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Research Article

IMPACT OF LEAN MANUFACTURING TECHNIQUES FROM THE PERSPECTIVE OF MANAGEMENT ACCOUNTING ON INVENTORY TURNOVER

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ABSTRACT
Lean manufacturing (LM) is currently enjoying its second heyday. Companies in several industries are implementing lean practices to keep pace with the competition and achieve better results. In this article, we will concentrate on how companies can improve their inventory turnover performance through the use of lean practices. According to our main proposition, firms that widely apply lean practices have higher inventory turnover than those that do not rely on LM. However, there may be significant differences in inventory turnover even among lean manufacturers depending on their contingencies. Therefore, we also investigate how various contingency factors (production systems, order types, product types) influence the inventory turnover of lean manufacturers. We use cluster and correlation analysis to separate manufacturers based on the extent of their leanness and to examine the effect of contingencies. We acquired the data from the International Manufacturing Strategy Survey (IMSS) in ISIC sectors 28–35.

Keywords: *Lean, Inventory Turnover, Manufacturing Techniques, Inventory Management*

INTRODUCTION
Every company has to invest in manufacturing management programs, methods and technologies in order to remain competitive. One very popular investment choice nowadays is lean production (LP), which consists of several manufacturing practices, including process focus, pull production, quality development, total productive maintenance, continuous improvement, worker empowerment, supplier development, and so on. The main objective of LP is to satisfy customer needs on the highest possible level through the elimination of waste. However, if this is true, and several kinds of waste can be reduced, why does every company not implement LP, and why do some fail during the implementation process? In the early literature, researchers blamed various conditions: for example, excessive demand fluctuation, a high level of product variation, or low demand that therefore cannot justify a line production system or cellular manufacturing. A few years later, however, we read about successful lean manufacturing program implementation at companies and industries that were far from satisfying these conditions (e.g., health care, Fillingham, 2007). In this paper, we investigate how various contingency factors influence inventory turnover performance, a very important indicator of the success of LP in companies applying lean practices (see e.g., Huson and Nanda, 1995). For this purpose, we formulate the following research questions:
1) How do lean practices affect firm inventory levels?
2) How do certain contingency factors (production systems, order types and product types) influence corporate inventories within an LP environment?
LP originated from the Toyota production system (TPS) and gained ground as a best-practice manufacturing strategy and repository of increasing competitiveness in recent decades (Voss, 2011; 2007). The best evidence of this phenomenon is the increase in the number of lean transformations all over the world in the preceding 10–15 years (Bruun and Mefford, 2003). It is extremely difficult, however, to determine what LP stands for. Unfortunately, definitions are rather vague and confused, with several elements and sub-elements put forth in various papers. Even in standard OM textbooks, one can find only definitions such as ‘‘[lean production is] an integrated set of activities designed to achieve high-volume production using minimal inventories of raw materials, work-in-process, and finished goods’’

(Lewis, 2012). The first publication using the term (Womack *et al.*, 2012) explained lean production simply as a journey leading to the use of less resource According to Karlsson and Ahlstrom (2010), LP permeates an entire organization (Figure 1). It consists of lean development, lean procurement, lean manufacturing (LM) and lean distribution. This shows that the proper utilization of LP affects the whole firm. However, LP is not only a set of practices connected to the value- creation process. Rather, LP constitutes the pursuit of excellence based on a mixture of performance, continuous improvement and organizational change (Toni and Tonchia, 2014). Empirical evidence supports the idea that LP partially explains high corporate performance. For example, the British auto components industry increased its stock turn ratio by 177.4% between 1992 and 1994 (Oliver *et al.*, 2010). Indeed, early implementation was seen in the automotive and electronics industries (Crawford *et al.*, 2012). We analyzed data from an international manufacturing survey that also contained questions from other corporate functions, but wherein manufacturing was in the focus. On this basis, we concentrated our subsequent efforts only on the LM part of lean production. This decision was also supported by the fact that manufacturing is the function whereby leanness is usually introduced to a company. Therefore, if one is looking for candidates for lean adaptation, one must look at the first area of LP implementation that is, manufacturing. Karlsson and Ahlstrom (2010) enumerate the following building blocks of LM: elimination of waste, continuous improvement, multifunctional teams, zero defects/JIT, vertical information systems, decentralized responsibilities/integrated functions, pull versus push (see Figure 1).

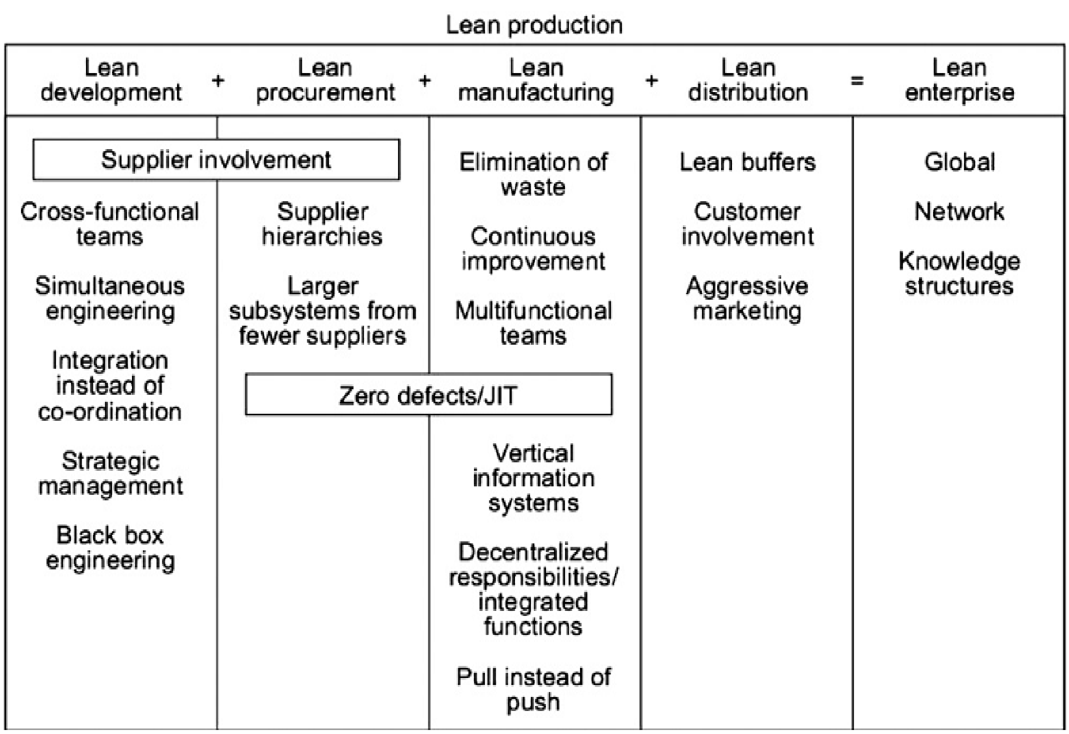

Figure 1: Elements of lean production (Karlsson–Ahlstrom, 2010)

Size is the contingency factor that we investigated thoroughly. Differences in size have two consequences. First, large manufacturers are more likely to implement lean practices than are small ones (Lowe *et al.*, 2013; Shah and Ward, 2014). Second, though small firms may also implement critical elements of LM, the applied practices will, to some extent, be different than the practices in large firms. One characteristic distinction is the use of multifunctional workers. Small companies cannot afford to employ different workers for every single task, so workers with multifunctional skills will be more welcome (Inman and Mehra, 2008; Shah and Ward, 2014). We used five contingency factors during our research.

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Now we are able to formulate our propositions and research model (Figure 2):
Proposition 1*:* Companies that use LM practices to a greater extent have lower levels of inventory than do companies that use LM practices less. From now on, we call the companies in the first group lean companies and the companies in the second group traditional companies.
Proposition 2*:* Inventory turnover is higher in lean companies that use line production systems (cellular layout or dedicated line) to a greater extent.
Proposition 3*:* Lean companies with make to order (MTO) and assemble to order (ATO) processes are better off in terms of their inventory turnover than are engineering to order (ETO) or make to stock (MTS) companies.
Proposition 4*:* Producing in batches in lean companies results in higher inventory turnover than does one-of-a-kind or mass production.

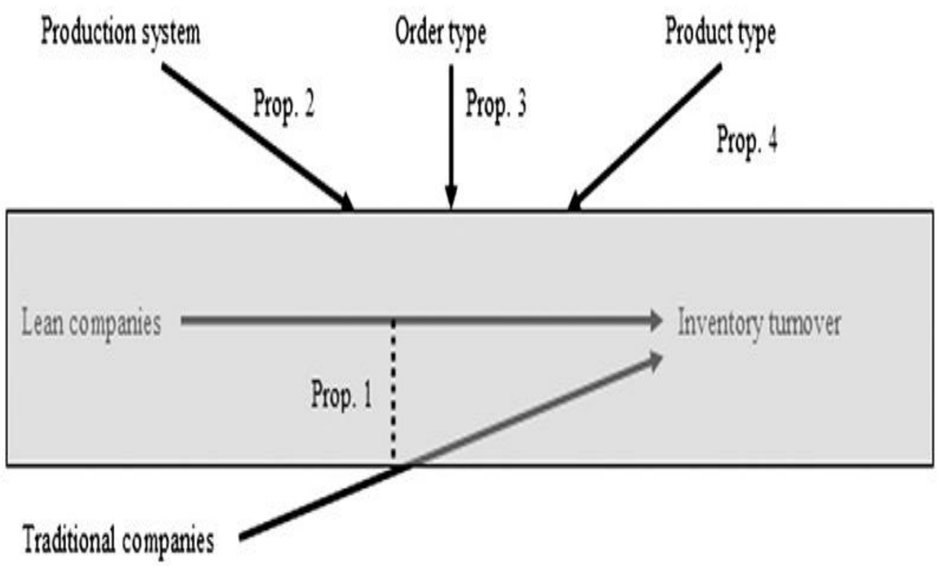

Figure 2: The Conceptual Model

The industry and country characteristics of the database can be seen in Tables 1 and 2.

Table 1: Number of observations in various industries in the survey

Manufacture of	Observations
Fabricated metal products	270
Machinery and equipment	146
Office, accounting and computing machinery	16
Electrical machinery and apparatus	92
Radio, television and communication equipment and apparatus	39
Medical, precision and optical instruments, watches and clocks	29
Motor vehicles, trailers and semi-trailers	68
Other transport equipment	41
Missing	10

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Table 2: Geographic disrtibution of the participating firms

Countries	Valid answers
Argentina	44
Australia	14
Belgium	32
Brazil	16
Canada	25
China	38
Denmark	36
Estonia	21
Germany	18
Greece	13
Hungary	54
Ireland	15
Israel	20
Italy	45
New Zealand	30
Netherlands	63
Norway	17
Portugal	10
Sweden	82
Turkey	35
UK	17
USA	36
Venezuela	30
Total average	31

MATERIALS AND METHODS

Our main goal was to ascertain how lean practices affect inventories. In order to investigate this effect, we first had to classify the companies as traditional or lean. For this division, we used the k-means cluster method based on six sets of LM practices: (a) process focus, (b) pull production, (c) quality programs, (d) increase in equipment efficiency, (e) form of lean organization and (f) continuous improvement.

We expect that the companies in the lean companies cluster use these sets of practices more intensely than do traditional companies, thus earning a higher average score for these sets of practices. Cluster means for the selected items for traditional and lean companies are summarized in Table 3.

Table 3: Cluster means of the manufacturing in traditional and lean companies

Variables (1–5 scale)	Traditional	Lean	F-value (*p*)
Process focus	2.64	3.90	258 (0.000)
Pull production	2.19	3.46	248 (0.000)
Quality programs	2.45	3.64	275 (0.000)
Increase of equipment efficiency	2.17	3.44	305 (0.000)
Form of lean organization	2.18	3.29	202 (0.000)
Continuous improvement	2.11	3.57	412 (0.000)

We call the two groups in question, traditional companies and lean companies. The group of traditional company's contained280 companies, while the lean group contained 330 companies (101 companies did not answer the relevant questions and were omitted).

The results can be seen in Table 4.

Table 4: Relation of company size and leanness

Type/size	SME	Large	Total
Traditional	196	84	280
Lean	159	171	330
Total	355	255	610

Small lean companies should be at least as high-performing in terms of these measures as their traditional competitors. If this does not hold, then our selection criteria for separating the two groups are wrong. We also checked these criteria for large companies. The differences are summarized in Table 5.

Table 5: Performance measures of traditional and lean companies in small and large companies

	Traditional	Lean	F-test	*p*
Small companies				
Ratio for JIT delivery from suppliers	36.1	42.8	3.2	0.077
Ratio for JIT delivery to customers	47.0	53.1	1.9	0.169
Throughput time efficiency	53.5	49.6	1.0	0.309
Late delivery	10.1	10.9	0.2	0.666
Scrap and rework costs	3.59	3.98	0.3	0.595
Large companies				
Ratio for JIT delivery from suppliers	26.1	40.5	9.4	0.002
Ratio for JIT delivery to customers	37.1	55.4	11.5	0.001
Throughput time efficiency	38.6	48.7	3.9	0.049
Late delivery	8.46	8.65	0.0	0.918
Scrap and rework costs	3.03	3.26	0.1	0.713

For the most typical lean measures (JIT deliveries, throughput time efficiency) large lean companies perform significantly better (at the p = 0.05 level) than do traditional companies, while in terms of reliability and quality, they are not worse than the others. On the other hand, we did not find any significant difference between small lean and traditional companies in the examined performance measures. Thus, following the literature and our results, we decided that our analysis would only include large companies. This meant that we had 255 companies to compare, of which 84 were traditional and 171 were lean companies.

RESULTS AND DISCUSSION

Our main research question was how LM practices affect inventory turnover. The survey asked about the inventories in terms of number of production days (see Question 7 in the Appendix). Unfortunately, this scaling caused difficulty in calculating inventory turnover in the usual way (365/inventory days). Several companies indicated that they have inventory that spans zero days, but the real inventory level could be anywhere between zero and one day. We chose not to replace these answers with some arbitrary average number, as a very small change in the number would cause a huge change in inventory turnover (e.g., a 12-hour inventory would mean a yearly inventory turnover of 730, while a 6-hour inventory would mean a turnover of 1460). Therefore, we decided to use inventory day data to characterize inventory turnover. We used correlation analysis for this purpose. The results can be seen in Table 6.

On the basis of Table 6, our proposition is supported. Each type of inventory turns faster at large lean companies than at large traditional ones. The greatest differences are on the supply and customer sides of the firm, even though our criteria for separation have been based on the internal manufacturing characteristics of companies (production control, quality, human practices). Nevertheless, the work-in-process (WIP) inventory based on production days is also lower for lean companies.

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Table 6: LM practices and inventory days

Inventory days	Traditional	Lean	F-test	p
Raw material inventory days of production	38.6	24.8	11.58	0.001
Work in process inventory days of production	22.8	15.1	4.37	0.038
Finished product inventory days of production	25.4	13.5	9.67	0.002

Discussion and Conclusion

LM seems to be a powerful tool for managing inventory turnover. Companies that implement lean practices in manufacturing have significantly better inventory turnover for each type of inventory (RM, WIP and FG) than do traditional companies.

We can draw several conclusions from this analysis. First, we found a significant relationship between LM practices and inventory turnover. Lean companies keep fewer inventories of any type. In addition, LM practices were mostly applied in environments described in lean theory.

In further research, it may worth examining the differences among the individual industries of the ISIR 28–35 industries. In addition, our model could be extended to include other business performance indicators. In this way, we could see whether there is a direct relationship between inventory turnover and business performance or whether this effect is not that strong in itself.

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