Chapter 4: From the JIT Revolution to Lean

Origins of JIT

- Japanese firms, particularly Toyota, in 1970's and 1980's
- Taiichi Ohno and Shigeo Shingo
- Geographical and cultural roots
- Japanese objectives
  - “catch up with America” (within 3 years of 1945)
  - small lots of many models
- Japanese motivation
  - Japanese domestic production in 1949 – 25,622 trucks, 1,008 cars
  - American to Japanese productivity ratio – 9:1
  - Era of “slow growth” in 1970's

Just In Time (JIT)

I tip my hat to the new constitution
Take a bow for the new revolution
Smile and grin at the change all around
Pick up my guitar and play
Just like yesterday
Then I get on my knees and pray
WE DON'T GET FOOLED AGAIN!

– The Who
Toyota Production System

Pillars:
1. just-in-time, and
2. automation, or automation with a human touch

Practices:
• setup reduction (SMED)
• worker training
• vendor relations
• quality control
• foolproofing (baka-yoke)
• many others

Supermarket Stimulus

• Customers get only what they need
• Stock replenished quickly
• But, who holds inventory?

Auto-Activated Loom Stimulus

• Automatically detect problems and shut down
• Foolproofing
• Automation with a human touch

The Seven Zeros

• Zero Defects: To avoid delays due to defects. (Quality at the source)
• Zero (Excess) Lot Size: To avoid “waiting inventory” delays. (Usually stated as a lot size of one.)
• Zero Setups: To minimize setup delay and facilitate small lot sizes.
• Zero Breakdowns: To avoid stopping tightly coupled lines.
• Zero (Excess) Handling: To promote flow of parts.
• Zero Lead Time: To ensure rapid replenishment of parts (very close to the core of the zero inventories objective).
• Zero Surging: Necessary in system without WIP buffers.

Zero Inventories

Metaphorical Writing:
The Toyota production squeezes water out of towels that are already dry. There is nothing more important than planting “trees of will”.

5W = 1H

Platonic Ideal:
Zero inventories connote a level of perfection not ever attainable in a production process. However, the concept of a high level of excellence is important because it stimulates a quest for constant improvement through imaginative attention to both the overall task and to the minute details.

The Environment as a Control

Constraints or Controls?
• machine setup times
• vendor deliveries
• quality levels (scrap, rework)
• production schedule (e.g. customer due dates)
• product designs

Impact: the manufacturing system can be made much easier to manage by improving the environment.
Implementing JIT

Production Smoothing:
- relatively constant volumes
- relatively constant product mix

Mixed Model Production (heijunka):
- 10,000 per month (20 working days)
- 500 per day (2 shifts)
- 250 per shift (480 minutes)
- 1 unit every 1.92 minutes

Implementing JIT (cont.)

Production Sequence: Mix of 50% A, 25% B, 25% C in daily production of 500 units
- 0.5 * 500 = 250 units of A
- 0.25 * 500 = 125 units of B
- 0.25 * 500 = 125 units of C

A – B – A – C – A – B – A – C – A – B – A – C – A – B – A – C ...

Inherent Inflexibility of JIT

Sources of Inflexibility:
- Stable volume
- Stable mix
- Precise sequence
- Rapid (instant?) replenishment

Measures to Promote Flexibility:
- Capacity buffers
- Setup reduction
- Cross training
- Plant layout

Capacity Buffers

Problems:
- JIT is intrinsically rigid (volume, mix, sequence)
- No explicit link between production and customers
- How to deal with quota shortfalls

Buffer Capacity:
- Protection against quota shortfalls
- Regular flow allows matching against customer demands
- Two shifting: 4 – 8 – 4 – 8
- Contrast with WIP buffers found in MRP systems

Setup Reduction

Motivation: Small lot sequences not feasible with large setups.

Internal vs. External Setups:
- External – performed while machine is still running
- Internal – performed while machine is down

Approach:
1. Separate the internal setup from the external setup
2. Convert as much as possible of the internal setup to the external setup
3. Eliminate the adjustment process
4. Abolish the setup itself (e.g., uniform product design, combined production, parallel machines)

Cross Training

- Adds flexibility to inherently inflexible system
- Allows capacity to float to smooth flow
- Reduces boredom
- Fosters appreciation for overall picture
- Increase potential for idea generation
Workforce Agility

Cross-Trained Workers:
- float where needed
- appreciate line-wide perspective
- provide more heads per problem area

Shared Tasks:
- can be done by adjacent stations
- reduces variability in tasks, and hence line stoppages/quality problems

Focused Factories

Pareto Analysis:
- Small percentage of sku’s represent large percentage of volume
- Large percentage of sku’s represent little volume but much complexity

Dedicated Lines:
- for families of high runners
- few setups
- little complexity

Job Shop Environment:
- for low runners
- many setups
- poorer performance, but only on smaller portion of business

Plant Layout

- Promote flow with little WIP
- Facilitate workers staffing multiple machines
- U-shaped cells
  - Maximum visibility
  - Minimum walking
  - Flexible in number of workers
  - Facilitates monitoring of work entering and leaving cell
  - Workers can conveniently cooperate to smooth flow and address problems

Total Quality Management

Origins: Americans (Shewhart, Deming, Juran, Feigenbaum)

Fertility of Japan:
- Japanese abhorrence for wasting scarce resources
- The Japanese innate resistance to specialists (including QA)

Integrity to JIT:
- JIT requires high quality to work
- JIT promotes high quality
  - identification of problems
  - facilitates rapid detection of problems
  - pressure to improve quality

Layout for JIT

Cellular Layout:
- Proximity for flow control, material handling, floating labor, etc.
- May require duplication of machinery (decreased utilization?)
- logical cells?

Advanced Material Handling:
- Avoid large transfer batches
- Close coordination of physically separate operations

Total Quality Management (cont.)

Techniques:
- Process Control (SPC)
- Easy-to-Ser Quality
- Insistence on Compliance (quality first, output second)
- Line Stop
- Correcting One’s Own Errors (no rework loops)
- 100 Percent Check (not statistical sampling)
- Continual Improvement
- Housekeeping
- Small Lots
- Vendor Certification
- Total Preventive Maintenance
Kanban

Definition: A “kanban” is a sign-board or card in Japanese and is the name of the flow control system developed by Toyota.

Role: Kanban is a tool for realizing just-in-time. For this tool to work fairly well, the production process must be managed to flow as much as possible. This is really the basic condition. Other important conditions are leveling production as much as possible and always working in accordance with standard work methods. – Ohno 1988

Push vs. Pull: Kanban is a “pull system”
- Push systems schedule releases
- Pull systems authorize releases

MRP versus Kanban

Goodbye JIT, Hello Lean

In 1990 lean appeared in The Machine That Changed the World (Womack, Jones, Roos)

Lean is a neater package than JIT; it focuses on flow, the value stream, and elimination of waste. Lean became the rage. Lean appears to be more successful than JIT in achieving results.

SixSigma appeared in 1985-1987 at Motorola as a method of creating radically better products 4.5 PPM

Motorola won the 1988 Malcolm Baldridge Quality Award

ABB, GE, Allied Signal, and Kodak have big successes

The Lessons of JIT/Lean

1. The production environment itself is a control
2. Operational details matter strategically
3. Controlling WIP is important
4. Speed and flexibility are important assets
5. Quality can come first
6. Continual improvement is a condition for survival
Key Insights of TQM/SixSigma

1. Quality and Logistics must be improved together
2. “If you don’t have time to do it right, when will you find time to do it over.”
3. Variability must be identified and reduced
   1. Determine the root cause
   2. Eliminate the root cause

What Went Wrong?

Look ma, the emperor has no clothes!
– Hans Christian Andersen

Our task is not to fix the blame for the past, but to fix the course for the future.
– John F. Kennedy

American Manufacturing Trouble in 1980s

- Slowdown in productivity growth
- Severe decline in market share in various markets
- Widespread perception of inferior quality
- Persistently large trade deficit

Causes

- Cultural factors
- Governmental policies
- Poor product design
- Marketing mistakes
- Counterproductive financial strategies
- Poor operations management

Management Tools

- Quantitative Methods
  - inventory
  - scheduling
  - plant layout
  - facility location
- Material Requirements Planning
- Just-in-Time

Trouble with Quantitative Methods

Cultural Factors:
- The frontier ethic – best and brightest shun OM
- Faith in the scientific method – emphasis on mathematical precision

Combined Effect:
- Top management out of OM loop
- Sophisticated techniques for narrower and narrower problems
**EOQ**

**Unrealistic Assumptions:**
- Fixed, known setup cost
- Constant, deterministic demand
- Instantaneous delivery
- Single product or no product interactions

**Ill Effects:**
- Inefficiency in lot-sizing
- Wasted effort in trying to fit model
- Myopic perspective about lot-sizing
  - Missed importance of setup reduction
  - Missed value of splitting move lots

**Trouble with MRP**

**MRP Successes:**
- Number of MRP systems in America grew from a handful in the early 1960's, to 150 in 1971
- APICS MRP Crusade in 1972 spurred number of MRP systems in the U.S. as high as 8000
- In 1984, 36 companies sold $400 million in MRP software
- In 1989, $1.2 billion worth of MRP software was sold to American industry, constituting just under one-third of the entire American market for computer services.
- By late 1990's, ERP was a $10 billion industry (ERP consulting even bigger); SAP was world’s fourth largest software company

**But ...**

**Scheduling**

- 2 & 3 machine min makespan problem (Johnson 1954)
- Virtually no applications
- Mathematically challenging
- Hundreds of follow-on papers

At this time, it appears that one research paper (that by Johnson) set a wave of research in motion that devoured scores of person-years of research time on an intractable problem of little practical consequence.

― Dulek Panwalker, Smith, 1992

**Surveys of MRP Users**

1980 Survey of Over 1,100 Firms:
- Much less than 10% of U.S. and European companies recoup MRP investment within two years

1982 Survey of 679 APICS Members:
- 9.5% regarded their companies as being Class A users
- 60% reported their firms as being Class C or Class D users
- This from an APICS survey of materials managers

1986 Survey of 33 S. Carolina MRP Users:
- Similar responses to 1982 survey
- Average eventual investment in hardware, software, personnel, and training for an MRP system was $795,000 with a standard deviation of $1,191,000

**OM Trends**

**Engineering Courses:** became virtually math courses

**Management Courses:** anecdotal case studies

** Calls for Changes:**
- Strategic importance of operational details
- OM is technical
- We need a science of manufacturing

**APICS Explanations**

1. Lack of top management commitment;
2. Lack of education of those who use the system;
3. An unrealistic master production schedule;
4. Inaccurate data, including bills of material and inventory records.
The Fundamental Flaw of MRP

... an MRP system is capacity-insensitive, and properly so, as its function is to determine what materials and components will be needed and when, in order to execute a given master production schedule. There can be only one correct answer to that, and it cannot therefore vary depending on what capacity does or does not exist.

— Orlicky 1975

- But, lead times do depend on loading when capacity is finite
- Incentive to inflate leadtimes
- Result is increased congestion, increased WIP, decreased customer service

Trouble With JIT

$64,000 Question: Is JIT a system, and, if so, is it transportable?

Answers:
- “Unquestionably” and “Yes” — Schonberger, Hall, Monden
- “Maybe not” and “To a limited extent” — Hayes

Conjecture: JIT is a system of beliefs, but a collection of methods

Historical Interpretation of MRP

- MRP is the quintessential American production control system
- When Scientific Management (developed here) met the computer (developed here), MRP was the result
- Unfortunately, the computer that Scientific Management met was a computer of the 1960's:
  - Insufficient RAM to process parts simultaneously
  - Fixed leadtimes allow transaction based system

Romantic versus Pragmatic JIT

Romantic JIT:
- An aesthetic ideal
- Simplicity in the extreme
- Almost trivial to implement
- Phrased in stirring rhetoric

Pragmatic JIT:
- Setup time reduction (SMED)
- Plant layout (e.g., U-shaped cells)
- Quality control
- Preventive maintenance
- Design for manufacturability
- Many others

MRP Patches

- MRP II provides planning hierarchy and data management features
- CRP in the sin of MRP repeated over and over
- Approaches like closed-loop MRP either
  - wait for WIP explosion to modify releases, or
  - fail to consider PAC in plan
- ERP extended MRP to supply chains but did not by itself change underlying paradigm
- Can MES save MRP?
  - Wide variety of commercial approaches to MES
  - Interface between planning and execution still critical

Mortals Emulating Genius

Persistence: Toyota took 25 years to reduce setups from 2-3 hours to 3 minutes.

Environmental Factors: Harder to address than direct procedures.

Prioritization: Systems view is first thing to get lost.

Deliberate obfuscation?

If the U.S. had understood what Toyota was doing, it would have been too good for us.

— Shingo

If the U.S. had understood what Toyota was doing, it would have been too good for us.

— Ohno
A Matter of Perspective

- Policies conflict
- Romantic JIT has the t-word (Schonberger)
- Japanese originators creatively balanced objectives
  - subtly, implicitly
  - pursued policies across functions
  - context-specific procedures
- Dangers of lack of perspective
  - management by slogan
    - inventory is the root of all evil
    - water and rocks analogy
  - effort wasted on chubchiks (e.g., unnecessary setup reduction)
  - failure to coordinate efforts (e.g., cells running large batches of parts)

Lean Manufacturing

Uses value stream mapping (VSM): a variation of process flow mapping. It has problems:
1. No exact definition of “value-added”
2. Value-added time is so short is does not offer a reasonable target for a cycle time
3. VSM does not provide a means of diagnosing causes of long cycle times
4. VSM collects capacity and demand data, but does not compute utilization
5. No feasibility check for a “future state”.

3rd Edition Updates were not in the slides in August

Trends in Manufacturing
1. 6σ an improvement methodology w/ training program
2. Lean philosophy promotes the right incentives
3. IT (SCM and ERP) provide data to make decisions

MISSING A SCIENTIFIC FRAMEWORK
relationships of between cycle time, production rate, utilization, inventory, WIP, capacity, variability in demand, variability in manufacturing process

Six Sigma (6σ)

Emphasizes the experimental aspect of the scientific method
- Define
- Measure
- Analyze
- Improve
- Control

Story about 6σ students ignoring Factory Physics training

Business Process Re-engineering

Systems Analysis applied to Management
“the fundamental rethinking and radical redesign of business practices to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service, and speed.

Most resign schemes included eliminating jobs, so it was associated with downsizing

Revolutionary aspect paved the way for ERP, which required restructuring manufacturing processes to fit software.

Where from Here?

Problems with Traditional Approaches:
- OM (quantitative methods) has stressed math over realism
- MRP is fundamentally flawed, in the basics, not the details
- JIT is a collection of methods and slogans, not a system

Reality:
- manufacturing is large scale, complex, and varied
- continual improvement is essential
- no “technological silver bullet” can save us
Where from Here?

What Can We Hope For?
- Better Education
  - basics
  - intuition
  - synthesis
- Better Tools
  - descriptive models
  - prescriptive models
  - integrated framework

A Science of Manufacturing...