

# Defining and developing measures of lean production

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## Abstract

Our research addresses the confusion and inconsistency associated with “lean production.” We attempt to clarify the semantic confusion surrounding lean production by conducting an extensive literature review using a historical evolutionary perspective in tracing its main components. We identify a key set of measurement items by charting the linkages between measurement instruments that have been used to measure its various components from the past literature, and using a rigorous, two-stage empirical method and data from a large set of manufacturing firms, we narrow the list of items selected to represent lean production to 48 items, empirically identifying 10 underlying components. In doing so, we map the operational space corresponding to conceptual space surrounding lean production. Configuration theory provides the theoretical underpinnings and helps to explain the synergistic relationships among its underlying components.

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## 1. Introduction

In 360 BC, Plato (in *Cratylus*) suggested that linguistic confusion arises because multiple terms may refer to the same object or idea, a single term may refer ambiguously to more than one object or idea, and terms may be confusing because they are out of date. The same observations can be made today with respect to a number of management approaches. The current study addresses these issues with regard to lean production. We believe that the price paid for lacking a clear, agreed-upon definition is high because empirical testing of inexact and

imprecise concepts lead to a body of research that examines slightly different aspects of the same underlying constructs masked by different terminology. Consequently, results from such testing do not improve our understanding, make marginal contributions to the existing knowledge base, and prevent academic fields from making real progress (Meredith, 1993). If theory and empirical work are to advance in this area, semantic differences between lean production and its predecessors must be resolved, the conceptual definition of lean production must be clarified, and operational measures must be more clearly specified. In this paper, we address these three issues.

The approach now known as lean production has become an integral part of the manufacturing landscape in the United States (U.S.) over the last four decades. Its link with superior performance and its ability to provide competitive advantage is well accepted among academics and practitioners alike (e.g., Krafcik, 1988; MacDuffie,

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1995; Pil and MacDuffie, 1996; Shah and Ward, 2003; Wood et al., 2004). Even its critics note that alternatives to lean production have not found widespread acceptance (Dankbaar, 1997) and admit that “lean production will be the standard manufacturing mode of the 21st century” (Rinehart et al., 1997, p. 2). However, any discussion of lean production with managers, consultants, or academics specializing in the topic quickly points to an absence of common definition of the concept.

This lack of clarity is evident from the multiplicity of descriptions and terms used with respect to lean production. The ambiguity stems in part because lean production evolved over a long period of time (Hopp and Spearman, 2004; Womack et al., 1990; Spear and Bowen, 1999) and because of its mistaken equivalence with other related approaches. Hopp and Spearman (2004) note that using closely related terms in the titles of some of the earliest publications may have also contributed to this confusion (see for example Sugimori et al., 1977). These primarily semantic differences between lean and its predecessors are unfortunate but can be resolved fairly easily. A greater source of confusion, however, is the more substantive disagreement about what comprises lean production and how it can be measured operationally.

Our objectives in this paper are as follows. First, we attempt to resolve the semantic confusion surrounding lean production and explain the different perspectives invoked in describing it using a historical evolutionary lens. Second, in our pursuit of a commonly agreed upon definition of lean production, we propose a conceptual definition that encompasses its underlying multidimensional structure. Finally, using a rigorous empirical method, we identify a set of 48 items to measure lean production and its main components. Additionally, we chart the linkages among the items and the components and map the operational space as it corresponds to the conceptual space. In short, we develop the concept of lean production based on extant knowledge and use data from a sample of manufacturers to develop an operational measure that consists of 10 reliable and valid scales.

## 2. Historical background

Defining lean production requires first examining its historical evolution and identifying the different perspectives that are commonly invoked in describing it. We highlight the key phases that have contributed to our current understanding of lean production in Table 1. Lean production directly descended from and is frequently used as a proxy for Toyota Production System (TPS), which itself evolved from Taiichi Ohno's

experiments and initiatives over three decades at Toyota Motor Company. TPS was formally introduced in the U.S. in 1984 when NUMMI was established as a joint venture between Toyota and General Motors, but its informal transfer to the U.S. began much earlier, occurring over time in a piecemeal fashion. A consequence of the slow geographic dispersion separated by a significant time lag was that the understanding of the new system in the U.S. evolved even more slowly and with an additional time-lag.

Because TPS was multifaceted and complicated, it was not easy for U.S. managers to comprehend the true nature of the production process. As in the age-old fable of the blind men touching different parts of an elephant and imagining very different animals, these managers often focused on a single, visible aspect of the process while missing the invisible, highly inter-dependent links of the system as a whole. By the time U.S. managers realized the numerous elements underlying TPS, and, by extension, lean production, these different terms had become deeply ingrained in the common lexicon of the academic and business publications. As a result, semantic discrepancies crept in even when no substantive difference was apparent. Currently, there are numerous academic and practitioner books and articles, yet we still do not have a precise and agreed upon way of defining or measuring lean production.

### 2.1. *Lean production—a literature review*

Reviewing the existing literature provides a starting point in defining lean production. Additionally, it helps us highlight the confusion in the conceptual and the operational space surrounding lean production and glean a set of operational measures that can be used to represent it. In conducting our review, we began with the earliest publications related to Japanese manufacturing/production systems ending with the most recent publications related to lean production. We observed that, in general, the early Japanese books were more precise in defining TPS and in identifying its underlying components (Monden, 1983; Ohno, 1988) compared to the research articles because the latter focused on defining and describing specific components of the system rather than the whole (Sugimori et al., 1977; Monden, 1981b). However, the distinction between the system and its components was missed by most early observers, perhaps because of the articles and monographs related to the components were published before the books (in English) that described the system.

This lack of distinction between the system and its components was further complicated by the general

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