PERFORMANCE OPERATIONS

In taking away the safety net of base stock, the just-in-time method forces managers to tackle problem areas in production. **Bob Scarlett** explains.

Just-in-time manufacturing (JIT) is a modern approach to production management that differs fundamentally from traditional practices, although the underlying idea is not new. As long ago as 1922, Henry Ford wrote: "We buy only enough to fit into the plan of production, taking into consideration the state of transportation at the time. If transportation were perfect and an even flow of materials could be assured, it would not be necessary to carry any stock whatsoever. That would save a great deal of money, for it would give a very rapid turnover and thus decrease the amount of money tied up in materials."

Both JIT and the associated lean enterprise models are often attributed to Ford, although Toyota is widely known as the first high-profile user of JIT practices.

In traditional manufacturing, production is organised according to a series of risk/reward trade-offs concerning stock holding levels and production batch sizes. The idea is that a series of economic optimalities can be identified using mathematical models. This may be illustrated by the following example.

SH Ltd uses units in its manufacturing process at an even rate of 30,000 a year. It can order units from its supplier in quantities of 1,000, 1,500 or 2,000 units. The cost of placing and processing an order is £300 and the cost of holding one unit is £10 a year. From the calculation in table 1, it can be seen that the optimum order size is 1,500 units. As long as SH is certain that its supplier will deliver units exactly when required, it can operate without a base stock. This implies that orders are placed so that the delivery is made at the moment that SH's stock runs out. But, where there is any uncertainty about the timing, a base stock should be kept in order to reduce the frequency of stock-outs.

Let's now assume that the cost of a stock out to SH is £1,000. The probabilities that a stock-out will occur with alternative base stock levels are shown in table 2 and, from the calculation that follows in table 3, we can see that the optimum base stock is 400 units. The best materials management policy for SH, therefore, is to place 20 orders of 1,500 units a year and to hold a base stock of 400 units. The company's average stock holding will be 1,150 units, being half the order level plus the base stock.

1 Determining the optimum order size for SH Ltd

Order size (units)	1,000	1,500	2,000
Number of orders required per year	30	20	15
Average stock holding (units)	500	750	1,000
Stock ordering cost (£)	9,000	6,000	4,500
Stock holding cost (£)	5,000	7,500	10,000
Total annual stock cost (£)	14,000	13,500	14,500

2 Probabilities of a stock-out at SH Ltd

Base stock (units)	200	400	600
Stock-outs per year		Probabilities	
0	0.05	0.55	0.70
2	0.20	0.30	0.25
4	0.75	0.15	0.05

Specimen calculation to determine the estimated annual stock-out cost of holding a base stock of 200 units:
£1,000 x [(0 x 0.05) + (2 x 0.20) + (4 x 0.75)] = £3,400.

3 Determining optimum base stock level

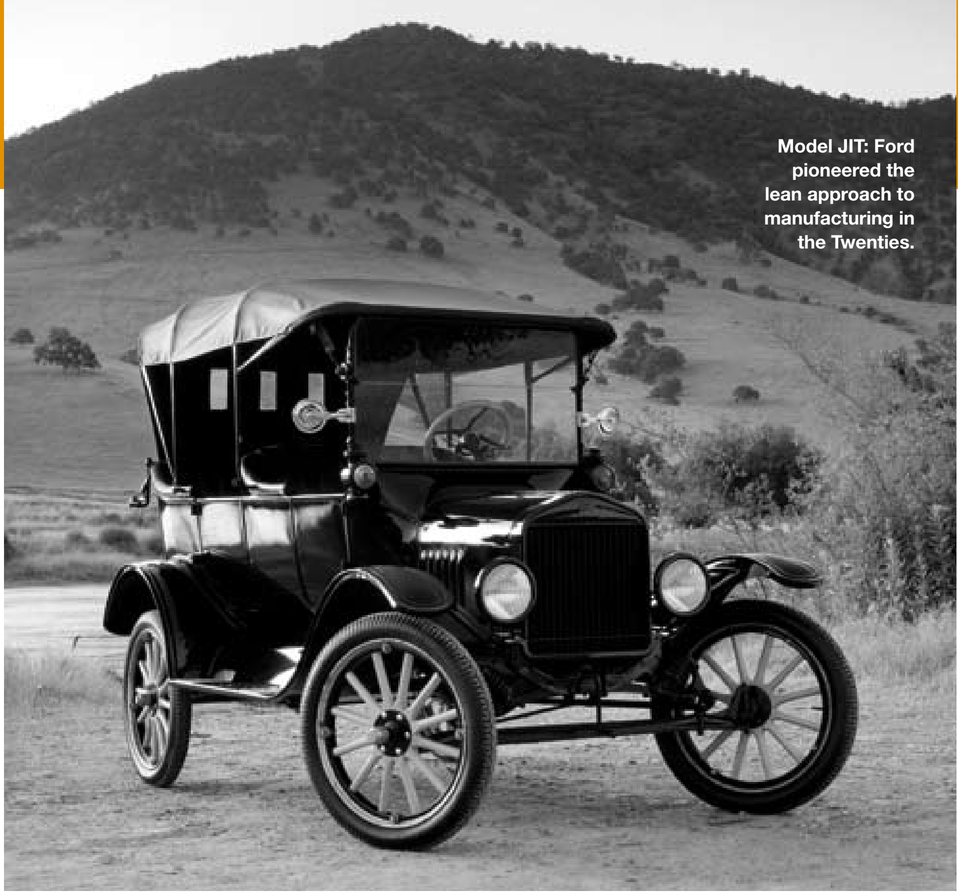
Base stock (units)	200	400	600
Estimated annual stock-out cost (£)	3,400	1,200	700
Base stock holding cost (£)	2,000	4,000	6,000
Total annual base stock cost (£)	5,400	5,200	6,700

A similar logic can be applied to the planning of manufacturing. An optimum production batch size can be calculated that minimises total production cost and an optimum finished goods base stock can be determined. The essential feature of this approach is that a set of optimalities for production and stock holding exist, all of which are decoupled from each other and from external influences on both the supply and demand sides. This is what's known as an exercise in "static optimisation".

JIT entails holding a minimum inventory of materials, work in progress and finished goods. This avoids holding costs ranging from finance and insurance to warehousing and spoilage. The idea is to schedule the delivery of materials and the supply of finished goods on an "as required" basis.

A company may have high inventory levels in order to compensate for production problems. These can include unreliable suppliers and equipment; variable process quality; a lack of flexibility among employees, poor customer relations; and inadequate capacity in the production and marketing processes. Adopting JIT involves applying a range of rigorous management practices to address them. Such practices include:

- The establishment of close relations with suppliers to ensure more reliable delivery. This will typically involve the adoption of small, frequent deliveries and the elimination of base stock.
- The achievement of an even and reliable flow of production through a high standard of equipment reliability, staff skills, operational flexibility and the elimination of production bottlenecks.


Model JIT: Ford pioneered the lean approach to manufacturing in the Twenties.

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- Product design across the whole range that facilitates the use of common components, tooling and facilities. Also, design should facilitate detailed customisation as required.
- The establishment of close relations with customers to ensure that goods are delivered on time to their specifications.

The above features, all of which would have been familiar to Ford, are designed to eliminate uncertainty rather than allow for it.

One well-known JIT practice is single-minute exchange of die (SMED), which was developed at Toyota in the Eighties when engineers found that the process of changing dies in metal presses was a crucial production bottleneck. This was a hard and lengthy task requiring many skilled workers to use heavy equipment. It gave rise to high fixed batch costs that resulted in a high economic batch size and hence high levels of finished goods inventory. Toyota focused its efforts on the die-changing process, which led to SMED. Harmonisation of design across the product range reduced the need to change dies. Equipment was adopted that allowed them to be adjusted in situ or changed faster when that was unavoidable. Dies were changed in a regular, scheduled wave that passed through the plant as each new batch moved through it. Shigeo Shingo, the engineer who pioneered SMED, claimed that the average batch set-up time in 1985 had been cut to 2.5 per cent of what it had been a decade earlier. SMED also made it economic to produce in smaller, more frequent batches. This resulted in lower inventory levels of parts and finished goods.

JIT may entail exchanging technical information and staff with suppliers and customers. It may also involve an integration of production systems in order to ensure that materials are supplied exactly when needed. It is, therefore, commonly associated with supply-chain management (SCM) and enterprise resource management (ERM). These two models involve the programming of business activities through the use of comprehensive IT systems in order to couple up ordering, production and delivery activities across corporate boundaries.

Various possible shortcomings have been identified with JIT. These include:

- The practice may amount to outsourcing material inventory to suppliers, which may not save costs. One study in the Nineties indicated that suppliers added an average premium of five per cent on to the prices they charged their JIT customers.
- Where product quality and/or prices are volatile, savings can be achieved via the early purchase of supplies and the holding of inventory. JIT precludes this possibility.
- JIT exposes manufacturers to unexpected supply-chain problems. For example, a blockade of fuel depots around the UK in 2000 immediately disrupted road haulage, which quickly affected all areas of industry.
- The practice of making small but frequent deliveries has an environmental cost that may in future result in a carbon emission charge being made to those responsible.

JIT and traditional practices such as the economic batch size model are not wholly incompatible. The main difference between them is that, while the traditional models accept cost structures and risk levels as given, JIT is concerned with how these might be altered. The introduction of SMED, for example, reduced the economic batch size and inventory levels by cutting fixed batch costs. JIT changes cost structures, while the economic batch size model determines how that change is reflected in production.

The two approaches do differ significantly at a conceptual level, though. Traditional practice involves considering the separate elements in the production process and determining how stock and production levels can best link those elements. JIT involves considering the production process as a whole without the significant use of stock to link the separate elements.

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P1 further reading

R Scarlett, *CIMA Official Learning System – Performance Operations* (2010 edition), CIMA Publishing, 2009.
Lecture notes on JIT by John Beasley, professor of mathematics at Brunel University: www.snipurl.com/ulj5g.
Strategos guide to lean manufacturing: www.snipurl.com/ulj61.
The Toyota Production System: www.snipurl.com/ulj71.