sigma, Agile Manufacturing, World Class Manufacturing, etc.), since LM can be considered the current dominant paradigm in operations management [15], we take its principles as the basis for our analysis. Thus, we first identify three main groups of organizational routines existing in any organization and then consider how IT can stimulate certain mutations giving rise to new (Lean-IT) routines that, depending on the traits of the specific manufacturing environment, are converted into specific static and dynamic capabilities. Section 3 explains the analytical method used and justifies its validity and reliability. Then Section 4, Results, describes the case study evaluating the interaction between lean principles (JIT, Jidoka and Respect for People –RfP–) and IT features: data reliability, real-time information and data integration. In Section 5, Discussion, we interpret the lessons learned from Jealsaís experience. In order to facilitate the line of reasoning from project evidence to case study analysis and development of propositions, we draw a complete parallel between the Results and Discussion sections in order to illustrate how concepts emerging from our data analysis provide a solid and grounded base for our conclusions. In Section 6 we describe the main implications for manufacturing industries. While analyzing the synergies between IT and LM in the food industry, we also try to explain how the conclusions obtained here might be transferable to other manufacturing sectors and different process types. Finally, Section 7 concludes with the main findings and theoretical implications.

2. AN EVOLUTIONARY INTERPRETATION OF OPERATIONAL EXCELLENCE

2.1. Toyota Production System, Lean Routines and Operational Excellence

Lean Manufacturing (LM), often known simply as “Lean”, is a systematic approach for eliminating the waste or *Muda* (non-value-added activities) by means of on-going improvement. LM is based on the Toyota Production System (TPS), which was largely grounded on the work done by Taichi Ohno in Toyota [2,5]. The generic term “LM”, coined by Womack et al. [16], appeared for the first time in their seminal book “The machine that changed the World”. Thirty years later LM is considered by many authors to be one of the most influential paradigms in operations management [15]. However it seems that there is still no consensus on a single definition of what “lean” is, what practices and tools it involves, or how it should be measured [17,18].

LM over the time has seen a lot of transformations (Lean Production, Lean Management, Lean Thinking, etc.) which have been discussed by contributors such as Womack et al. [16], Womack and Jones [19], Shah and Ward [20,9], Bhamu and Singh Sangwan [18], etc. In fact, the eclectic nature of this concept has led to many different approaches in the literature [21,9]. Continuing on from the summary drawn up by Bhamu and Singh Sangwan [18], two main streams can be identified, one practical and one philosophical. While the practical approach or “lean toolbox” considers LM as a set of tools and techniques to reduce waste (e.g. [20,9]); the philosophical or “lean culture” approach describes LM as a bundle of overarching guiding principles for achieving total transformation of the firm (e.g. [19,22]).

Our aim is to build an analysis based on what is permanent, so we address the study of LM from the two main organizational routines of this philosophy: JIT and Jidoka [16,21] and recovering a third pillar, Respect for People (RfP), very much present in the foundations of the TPS but not in the subsequent dissemination of LM [2,23].

It is precisely this concept of routine, as a unit of analysis in the study of organizational change, one of the most important ideas in our framework: the Evolutionary Theory of the Firm [24]. Although firms are subject to stochastic processes giving rise to irregular and unpredictable patterns of behavior —an idea that is essential in the paper— the concept of routine reflects what is permanent in a firm’s behavior. Routines operate as protocols whose capacity for reproduction —like genes in biology— preserves and reproduces the information they contain over time and thus serves as a firm’s “organizational memory” ().

LM routines cannot therefore be confused with tools such as 5S, Kanban or the 5 Whys. More broadly, they provide the warehouse where the knowledge of each organization is stored (knowledge on specific tools and on how to improve them), and simultaneously allow the coordination of individuals with different interests, know-how and information. We can thus identify Just in Time (JIT), Jidoka, and Respect for People (RfP) as the key sources of LM routines [1,2].

In this way, routines allow organizations to coordinate the decisions and behaviors of a multitude of agents with different interests and know-how. Three main areas can be distinguished: a) information processing for coordinating the members of the organization, b) solving technical problems, and c) designing solutions to the conflicts generated among stakeholders [24–26]. These three types of routine can be perfectly transferred to the field of OE according to the three pillars of LM as identified by seminal authors [1,2,5]: Just in Time (JIT), Jidoka and Respect for People (RfP).

To understand how routines for processing information can be reflected in JIT as a management philosophy, such operations have to be considered as activities that transform, transfer and transport information assets made up of materials and energy [27]. In fact, information cannot exist without the materials or energy with which it is associated. Hence, when we sustain that JIT seeks to produce the products required at the right time [1], we are really stating that information transmission routines must guarantee the coordination of operations by generating the right information at the right time.

However perfect the initial design of information transmission routines might seem, deploying them is subject to constant pressures that obstruct coordination. Complementary routines thus have to be designed to guarantee the quality of processes so that information is incorporated in products in the way planned. The problem-solving routines identified by Evolutionary Theory of the