A productivity study to support the future manufacturing concept

A. ROLSTADÅS

The Norwegian Institute of Technology University of Trondheim Department of Production and Quality Engineering

B. MOSENG

SINTEF Production Engineering

SUMMARY

The paper describes different methods (self audit, extended audit and self assessment) for measuring of productivity and competitiveness. The methods are developed in the Norwegian Productivity Program - TOPP, and have been used in approximately 40 companies participating in the program. The self audit and external audit are developed mainly for mechanical industry (including shipyards, offshore and electromechanical industry), while the self assessment is a modular system consisting of a set of business processes and indicators which the companies can use to build their own self assessment system for continuous improvement.

1 INTRODUCTION

The future enterprise will be based on global manufacturing. This means that the different functions of an enterprise such as product development, engineering, part production, assembly etc. may be geographically spread. This is referred to as the virtual enterprise.

The need for the virtual enterprise is based on the international market competition. The enterprise of today competes on an international market. To survive it must adapt to the best practice world wide. Productivity and competitiveness then becomes a significant issue.

2 PRODUCTIVITY MEASUREMENT

Measurement of productivity and competitiveness in industry companies is difficult and raise several questions. What is productivity? Does productivity mean the same for different people and organizations? Different viewpoints and positions give different answers.

The classic definition of productivity is produced goods pr. unit of production factors. This definition indicates a focus on the value adding and physical production process. The physical production process is well defined in most enterprises, and input and output can easily be counted, measured or calculated. Internal services, however, are not so easy to describe, and even more difficult to measure. Industry has a tradition of focusing on 'blue collar workers' rather than 'white collar workers'. This view has changed in the 1980s, but there are still people who defend the old way of thinking in respect of productivity.

However, it has no sense to produce a lot of products if there is not a market. Customer satisfaction is an extremely important factor in obtaining competitiveness.

Measuring of performance and productivity should be done from different viewpoints. Figure 1 shows 3 dimensions.

Figure 1 Performance measurement

In business terms the 3 dimensions could be described as follows:

Effectiveness	- to which extent are customer needs satisfied
Efficiency	- to which extent are the total resources in the company used in an effective and economic way
Ability to change	- to which extent are the company prepared to handle changes in surrounding conditions (strategic awareness)

When establishing a methodology for productivity measurement it is important to have in mind all 3 dimensions. A lot of surrounding factors will influence the productivity and competitiveness of a company. Some important factors to consider are shown in figure 2.

Figure 2 Company surroundings

3 THE NORWEGIAN PRODUCTIVITY PROGRAM - TOPP

Introduction: Norwegian economy is based on export of raw materials and semi finished products. Companies working on the international market are often sub-suppliers to multinational customers. The contribution from Norwegian industry to the gross national product (BNP) is low (18%).

Those factors were important arguments to look at productivity and international competitiveness in Norwegian industry. To meet this challenge the productivity program TOPP has been launched in Norway.

The overall goal of the TOPP program is

to focus on total productivity for the whole enterprise and stimulate an industrial climate that improves international competitiveness

Important objectives and key issues in TOPP are

- time to market
- quality
- flexibility
- total cost

The program involves cooperation between

- The Federation of Norwegian Engineering Industries
- The Norwegian Institute of Technology (NTH)
- Industrial companies (~ 40)

and is sponsored by

- The Research Council of Norway

The TOPP program is planned for the period 1992-95. Following subprograms exist:

1. Analysing company productivity and competitiveness (self audit, extended audit, self assessment, benchmarking etc.)
2. Implementing actions for industrial productivity improvements (industrial projects, seminars, courses, industrial networks, etc.)
3. Generating new knowledge (research projects, analysing productivity data, etc.)
4. Long term competence program (education , courses, dr.ing. programs, master degree)

Methods: Taking into consideration the different views and dimensions in productivity and performance measurement, following approaches (methods) have been developed and used

- a) Self audit (questionnaire)
- b) Extended audit (performed by experts)
- c) Self assessment (continuous improvement)
- d) Benchmarking (breakthrough)

The different methods a),b) and c) will be briefly described in the following.

4 SELF AUDIT

Methodology: The self audit is based on a questionnaire answered by the companies. The questionnaire consist of 3 parts asking for different types of information.

Part 1 Facta data

Part 2 General evaluation of functions and system variables (by individuals)

Part 3 Detailed evaluation of functions and system variables (by groups)

Part 1 consist of general information about the company, product data, cost distribution, maintenance cost, quality cost, customers, sub suppliers, financial and economic data etc. The data is facta or estimates.

In part 2 individuals (~20) in the company are asked to give their own evaluation of different functions (primary and support) and system variables (facilities, equipment, personnel, organization etc.). This evaluation is given confidentially and is later compared with information given in part 3 (see figure 4).

Part 3 is the largest and most detailed part of the questionnaire. The company is asked to build groups to evaluate a lot of detailed questions concerning all functions and system variables. Example of questions to evaluate the design function is shown in figure 3.

Functions and system variables are evaluated on a scale 1-7 where

- 1 is far behind competitors
- 4 is on same level as competitors
- 7 is "best practice"

By design we mean the function responsible for the production support for order production or in connection to product development. Typical activities will be analysis, calculation, work out drawings etc.

- 6201 Evaluate the following areas/aspects as to current situation, and give a realistic possibility for improvement by estimating the status after 2 years. Judge how important the factors are for the company's competitiveness (N - No importance, M - Medium importance, G - Great importance).

Very bad		Medium				Very good	
1	2	3	4	5	6	7	
			Status today	Realistic status in 2 years	Importance for the company	+	1 ML
a)	Tools and technical facilities		1-2-3-4-5-6-7	1-2-3-4-5-6-7	N-M-G		
b)	Design competence in own company		1-2-3-4-5-6-7	1-2-3-4-5-6-7	N-M-G		
c)	Design investigation and work through		1-2-3-4-5-6-7	1-2-3-4-5-6-7	N-M-G		
d)	Laying down of product parameters (function, form, material, dimension etc.)		1-2-3-4-5-6-7	1-2-3-4-5-6-7	N-M-G		
e)	Presentation of production support (drawings, piece lists etc.)		1-2-3-4-5-6-7	1-2-3-4-5-6-7	N-M-G		
f)	Quality safeguarding system for design work		1-2-3-4-5-6-7	1-2-3-4-5-6-7	N-M-G		
g)	Procedures for treatment of change orders		1-2-3-4-5-6-7	1-2-3-4-5-6-7	N-M-G		
h)	Systematic registration and reuse of empirical data		1-2-3-4-5-6-7	1-2-3-4-5-6-7	N-M-G		
i)	Co-operation with production/production planning		1-2-3-4-5-6-7	1-2-3-4-5-6-7	N-M-G		
j)	Market and customer contact		1-2-3-4-5-6-7	1-2-3-4-5-6-7	N-M-G		
k)	Co-operation with contractors		1-2-3-4-5-6-7	1-2-3-4-5-6-7	N-M-G		
l)	Co-operation with purchase		1-2-3-4-5-6-7	1-2-3-4-5-6-7	N-M-G		

Figure 3. Questions to evaluate the Design function (example)

Report - analysing of data: The data is collected and stored in a database. Different types of reports can be generated automatically. Individual reports based on data for one company or reports based on average data from a given number of companies can be produced. The report layout is the same which means that companies easily can compare own data with data from groups of other companies. The report consist of 3 parts

- Main report with key indicators (10 - 15 pages)
- Enclosure for comparison (~ 50 pages)
- Enterprise specific enclosure (detailed economic and financial data) (~15 pages)

Figure 4 shows results from evaluation of primary functions.

Figure 4. Evaluation of primary functions

5 EXTENDED AUDIT

Methodology: The extended audit is performed by experts analysing the company. Measuring of productivity and competitiveness is done on 2 levels.

- Company level** - using indicators and key factors with focus and viewpoint on the whole enterprise
- Company split up level** - using indicators and key factors with focus on parts and specified areas in the company

An overview of the different areas (37) in the model is shown in figure 5. Characteristics for the analysing areas are:

Company level

Economy - indicators and key factors which describes the economic conditions and potential. An important issue of this analysis is to evaluate the economic capacity for future investments and change.

External relations - indicators and key factors to measure the ability of the company to exploit and take advantage of surrounding conditions. This includes evaluation of customers, competitors, use of external resources, strategic alliances, etc.

Internal relations - the ability to use existing internal resources (products, machines, personnel etc.) in a time and cost effective way, and to take care of the internal milieu.

Ability to change - the ability to foresee and be prepared to meet new trends and quick changes in the environments.

Company split up level

Systems variables - primary resources and conditions necessary to produce products

Functions - Activities in the product life cycle. The functions are divided in primary and support functions.

Cycles - to follow and analyse flows between functions. Flows could be of different types (material , information etc.). The objective is to measure co-operation and infrastructure between functions.

Philosophies - to analyse overall production and management philosophies used in the company

Figure 5. Analysing areas - extended audit

The 37 analysing areas are broken down in a hierarchy of subindicators which are given points and weighted. Check list for all levels exist. Indicators for evaluation of the TQM process are given in figure 6.

No.	Description sub indicators	Points	Weight
1	Goals and strategy	3	10
2	Know-how and competence	5	10
3	Organisation and management	2	5
4	Information and analysis systems	2	5
5	Strategic quality management	2	15
6	Use of human resources	2	5
7	Quality control and quality improvements	3	5
8	Results of quality work	4	20
9	Customer satisfaction	3	20
10	Cooperation and information	4	5
Calculated		3,15	100%
Total score		3	

Figure 6 Evaluation of TQM (example)

Report: The audit is performed by an expert team (normally 2 persons) asking questions and analysing all relevant areas in the company.

The results are presented in a report organized in 3 parts.

- 1) Analysis of main productivity key factors and indicators (~5 pages)
- 2) Proposed actions and plans for the company to obtain better results (5-10 pages)
- 3) Detailed description of subindicators for all analysing areas (~50 pages)

6 SELF ASSESSMENT

The TOPP Self assessment is a modular system to help the companies to build their own system for performance measuring. The objective is to follow trends and check if a business process is in control and continuous improvement is taking place.

The methodology consist of following steps:

- a) Identification of critical and important business processes in the company
- b) Selection of analysing areas and indicators to measure the business processes
- c) How to organize the self assessment
- d) Collection of data
- e) Presentation of results
- f) Evaluation of results, actions

An overview of the methodology is shown in figure 7. 22 different business processes with analysing areas, indicators and measuring techniques are described.

7 RESULTS

All the described methods have been used in the TOPP program. The number of companies involved are:

- a) Self audit ~ 60 companies
- b) Extended audit ~ 40 companies
- c) Self assessment individual use

A lot of data about productivity and competitiveness are collected in the audits. A special research project has analysed those data, trying to find some general results and conclusions concerning the status of productivity and competitiveness of Norwegian industry. 8 different reports have been written focusing on different topics. The reports are:

1. General characteristics and possibilities
2. Analysing methodology
3. Analysing of procurement
4. Analysing of quality
5. Analysing of production planning and control
6. Analysing of product development
7. Analysing of marketing and sales
8. Analysing of strategy development

Figure 8 show a gap analysis from evaluation of different functions in the companies (self audit questionnaire).

Figure 8 Gap analysis concerning performance and importance of different analysing areas (37 companies)

The analysis is showing gaps between performance and importance of the different functions. The data are calculated as deviations from the average value for all the functions. The functions are sorted in 6 groups. Group 1 shows functions where both performance and importance are better than the average. However the importance is greater than the performance, which indicates that the area is good, but there is still a lot to do.

A number of functions (group 3) show high importance and scores performance less than the average. These functions are

- Quality Management
- Process planning
- Product development
- Production planning and control
- Procurement
- Material flow

This gap analysis is based on average values from 37 companies. However the companies are quite different (size, products, production methods etc.). Another grouping of the companies in more homogeneous branches would perhaps give other results.

A lot of detailed analysis on specific areas have been performed (ref. mentioned reports and special reports for branches). Analysis of the design function indicates that improvements have to be done in

- design review
- definition of product parameters
- quality assurance in design
- systematic registration and reuse of knowledge and experience data

8 CONCLUSIONS

Measuring of productivity and competitiveness for a whole enterprise is difficult. To find indicators, key factors and analysis areas which are relevant to different types of companies, and to harmonize this into a common methodology is even more difficult.

The methodology described is based on different approaches. However in any case there is much individual judgment. It is difficult (or impossible) to measure total productivity by summarizing local measurements of sub areas. This is the reason for analysing the enterprises from different viewpoints. History has shown that economic success one year does not guarantee a competitive edge. Many perspectives that measure different factors have to be used to get a better understanding of competitiveness.

REFERENCES

- (1) TOPP Questionnaire for measuring of competitiveness (54 pages)
- (2) TOPP Self audit company report (~75 pages)
- (3) TOPP Extended audit - method handbook
- (4) TOPP Extended audit - operation handbook
- (5) TOPP Extended audit - company report (~70 pages)
- (6) TOPP Self assessment handbook
- (7) TOPP Benchmarking handbook
- (8) Moseng B., Bredrup H.: A methodology for industrial studies of productivity performance, *Production Planning and Control*, 1993 vol 4 no. 3
- (9) Moseng B.: Productivity Measurement, Methods and tools developed in TOPP. IFIP WG 5.7 Workshop Benchmarking - Theory and practice, june 94.Trondheim,Norway
- (10) Bredrup R.: PMS Factors influencing on Enterprice Profitability. 8th International Working Seminar on Productions Economics 1994. Innsbruck, Østerrike
- (11) Bredrup H.,Bredrup R., Rolstadås A.: PMS contribution to Improved Enterprice Productivity. IFIP WG 5.7 Working Conference on Evaluation of Production Management Methods 1994, Porto Alegre, Brasil
- (12) Bredrup H., Bredrup R., Estensen L.: Factors influencing Effectiveness of Investments in Modern Manufacturing Technology. *Automation '94*, Taipei, Taiwan.
- (13) Bredrup H., Bredrup R.: Performance Measurement to support Continuous Improvement of Customer Satisfaction. *EOQ '95*, Lausanne, Switzerland
- (13) Sink D.S., Tuttle T.: Planning and measurement in your organization of the future. *Industrial and Engineering Management Press*, Norcross, GA. 1988
- (14) Porter M.E.: *The Competitive Advantage of Nations*. Macmillan, London 1990.

The references 2, 3, 4, 5, 6 and 7 are written in Norwegian

BJØRN MOSENG obtained his MSc in Mechanical Engineering at The Norwegian Institute of Technology, University of Trondheim, in 1970. He is now Research Manager at SINTEF Production Engineering, section Integrated Manufacturing Systems. During the last years he has been involved in the Norwegian Productivity Program TOPP as project leader. His main fields of competence are technology planning, CAD/CAM/CIM and information technology. He has been involved as project manager in several international projects (ESPRIT, BRITE-EURAM etc.).

ASBJØRN ROLSTADÅS is professor of production and quality engineering at the University of Trondheim, The Norwegian Institute of Technology. His research covers topics like numerical control of machine tools, computeraided manufacturing systems, computeraided production planning and control systems and project management methods and systems. He is a member of the Norwegian Academy of Technical Sciences, the Royal Swedish Academy of Engineering Sciences and APICS. He serves on the editorial board of the journal *Computers in Industry*, and is the editor of the *International Journal of Production Planning and Control*. He is president of IFIP and past chairman of IFIP TC5 and WG5.7. He is also past president of the Norwegian Computer Society and the Nordic Data Processing Union.