Chapter 2
Systematic Approach for Manufacturing Strategy

Chapter 2 reviews the seven obvious losses regarding productivity and profitability while performing a diagnosis, or value stream map, of four productivity boosters that ultimately lead to profit. There are different ways to evaluate current conditions regarding productivity and each result makes a different evaluation for the present. Applying different techniques leads to a different outcome for each shop. The purpose of a feasibility study (FS) is to ascertain the possibilities of increasing productivity and the level of competitiveness. Through FS analysis, the most important project areas are established with regard to improvement potential, priority, likelihood of success, and likely resultant effects. The four steps are: recognizing poor productivity levels and conquering them; eradicating old corporate position; preparing an auditing system for productivity; and carrying out manufacturing processes that involve management through and through, then to accomplish world-class manufacturing (WCM).

2.1 Seven Losses Regarding Productivity and Profitability

There are seven losses that management does not recognize and address adequately. Those are:

Loss of lower utilization of hourly base ability compared to standard time. How do you measure and evaluate workers' performance? There is a world standard for working pace. It is very common that working pace differs more than 20% with standards and without standards. As evidenced by appropriate implementation of standard time and workers' performance measurement in Japan, the performance improvement is invariably almost 200% compared to results with no standards or control system.

Loss of utilized areas of factory square footage. How many areas should there be for work areas, machines, passageways, storage, and other uses? It is much more desirable to have areas within distribution designated for work areas rather than for storage. Building costs are normally expensive, so it is effective not only from an investment point of view if redundancy areas are created, and that those areas are utilized well after labor productivity improvement.

Loss of lower utilization of possible operation hours for shift hours. How do you measure the right utilization for shift hours? Is it correct that measurement that shifts hours minus nonworking hours is based on reported idle time? No, because there is 20–30% of difference in utilization between this calculation of results and calculated results of time value on standard time that is theoretical working hours to produce reported products. The difference is between decomposition utilization and piling up utilization. The latter utilization is a more reasonable measure for management.

Loss of lower utilization of machines and/or facilities within a reasonable capacity. This is quite similar to the point of view above, but the number of shifts in conjunction with utilization machines full time without break time (even operators) includes set-up/change-over time, a short break for lunch, coffee breaks, *etc.* The theoretical maximum utilization for 24 h is 100%.

Loss of difference between production and shipment. How about the relative value of production and shipment? It is easy to measure if you can write up "accumulated charts", which equal the accumulation of production and shipment on the Y line and production days on the X line. The vertical difference in production and shipment is indicated in inventory level and horizontal indicates production lead time.

Loss of inappropriate investments. This is the profit margin spent for investment, allotment for shareholders, and employees. Innovation of products and/or processes is developed through adequate investment. Utilizing old machines or facilities that are depreciated may look like cost-saving measures, but this move might result in lost processing time. Innovation speed is rapid today. Developing concrete planning of ideal "dream factories" is possible with an established investment for new machines or facilities.

Loss of management does not improve profitability. Do you measure profitability every month? Is the outcome a key measure or index for corporate performance? This is the most important aspect of losses that is often not recognized by top and middle management. Nothing happens without management's interest or measurement.

These losses are not simply waste. Because management does not understand and implement current practices, nobody realizes the losses they have. Unknown issues are not identified; therefore, they cannot be improved upon.

2.2 Feasibility Study of Productivity Improvement

2.2.1 Difference Diagnosis and Different Results

Let's look at Figure 2.1 (Sakamoto 1991) which introduces different ways to evaluate current conditions regarding productivity, and shows that each result makes

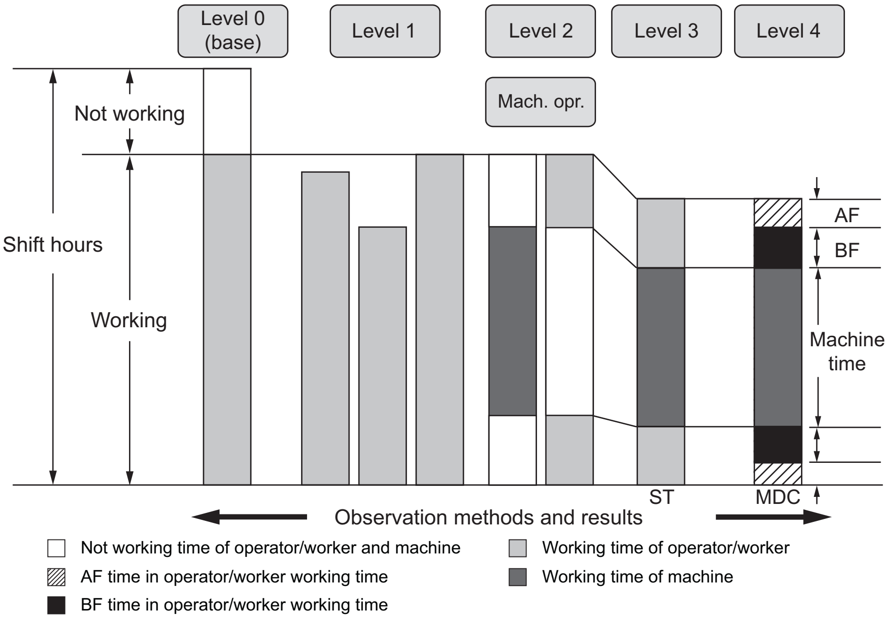


Figure 2.1 Study methods and found results (Sakamoto 1991)

a different evaluation for the present. Note that applying different techniques results in a different conclusion for a given shop. There are 5 levels (0 to 4), with the upper level being more reasonable. For example, you find more than 80% of operators' working time for the shift through work sampling (WS) study. "0 level" is the base of this explanation, but it is a common conclusion that industrial engineers use to identify the current condition. WS study as a tool is applied for evaluating the current condition (0 level). WS study is done by dividing working or nonworking time in a shift; the conclusion will be 80% of working time in one shift. This is why 80% utilization is not bad or good; there are no special problems in the shop, so the rate is average.

The first level of study brings in line balancing. Line balancing is normally approximately 90%; 10% of balancing loss is shown. What does 80% of WS results mean? This rate of working-hour utilization is correct only for the bottleneck worker. Any other workers who belong to the line have 10% balancing loss as standard work contents distribution by industrial engineers. This means that workers at nonbottleneck stations do not work 80% on line-balanced work contents, and this line balancing loss is impossible to find with WS at shops. Balancing loss value is not easy to recognize at shops because the pace of workers is adjusted to meet bottleneck pace by each worker. Besides, it is easy to find small idle or waiting time through analyzed multioperator charts such as a man-machine chart.

Workers often wait during the processing time for completion of machines. If the cycle time of the bottleneck is not set as an engineered time standard such as MTM, nobody can recognize the validity of the bottleneck or standard time. That is why the cycle time of the bottleneck measured against an MTM standard should be differentiated from the *actual* cycle time of the bottleneck. This cultivates the meaning of working time ratio percent in terms of movement of hands and/or body elements, or physically doing operations. An important point of recognition for the operation or body elements movement is that it contributes directly to increasing output (OP), but that is not waste just for supporting functions.

The second level of study introduces operator-machine relation analysis. Taking punch press workers as an example, machine time is about 60%, so the worker operates in the remaining 40%. Therefore, 60% of the cycle time is not real working time; it is time processed in waiting on a machine.

The third level of study relates to a worker's pace measured by a worldwide standard such as MTM or rating scale. The working pace for the worker who does not know its standard will be about 80%.

The fourth level of study corresponds to content related to OP, such as the working contents that contributes to increasing OP. These are basic function (BF) and auxiliary function (AF). BF percent for working time is almost 60% with 40% left of AF, meaning that the work does not increase OP (BF and AF are described in Chapter 6).

To summarize these results in an equation, ($80\% \times 90\% \times 40\% \times 80\% \times 40\% = 14\%$). The example shows only about 14% as a worker's real working time for work that increases OP (14% of utilization of shift hours for meaningful work contents).

It is important to take action at shops for current methods, but those are deemed performance dimension of theoretical productivity analysis. Those improvements of performance are made possible by FM and workers themselves. On the other hand, development of ideal methods concerning manufacturing systems, operation methods, layouts, jigs, and fixtures are much more significant for increasing BF. Designing ideal methods that increase BF in cycle time is rarely the job of industrial engineers.

This basic example explains that completely different results can be offered with study methods as simple as the process of utilization. As you understand, a problem or possibility of improvement cannot show itself through simple study like WS. Formal engineering approaches present better possibilities. WS makes it easy to study shop conditions from the perspective of improvement, but the result does not give a reasonable subject to be improved in the first place. Reasonable improvement subjects in shops are possible through engineering steps like detail analysis of method engineering and measurement such as MTM. And again, methods design concept (MDC) gives more room for productivity improvement with a ratio of BF in working time.

BF is approximately 60% of working time before working methods are designed well. This lead $23\% \times 60\% = 14\%$, only about 15% of working time contributes to increasing production OP, which means that the remaining 85% of working time is potentially subject to improvement. Instead of focusing on current methods in a shop alone, tap into a theoretical way of thinking.

In the conclusion of this FS, Klaus Helmrich summarizes my supporting experiences above as:

The purpose of an FS is to ascertain the possibilities of increasing productivity, and thus competitiveness. Through analysis, the most important project areas are established with regard to improvement potential, priority, likelihood of success, and likely resultant effects. For your company's implementation, an should include the following steps:

Step 1 Select the processes to be studied. Design models for each process category. Establish improvement goals, such as increased capacity or increased productivity.

Step 2 Identify current losses. Study machine and human utilization and mechanical stoppage times. Perform MTM analyses for manual activities. Perform video and sampling studies. Identify balancing losses and prepare production statistics concerning variations in speed, OP, and scrap.

Step 3 Search for possible directions for improvements.

Step 4 Establish the potential for improvement. Calculate the optimum results.

Step 5 Summarize the results.

Step 6 Choose project areas and set realistic targets. Establish time schedules for implementation (Helmrich 2003).

2.2.2 Symptoms and Background

FS are required for setting quantifiable targets that can be met over a period of a few years. An FS should be used for a long-term improvement program.

Now, consider where you visit when you feel ill. There are three options for your care: drug stores, clinics, and hospitals. A person goes to a drug store just to buy medicine, which he knows will improve his body's condition; he knows the effectiveness of a medicine through a commercial on TV, pharmaceutical advice or other. He is responsible for his decision to purchase that medicine. It is a simple way to alleviate the sickness, and the required time may be less than 10 min for the medicine to work.

The person visits a clinic to see a specialty doctor. The clinic doctor asks for a briefing on the person's symptoms and then measures blood pressure, takes temperature, and may check other activity (pulse, dilation of pupils, *etc*.). Then the doctor completes a medical evaluation and records the information. The person receives a particular medicine following the evaluation. The doctor's diagnosis process may be less than 10 min. That is the complete process if the patient becomes better. If the person still feels ill, he takes the next logical step.

The sick person visits a hospital. The person isn't seen by the doctor immediately upon arrival even if he has a temperature, feels sick and wants to see the doctor right away. First there are a few checks and measures: weight, height, urinalysis, blood pressure, and so on. It takes more than half an hour. Then the person waits another half an hour. After 1 hour or more, a doctor repeats steps that were done at the clinic (talking about the person's symptoms, measuring blood pressure and temperature, *etc*.). This takes 5 more minutes.

Why does the hospital go through such a careful diagnosis process? The reason is that the hospital must see the feasibility of symptoms that the patient either ignored until the sickness escalated or which were prescribed the wrong treatment. There are several scenarios that must be eliminated for the care of the patient. The three options for care, even though they took a long time for the patient to explore, collectively resemble a FS of an everyday challenge (state of health).

2.2.3 Points of Feasibility Study Practice

2.2.3.1 Objective Diagnosis

The importance of an FS is to develop top management's interest concerning productivity and/or profitability improvement. An FS can show attractive possibilities based on numerical or concrete tasks to accomplish and set reasonable quantifiable targets.

Let's return to productivity matters. Which option of the decision process would you have chosen for the best outcome? The options make different conclusions and targets, require different timeframes and incorporate a unique vision respectively for diagnosis. An FS for productivity and/or profitability is recommended to follow the way a hospital executes diagnoses. An FS includes an objective diagnosis and quantitative analysis based on theory (extensive diagnosis).

In objective diagnosis, there are actual professionals of productivity who come to shops and point out the possibility of improvement from place to place in a shop. Those professionals are similar to pharmacists who advise walk-up consumers. The shop that is advised can improve current conditions *if* the professional is an expert in that shop's respective field. But how long can workers accept and tolerate such scrutiny? How long will the improvement continue after the professional is gone?

This approach does not deny results, but it is a subjective approach. Targets must be established and this usually happens with a long-term plan. Kaizen activities directly result in productivity improvement, but not only with participative management; a company as a whole must believe that it is a key matter for profitability and productivity. So, the diagnosis should be kept on an objective study basis. An objective basis of diagnosis dwells upon *object areas*. For further clarification, what is the definition of Muda (waste, or something that does not add value) in kaizen activities? It is not a single way that is considered. One person uses the term Muda but others do not refer to it for particular shop floor practices.

This is a typical subjective way of evaluating Muda. Let's consider a particular operation. First, think about production line operation: it is the line balancing of static line balancing (SLB) or dynamic line balancing (DLB). The ratio can be calculated with engineered standard time or measuring. A bottleneck station in

SLB may coexist with another station that may be a bottleneck station in DLB. The actual condition is a single fact, but objective assessment is different and should assume actions that are also different with objective diagnosis as current assessment.

In order to design a fully mechanized production line (for example, camera production), an effective production engineer would probably use SLB. While its line balancing is adequate with SLB, it does not protect from stoppage of the machine, or CHOKOTEI (a maintenance concept used frequently in Japanese manufacturing, meaning the production is stopped due to defects, parts shortage, *etc*.). The feeding cycle of parts cannot be set with a fixed, constant time value. The use of SLB is satisfactory, but DLB might lose time with unexpected circumstances. Designing cycle time balancing for all workstations and float sizes between particular work stations has to be considered to stave off the point of entry of CHOKOTEI. This definition of balancing ideas would be part of an industrial engineer's skill set. Considerations of DLB must be accounted for so as not to make expensive mistakes.

2.2.3.2 Quantitative Analysis Based on Theory

Many steps in a qualitative analysis help to avoid subjective diagnosis. How much loss is there? How much improvement is possible? Can capacity increase with a reduction in man-hours? A plan can be established with a quantitative prospect, such as the type of development organization (project or nonproject), number of project members and their expected backgrounds and the number of years for developing the plan. A project target should be set at the beginning of project activity. There are endless activities like Kaizen and quality control circle (QCC) that can help carry out the plan; however, company-wide improvements can only be made with results-oriented activity; there must be a limited term for project activities. A key reason that management makes this decision along with the prospected improvement is the result of FS for productivity/profitability with a quantitative base.

2.2.3.3 Extensive Diagnosis

Extensive, overall diagnosis regarding productivity and profitability has to be executed fully. Productivity is divided into method (M), performance (P), and utilization (U). These three aspects create a synergistic product.

For example, if top management asked middle management if 200% productivity improvement (2×) is possible, it is difficult to reply "Yes". Why would management set such a target? A productivity improvement increase of 2× is possible through 30% ($1.3 \times 1.3 \times 1.3 = 2.2$) for each of three dimensions, M, P, and U. How much in total cost can be accepted for the target? This is an important component of engineering economy.

Incremental Cost

It is incremental in that the additional cost that will be incurred as the result of increasing the OP one more unit. Conversely, it can be defined as the cost that will not be incurred if the OP is reduced one unit. More technically, it is the variation of OP resulting from a unit change in input (IP). It is known as the marginal cost. Further, according to *Industrial Engineering Terminology* (American National Standard, 1983), there are two types of additional cost:

Opportunity cost: the cost of not being able to invest in an alternative, due to limited resources being applied to another "approved" alternative, and thus not being available for investment in other income-producing alternatives.

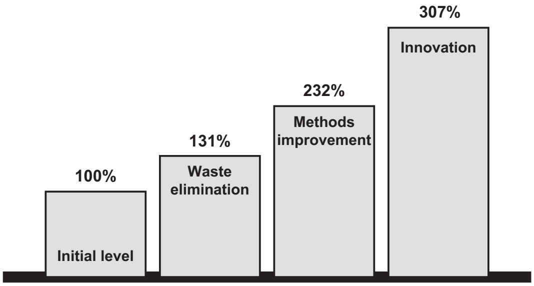
Sunk cost: (a) a cost, already paid, that is not relevant to the decision concerning the future that is being made, *i.e.*, capital already invested that for some reason cannot be retrieved; (b) a past cost which has no relevance with respect to future receipts and disbursements of facility undergoing an engineering economy study. The concept implies that since a past outlay is the same regardless of the alternative selected, it should not influence the choice between alternatives.

An example follows: JPY 10,000,000 (approximately 100 JPY = 1 USD) for decreasing five workers, that is, JPY 2,000,000 per worker. This cost of 2M JPY cannot be used to decide this improvement because it is missing the aspect of incremental cost. Again, incremental cost depends on the relationship between increasing cost and improving effect. Total cost is 10M JPY, but the incremental cost for the first worker is not equal to the average 2M JPY, the second as well, and so on. In my experience, reducing the first worker incurs almost no cost, but the fifth one may require 10M JPY or more, because increasing the number of reduced workers from four to five requires a more machine-oriented or automated facility. The result could be that the first is 0 cost and the fifth is 10M JPY. Considering this example, decide to adopt whatever level of reduction of workers would be evaluated as a reasonable cost for not only the object area but also an acceptable cost for improvement areas. This is also a key aspect of diagnosis in general. This is simple to understand in definition, but often missing in practice. To reduce manning from 5 to 4 and 1 to 0 are quite different as you can imagine from an expenditure point of view, because 1 to 0 means eliminating the operation purpose or full mechanization.

Tools for FS are mainly WS studies recognizing: BF ratio regarding M dimension, direct time study, methods-time measurement, analysis for measuring and evaluating labor performance (P dimension), an accumulated chart of WIP, and product inventory (U dimension).

2.2.4 Practice of Feasibility Study

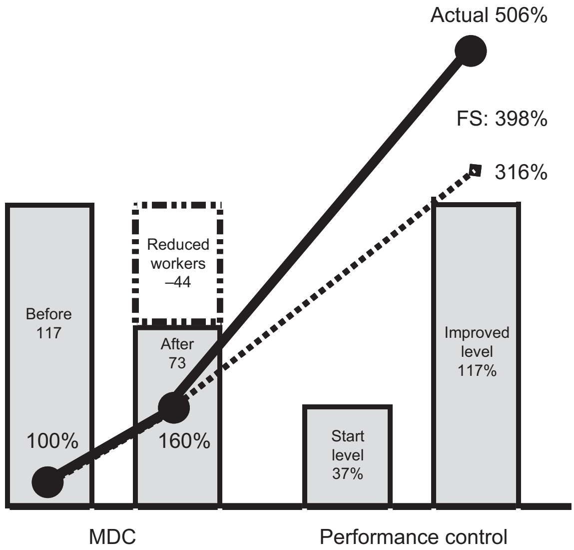
Figure 2.2 is an example of a FS regarding M, the methods dimension of productivity at Tilten, Torslandaverken, Volvo Car Corporation in Sweden. Tilten is a fully-automated station with three welding robots in which small components are added to the top and underside of the floor plan. The station was a bottleneck.



M :	100%	116%	154%	172%
P :	100%	100%	100%	100%
U :	100%	113%	151%	179%
M · P · U = :	**100%**	**131%**	**232%**	**307%**

Figure 2.2 FS result regarding capacity increase in Volvo

Figure 2.3 Productivity improvement results of FS and actual results (Sakamoto 1991)



Starting with an index of 100, by eliminating waste it was possible to increase capacity to index 131 (+31%). After method improvements, the capacity was at index 232 (+132%), and after so-called innovative changes capacity was at index 307 (+207%).

Note that there is no need to increase productivity of method innovation for 3–5 years of a short-term plan. This is why work simplification and improvement of changes were decided as a project activity. Therefore, the cycle times of the workstations were reduced by 47% in less than 1 year. In addition, U was increased by 16%. The example shows that there are many opportunities for productivity and capacity improvements, not just in manual work but also in automated process as well. The value of this for the company is gigantic considering the investments that have been made in this type of operation.

Consider another example of diagnosis results at a welding shop. The shop is fully robotic and one workstation was floor welding, which involved a big machine. The diagnosis result was 2× the capacity increase with function analysis of the current waiting time of the machine process. It was found with functional analysis of BF and AF of MDC. It turns out that 2× (200%) the capacity increase was not necessary, so a project target was set at 30% for 2 years, which was sufficient. This means the target 30% is possible with work simplification of method change. This is why expenditure for this change was limited under a small budget.

Figure 2.3 shows another case of FS result and actual result of productivity improvement: about 400% of productivity improvement regarding M and P dimensions of productivity at FS stage. The actual result was 506% of productivity improvement.

2.2.5 Sensitivity Analysis of Profitability

Figure 2.4 is a sensitivity analysis among related subjects regarding return on investment (ROI), otherwise profitability.

It shows possible areas and concrete activity subjects to improve the possibility of profitability in the short term. If you think of the term, *sensitivity* it means acute perception; this is a positive business trait for management to have. As such, sensitivity analysis is a systematic approach that can lead to profitability. The opposite would be random approach, which makes decisions and challenges certain subjects without sensitivity analysis.

Now that we have discussed various upper-level tools in support of profitability and productivity, this is a good time to examine what makes industrial engineers equipped to play a supporting role to management when it comes to capital investment for machines or facilities.

Management is sometimes less skilled in making investment decisions, so industrial engineers can support them in the following ways:

Change initiatives focused from capability to necessity: an investment proposal insists on capability of investment effectiveness. An investment for a machine is justified with the proper forecasting of quality and level of productivity. Industrial engineers ask questions that help map future conditions.

Emphasis on effectiveness and efficiency: effectiveness, such as methods, requires investment. Efficiency in this matter has to be forgotten; the current machine may increase its capacity without methods changing, which would make this a question of efficiency rather than effectiveness. With not only productivity but any subject regarding investment, the two functions effectiveness and efficiency, must be balanced. Effectiveness improvement normally requires higher expenditure but efficiency does not.

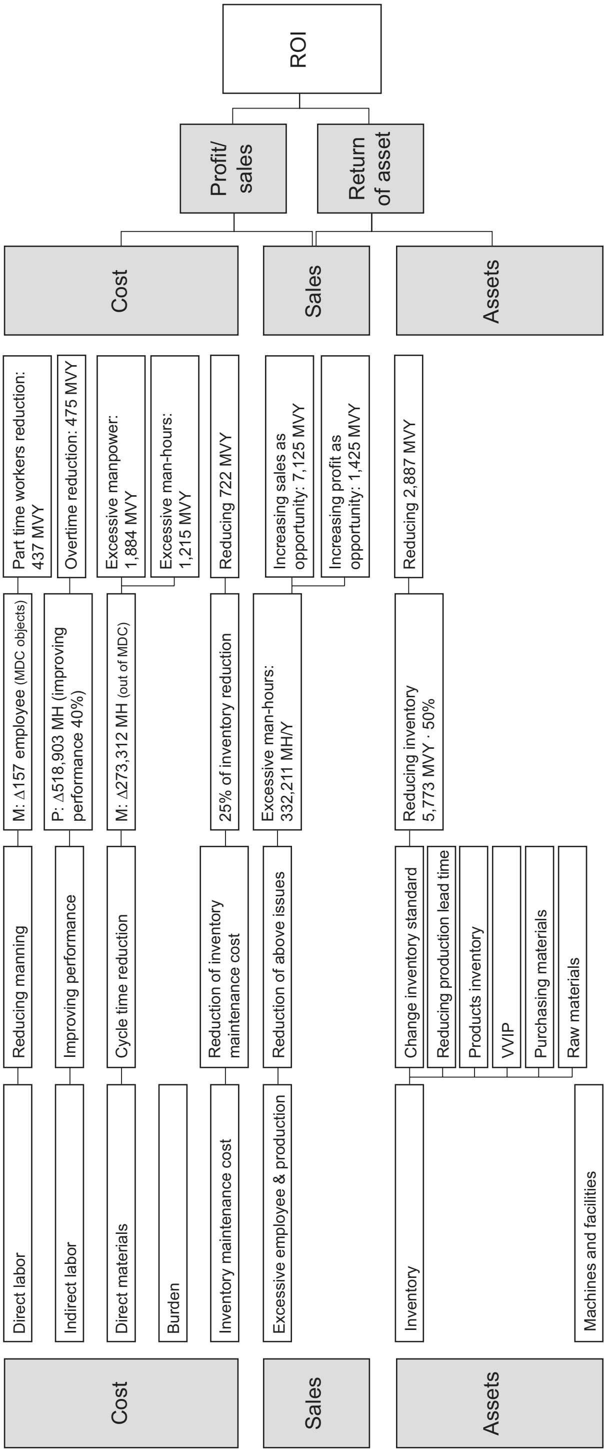


Figure 2.4 Sensitivity analysis of profitability: company C

Objective reports of expenditures: A proposal has to be a summary of expenditure and its effects. A question is objective, not subjective calculation and the items are included or not. Biased, imbalanced calculation is not difficult to find in actual cases, but industrial engineers must be the ones looking for the calculation.

Application of engineering economy: this is the decision support that should be used for all capital investments. It seeks solutions to problems and the economical viability of each potential solution while also considering the technical aspects that can be missed by general management.

Total expenditure savings: Total expenditure should be controlled tightly. If you remember the calculation formula of ROI, a large amount of cost reduction with expensive investment leads profit margin improvement with cost reduction, but return on assets decreases.

In sum, a new kind of management behavior should be implemented, and industrial engineering provides the foundation for this behavior.

2.3 Four Levels of Manufacturing Strategy

There is a different initial position when a company starts productivity improvement as a manufacturing strategy. The beginning must be basic and every employee must understand the steps that will be enacted. The typical four categories of activity are: recognizing poor levels and conquering them, changing the old corporate position, preparing an auditing system for production, and achieving WCM.

2.3.1 The First Level: Recognizing Poor Levels and Conquering Them

The first step of creating a manufacturing strategy is to know the current level of productivity before planning for the future state. Understand the information and activities that are keeping your company from being competitive. For example, a company that possesses engineered time standard will have a higher productivity level than those without such a standard. Basic industrial engineering techniques conquer this level of weakness.

At this stage, implementing scientific management based on standard time is effective in not only improving workers' performance level, but also serves as the objective for any planning and control. Training in management techniques such as IE techniques of analysis and syntheses is effective for heightening management skills concerning productivity. Outside consultants work well for whole organization hierarchy in this way as well.

The following issues and activities are useful once you understand the current level of productivity:

- Losses should be recognized as waste.
- Implement scientific management.
- Adopt engineered work measurement.
- Implement a system that shows effectiveness of management activity.
- Develop a system of quick response for top management decisions to be carried out.
- Cross-train corresponding management.

2.3.2 The Second Level: Eradicate Old Corporate Position

Measuring profitability every month is necessary after middle management takes proper action. These types of managers know cost and cost reduction well, but tend to ignore profitability measurements that reveal results, which often show high-priority problems to solve. Through step-by-step activities, fundamental actions can turn into improvements that outshine competition; for example: level of workers' performance, annual rate of productivity, productivity of direct and indirect departments, productivity improvement subjects such as M, P, and U, production and ordering lead time, and quality.

To turn issues into productive activities, implement a profitability management system, expanding step 1 into an experience for the whole company, identify an outside level of productivity/profitability as a benchmark, and improve the effectiveness of capital investment or improvement expenditures.

2.3.3 The Third Level: Preparing an Auditing System for Production

Preparing a system of objective measurement and evaluation for productivity and profitability is a required project. There are many different cases of successful corporate performance improvement to be inspired by. In other cases, the results are satisfactory, but the approach was a common random approach; management just found problems or improvement objects by chance. Systematic approaches should be adopted for the best practices company wide. Additionally, manufacturing strategy consulting firms have experiences and know how to develop the appropriate auditing system. As a result of auditing, a company can set a middle- and long-range management plan with a reasonable scenario that will guide manufacturing contribution under a corporate strategy. That strategy might be to increase reliability of production departments, give top management consensus for investment, and obtain a long-range view of manufacturing. Outside references as benchmarks are useful for establishing challenging targets for worldwide competition. Reinforcement of top management's involvement in manufacturing divisions will help to define a long-range outlook of manufacturing vision.

2.3.4 The Fourth Level: Accomplishing WCM

The final step is to strive to be the world's "best company of best companies". Pursue a strategy with production as the foundation. Mine the untapped ability of workers for a new production system with the production department itself and/or with an enjoined engineering department. Develop human resources who can strengthen their own skills in daily activities. Enforce the production department's point of view related to marketing efforts and R/D activities. Increase production engineering. Prepare a program not just for short-range requirements such as cost reduction for domination price competitiveness, but with long-range parameters improving the effectiveness of capital investment. Finally, expect a more practical contribution from corporate level of performance.

Staying at the current level using these four steps is simple. Reaching for a world-class level using these four steps is ideal. Planning for a 10-year span of decision making, which is a typical timeframe for the groundwork, demands that top management be eager to improve and have strong intentions achieve a level of WCM. Again, I emphasize that WCM cannot be established in a few years.

Now we look at evidence. Table 2.1 shows practice of a plan in place by company A. This company organized 20 engineers for a productivity and profitability improvement project. Their backgrounds were not primarily in industrial engineering, but rather mechanical and electrical engineering having received training from a graduate university or technical high school. They eventually trained in basic

Table 2.1 A plan for WCM: company A

Step 1	Step 2	Step 3	Step 4
Recognize poor level	Eradicate old corporate position	Auditing	Accomplish WCM
1st–2nd year	3rd–4th year	5th–7th year	8th–10th year
Productivity and profitability improvement	Measurement based management	Compare to bench-mark of others	Searching and improvement of long term subjects
Direct: M&P improvement	MBM practices		
U improvement indirect: MOP MBM system	Profitability improvement practices		

courses of industrial engineering including MDC, and Methods-time measurement (MTM). The project the 20 engineers executed covered the three productivity dimensions: M, P, and U. The project activities not only improved productivity and profitability, but also trained the members to be internal consultants. The company, considered the “mother plant”, has overseas plants that are now supported by these internal consultants.

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