ETM
ENGINEERING & TECHNOLOGY MANAGEMENT

Title: A Critical Review of "Comparison of Manufacturing Performance of Three Team Structures in Semiconductor Plants"

Course: EMGT 520/620
Term: Fall
Year: 1998
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Report No: P98032

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Report No.:	See Above
Type:	Student Project
Note:	This project is in the filing cabinet in the ETM department office.

Abstract: A paper titled "Comparison of Manufacturing Performance of Three Team Structures in Semiconductor Plants" is critically reviewed in this individual report.

A Critical Review of "Comparison of Manufacturing Performance of Three Team Structures in Semiconductor Plants"

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EMP-P98032

1. Concepts

Today many industries face a constantly increasing competition and dynamics in their business environment. Many companies responded to this development with a more flexible organizational structure. At the productivity level different forms of improvement teams have been employed: continuous improvement teams (CIT), quality circles (QC), and self directed work teams (SDWT) are the most common ones. They differ in the level of autonomy, amount of received training, and the modification of the employee tasks compared to the previous workgroup, with an increase in progression from CIT to QC to SDWT. The literature calls these forms of employee participation "cognitive models". These models predict that the productivity increases through the participation of the workforce in the decision making process.
This paper tries to verify this hypothesis through studying the performance of the mentioned three group participation programs in 8 semiconductor manufacturing plants.

2. Methodology

For this study quantitative and qualitative data of 89 workgroups was collected during visits in the 8 sites in 1991 and 1992. These semiconductor plants of 7 major companies employed always only one form of improvement team program, so that 3 CIT, 2 QC, and 3 SDWT could be analyzed. Quantitative data from production and workforce records was the main source for the performance analysis of the workgroup, which allowed building three key ratios: direct labor productivity, indirect labor productivity, and wafer scrap percentage. This data was supplemented through employee surveys, measured on a five-point Likert-type scale, with a good response rate of 72 percent. To analysis all this data an ANOVA (analysis of variances) design was chosen, where the self-reported measures served through the Tukey contrast test as a validity check on the independent variable: the type of team program.
Finally over 100 interviews with employees from all job levels were hold for background information of the teamwork and explanation of the results.
This methodology was tested in a pilot fab employing a QC team in order to get familiar with the semiconductor manufacturing processes and to adjust the survey and interview questions to the latest findings.

3. Contribution to the literature

As mentioned in the summary, the cognitive models describe the connection between employee participation and productivity increase. Though the conclusion of the models sounds very logic, there have been only a few research studies for its verification. The existing studies in the area were mainly limited on single plants, which made it difficult for the generalization of the findings. Another gab in the literature was that mainly manufacturing companies in traditional industries had been investigated. But the manufacturers of traditional products are not the ones with very high percentage of team based work structure. It is mainly high-technology industry which widley introduced and experimented with different employee participation programs. Therefore the examination in this industry sector is a contribution to fill the gap in this research area.

The findings of the paper were very surprising as they belied the premise of the cognitive models. The analysis of the quantitative data through a comparison of direct and indirect labor productivity and the scrap percentage showed that the fabs with CIT programs performed always better than the plants with SWDT and QC programs.

The data from interviews and surveys give an insight into the organizational design of the programs. CIT programs seem to get low priority of the management and that they received only a low level of training and autonomy. The workgroups with QC programs in comparison had much higher technical autonomy and management provided much more structure, attention, and guidance to these teams.

Finally the operators in plants with SDWT programs had far-reaching administrative and technical autonomy and received extensive training in maintenance and teamwork.

4. Other research studies

There are some related studies examining the effects on group-based participation programs in manufacturing plants:

- Marks [8] analyzed the impact of employee participation in QC programs on productivity, quality of work life, and absenteeism. He found that these programs increased the individual productivity.
- Another study done by Pearson [9] evaluated autonomous groups in an engineering workshop and found that these teams had significantly better productivity than traditional groups.
- Blatt and Appelbaum [2] found by analyzing the participation of workers in different workgroups that the job satisfaction and commitment in the autonomous ones was highest.
- A long-term field experiment conducted by Wall [10] studying the outcomes of autonomous workgroups showed only an improvement in the indirect labor productivity due to reduced supervisors, but not in the direct labor productivity.

The first three studies seem to support the cognitive models of employee participation. But it has to be mentioned that only the study of Marks [8] directly supports the hypothesis of this paper, whereas Pearson [9] analyzed the influences on the work of engineers and Blatt and Appelbaum [2] looked more on the impact of the employees. It is also important to see the different industries where these studies were made: from confectionery to dog food and telecommunication plants. As most of them were single site studies it is difficult to generalize the findings.

This paper differs from all these studies in the size of involved plants and the industry.

5. Strength

This paper is one of the very few studies in this research area, which looked at several plants and it is also one of the first in the high-technology industry. The sample of 89 workgroups is compared to most other studies pretty large and should give a good basis for the analysis.
It further explains in detail the concepts of the cognitive models and the different work group programs used in today's companies. Especially the brief description of the wafer production characteristics is good for readers with no knowledge of the manufacturing process in the semiconductor industry.
The chosen methodology with collecting qualitative and quantitative data and testing the surveys and interview questions in a pilot fab meets the requirements of scientific work methods. The sample and the data collection and documentation process, is described in detail and occurred problems are mentioned.

6. Weaknesses

The first point I want to mention is the explanation of the qualitative results. In this section the author does not really summarize her findings. It is rather a list of individual experiences of the employees with their group program than a support of the statistical results as stated at the beginning. I also disagree with this statement. The findings, like disorganized management of the CIT programs, more technical autonomy, structure, attention, and guidance in fabs with QC programs, and incredible administrative and technical autonomy in conjunction with increased skills stressing maintenance and teamwork in SDWT programs, do not support the good performance of the CIT groups at all.
Secondly, though the study provided a lot of data, some important information for the explanation of the surprising findings is not given.
In the section Validity Check on the interdependent Variable the author mentions that the "workgroup tenure averaged between two and three years, organizational tenure between six and seven years. ... These results rule out the possibility confounding effect of these workforce characteristics on the performance results". First we have to see, that these figures are means and therefore reduce the information dramatically. For example, Table I shows that two of the plants were only around one year old and this could have several impacts on the results of the study. The author does us not give the information which group programs these two plants employed. The problems occurring during the starting phase of the new production process might reduce the possible productivity of the fab. Furthermore the implementation of a new group program takes same time, as Katz found: "the negative impact of work teams on plant productivity ... resulted from problems associated with introducing the system".
A third major weakness of this paper is the chosen ratios for the analysis of the quantitative data. As the author chose the labor productivity measured as the number of wafers processed per operator hour the gained productivity differences could result from the following circumstances and not lay in the structure of the team program itself. To able to compare the team labor productivity in the different plants the production equipment and processes must be totally identical. Though the author mention this, I still

have same doubts about this assumption because of the significantly variation in the plant age, the clean room particle level, and the line width. Also the number of operators at the same functional production steps in the different plants should be nearly the same. But this information is missing in this report.
Additional outcome variables should have measured, as the participation in the described team programs leads first to idea generation, which leads afterwards to idea implementation, and which in turn leads to improved productivity. The measurement of the effectiveness should according to Hackman [4] include the number of suggestions and the implementation rate of quality and process proposals. This gives information on the reason for the poor performance of the team. For example it could show you that the team performed in fact was pretty good, but the management did not encourage the implementation of the ideas.

7. Conclusion

The author sees her study indicating that "SDWT's did not perform as well as more traditional organized and supervised workgroups whose member participate in QC's or CIT's" and that this finding belies the premise of the cognitive model. But this stands in contrast to the comparison of the productivity results in Table III, which shows that the indirect labor productivity of the SDWT's is always higher than of the QC's. SDWT programs also have a higher direct labor productivity in every functional area besides the etch operation. Therefore the hypothesis can not totally be rejected.
The author continues with a number of possible explanations. The first possible reason she discusses is that work in semiconductor manufacturing is simply ill suited to employee participation programs. But the study of the situation in the teams and the findings of other researcher do not support this explanation. The second explanation she gives is that the low performance of QC and SDWT programs lies in the long-time evolution and frequent poor design of team involvement The data from the interviews and surveys support this assumption mostly. Another possible explanation for the surprising findings is according to the author the choice of the outcome metric of productivity as a measure of effectiveness. She agrees that quality measures are more significant than productivity measures. However, she can invalidate this argument by referring to her quality metric of scrap percentage which show no significant difference between the three different programs. But she admits that other measures as discussed in the previous paragraph would provide better measures of teams dedicated to improvements in manufacturing performance. This is in my opinion as mentioned earlier the main weakness of this paper.

My research of related studies found no papers in the same area. There are several single site studies besides the mentioned ones in this paper, but not in the high-technology industry.
A study done by Banker [3] et al shows a considerable productivity increase in an electromechanical assembly plant by switching from CIT to high performance work teams, which are between QC and SDWT as they have only some decision making authority.

Magjuka [6] found in a comparison of different group structures that self-managed teams achieved the highest results in continuous improvement efforts.
Griffin used a longitudinal and experimental research design to examine the impact of QC's in an industrial setting and found positive impacts individual-level dependent variables like job satisfaction, organizational commitment, and performance.
MacDuffie [7] documented a positive impact of a bundle of innovative work team programs on the manufacturing performance in the automobile industry.

8. Future Work

The study of the related literature showed that this paper is still unique in size of the sample and in the conducted industry: the high-technology industry. But as the paper has some significantly weaknesses and the findings stand in total contrast to most of the other research results more studies with a large and more comparable sample have to be done. This future research is absolutely necessary: To maintain the competitive advantage in the high-tech industry the understanding of the impacts of team programs on the manufacturing performance is crucial as many companies in this industry sector currently use these organizational structures

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