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ORGANIZATION THEORY AND GROUP TECHNOLOGY MANUFACTURING SYSTEMS

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ABSTRACT

A survey has been made of the manufacturing characteristics and performance of 35 engineering companies which are using Group Technology (GT) methods in production. Data have been collected from these companies on a "before" and "after" GT basis. This study investigates the changes in staffing levels brought about by introducing GT, and the findings reported here are compared with those of other researchers. In this paper we argue that it is doubtful whether the extensive research work carried out on the relationship between the "technology" of organizations and structures can be used to extrapolate the changes which might take place in staffing levels when a GT system is introduced into a firm.

INTRODUCTION

Woodward (1958 and 1965), Pugh et al. (1969) and Hickson et al. (1970) carried out extensive examinations of the relationships between the "technology" of organisations and their structures. Woodward's contribution was to identify relationships between the type of manufacture and the organisation structure. She related "configuration" aspects of the structure of manufacturing organisations, such as number of levels of authority, to different production systems according to the "controlability and predictability" of the process. Woodward's technology was the conventional classification of production into unit/mass/process sub-divided into ten categories, as shown in Table 1. Pugh et al. and Hickson et al. attempted to define more precisely the Woodward "technology" classification according to a scale of production continuity, e.g. batches were called "small" if re-setting occurred once or more each week. Another measure of "technology" used was called workflow integration and, although this had affinities with the production continuity scale, it was not based on the unit/batch/mass/process notion as such.

This work was later used as a basis by Gallagher (1971), Sabberwal (1973) and Reynold et al. (1975) in investigating whether the change from small batch to Group Technology (GT) production would demand any radical change in organisation structure and whether there were any differences in organisation and management ratios between firms using GT and functional production systems.

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TABLE 1

Production continuity — a further operationalisation of Woodward's classification of production systems (After Hickson et al., 1970)

	Woodward classification		Scale of production continuity	31 manufacturing organisations
Unit and small batch	I.	Production of simple units to customers' orders.	Simple units = units basically single-piece, not assemblies, produced one by one.	0
	II.	Production of technically complex units.	Complex units = assemblies, produced one by one.	0
	III.	Fabrication of large equipment in stages.	Fabrication one by one, in which work-people come to the unit of output (which moves about very infrequently) rather than the unit moves around to different workpeople.	2
	IV.	Production of small batches.	Small batches = equipment reset every week or, more often, for outputs measured in items.	11
Large batch and mass	V.	Production of components in large batches subsequently assembled diversely.	Large batches = equipment reset at intervals longer than a week for outputs measured in items. BUT items assembled diversely (i.e. variety of assembly sequences, including assembly by unit and/or small-batch methods).	3
	VI.	Production of large batches, assembly line type.	Large batches, as No. V, but with large-batch assembly.	5
	VII.	Mass Production.	Mass = batch size, measured in items, is indefinite (i.e. a change of batch requires decisions on (a) design modification, (b) re-tooling, which are beyond the normal authority of the line production management and production planning to vary production programmes).	4
Process	VIII.	Process production combined with the preparation of a product for sale by large-batch or mass-production methods.	Process throughputs measured by weight or volume. BUT outputs become items at finishing stage.	0
	IX.	Process production of chemicals in batches.	Process, but ingredients (i.e. recipes) of the throughputs change periodically.	3
	X.	Continuous flow production of liquids, gases and solid shapes.	Process, but constant ingredients (i.e. recipe change is beyond the normal authority of the line production management and production planning to vary production programmes).	3

SUPERVISORS' SPANS OF CONTROL

Woodward (1958) found that the span of control of first line supervisors in large batch and mass production averaged 46, whilst in unit and small batch production it averaged 22.

Connolly's (1969) definition of GT, as "the technique which enables large batches of similar components to be formed from small batches of identical components", implies that the introduction of GT into a company tends to change the "technology" from small-batch to large-batch production. Therefore the results obtained by Woodward might suggest that with the introduction of GT into a company the supervisors' spans of control ought to increase. Sabberwal (1973) reported that at Ferodo Ltd. the number of supervisors had been reduced because the span of control of the changed "technology" (GT) had become larger than that of the old "technology".

Reynold et al. (1975) in a study of three companies operating along GT lines, found that the average span of control of a first line supervisor was 33.

From the survey of 35 firms carried out by the authors it was found that the ratio of number of manufacturing employees per supervisor before and after the introduction of GT averaged 16.5 and 15.8, respectively. Note that the results obtained by the authors indicate that the supervisors span of control decreased rather than increased after the introduction of GT. The figures are also approximately 50% smaller than those obtained by Woodward (1958), Pugh et al. (1969) and Reynold et al. (1975). It is interesting that Hickson et al. (1970) state that the ratio of subordinates to first line supervisors is the only measure with which the Woodward results and their results agreed.

The following are some possible reasons for differences between the authors' findings and those of other researchers:

(i) The organisations investigated by the authors were in engineering manufacture, whilst Woodward (1958) and Pugh et al. (1969) also studied a number of different types of organisations in other fields.

(ii) Woodward (1970) modified her views after publication of her initial result, concluding that, while "technology" had a clear influence on structure at extreme ends of the "technology" scale (unit and process production), in the middle range of small- to large-batch production the situation was not clear. She also concluded that influences other than "technology", particularly in this middle range, might be of more importance. GT is for use in jobbing and batch manufacture, it is therefore significant that it comes into this middle range.

This later work of Woodward was supported by Pugh et al. (1969) who concluded that "technology" (as defined by Woodward) ranks fairly low as a factor affecting organisation structure. So changing to GT from a functional organisation might not increase the supervisors' span of control.

(iii) In a GT system the supervisor is responsible for a number of different types of skills and machines, within the cell(s) under his control. From the survey it was found that the average cell size was 8.1 operatives and 12.4 machines. In general, smaller groups obtain greater benefits from GT organisation than do larger groups, although the latter cope better with load imbalance problems. So the number of employees under the direct control of one supervisor in GT system is kept small due to the problems of supervising different skills and companies aiming to optimise the benefits obtainable from GT.

(iv) In a number of the companies surveyed, GT had only been introduced on a small scale i.e. one or two cells, thus having very little effect on overall staffing levels.

CHANGES IN STAFFING LEVELS AND RATIOS

Hickson et al. (1970) concluded that among the extensive range of organisational features studied only those directly centred on the production workflow itself show any

connection with technology: these are all "job-counts" of employees on production-linked activities. They go on to suggest some conditions under which technology has marginal effects on organisational structure. These are illustrated in Fig. 1, reproduced from Hickson et al. (1970), the smoothed curves were deliberately intended to simplify

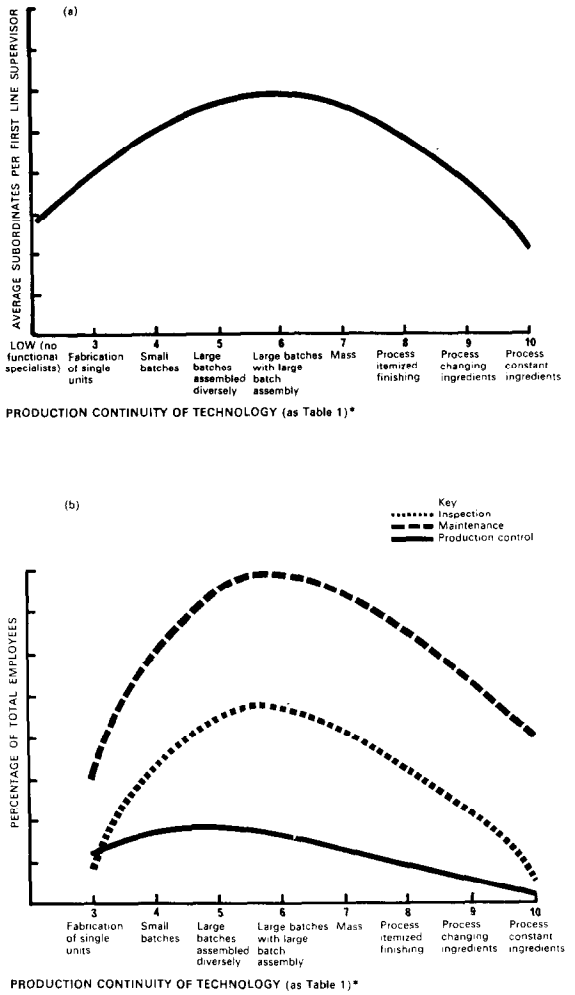

Fig. 1. Some features of organization that are related to the technology of production. (a) Average number of subordinates per first-line supervisor, related to production continuity of technology. (b) Three features related to the production continuity of technology. Curves are smoothed for visual clarity. *Categories I, II and VIII were not represented in this sample of organizations (see Table 1).

and exaggerate the statistical relationship found, and are merely illustrative. Gallagher (1971) suggested that the introduction of GT into a company would create a change in the "technology" index from point 4 to 5 or at most 6 (see axis label on graphs), this is a move from small-batch to large-batch production. Later Gallagher tentatively inferred that in a company which introduced GT, any organisational changes which would occur, could involve:

(i) The number of subordinates per first line supervisor increasing slightly.
(ii) The number of inspectors in the factory increasing slightly.
(iii) The number of maintenance workers increasing slightly.
(iv) The number of production control personnel remaining unchanged.
(v) The number of employees involved with purchasing and stock control decreasing slightly.
(vi) The number of employees concerned with internal and external transport increasing slightly.
(vii) The number of employees concerned with personnel work remaining unchanged.

By contrast Table 2 shows the changes which took place in staffing levels (which can be compared with Gallagher's) in the 35 companies surveyed by the authors. When the tentative results of Gallagher are compared to those actually achieved in companies which introduced GT, it can be seen that there are big differences. Where Gallagher suggested an increase or no change, the survey found a decrease. One reason for these differences could be that Gallagher suggested that the introduction of GT in a company would involve a change in the "technology" index from point 4 to 5; yet on the scale of Hickson et al. (1970) production continuity point 5 denotes large batches with equipment re-set at intervals of longer than a week. All companies in the survey re-set their machines at least once a week. This is indicated by the average total time (including setting

TABLE 2

Changes in particular staffing levels and ratios after the introduction of GT

Type of staffing level or ratio	Average value before the introduction of GT	Average value after the introduction of GT	Average reduction (%)
Average number of subordinates per first line supervisor	16.5	15.8	0.43
Average number of inspectors	13.8	8.8	11.3
Average number of production control staff	9.5	7.2	15.1
Average number of progress chasers	3.9	1.7	41.6
Average number of production control staff including progress chasers	16.3	12.1	21.9

and processing) a batch of work spent on machines, which averaged 35.5 and 28.3 hours respectively before and after the introduction of GT. This would suggest that few of the companies surveyed are in the large batch category as defined by point 5 on the technology index scale. Thus, GT has not created a change from point 4 to 5 in the technology index. Due to the relatively broad definition of point 4 i.e. small batches with equipment re-set every week or more often, any changes in "technology" arising from the introduction of GT would appear to have taken place within the small batch classification of manufacture.

RELATIONSHIP BETWEEN BATCH SIZE AND STAFFING LEVELS AND RATIOS

Woodward's (1958) "Classification of Production Systems" and Pugh's et al. (1969) "Scale of Production Continuity" were mainly based on batch size. The authors of this paper were interested in investigating the relationship between batch size and staffing levels and ratios in the companies from which data was collected, in particular:

(i) The average batch size before GT and percentage change in various staffing levels and ratios after GT.

(ii) The average batch size before GT and the values of various staffing levels and ratios before and after GT.

Significance tests were carried out using linear, curvilinear, and exponential functions. None of the relationships investigated showed significant correlation at the 95% level of confidence, though linear regression and correlation analysis showed the strongest correlations.

Although this is a negative result, it would be of interest to determine if companies with smaller average batch sizes achieve larger changes in staffing levels and ratios after the introduction of GT than companies with larger batch sizes. If GT does cause a company to change its technology from small- to large-batch manufacture then according to Woodward (1958) and Hickson et al. (1970) the largest percentage change in staffing levels and ratios would be expected to take place in those companies with smaller batch sizes. By taking each of the staffing levels and ratios measured and plotting the linear regression line for the percentage change in the levels and ratios after introduction of GT, it was possible to see whether larger changes occurred for firms with small or large batches. A positive slope regression line would indicate that firms with a larger batch size achieve greater changes after GT. A negative

sloping regression line would indicate that greater changes are in firms with smaller batch sizes. For the 11 staffing levels and ratios tested no significant pattern emerged.

THE EFFECT OF OTHER FACTORS ON STAFFING LEVELS AND RATIOS

Hickson et al. (1970) concluded that the features of organisations are more closely associated with company size than any other factor they tested. The authors carried out tests on the relationship between average batch size, average range of batch size, component variety, company size, and number of machine tools with the percentage changes in 11 various staffing levels and ratios after GT had been introduced. Four of the 11 component variety relationships were significantly correlated at the 95% level of confidence. None of the other relationships was significant. Generally correlation co-efficients calculated for each of the 11 relationships tested were strongest for component variety. The average correlation co-efficient calculated from the 11 relationships measured was strongest for component variety (0.68), followed by average batch size range (0.33) and number of machine tools (0.31), then company size (0.26) and finally average batch size (0.24). Thus, component variety appears to be the most important parameter determining changes in staffing levels when GT is introduced. This is interesting as component variety is a technology factor affecting types of manufacturing system, machines, tooling and skills.

THE INFLUENCE OF STAFFING RATIOS ON GT BENEFITS

The authors were interested to determine whether a particular staffing ratio or a combination of them could influence companies in achieving the full benefits of GT. An investigation was carried out using linear regression and correlation analysis into the relationship between the value of certain staffing ratios before GT and the percentage changes in various factors and ratios after GT had been introduced. The 4 staffing ratios tested were those thought to be directly affected by the introduction of GT.

The findings from this work tentatively suggest that a company likely to achieve the greater benefits from GT will have, in the functional system, the following staffing levels:

(i) The supervisors will have a relatively small span of control.

(ii) The ratio of number of manufacturing employees to number of production control staff including progress chasers will be relatively small.

(iii) There will be a relatively small number of manufacturing employees per inspector.

(iv) The ratio of production control staff to progress chasers will be large relative to the other three ratios.

The first three results may indicate that control of manufacture in the pre-GT situation was both complex and difficult and the only way of obtaining some sort of control was to have a large number of supervisors, production control staff and inspectors, relative to the number of manufacturing employees. It is puzzling that a relatively large value is indicated for the ratio of production control staff to progress chasers, since in the situation described, it could be envisaged that a large number of chasers would have been required, resulting in a smaller ratio although it might have been that the production control staff also did some progress chasing.

CONCLUSIONS

The authors are of the view that the work of Woodward, Pugh et al. and Hickson et al. cannot be used as a reliable model to predict the changes in staffing levels which take place when a GT system is introduced into a firm. On average in the 35 companies surveyed,

changing from functional to GT manufacture has not increased the supervisor's span of control. Predictions by other researchers based on the work of Woodward, Pugh et al. and Hickson et al. suggested a change in the opposite direction.

In the companies surveyed by the authors it would appear that GT has not led to any great changes in organizational structure. Apart from the function of progress chasing, where less personnel are required and supervision where the supervisor's prestige and standing in companies has been enhanced, along with increases in responsibilities, work load and in specific cases accountability, in general GT has not significantly affected other personnel groups such as lower and middle management, production controllers, setters, inspectors and storekeepers.

If work is to be pursued on investigating the effects of GT on staffing levels, it is suggested that profiles such as those shown in Figs. 1(a) and (b) should be established using graph axis points 4 and 5 as boundaries.

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