Constraint Management and Continuous Improvement

Donald J. Klein and Marinus DeBruine

EXECUTIVE SUMMARY

- Although many companies have adopted new manufacturing philosophies to gain a competitive edge, many of these attempts have failed to achieve the company's objectives of nurturing continuous improvement and making more money.
- Companies often fail to focus their limited time, energy, and resources on the weakest link. Continuous improvement programs will fail if they do not focus on constraints.
- Constraint management can lead to improvements in areas such as quality, engineering, production efficiency, and reductions in setup times.
- Management accountants play a crucial role in designing appropriate measurements for achieving continuous improvement. They should focus more on educating managers about the impact of physical constraints on decision making.

The term *continuous improvement* has become an integral part of many mission statements as companies attempt to stay ahead of the competition and achieve the goal of making more money—both now and in the future. To make more money, companies must take actions that translate into positive bottom-line results.

Traditional management accounting measures used in projecting the impact of local activities on the periodic, firmwide income measure may masquerade for tracking continuous improvement when, in fact, they are not. Some managers realize this and ignore the reports for local decision making. At other times, however, this problem can cause dysfunctional decision making, subvert continuous improvement programs, and ultimately spell disaster.

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This article illustrates how a company that fails to manage its physical constraints usually makes counterproductive decisions that can slow or stop continuous improvement. To contrast traditional decision making with decision making that focuses on constraints,

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the article gives examples of quality improvements, engineering changes, reductions in setup times, and production efficiencies.

CONTINUOUS IMPROVEMENT PHILOSOPHIES

The Japanese philosophy of *just-in-time* (JIT) manufacturing was adopted widely in the United States in the early 1980s and has guided the development of policies designed to simplify and eliminate waste. JIT is supposed to help companies reduce inventory, scrap, rework, and the space and equipment required to handle inventory. Indirectly, reducing inventory accomplishes the following:

- Improves market responsiveness.
- Lowers lead times.
- Accelerates engineering changes.
- Increases product quality.
- Lowers per unit costs.
- Reduces investment cost per unit.

The improvements gained by eliminating waste and reducing inventory give companies that successfully implement JIT a competitive advantage. (For an expanded discussion of just-in-time, see Schonberger, 1982.)

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TOTAL QUALITY MANAGEMENT

The *total quality management* (TQM) philosophy gained popularity in the mid-1980s as U.S. companies recognized the importance of curtailing quality costs in an increasingly competitive marketplace.

Like JIT, TQM was made operationally successful in Japan. It evolved from a technique (*statistical process control*) to a management philosophy that emphasizes creating a corporate culture conducive to bringing out the best efforts of employees at all levels in the company. Instead of focusing on fixing quality problems, the aim of TQM is to prevent problems from occurring through a process of ongoing improvements in both employees and the work systems. (For an expanded discussion of the total quality management philosophy, see Scherkenbach, 1988.)

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THEORY OF CONSTRAINTS

The *theory of constraints* (TOC) was developed in the late 1980s by Eliyahu Goldratt. Goldratt was trying to provide a systematic approach for identifying what prevents a company from achieving the goal of making (more) money for its owners (Goldratt and Cox, 1984). The principal objective of TOC is to establish a process of ongoing or continuous improvement through *synchronized manufacturing.*

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The term *synchronized manufacturing* refers to a systematic method of moving material through the productive resources of a facility in response to market demand. Simply put, the TOC approach attempts to achieve synchronization by improving the management of constraint resources (bottleneck operations) and then scheduling all operations from these critical resources (Fawsett and Pearson, 1991).

In the TOC framework, the global impact of individual (or local) actions on a company's goal of making more money is evaluated by examining the effects of the actions on three measurements:

- *Throughput* (*T*).
- *Investments* (or *inventory*) (*I*).
- *Operational expense* (*OE*).

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Unlike the conventional accounting measures of net profit, return on investment, and cash flow, these TOC measures lend themselves well to evaluating the daily operations of the manufacturing organization. That is, local actions can be evaluated by their impact on the global operational measurements of throughput, investments, and operational expenses. Unlike the traditional accounting measures, these three measurements track progress toward the global goal of making money.

Throughput, inventory, and operational expense can also be related back to the traditional measurements of *net profit*, *return on investment*, and *cash flow* by doing the following:

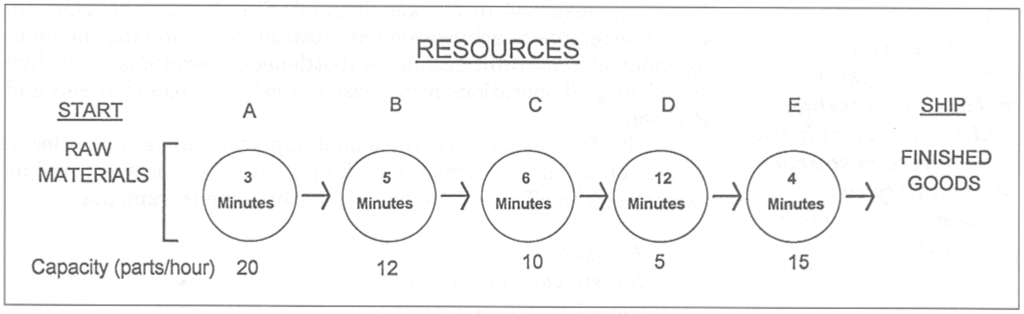
- *Net profit* = $T - OE$.
- *Return on investment* = $(T - OE)/I$.
- *Cash flow* = $T - OE$ *plus* or *minus* the change in I.

By using these simple measurements of T, I, and OE, quantitative management decisions can be made with speed and ease. The desired direction of T is an increase (↑), while for I and OE the desired direction is a decrease (↓). These measurements are used in the constraint-management decision that follows.

MEASURING CONTINUOUS IMPROVEMENT

Most manufacturing processes involving the use of a sequence of resources (i.e., an "independent chain") contain a single *constraint*. A constraint is anything that limits the system from achieving higher performance relative to its goal. A constraint can be physical (e.g., a machine, labor, or materials) or a policy. An example of a policy constraint is not operating a plant on Sundays or choosing not

Exhibit 1. Magic Inc.'s Production Process: Where Is the Constraint?



to operate a third shift. This article focuses on a physical constraint. And, since the goal of most publicly held companies is to make money now and in the future, that is also assumed to be the goal of the hypothetical company called Magic Inc. used in this example.

Example

Magic Inc. employs the simple manufacturing process depicted in Exhibit 1. Raw materials provided by the supplier are released into the production process at Resource *A* and flow through Resources *B*, *C*, *D*, and *E* to become the finished product.

Given the average time spent at a particular resource, how many parts can each of these resources accommodate per hour (i.e., what is their capacity)? Dividing the number of minutes required by operations into an hour determines the theoretical capacity for each resource per hour. For example, since operations at Resource *A* require three minutes per part, the capacity of Resource *A* is 20 parts per hour. The constraint resource limiting the material flow through the sequence in this illustration is Resource *D* because it requires the most time (twelve minutes per part, or 5 parts per hour). All the other resources *A*, *B*, *C*, and *E* can process more than 5 parts per hour.

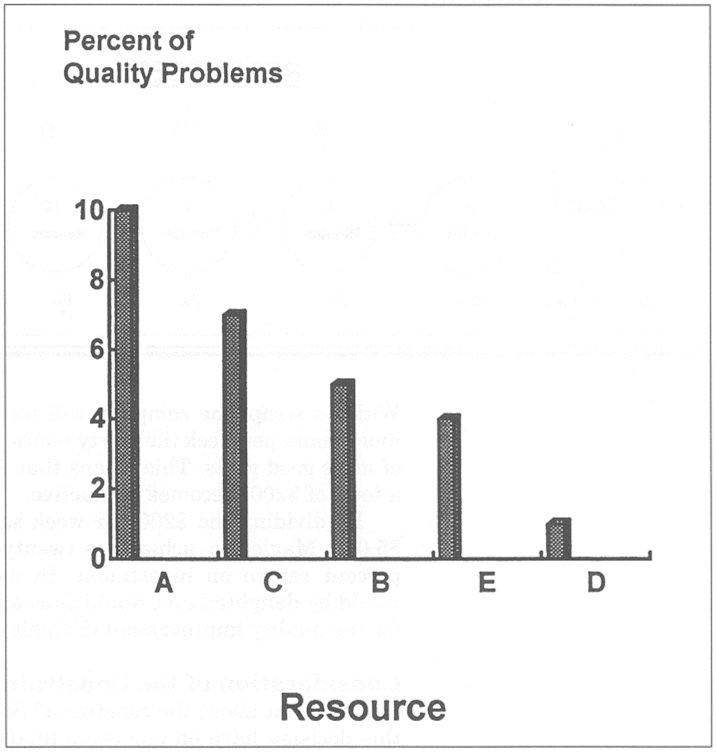
Recognizing the effect of resource dependencies and statistical fluctuations in production cycle times is extremely important in planning operations and system output. Even though Resource *E* requires only four minutes per part and thus could process 15 parts per hour, in this particular production sequence, Resource *E* depends on Resource *D* for its input. Thus, Resource *D* limits the system's throughput to 5 parts per hour.

The first step in TOC is to identify the constraint as Resource *D*. The next step is to exploit what can be done with this information in terms of continuous improvement decisions.

QUALITY IMPROVEMENT

Magic Inc. was having quality problems, so it established a focus group to investigate where to focus its efforts for achieving quality

Exhibit 2. Quality Improvement (Pareto Chart).



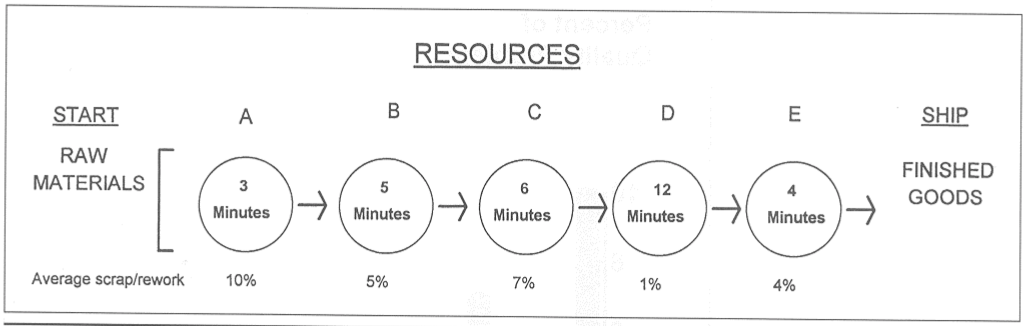
improvements. The first step was to collect data and present it in the format of a Pareto chart (see Exhibit 2).

Since Resource *A* in Exhibit 2 has the most quality problems with rework and scrap (10 percent), the focus group decided to study how improvements could be made at Resource *A*. After some deliberations and discussion, the group discovered that an expenditure of $5,000 would reduce the 10 percent quality problem at Resource *A* to 0 percent. Management was delighted, but asked what the payback would be for the quality improvement investment.

The direct labor cost in Resource *A* averages $10 per labor hour, and the overhead rate is 400 percent of direct labor costs. On average, therefore, it costs $50 per direct labor hour (i.e., $10 + $40) to operate Resource *A*. Consequently, the average savings or payback per week can be calculated by taking the normal standard work week of (40 hours × the 10 percent rework/scrap savings per week × $50 per direct labor costs) $200 savings per week.

This means that, from the 2,400 minutes available each week for production, 240 minutes (i.e., 10 percent) are used to produce scrap.

Exhibit 3. Magic Inc.'s Quality Improvement: Where Should We Focus our Efforts for Quality Improvement?



With no scrap, the company will have gained approximately four more hours per week (i.e., forty hours × 10 percent), or 240 minutes of more good parts. This means that four hours of labor × $50 (for a total of $200) becomes productive.

By dividing the $200 per week savings into the investment of $5,000, Magic Inc. achieves a twenty-five-week payback, or a 208 percent return on investment. In most companies, management would be delighted and would thus approve the $5,000 investment for the quality improvement (Exhibit 3).

Consideration of the Constraint

But what about the constraint? Specifically, what impact would this decision have on our three financial measurements of *T*, *OE*, and *I*? First, nothing has happened to *T*. You can still produce—and thus sell—only five units per hour.

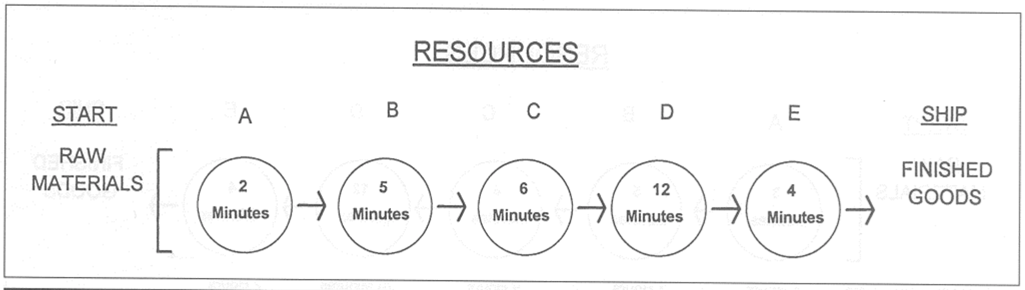
What about *OE*? It has increased because carrying costs are now greater because of the additional inventory. (The savings from less scrap and rework is assumed to not exceed the continuous buildup of carrying costs.)

What has happened to *I*? It has increased by $5,000 plus the permanent working capital for increased inventory. In summary, what has happened? *T* is constant, *OE* has increased, and *I* has increased. This is why many times quality initiatives slow down or stop. Without an understanding of constraint management, many traditional ways of making decisions lead to counterproductive decisions. Quality improvements should focus primarily on the constraint.

ENGINEERING CHANGE

Consider another example: One of Magic's engineers tells his supervisor that he has discovered a way to reduce the process time of Magic's Resource *A* by 33 percent. He states that the cost will be $10,000 and the payback period less than six months. Management

Exhibit 4. Magic Inc.'s Engineering Change: Is a 33 Percent Reduction in Processing Time Acceptable?



is delighted and commits the $10,000 for the continuous improvement change. Again, however, without an understanding of constraint management and where the constraint is located, it is a poor decision (Exhibit 4).

The engineer accomplished what he had in mind: a 33 percent reduction in processing time at Resource *A* (i.e., a reduction of processing time from three minutes to two minutes). But what financial impact has this decision achieved? What has happened to *T*? It stayed the same. What has happened to *OE* and I? They both have increased. It is definitely not a good financial decision. Yet, traditionally, we would have complimented and maybe even rewarded the engineer for the suggestion.

REDUCTION IN SETUP TIMES

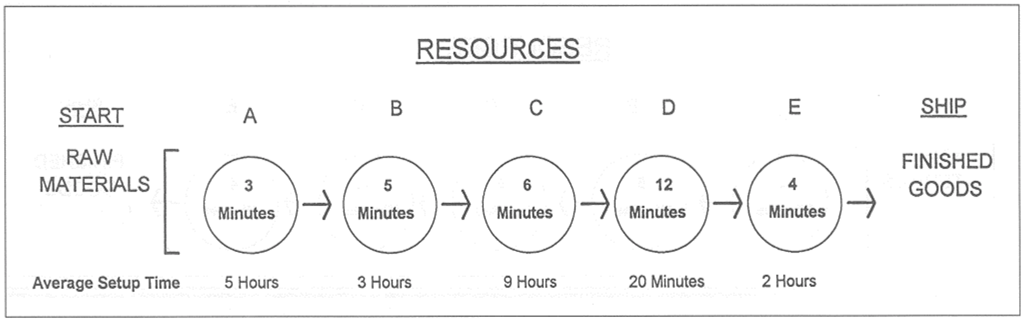
The benefits of reducing setup time are many and well recognized. Reductions in setup times defer future investments and increase return on investment per unit; they also improve the competitive-edge factors of on-time delivery, shorter lead times, and quicker discovery of quality problems. Therefore, Magic's traditional management decision making focuses on reducing setup times. Exhibit 5 shows the results of Magic's data collection study. In particular, Resource *C* (with a nine-hour setup time) shows the greatest opportunity to reduce setup times.

Traditionally, management would have had employees concentrate on ways to reduce the nine hours. But what financial impact does this have? What happens to *T*? It stays the same. What happens to *OE* and *I*? They both increase. Once again, therefore, the conclusion is that unless Magic focuses on the constraint, its efforts are not beneficial. Improved financial and operational results come only by focusing on reducing the setup time at the constraint—Resource *D*.

PRODUCTION EFFICIENCY

Standard costing and variance analysis have been around a long time. Traditionally, management has always tried to maximize ef-

Exhibit 5. Magic Inc.'s Setup Time Reduction: Where Should Management Focus Their Setup Time Reduction Efforts?



ficiencies by making sure that the quantity standards were high. Supposedly, greater productivity would lead to more profitability. But consider this assumption with reference to Magic's production system. Magic's process (as shown in Exhibit 6) indicates that 15 units of work-in-process inventory will be built every hour if the system continues to maximize its production capability.

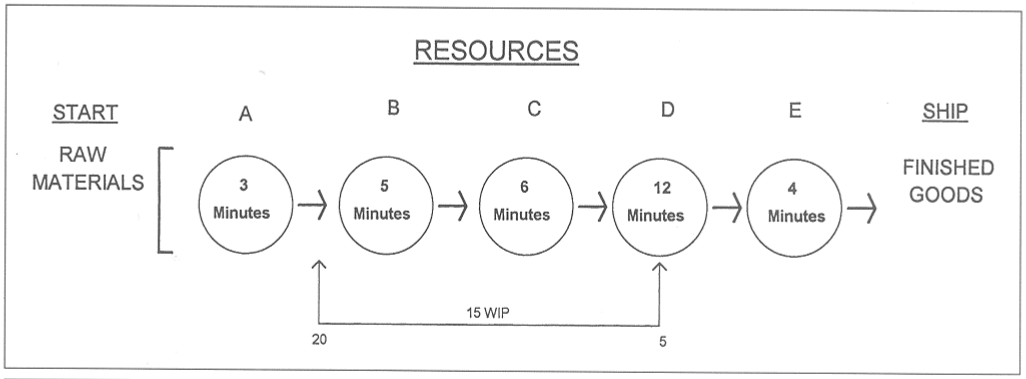
Assume now that Magic's management recognizes that Resource *D* is the constraint and implements the following actions. It removes all inventory that is not being worked on and places an eight-hour time buffer of inventory in front of Resource *D*. It also does of all the following:

- Implements setup time reductions (especially for Resource *D*, the constraint, although also for other resources).
- Lines up outsourcing and off-loading capabilities.
- Cross trains its workers.
- Develops a quick recovery team for crisis equipment repairs.
- Establishes a reliable preventive and predictive maintenance program.
- Makes everyone in Magic aware of the necessity to constantly keep Resource *D* running.

Now, how many units should employees at Resource *A* produce per hour? Resource *A* has the capacity of 20 units per hour. Traditionally, our standard quantity of output for *A* would probably expect performance of at least 18 units per hour (i.e., a 90 percent efficiency level). However, given an understanding of constraint management, the output should probably be only 5 units per hour instead of 20 units per hour (i.e., a performance efficiency of only 25 percent).

But what would most traditional decision makers say and do about such a low efficiency performance? Furthermore, many managers would have trouble understanding that by having Resource *A* operate at a 25 percent performance efficiency, the company will

Exhibit 6. Magic Inc.'s Production Efficiencies: How Will Magic Make More Money With a Performance Efficiency of 25 Percent at Resource A?



make more money than if Resource *A* operated at a 90+ percent performance efficiency.

The results of operating Resource *A* at a 25% performance efficiency rather than at a 90+ percent performance efficiency are as follows: *T* is the same, but *OE* and *I* are lower because there is less inventory to carry and finance. Thus, traditional management decision making often leads to bad decisions unless constraint management is taken into consideration.

CONCLUSION

Constraint management leads to more sustainable continuous improvements, a better use of existing resources, and a better return on capital investments. When a company focuses on constraint resources, the very nature of key management decisions change. Failure to recognize and manage a physical constraint can lead to bad decisions about quality improvements, engineering changes, reductions in setup times, and production efficiency. ♦

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