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Paul M. Swamidass
Professor of Management
Thomas Walter Center for Technology Management
Tiger Drive ,Room 104
Auburn University , AL 36849-5358

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(334) 844-4333
Fax: (334) 844-1678
swamidp@eng.auburn.edu
http://www.eng.auburn.edu/center/twc/pms.html

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Technology on the factory floor III : technology Use and Training in the U.S Manufacturing Firms

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Foreword

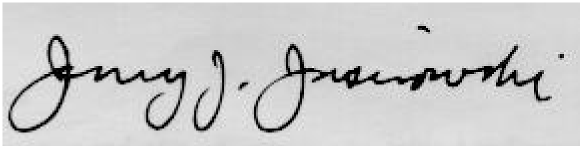
Technology accounts for as much as one-third of the long run economic growth and two-third of productivity
gain, according to the consensus of leading economists and CEOs i my book, The Rising Tide(John Wiley,
1998). Paul Swamidass's careful and continuing work, in this third Technology on the

factory floor study, comp-
lements this macro analysis and perspective of the compelling plant-level data yet released. U.S. man-
ufacturers are investing in technology especially information technology, and they do, indeed, have positive
operational and financial results to show for their investments. If there ever was a "productivity paradox" in
manufacturing , it exists no more.

Likewise, this third report shows that the long, hard work by the manufacturing companies and their employees to
cut costs , improve quality and meet customer demands more quickly has taken hold. There is no going back.
Companies are now poised to meet the next challenge; electronic integration of suppliers and customers. One
can only rejoice that the domestic auto industry, whose prospects looked so poor 15 years ago, now moves its
inventory nearly twice as fast as the rest of the economy.

Not everything is rosy. While companies are spending a surprisingly high amount on training, many workers
lack even the basic educational foundation needed to progress to the higher-skill level required by manufacturers
using hardware, software, networking and rapid-response procedures. The results here confirm those of the
Bureau of Labor Statistics and a separate, recent NAM survey on workforce issues conducted by Grant
Thornton LLP. We have our work cut out for us.

Executives will find useful, specific benchmarking data in the report. The success of manufacturers in putting
the products of the information technology industry to fruitful use makes for impressive reading.

 Jerry Jasinowski

President
The Manufacturing Insitute

Executive Summary

This study presents much good news about manufacturing in America. Skilled technology deployment and use is leading to operational excellence, which yields higher productivity, and ultimately higher profitability. Plants are making substantial gains in manufacturing flexibility and agility - important reasons for productivity gains - through the increased use of computerized integration, manufacturing cells, and Just In Time inventory practices.

This is the third iteration of the Technology on the Factory Floor series, based on 1997 data from 1,000 plant managers. Following the previous survey by four years, it captures U. S. manufacturers in a very healthy condition. Table 1 lists all the technologies surveyed, both "hard" ones like local area networks (LANs) and "soft" ones like shop-floor organization by relatively self-contained cells, as opposed to traditional linear assembly lines. Table 2 compares the 1997 and 1993 results.

The U.S. trend towards manufacturing excellence continues, as evidenced by a variety of different measures: overall financials, improved operational capabilities, specific technology use, and successful classes of plants.

The Financial Performance of U.S. Manufacturing Continues To Improve

Profitability Shows Strong Gains. Return on investment now stands at 16.9 percent, compared to 13.0 percent in 1993. This gain is higher than expected.

Productivity (Sales per Employee) Increases. Equally strong annual gains in productivity as measured by sales per employee -- about four percent since the last study in 1993 - lies behind the strong gains in profitability. Sales per employee is a key index of productivity and is crucial to measure because improvements in productivity drive improvement in standards of living. If you are able to produce more, you are able to earn more. Table 2 shows continued productivity improvement by the U.S. manufacturing sector as sales per employee grew from $133,000 in 1993 to $147,000 in 1997 - a 10 percent gain. An independent estimate of productivity by the Labor Department's Bureau of Labor Statistics concurs with this rate of growth.

Manufacturing Plants Gain in Operational Capabilities

Inventory Turnovers Increase. Turnover rates measure industry efficiency. As Table 2 indicates, the inventory turnover ratio was 9.7 in 1997 - in other words, the average manufacturing plant covered in this report was turning over its inventory every 1.23 months. Our 1993 report found an 8.0 ratio, indicating that plants were then turning over their inventory every 1.5 months. The Commerce Department's 1995 estimate of 8.5 confirms our findings (Office of Industry Analysis).

Rejection and Rework Decrease. The rejection and rework rate is another important index of manufacturing performance. It measures the ability of the manufacturers to produce consistently high-quality products with few defects. Rejection and rework rates have decreased from 4 percent in 1993 to 3.5 percent in 1997. Thus, manufacturers have gotten rid of one-eighth of their waste.

Cycle Time and Manufacturing Costs Decrease. Seventy-six percent of all manufacturers report reduction in cycle time (from receipt of a customer order to delivery) and 75 percent report reduction in manufacturing costs as a result of technology use. Figure ES-1 displays other benefits of technology use by manufacturers.

Highlights of the Most Successful Groups of Plants

Larger Plants Use Technologies More Extensively and Effectively Than Small Plants. Eight positive performance measures increase with size: sales per employee; inventory turns; LAN use; cell use; percent of transactions computerized between shops and production planning; percent of plants with 90%+ computerization between shops and production planning; percent of plants reporting cycle time reduction as a result of technology use; and return on investment.

And four positive performance measures decrease with size: on-the-job training time; training budget as a percent of sales; percent of extremely skilled operators in the plant; and the delay in the skilled use of technologies for want of skilled workers.

Not all technologies may be appropriate for small plants. They may need assistance to understand the use and benefits of several new technologies if they are to exploit all relevant manufacturing technologies. The training expense associated with the use of soft technologies may be holding back small manufacturers from using soft technologies more aggressively.

Exporters Use Manufacturing Technologies More. The use of technology rises with the degree to which firms gain their revenues from abroad. Without exception, exporters rely on technologies more extensively than non-exporters. The difference is most pronounced in soft technologies such as cells, concurrent engineering (allowing interplay between design and manufacturing rather than the traditional linear treatment of design as prior and then fixed), as well as materials resource planning. Overall, the evidence indicates that the use of manufacturing technologies adds a measure of competitive advantage to U. S. exporters.

The Transportation Industry Leads in Inventory Turnovers. Perhaps our most remarkable operational finding is the inventory turnovers of 19.4 reported by the surface transportation industry (SIC 37), which includes the auto industry -- twice the national average of 9.7. The transportation industry has become a mature user of lean manufacturing principles; the industry is reaping the benefits of consistent, long-term use of such practices. Formerly, an average of 19.4 turnovers for an entire industry was only a dream.

The auto industry, which forms the bulk of this SIC class, started adopting soft technologies such as JIT, TQM and SQC about fifteen years ago due to severe import competition from Japan and the rapid erosion of their domestic market share. The Big Three auto makers have instituted standards and certification for their suppliers based on world-class manufacturing principles, thus spreading the practice all across the nation. In the process, the industry has proved to be a good training ground. Personnel moving from this industry to others may have contributed to the spread of such successful techniques. Moreover, the auto industry, having mastered the challenges of the agile business model, is poised to face the next level of challenge - and opportunity - in electronically based supply-chain integration.

Extremely Skilled Use of All Technologies Has Superior Operational Payoff. Not all manufacturers use manufacturing technologies with equal skill, and the level of skill matters considerably in how much a firm's performance is improved. Extremely skilled use of technologies requires a thorough understanding of the technology being used, as well as constant training and retraining. Self-identified extremely skilled users of JIT and its variations report the best inventory turns (19.4), lowest manufacturing lead times (5.7 weeks), and one of the highest returns on investment (20.8%). Extremely skilled users of manufacturing cells comprise the highest single return-on-investment category (21.8%).

Table 1

List of Technolgoies Covered by Studies

(*Amore detailed description of these technologies can be found in Appendix II*)

Hard Technology Investigated

1. Automated Inspection
2. CAD.......Computer-aided design
3. CAM......Computer-aided manufacturing, including programmable automation of single or multi-machine systems
4. CIM.......Computer integrated manufacturing
5. . CNC......Machines with computerized numerical control
6. LAN......Local Area Networks
7. FMS.....Flexible manufacturing systems:automated multi-machine systems linked by an automated material -handling system
8. Robots....All kinds of robots

Soft Technology Invetsigated

1. Bar Codes*
2. Concurrent Engineering*
3. JIT........Just-in-time manufacturing
4. Manufacturing Cells*
5. MRP....... Material Resource Planning
6. MRP II....Manufacturing Resource Planning
7. SQC.......Statistical Quality Control
8. Simulation Modeling*
9. TQM......Total Quality Management.

*Denotes technologies not included in the previous studies

Table 2

A Comparison of Selected 1993 and 1997 Data

	1993 sample	1997 sample
1. Sample	1042	1025
2. Sales($million)	47.2	34.5
3. Employment(average)	228	168
4. Sales per Employee	133k	147K
5. Inventory turns	8.0	9.7
6. Direct Labor	18.3	19.8%

7. Rejection and rework	4.0%	3.5%
8. Lead Time (weeks)	7.2	7.4
9. ISO-certified plants	4%	20%
10. Foreign-owned(foreign ownership more than 50%)	3.4%	6.3%
11. No sales to defense department	54%	64.8%
12. Percent reporting cycle0time reduction	66%	76%
13. Return on Investment	13.0%	16.8%

Employers Invest Highly in Training, Yet Some Workers Are Not Ready to Progress. Without question, the manufacturing workforce must progress to higher skill levels to master new technologies. Accordingly, this third survey includes new questions not asked before about training investments, practices, and results - questions whose answers confirm that the weakest dimension of U.S. manufacturers' continued ability to lead the world is the education, training, and skill level of the U.S. workforce.

First, the companies covered in our survey reported an average training budget of five percent of payroll. This is higher than most studies on this subject. By comparison, a 1995 Bureau of Labor study found that the training budget was about four percent of payroll. The unexpectedly high training expenses may reflect any of the following: import competition, the multiple skills needed in cells, employee reassignment and new hires resulting from downsizing, and maintaining high skill levels and corporate agility.

Second, on-the-job training (OJT) is the most commonly used training technique although it takes more time to train an employee (8.3 months) than otherwise. Training by vendors is the quickest training method (5.3 months). If vendors can provide training, small plants have more to gain by using vendors than larger plants - about four months, compared to two months for larger plants. Each plant should evaluate its own time-money tradeoff.

Third, the lack of availability of trained operators causes delays in the skilled use of technologies by as much as 4.9 months.

Fourth, plant managers find 36 percent of operators lacking the education for advanced training, while they consider 40 percent skilled and 47 percent eager to solve problems and learn new skills.

Widespread Soft Technology Use Has Brought Systemic Changes. Since 1993, slightly fewer plants are reporting the use of JIT, TQM and SQC techniques; however, the benefits associated with the use of these soft technologies are on the rise. For example, inventory turns and rejection and rework rates have improved to 9.7 and 3.5 percent, respectively. One can only conclude that, over the last 15 years, essential features of JIT, TQM and SQC have become such generic and ingrained manufacturing practices in this country that they are losing their association with any specific technique. These systemic changes bring permanence to the improvements we have noticed so far, and the continuous improvement theme underlying these practices should continue to improve manufacturing performance in this country.

Technology Use Produces Faster Customer Response

Networking Leads Growth In Technology Use. Data from companies who answered both our 1993 and 1997 surveys show that the use of local area networks (LANs) has grown more than the use of any other technology since 1993. As seen in Figure ES-2, 72 percent of these plants used LANs last year, compared to 46 percent then.

Clearly, by 1993, the use of certain discrete technologies had reached saturation. Manufacturers typically began to invest in several different technologies, hard or soft, in the form of internal "islands of automation." LAN technology enables the integration of these "islands" and taps the synergistic benefits that flow from integration of several technologies, both within the factory and between factories and their customers or suppliers.

The increase in networking has yielded paperwork-cutting, time-saving efficiencies. Transactions between the shop floor and production/materials planning are now 58% computerized, with transactions between design and customers being 41% computerized. The growth in the use of individual technologies may taper off, but growth will continue in the integration of technologies through the computerization of transactions between internal and external units of manufacturing plants.

Manufacturing Cell Use Also Grows Dramatically. Next to LAN use, the use of relatively self-contained manufacturing cells has shown the second-highest increase among the NAM 100 plants (Figure ES-2). Manufacturing cells and computerized integration contribute to the flexibility of manufacturing plants. Further, manufacturing cells reduce inventory, increase quality and productivity, and enable factories to become better focused. Since the implementation of cells requires multi-skilled operators, the increased use of cells increases the need for operator training.

The upshot in the combination of LAN and cell growth is increased agility-the ability of a plant to respond faster to customer orders. Computerized integration of units inside and outside a factory contributes to agile manufacturing by enhancing the speed of information flow and the ability of manufacturing systems to respond to changes. Manufacturing cells require operators to be skilled in the use of multiple tasks, which also adds to the agility of the plant.