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German inventory to sales ratios 1971–2005—An empirical analysis of business practice

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ABSTRACT

The purpose of this study is to test empirically for the first time the general hypothesis that inventory to sales ratios have decreased over time in the German economy. Although inventory reduction has been a prevalent topic in the production and operations management literature, there is a lack of empirically confirmed answers to questions. They are as follows: Have inventories in German firms decreased overall during the past decades? What sectors of German industry are leading (lagging behind) inventory reduction? Has inventory reduction developed differently for raw materials, work-in-process, or finished goods? In which periods was marginal inventory reduction greatest? To the best of our knowledge, this empirical study is the first to broadly investigate inventory development from the 1970s until the present for a major European economy, Germany, and will provide the first answers to the research questions stated above using aggregate industry-level data provided by the Deutsche Bundesbank. We show that inventory levels decreased overall in many sectors of German industry. This reduction was mainly marked for raw materials and finished goods, particularly for the second-half of the time frame investigated.

1. Introduction

For more than three decades now there has been continuing discussion about how lean a company should be. The starting point can be seen in the early 1980s, when Western managers and scientists began to discover the tremendous success of Japanese firms at that time. Most visitors to Japanese companies were mainly impressed by their drastically reduced inventory levels. Hence, inventory reduction became a prevalent topic. Myriads of articles and case studies have been written about the needs of firms and their efforts to reduce inventories and inventory carrying costs. Furthermore, a new management paradigm was coined. Interpreting inventory as a consequence of underlying waste to be eliminated causing inventories to drop and productivity to rise, a level of "zero inventory" became one of the main goals for managing production processes under this paradigm (Nakane and Hall, 1983; Grünwald and Fortuin, 1992; Zangwill, 1992; De Haan and Yamamoto, 1999). In the course of time, more and more activities from operations and supply chain management trying to achieve the goal of stockless production were summarized under the "just in time" paradigm in its broadest sense (Hall, 1983), and were conceptualized even more broadly some years later under the "lean production" paradigm (Womack and Jones, 1994). JIT systems have been widely established in business practice during the past decades. However, although these concepts have been known for decades, they are currently enjoying their second heyday (Demeter and Matyusz, 2010). Companies in several industries are still applying such practices or are even starting to implement them to provide more fuel for their race for profits.

There are very few papers, which empirically analyze the effects of these paradigms on business performance in general and on inventories in particular. With respect to national economies there is only one country in which inventories are sufficiently studied: the United States (US). Outside the US empirical inventory research is largely unexplored (Chikán et al., 2011). This is all the more surprising as there is a great deal of capital tied up in inventories, costing firms a lot of money (not only in times of recession). At the end of 2005, German businesses held more than 400 billion EUR worth of inventory. Undoubtedly, this is a remarkable sum: roughly estimated over 5000 EUR per head in Germany. But who actually holds inventories? Companies of course; at the end of 2005 there were nearly two million of them holding an average of 200,000 EUR worth of inventory.

The motivation behind this article is the lack of empirically confirmed answers to the following research questions: Have inventories in firms actually decreased overall during the past decades? What industry sectors are leading (lagging behind)

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inventory reduction? Has inventory reduction developed differently for raw materials, work-in-process, or finished goods? Has marginal inventory reduction been greater since the 1990s, when inventory consciousness increased due to the "zero inventory" paradigm? Can we see any effect of modern systems of inventory control on inventories held? How far are German firms away from "zero inventory"?

Outside the US economy there is hardly any empirical evidence on inventory performance over the long term. Therefore it seems fruitful to compare existing knowledge with findings from Germany, as a major European economy. German industry is especially concerned with different manufacturing sectors at all stages of the production process, i.e. raw materials, work-in-process, and finished goods. This study is the first to conduct a broad, empirical investigation of inventory development for the German industry from the 1970s until the present and will provide answers to the research questions stated above. Furthermore, this is the first study to use aggregate industry level data provided by the Deutsche Bundesbank over a time frame of four decades and to be based on the most extensive statistical analysis of financial statements in Germany.

The paper is organized as follows: In the following section we review the existing body of literature and summarize major findings. In Section 3 we describe our research methodology as well as the data sources used and develop several hypotheses regarding inventory trends in the past decades. The results are presented and discussed in Section 4. We conclude with limitations and further opportunities for research.

2. Literature review and hypotheses

There are several reasons that cause firms to hold inventories: inventories are held to smooth production levels, to avoid costs of adjusting production capacity when demand is variable, to reach high customer service levels, to avoid stock-out costs, as a buffer against uncertain supply and demand, to keep manufacturing processes running even when there is a breakdown or a need to rework low-quality output, to speculate on or hedge against price or cost movements, or to reduce purchasing costs by buying greater amounts or to realize economics of scale by producing greater quantities (e.g. Blanchard, 1983; Blinder and Maccini, 1991; Rotemberg and Saloner, 1989; Cuthbertson and Gasparro, 1993). However, product variety also drives inventories. Analyzing data from a General Motors automobile assembly plant together with simulation analyses, Fisher and Ittner (1999) find higher inventory levels as a consequence of greater product variety. To build the theoretical foundations of this study we reviewed four streams of literature. These are operations research (OR), just-in-time (JIT), and supply chain management (SCM) with its extensions to value-based management (VBM).

For over 50 years now scholars from operations research have been concerned with "inventory theory in the service of practice—not theory for the sake of theory" (Wagner, 2002, p. 217), developing and applying inventory models and advanced inventory control systems with a view to avoiding excess inventory, because there is one central argument against inventories: holding them costs money due to storage, security, insurance, obsolescence, and tied-up capital.

Considering this conflicting relationship between setup costs, replenishment costs and stock-out costs on the one hand and carrying costs on the other, numerous models were developed in operations research to determine optimal lot sizes and inventory levels under different circumstances (e.g. Silver, 1981; Silver et al., 1998). Accordingly, it should be possible for the implementation of such inventory models in modern material requirement planning (MRP) and enterprise resource planning (ERP) systems, which are widely used in business practice to reduce inventories by applying modern optimization procedures, tighter scheduling within factories and better matching resource requirements and internal operations to customer orders. Furthermore, from their formal model of a firm utilizing modern manufacturing technology Milgrom and Roberts (1990) derive that lower levels of inventories are to be expected over time. Besides the adoption of modern techniques there might also be a simple theoretical argument for the hypothesis that inventory must decrease over time on condition that product variety is constant. Following the EOQ model a sales increase of 10%, for example, leads to an inventory increase of a lower percentage: Imagine a quantitative sales growth for a specific product of 1000–1100 (i.e. 10%), whereas setup costs remain at 50 EUR and holding costs at 1 EUR per unit. Following the classic EOQ model we can figure out that lot size will only change from 316 to 332; i.e. 5%. As a consequence, inventory ratios like inventory-to-sales should decrease over time with an increase in output.

Despite these operations research driven efforts in reducing inventory, the "just-in-time" paradigm does not accept the implication of "necessary" costs of holding inventory. The core principle of JIT is that inventory reflects waste and should be eliminated, causing productivity to rise (Nakane and Hall, 1983; Schonberger, 1982; De Haan and Yamamoto, 1999). Lieberman and Demeester (1999, p. 466) point out that "inventories prevent the discovery of problems on the shop floor and thus [are] detrimental to productivity". Hence, the key argument behind the JIT logic is that inventory would only be necessary because of unsolved problems. In the context of determining optimal lot sizes, such unsolved problems could be time-consuming set-up processes, which it would be better to eliminate or reduce to a minimum with the consequence that the classical lot-sizing problem would go up in smoke. Another class of unsolved problem could be defects and machine breakdowns as well as low output quality. Eliminating these defects and quality failures would contribute to a production system that can operate at minimum, if not "zero inventory". Delbridge and Oliver (1991), for example, compare Japanese car manufacturers with their Western counterparts during the period 1975–1989 and find that the Japanese had a significantly higher inventory turnover. A similar pattern was found with Japanese and Western car manufacturer suppliers, which negates the idea that superior inventory turnovers of Japanese manufacturers are achieved by compelling their suppliers to carry inventory for them. Huson and Nanda (1995) study a sample of 55 JIT adopters, discovering increased inventory turnover subsequent to their JIT implementation. Furthermore, they find a significant correlation between inventory turnover improvements and increasing earnings per share. Balakrishnan et al. (1996) also compare a sample of 46 JIT adopters with a sample of non-adopters of the same size but observe no significant effects on financial performance. This also holds for a survey conducted by Sakakibara et al. (1997). Lieberman and Demeester (1999) study 52 Japanese automotive companies over a time period from the late 1960s to the early 1980s, shedding light on the linkage between inventory and productivity: as expected from the view of the "zero inventory" paradigm they find that firms reducing inventory substantially were able to improve labor productivity significantly. Although the majority of studies empirically support the notion that JIT adoption improves inventory performance, there is a mixed picture due to those studies finding the opposite. Furthermore, most of these studies are limited to a few firms in selected industries, mainly the automotive industry, and are therefore not able to deliver the "big picture".

The third stream of literature has to do with uncertainty of supply, which could be reduced by closer coordination with