A Review of Just-in-time Manufacturing

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Just-in-time (JIT) manufacturing, also known as just-in-time production or the Toyota Production System (TPS), is a methodology aimed primarily at reducing times within the production system as well as response times from suppliers and to customers. Its origin and development was in Japan, largely in the 1960s and 1970s and particularly at Toyota.

Alternative terms for JIT manufacturing have been used. Motorola's choice was short-cycle manufacturing (SCM). IBM's was continuous-flow manufacturing (CFM), and demand-flow manufacturing (DFM), a term handed down from consultant John Constanza at his Institute of Technology in Colorado. Still another alternative was mentioned by Goddard, who said that "'Toyota Production System is often mistakenly referred to as the 'Kanban System'", and pointed out that kanban is but one element of TPS, as well as JIT production.

But the wide use of the term JIT manufacturing throughout the 1980s faded fast in the 1990s, as the new term lean manufacturing became established, as "a more recent name for JIT". As just one testament to the commonality of the two terms, Toyota production system (TPS) has been and is widely used as a synonym for both JIT and lean manufacturing.

Evolution in Japan
The exact reasons for adoption of JIT in Japan are unclear but it has been suggested it started with a requirement to solve the lack of standardisation. Plenert offers four reasons, paraphrased here. During Japan's post-World War II rebuilding of industry: 1) Japan's lack of cash made it difficult for industry to finance the big-batch, large inventory production methods common elsewhere. 2) Japan lacked space to build big factories loaded with inventory. 3) The Japanese islands were (and are) lacking in natural resources with which to build products. 4) Japan had high unemployment, which meant that labour efficiency methods were not an obvious pathway to industrial success. Thus the Japanese "leaned out" their processes. "They built smaller factories ... in which the only materials housed in the factory were those on which work was currently being done. In this way, inventory levels were kept low, investment in in-process inventories was at a minimum and the investment in purchased natural resources was quickly turned around so that

additional materials were purchased." Plenart goes on to explain Toyota's key role in developing this lean or JIT production methodology.

Migration to the West

News about JIT/TPS reached western countries in 1977 in two English-language articles: one referred to the methodology as the "Ohno system", after Taiichi Ohno, who was instrumental in its development within Toyota. The other article, by Toyota authors in an international journal, provided additional details. Finally, those and other publicity were translated into implementations, beginning in 1980 and then quickly multiplying throughout industry in the United States and other developed countries. A seminal 1980 event was a conference in Detroit at Ford World Headquarters co-sponsored by the Repetitive Manufacturing Group (RMG), which had been founded 1979 within the American Production and Inventory Control Society (APICS) to seek advances in manufacturing. The principal speaker, Fujio Cho (later, president of Toyota Motor Corp.), in explaining the Toyota system, stirred up the audience, and led to the RMG's shifting gears from things like automation to JIT/TPS.

At least some of audience's stirring had to do with a perceived clash between the new JIT regime and manufacturing resource planning (MRP II), a computer software-based system of manufacturing planning and control which had become prominent in industry in the 1960s and 1970s. Debates in professional meetings on JIT vs. MRP II were followed by published articles, one of them titled, "The Rise and Fall of Just-in-Time". Less confrontational was Walt Goddard's, "Kanban Versus MRP II—Which Is Best for You?" in 1982. Four years later, Goddard had answered his own question with a book advocating JIT. Among the best known of MRP II's advocates was George Plossl, who authored two articles questioning JIT's kanban planning method and the "Japanning of America". But, as with Goddard, Plossl later wrote that "JIT is a concept whose time has come".

JIT/TPS implementations may be found in many case-study articles from the 1980s and beyond. An article in a 1984 issue of Inc. magazine relates how Omark Industries (chain saws, ammunition, log loaders, etc.) emerged as an extensive JIT implementer under its US home-grown name ZIPS (zero inventory production system). At Omark's mother plant in Portland, Oregon, after the work force had received 40 hours of ZIPS training, they were "turned loose" and things began to happen. A first step was to "arbitrarily eliminate a week's lead time [after which] things ran smoother. 'People asked that we try taking another week's worth out.' After that, ZIPS spread throughout the plant's operations 'like an amoeba.'" The article also notes that Omark's 20 other plants were similarly engaged in ZIPS, beginning with pilot projects. For example, at one of Omark's smaller plants making drill bits in Mesabi, Minnesota, "large-size drill inventory was cut by 92%, productivity increased by 30%, scrap and rework ... dropped 20%, and lead time ... from order to finished product was slashed from three weeks to three days." The Inc. article states that companies using JIT the most extensively include "the Big Four, Hewlett-Packard, Motorola, Westinghouse Electric, General Electric, Deere & Company, and Black and Decker".

By 1986, a case-study book on JIT in the U.S. was able to devote a full chapter to ZIPS at Omark, along with two chapters on JIT at several Hewlett-Packard plants, and single chapters for Harley-

Davidson, John Deere, IBM-Raleigh, North Carolina, and California-based Apple Computers, a Toyota truck-bed plant, and New United Motor Manufacturing joint venture between Toyota and General Motors.

Two similarly-inclined books emergent in the U.K. in the same years are more international in scope. One of the books, with both conceptual articles and case studies, includes three sections on JIT practices: in Japan (e.g., at Toyota, Mazda and Tokagawa Electric); in Europe (jmg Bostrom, Lucas Electric, Cummins Engine, IBM, 3M, Datasolve Ltd., Renault, Massey-Ferguson); and in the USA and Australia (Repco Manufacturing-Australia, Xerox Computer and two on Hewlett-Packard). The second book, reporting on what was billed as the First International Conference on just-in-time manufacturing, includes case studies in three companies: Repco-Australia, IBM-UK, and 3M-UK. In addition, a day-2 keynote discussed JIT as applied "across all disciplines, ... from accounting and systems to design and production".

Middle era and to the present

Three more books which include JIT implementations were published in 1993, 1995, and 1996, which are start-up years of the lean manufacturing/lean management movement that was launched in 1990 with publication of the book, The Machine That Changed the World. That one, along with other books, articles, and case studies on lean, were supplanting JIT terminology in the 1990s and beyond. The same period, saw the rise of books and articles with similar concepts and methodologies but with alternative names, including cycle time management, time-based competition, quick-response manufacturing, flow and pull-based production systems.

There is more to JIT than its usual manufacturing-centred explication. Inasmuch as manufacturing ends with order-fulfillment to distributors, retailers and end users, and also includes re-manufacturing, repair and warranty claims, JIT's concepts and methods have application downstream from manufacturing itself. A 1993 book on "world-class distribution logistics" discusses kanban links from factories onward. And a manufacturer-to-retailer model developed in the U.S. in the 1980s, referred to as quick response, has morphed over time to what is called fast fashion.

Methodology

Sepheri provides a list of methodologies of JIT manufacturing that "are important but not exhaustive":

Housekeeping – physical organisation and discipline.
Make it right the first time – elimination of defects.
Setup reduction – flexible changeover approaches.
Lot sizes of one – the ultimate lot size and flexibility.
Uniform plant load – levelling as a control mechanism.
Balanced flow – organising flow scheduling throughput.
Skill diversification – multi-functional workers.
Control by visibility – communication media for activity.
Preventive maintenance – flawless running, no defects.

Fitness for use – producibility, design for process.
Compact plant layout – product-oriented design.
Streamlining movements – smoothing materials handling.
Supplier networks – extensions of the factory.
Worker involvement – small group improvement activities.
Cellular manufacturing – production methods for flow.
Pull system – signal [kanban] replenishment/resupply systems.

Objectives and benefits
Objectives and benefits of JIT manufacturing may be stated in two primary ways: first, in specific and quantitative terms, via published case studies; second, general listings and discussion.

A case-study summary from Daman Products in 1999 lists the following benefits: reduced cycle times 97%, setup times 50%, lead times from 4 to 8 weeks to 5 to 10 days, flow distance 90% – achieved via four focused (cellular) factories, pull scheduling, kanban, visual management, and employee empowerment.

Another study from NCR (Dundee Scotland) in 1998, a producer of make-to-order automated teller machines, includes some of the same benefits while also focusing on JIT purchasing: In switching to JIT over a weekend in 1998, eliminated buffer inventories, reducing inventory from 47 days to 5 days, flow time from 15 days to 2 days, with 60% of purchased parts arriving JIT and 77% going dock to line and suppliers reduced from 480 to 165.

Hewlett-Packard, one of western industry's earliest JIT implementers, provides a set of four case studies from four H-P divisions during the mid-1980s. The four divisions, Greeley, Fort Collins, Computer Systems and Vancouver, employed some but not all of the same measures. At the time about half of H-P's 52 divisions had adopted JIT.

	Greeley	Fort Collins	Computer Systems	Vancouver
Inventory reduction	2.8 months	75%	75%	
Labour cost reduction	30%	15%		50%
Space reduction	50%	30%	33%	40%
WIP stock reduction	22 days to 1 day			
Production increase	100%			
Quality improvement		30% scrap, 79% rework	80% scrap	30% scrap and rework
Throughput time reduction		50%	17 days to 30 hours	
Standard hours reduction	50%			
No. of shipments increase				20%

Potential risks
According to Williams, it becomes necessary to find suppliers that are close by or can supply materials quickly with limited advance notice. When ordering small quantities of materials, suppliers' minimum order policies may pose a problem, though.

Employees are at risk of precarious work when employed by factories that utilise just-in-time and flexible production techniques. A longitudinal study of US workers since 1970 indicates employers seeking to easily adjust their workforce in response to supply and demand conditions respond by creating more non-standard work arrangements such as contracting and temporary work.

Natural and man-made disasters will disrupt the flow of energy, goods and services. The down-stream customers of those goods and services will, in turn, not be able to produce their product or render their service because they were counting on incoming deliveries "just in time" and so have little or no inventory to work with. The disruption to the economic system will cascade to some degree depending on the nature and severity of the original disaster. The larger the disaster the worse the effect on just-in-time failures. Electrical power is the ultimate example of just-in-time delivery. A severe geomagnetic storm could disrupt electrical power delivery for hours to years, locally or even globally. Lack of supplies on hand to repair the electrical system would have catastrophic effects.