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Inventory configurations and drivers: An international study of assembling industries ☆

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ABSTRACT

In recent decades, inventory reduction has been a key objective of companies in various industries and is particularly important in the current crisis. Inventory is closely related to a company's production system and supply chain and a one-way strategy towards zero-inventory can be inapplicable or too general. As a matter of fact, there is a complex relationship between inventory types (input, WIP and output) and the factors causing or affecting them. On the basis of three editions of a survey in different assembly industries (IMSS) carried out in 2001, 2005 and 2009, we demonstrate in this paper that the actual configurations that companies adopt, as well as the factors behind the chosen configurations, are stable and consistent over time, in terms of the levels of each type of inventory. We also show that not all of the companies are stuck in a configuration; with the right measures, they can reduce the stock of inventory and become more competitive.

1. Introduction

Inventories are costly. For instance, in the automotive industry, the level of inventory to be financed compared to the level of sales was 4.4% in Japan and 8% in the US from 1990 to 1993 (Lieberman and Asaba, 1997). Nevertheless, inventories are unavoidable parts of operations. Inventories are generally kept in order to: (a) prepare for future operations (anticipation inventory); (b) cover usage between two supplies (decoupling inventory); (c) provide economies of scale in production and deliveries (cycle inventory) and (d) buffer against demand uncertainties (buffer inventory) (Slack et al., 2007). Each of these purposes is applicable for each type of inventory: input, work-in-process (WIP) and finished goods (FG). However, certain factors affect these inventory types differently.

First, regular shortages can lead to higher levels of input inventories (Kornai, 1979; Kraljic, 1983). Consequently, companies may buy and pile up raw materials to avoid production stoppages. In contrast, companies in competitive product markets keep relatively high levels of FG inventories to provide products to customers at any time. Other key factors, related to the supply chain (Jones and Riley, 1985) or the production characteristics (Demeter and Matyusz, 2011), as well as the strategy of firms (Ward et al., 1996), lead to different inventory configurations, that is, to different ratios of input, WIP and FG inventories.

Understanding the drivers behind these configurations is fundamental to setting up an inventory optimisation strategy because the drivers can have very different impacts on inventory levels. For instance, higher product variety can increase each type of inventory: more kinds of input are needed, more kinds of FG are produced and production processes become more complex, resulting in higher WIP inventories. On the other hand, changing the decoupling point (Olhager, 2003) by allowing customer orders to enter ahead into the production flow can change the ratios of inventory types by decreasing the ratio of FG inventories and increasing WIP inventories.

As a result, identifying the typical inventory configurations and the drivers behind them provide a powerful strategic tool to inventory managers. Inventory managers can understand the constraints of their inventory reduction efforts and make their decisions more logically.

Inventory characteristics may vary among industries, however. Process industries (with non-discrete products) and assembly industries (with discrete products) differ greatly from one another (Dennis and Meredith, 2000). While the variety of inputs in the process industries is usually low and there are only a few places within the production process to keep inventories, the variety of FG can be high. Sometimes these processes are referred to as *analytic*, meaning that singular input is processed into many separate outputs (Meredith, 1992). Nevertheless, there are large differences even within the process industry (Dennis and Meredith, 2000). However, in the

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assembly industry, the input variety is usually high, there are several points to keep WIP and the variety of FG can also be high. Assembly industries are called *synthetic* because many materials come together to form a singular discrete output. We focus on the assembly industry in this paper.

The aim of this paper is to illuminate the typical inventory configurations and their relationship with internal and external factors within the assembly industry. We start with a literature review to identify possible factors related to different types of inventories. Next, using data from the 2001, 2005 and 2009 International Manufacturing Strategy Surveys, we identify different inventory-based configurations and relate these configurations to explanatory factors. Finally, we discuss our findings and draw conclusions.

2. Literature review

Inventories have a clear impact on the financial performance of firms (Capkun et al., 2009). Chikán (2011, 2009) reported that inventories "*serve as strategic tools in achieving customer satisfaction and profit simultaneously*", but that they can be "*efficiently managed only as parts of the supply chain, jointly with other company functions*". These two statements show, on one side, the strategic importance of inventories and, on the other side, the growing complexity of effective inventory management. As a matter of fact, inventory decisions must be coordinated among company functions (e.g., purchasing, manufacturing, logistics and marketing). These functions are responsible for different types of inventories, namely input (i.e., material and components), WIP and FG. Moreover, while WIP inventory represents an intra-firm buffer, input and FG inventories are called inter-firm buffers because they must be coordinated with suppliers and customers (Lieberman and Demeester, 1999). Thus, discussing inventory management issues inevitably requires involving both intra- and inter-company factors.

In recent decades, lean management has had the largest impact on inventory management practices and performance (Capkun et al., 2009). Following lean principles, companies can reduce the level of different types of inventories. A trend of WIP inventory reduction has occurred in many industries, starting in the Japanese automotive industry (Lieberman and Demeester, 1999).

Chen et al. (2005) extended their analysis to other inventory types and found a similar pattern of reduction (2%, on average, between 1981 and 2000). However, the FG inventories tended to stay more stable compared to input and WIP, both of which significantly decreased. The stability in FG inventories was confirmed by Rajagopalan and Malhotra (2001), who found that input and WIP inventories significantly decreased from 1961 to 1994 in most industries, while FG decreased in only a few industries (such as the electric, electronic equipment, rubber, leather, food and tobacco industries).

Lean management has some limitations; however, particularly in regard to product variety and high geographical distances (Cusumano, 1994). Moreover, being too lean can be counterproductive. There is a broad range of literature on lean versus agile supply chains (Bruce et al., 2004; Cagliano et al., 2004; Goldsby et al., 2006; Mason-Jones et al., 2000; Naylor et al., 1999), which claim that inventories in fast markets can create higher responsiveness and avoid lost sales. Moreover, in global contexts characterised by risks and uncertainties, inventories can play a buffer role in hedging possible supply or production disruptions (Juttner et al., 2003).

Additionally, empirical evidence has demonstrated that being too lean is not always good. Chen et al. (2005) show that firms with very high inventories have poor long-term stock returns. However, very low inventory is not associated with higher financial performance.

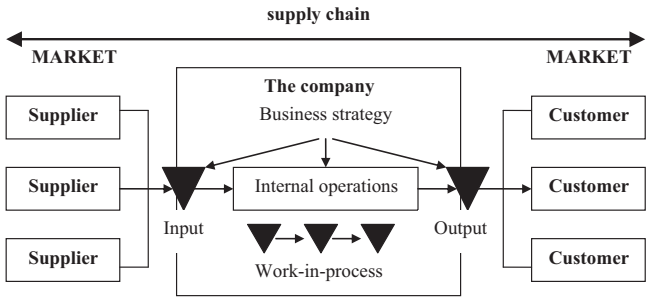

Fig. 1. Factors influencing business unit inventories.

Consequently, some companies keep some inventory where it is more strategic. This decision depends upon some characteristics of the market, of the supply chain or of the company (see Fig. 1). At this stage, it is important to specify that, even if we take into account supply chains (which have a large impact on business unit inventories), our unit of analysis is the business unit and we do not consider inventory optimisation issues at the supply chain level.

Adopting a contingency-based perspective, as advocated for our discipline (Sousa and Voss, 2008), we checked the literature for the factors that can influence the aforementioned types of inventories. In particular, we identified four groups of factors (Fig. 1):

1) Market factors (both supplier and customer sides) that give the external context for company operations (Porter, 1980) and inventory decisions
2) Internal operations, which provide the internal context through existing operating technologies, processes and procedures
3) The characteristics of the supply chain the company belongs to, which determines the type and variety of materials and products it buys, produces and sells, as well as the partner relationships themselves

Business strategy, which has an impact on the priorities companies follow in their internal and external decisions. It should be emphasised that the factors above are logically interrelated. For instance, market factors affect not only input and FG inventory, they may also influence WIP, as more refined needs of customers may drive implementation of manufacturing customization, which means interference into WIP. Nevertheless, we focus on the most important impacts in our paper.

These direct or mediated impacts on inventories (e.g., Cachon and Olivares, 2010) will be discussed in the following sections.

2.1. Market factors

Market factors influence input and FG inventories. The power of partners, and thus the conditions of services and products they provide/expect, depend on the competition on the market.

In resource-constrained systems, for example, if the number of suppliers is limited or uncertainty of deliveries is high, customers tend to buy larger amounts at one time and are more ready to substitute. In these markets, it is easy to sell and difficult to buy. The ratio of FG is low for suppliers, while the ratio of input is high for customers. In demand-constrained systems, the situation is the opposite (Chikan, 1996; Kornai, 1979).

Furthermore, material cost plays an important role in inventory decisions. If the material cost is high compared to other costs (e.g., work or overhead), then holding inventory of any type, even of raw materials, will be more costly (Beamon, 1998), forcing companies to reduce the inventory. Material costs depend heavily on market characteristics, such as the number and bargaining power of suppliers (Porter, 1980).

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