The effects of group structure, management accounting feedback and incentive systems on decision making in groups

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THE EFFECTS OF GROUP STRUCTURE, MANAGEMENT ACCOUNTING FEEDBACK AND INCENTIVE SYSTEMS ON DECISION MAKING IN GROUPS

By

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Doctor of Philosophy to the University of New South Wales

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CERTIFICATION

I hereby declare that this submission is my own work and to the best of my knowledge it contains no material previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any other degree or diploma at UNSW or any other educational institution, except where due acknowledgment is made in the thesis. Any contribution made to the research by others, with whom I have worked at UNSW or elsewhere, is explicitly acknowledged in the thesis.

I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project's design and conception or in style, presentation and linguistic expressions is acknowledged.

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ABSTRACT

Significant changes in production technologies have recently taken place resulting in changes to the type of work-flow interdependence faced by individuals involved in the production process. Where task interdependence (i.e. work-flow) has increased, organisations have faced increased coordination requirements which have flowed down to the individual level. In response to increased task interdependence, organisations have the opportunity to use two important coordination mechanisms (group-interaction and feedback aggregation) which were examined in this thesis. Two existing theories in the organisational behaviour literature (Hackman and Morris, 1975) and psychology literature (Nadler, 1979) formed the basis for examining the benefits of both group-interaction and feedback aggregation. An experimental approach was adopted to test performance benefits of group-interaction and feedback aggregation. Results found that under high task interdependence, the presence of group-interaction leads to better performance than the absence of group-interaction. This difference was attributed to a higher level of actual coordination achieved by individuals with group-interaction due to both better motivation and better ability to coordinate. Results also showed that the benefits of additional aggregated information provided by global feedback over local feedback only translated into performance differences where group-interaction was not possible. The additional benefits were again attributed to higher levels of coordination, but only individual motivation differences were found. As such, global feedback stimulated additional commitment for individuals who generally understood the implications stemming from high task interdependence. How to remunerate interacting groups is another aspect of group coordination that has received some interest recently. An established theory by Deutsch (1949a) was integrated into the Hackman and Morris (1975) group framework to examine three types of reward systems; group, individualistic and fixed-rate. Based on results from the second experiment, group rewards resulted in the highest performance, with individualistic and fixed-rate rewards producing similar lower performance levels. Associated cooperation levels were the highest for both group and fixed-rate rewards, leading to the conclusion that group rewards are a superior form for rewarding groups under high task interdependence as it leads not only to the highest level of cooperation but also the highest performance. Combined the results of the two experiments provide substantial guidance to practitioners facing issues with respect to facilitating coordination of highly interdependent tasks and issues around motivating effective use of these coordination devices, particularly group-interaction.

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Chapter 1

Introduction

1.1 Background and Motivation

Dramatic changes have taken place in both the manufacturing and service sectors with respect to the type of technology employed and the form of competition faced by organisations (e.g. Schonberg, 1986; Johnson and Kaplan, 1987; Young, Shields and Wolf, 1988). These changes, particularly in the manufacturing sector, have direct consequences for management accountants concerned with developing controls to aid in planning, motivation and controlling of individual participants' contributions to the organisation (Young et al., 1988). A considerable amount of literature exists on the importance of matching management controls with organisational structure (e.g. Hopwood, 1976; Otley, 1980; Chenhall and Morris, 1986; Abernethy and Stoelwinder, 1991). However, relatively less attention has been given to the changes needed in organisational structure and control to support new production technologies such as Just in Time (JIT), Total Quality Control (TQC) and Theory of Constraints (TOC). In addition, recent research has started to question the relevance of management accounting controls in organisations departing from traditional production technologies (Kaplan, 1990; Abernethy and Lillis, 1995).

Changes witnessed in organisations over recent years, such as the introduction of new production technologies have increased the level of interdependence between organisational participants. In this context, individuals acting in isolation can have disastrous effects on the organisation as a whole, as their individual decisions have direct consequences for other individuals in the organisation. Interdependence in firms has a number of dimensions - for example, Johnson and Johnson (1989) distinguished between resource interdependence, role interdependence and task interdependence. While changes in production technologies can affect these interdependencies, it is task interdependence that impacts the important consequences of individual decisions most directly. Task interdependence, defined by Thompson (1967) in terms of the work-flow or task sequencing, is concerned with the effects work-flow has on the demand for coordination. As the flow of physical products and/or decisions among individuals increases in interdependence, more demands are placed on an individual to integrate his/her decisions with those of other individuals (Selto, Renner and Young, 1995).

For example, recent developments in the manufacturing industry have seen a change in manufacturing technologies. Historically, most manufacturing systems, particularly in Australia and the US, have operated under a *push* system (Chase and Acquilino, 1985). *Push* systems consist of an initial forecast of demand for products, which is incorporated into production scheduling for each individual sub-process in the manufacturing system. Production begins with the workers in the first sub-process, and products are subsequently pushed down the line in the form of Work in Process (WIP) to the next sub-process until each product is completed and delivered to the customer. WIP inventory, as well as Finished Goods (FG) inventory, represent buffers which shield the production process from production variations, quality problems, forecasting errors, line imbalances and other manufacturing problems. Demands placed on the individual worker in the *push* system have been centred on efficiency, which entails pushing products through each particular sub-process as fast as possible. One consequence of the *push* system in the past has been the build up of excess inventory both in the form of WIP and FG. While this can be perceived to be beneficial in terms of shielding the production process from breakdowns and quality failures, the overriding negative impact on organisational profitability due to inventory costs, such as obsolescence, quality failures and storage costs, usually outweighs the benefits (Goldratt, 1990; Goldratt and Cox, 1993).

In contrast, new manufacturing technologies have been concerned with eliminating excess inventory. Traditional *push* systems have been replaced by *pull* systems (e.g. JIT) where each sub-process only produces, upon request, from either the final customer or a down stream sub-process. While the "appropriate" level of inventory is still under debate between advocates of these new manufacturing technologies (such as TOC and JIT[1]), the overall emphasis on eliminating excess[2] inventory is consistent across these new technologies. With reductions in buffer inventories, the relationship between individuals in these sub-processes increases in importance. Individuals are now more interdependent as each succeeding task depends on the quality and timeliness of the proceeding task (Selto et al., 1995). In order to keep production flowing effectively, individuals have an increased need to communicate with each other, so as to identify current production problems, develop solutions to these problems, as well as coordinating subsequent corrective actions. For example, with the introduction of TOC, emphasis is placed on identifying constraining resources (i.e. bottlenecks) in the

[1] TOC advocates argue for strategic inventory buffers to prevent constraining (or critical) resources from losing capacity, whilst JIT advocates argue for zero inventory buffers.

manufacturing process (Umble and Srikanth, 1990; Goldratt, 1990; Goldratt and Cox, 1993). Therefore individuals need to communicate information about their production levels in order to identify the location of constraints, develop a plan of action to minimise the constraint, and subsequently, coordinate their production levels to minimise or eliminate these constraints.

Effective implementation of new manufacturing technologies has much to offer to an organisation both in terms of higher quality products as well as better competitive costs and/or higher profitability (anecdotal evidence regarding the superior performance of these new methods is abundant, e.g. Selto et al., 1995). But an important consequence of such initiatives is an increase in the level task interdependence, which in turn has implications for both structural and control issues..

In responding to high task interdependence, organisations have essentially two coordination mechanisms available to them, in addition to traditional plans and procedures used under low task interdependence (Galbraith, 1973); the use of groups and feedback. The first coordination mechanism of interest is the use of groups, which provide individual participants with the opportunity to interact with each other. As such, it potentially reduces existing divisions between these participants[3](Reid, 1992). Groups are argued, *inter alia*, to be an appropriate structure for sharing information (Young, Fisher and Lindquist, 1993), for joint problem solving (Walton, 1987; Dumain,

[2] Excess inventory is defined here as inventory over and above the appropriate level.

[3] These divisions are often characterised as walls that prevent coordination between workers in different sub-processes.

1994) and the sharing of expertise (Ravenscroft and Haka 1996). Young et al. (1993), based on their field visits to three *Fortune 500* manufacturing firms, have provided anecdotal evidence that a change to the group structure was happening in organisations. Further empirical evidence in the organisational behaviour literature[4], has supported the claim that groups are used more extensively by organisations operating under high task interdependence (Van de Ven, Delbecq and Koenig, 1976). In the accounting literature Macintosh and Daft (1987) have found a related decrease in reliance on standard operating procedures (SOP's) in this task context. Although organisations are adopting groups in response to the increase in task interdependence, Safizadeh (1991) has stated that there is no well-tested and accepted body of research to guide practitioners in using groups.

While there has been a lack of an accepted body of research to guide the use of groups, normative models, such as Hackman (1983), have offered some directions and underscored the importance of task characteristics in trying to understand the value of group-interaction. The use of laboratory experiments is appropriate to progress some of the empirical testing called for by authors such as Safizadeh (1991), as they provide a high degree of internal validity which facilitates greater precision regarding measurement and control (Young et al., 1988). In fact, laboratory based research has already started in this area (Young et al., 1993), yet recent experimental work in both accounting and psychology has been inconclusive as to the value of interaction provided by groups in the context of high task interdependence.

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[4] This research has generally been conducted at the organisational level.

To date the only study in accounting that has attempted to examining the use of group-interaction and high task interdependence (Young et al., 1993) failed to find support for the advantage of using group-interaction to coordinate decisions in an interdependent manufacturing process. A potential explanation for their results is that there was, in fact, relatively low task interdependence inherent in their sequential experimental manufacturing task. The authors acknowledged this possibility in their study, yet there has not been a subsequent study, which has tested for the advantages group-interaction is perceived to bring to coordinating highly interdependent tasks. With more companies adopting groups to coordinate highly interdependent manufacturing tasks (Young et al., 1993; Scott and Tiessen, 1997), and only one inconclusive study testing the value of group-interaction directly, more careful experimental work is needed to understand how group-interaction impacts on coordination of highly interdependent tasks. The first objective in this thesis is, therefore, to investigate the importance of group-interaction to coordinating decisions in the context of high task interdependence.

The second coordination mechanism of interest is the use of information (i.e. feedback) provided by management accounting systems to individuals in the organisation to assist them in detecting and correcting errors (Argyris, 1976; Luckett and Eggleton, 1991). One criticism that has been levied against the traditional accounting system is that it focuses on the efficiency of individuals (such as sub-assemblies in a manufacturing context), which is argued to be inappropriate where the actions and decisions of these individuals are highly interrelated (Kaplan, 1990; Abernethy and Lillis, 1995). By providing only *local* (individual) feedback, traditional accounting systems fail to provide information and motivation useful to individuals coordinating their decisions with other individuals in the organisation. One avenue open for designers of management accounting systems is to provide more aggregated information[5] in addition to the local information. The resulting *global* feedback (which is comprised of local information plus more aggregated information) provides individuals with a more comprehensive view of the overall process, which should assist them in both their ability and motivation to coordinate their decisions. Prior research has not examined the difference between local and global feedback directly in the context of high task interdependence. While some related research in the psychology literature dealing with groups (Nadler, 1979; Saavedra, Early and Van Dyne, 1993) points towards a potential performance advantage from global feedback, the direct examination of differences between local and global feedback remains the second objective of this thesis.

With the advent of more groups being used in organisations (Young et al., 1993; Scott and Tiessen, 1997), another area of interest in management accounting has been the interaction between management accounting systems and groups. This interest is often expressed in terms of management accounting systems assisting groups in their interaction (Young et al., 1993; Atkinson, Balakrishnan, Booth, Cote, Vrieje, Malami, Roberts, Uliana and Wu, 1997). Providing individuals in groups with more aggregated information (i.e. global versus local feedback) can be argued to lead to performance advantages, as individuals in the group gain a better overall understanding and motivation to coordinate their decisions through group-interaction. Evidence of this is

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[5] More aggregated information refers to information provided about the system as a whole, which includes information about the actions or decisions made by all other members of the system.

found in the group literature (Nadler, 1979; Saavedra et al., 1993). However, some of the benefits of providing aggregate information to individuals in groups is reduced, as group-interaction itself can be used to aggregate individual information. That is, group members have the opportunity to combine their individual information during the interaction with their fellow group members and construct some of the information provided by the global feedback. As such, the potential gain from global feedback over local feedback is expected to be greater where group-interaction is not possible. The relative importance has not been examined in prior research, and constitutes the third objective of this thesis.

In addition to the importance of management accounting information (feedback), incentive (reward) systems also form an important element of an organisation's control system (Emmanuel, Otley and Merchant, 1990). Accountants regard the role of rewards in management control systems to be extremely important (e.g. Young et al., 1988; Ravenscroft and Haka, 1996). It has been widely acknowledged that rewards affect the performance of both individuals and groups. Yet the majority of accounting research has focused solely on the individual context (for a review of the incentive contracting literature see Young and Lewis, 1995; as well as Bonner, Young and Hastie, 1996). More recent studies have started to extend this stream of prior research into the group context (Young et al., 1988; Ravenscroft and Haka, 1996; Awasthi, Chow and Wu, 1996). As the focus of the reward system examination in this thesis is primarily on motivational effects on group members' desire to interact cooperatively, corresponding non-interacting (i.e. individual) structures were not considered further[6].

Some anecdotal evidence (Economist, 1995) has indicated that unsuccessful group experiences have loosely been associated with the failure of firms to change the reward system from an individual to a collective system. The need for such a change has been discussed in two normative articles by Safizadeh (1991) and Saunier and Hawk (1994), who stated that most compensation systems are designed to emphasise and reward individual performance and need to be rethought in terms of group needs. Saunier and Hawk (1994) further recommended incentive (reward) systems should be based on the group's collective performance. Such a change from individual performance-based rewards to group performance-based rewards is anticipated to result in increased group cooperation demanded by high task interdependence[7].

Cooperation theory, as developed by Deutsch (1949a), provides theoretical support for the superiority of group-performance-based reward systems over individualistic reward systems. Group rewards are theorised to provide group members with more closely aligned goals, which, in turn, increase the individuals' desire to cooperate. Resulting group-interaction is argued to be superior which is reflected in higher levels of group performance under high task interdependence.

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[6] The reason for omitting non-interacting work structures at this point is due to the sequential nature of the investigation undertaken in this thesis. The first three objectives were investigated in a separate experiment to the second three objectives. As such, it was clear from the results of the first experiment that the non-interacting groups were not as effective as the interacting groups. The focus therefore shifted to control mechanisms in interacting groups.

While theoretical arguments put forward to support the incremental benefits of group rewards over individualistic rewards are convincing, empirical research conducted in both the psychology and engineering literatures has resulted in mixed findings. One of the more robust findings has been the superiority of cooperative rewards over competitive rewards. However, while it can be argued that group rewards are equivalent to cooperative rewards (as both are based on a common goal definition), individualistic rewards are not necessarily equivalent to competitive rewards. Individualistic rewards are argued to be less cooperative than group rewards, as individuals are paid based on their own performance, which may not be directly compatible with the performance of other group members. The only empirical study, which has examined differences between group and individualistic rewards in terms of coordination differences (Rosenbaum, Moore, Cotton, Cook, Hieser, Shovar, Morris and Gray, 1980) has failed to find any such differences. One potential explanation for the absence of results in that study is the lack of coordination demanded by the task, which was not anticipated by the authors. As coordination of individual decisions was provided as one of the primary reasons for using groups under high task interdependence, it is important to clarify how coordination is affected by group and individualistic rewards. Empirically testing the difference between group and individualistic rewards on group performance constitutes the fourth objective in this thesis.

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[7] Both group and individualistic rewards are essentially piece rate systems, as the reward is directly linked to the performance of either the group or the individual.

A related issue, which has not received much attention in either the accounting or the psychology literature, with the exception of Young et al. (1988), is the feasibility of fixed-rate rewards. But while fixed-rate rewards are of interest, as they represent a popular form of rewarding workers particularly in bureaucratic organisations, it is unclear how they would fare in the context of the new manufacturing technologies. Unlike the previous comparison between group and individualistic rewards, which are both piece-rate systems, fixed-rate rewards provide a return without a direct link to either individual or group performance. At the individual level economists have demonstrated analytically that performance is better with performance contingent rewards than with fixed-rate rewards (Demski and Feltham, 1978). And empirical evidence has concurred with this analytical modelling (Chow, 1983; Chow and Waller, 1985). Yet, Young et al. (1988) found performance increases independently of the level of task interdependence, which suggests that performance contingent rewards result in individual group members working harder at their individual tasks without changing their level of coordination. Drawing on cooperation theory, it is proposed that fixed-rate rewards result in lower levels of coordination than group rewards, as they do not actively promote goal congruence. But compared to individualistic rewards, it is anticipated that coordination will be higher under fixed-rate rewards as the latter also does not detract from a common goal. Under high task interdependence the differences in coordination are anticipated to translate into performance differences. Examining the feasibility of fixed-rate rewards vis-a-vis group and individualistic rewards is the subject of the fifth and sixth objectives in this thesis.

In summary, this thesis is concerned with providing guidance to organisations facing increased task interdependence. This guidance consists of an examination of a series of theoretical propositions concerned with two coordination mechanisms, group-interaction and feedback aggregation, as well as the interaction of the two mechanisms and the impact three reward systems (group, individualistic and fixed-rate) have on group members' motivation to coordinate.

1.2 Research Questions

In response to the changes in manufacturing technologies, the previous discussion has centred on the importance of group-interaction and management accounting feedback aggregation in coordinating highly interdependent tasks. The importance of incentive systems has also been discussed. Accordingly, this thesis addresses a series of research questions concerned with group-interaction, management accounting feedback aggregation and rewards. The six research questions were tested empirically by running two separate experiments. More specifically, the first research question deals exclusively with the issue of group-interaction, followed by two research questions on feedback aggregation and three research questions on reward systems.

The first research question is specifically aimed at testing the importance of interaction provided by groups. By manipulating the ability to interact among individuals in the manufacturing system (from completely to not at all), it is possible to test the value groups provide in coordinating highly interdependent tasks. More specifically, research question one asks: **Is the interaction provided by groups important to performance under high task interdependence?** Results from Experiment One confirmed that interaction is beneficial, which makes the group structure an important tool for coordinating highly interdependent tasks.

The second and third research questions examine the importance of aggregated feedback both in general (regardless of the level of group-interaction) and specific to the level of group-interaction. Research question two is based on the argument that regardless of the level of interaction, individuals under high task interdependence have to coordinate their decisions. Global management accounting feedback is argued to provide incremental information over local feedback, which aids the individuals in both the strategy involved in integrating their work and their motivation to do so. More specifically, research question two asks: **Does global feedback result in better performance than local feedback under high task interdependence?** Results from Experiment One did not support this expectation.

The third research question deals with the relative effectiveness of global feedback over local feedback in groups when compared to non-interacting individuals. While global feedback is anticipated to assist both groups and non-interacting individuals, it is proposed to be more important to non-interacting individuals, as interacting group members have the opportunity to perform some of the aggregation through the interaction process. Research question three therefore asks: **Is global feedback relatively more important where individuals are not able to interact than where individuals are able to interact in groups to coordinate highly interdependent tasks?** Experimental results here found that there was an interaction between group-interaction and feedback aggregation. Global feedback had a greater positive effect on performance when workers were not in the group structures. Individuals in groups receiving only local feedback had already disseminated some of the information provided by global management accounting information. As such, these individuals were able to construct their own global feedback from each of their individual feedback, bringing them up to a similar level to individuals receiving global feedback in the first place.

The final three research questions deal with the effectiveness of group, individualistic and fixed-rate reward systems. More specifically the fourth research question deals with the difference between group and individualistic rewards in groups operating under high task interdependence. Based on cooperation theory, group rewards are anticipated to result in greater cooperation and coordination between group members than individualistic rewards. The fourth research question deals with the effect of this difference on the level of group performance. More specifically research question four asks: **Do group rewards result in higher group performance than individualistic rewards?** Results from Experiment Two confirmed this proposition as group rewards resulted in higher performance than individualistic rewards.

An alternative to group and individualistic rewards, which has received less attention in either the accounting or psychology literature, is the use of fixed-rate rewards. The fifth research question specifically investigates the difference between fixed-rate rewards and group rewards. Based on cooperation theory, it is anticipated that group rewards result in higher levels of cooperation and coordination than fixed-rate rewards. Research question five specifically deals with the performance difference anticipated to result from the difference in cooperation. More specifically research question five asks: **Do group rewards result in higher group performance than fixed-rate rewards?**

Results from Experiment Two confirmed that group rewards resulted in higher performance levels to fixed-rate rewards.

Finally, the sixth research question examines the comparison between fixed-rate and individualistic rewards. In keeping with cooperation theory, fixed-rate rewards are anticipated to result in higher levels of cooperation and coordination, as they do not detract from a common group goal, when compared to individualistic rewards which have the potential to detract. Research question six concentrates on the anticipated performance difference resulting from this difference in the level of cooperation. More specifically, research question six asks: **Are fixed-rate rewards more effective than individualistic rewards in promoting group performance?** Contrary to expectation, experimental results showed no difference in performance levels between individualistic and fixed-rate rewards.

1.3 Contributions of the Thesis

In addressing the research questions put forward in the previous section, this thesis makes a number of contributions to prior theory about group dynamics developed in both the psychology and the organisational behaviour literatures. More specifically, theoretical contributions are made regarding performance differences resulting from group-interaction and feedback aggregation. In addition, this thesis further represents a number of methodological contributions, which involve testing propositions put forward in prior theories, as well as, theory developed in this thesis. Finally, this thesis has practical implications for managers interested in implementing groups in response to circumstances resulting in high task interdependence. It clarifies the importance of group-interaction, as well as, the relationship between group-interaction and management accounting information, and the role of incentives in promoting group-interaction.

1.3.1 Theoretical Contributions

In terms of theoretical contributions, this thesis makes three contributions to the understanding of group processes and how they relate to management accounting information system feedback and reward systems.

The first theoretical contribution is the extension of prior group feedback literature into the context of interacting and non-interacting groups. More specifically, Nadler's (1979) model did not address potential interactions between group-interaction and feedback aggregation. Gaining an understanding is particularly useful in deciding whether to use groups, or feedback aggregation, or a combination of both to coordinate highly interdependent tasks.

The second and third contributions are more directly related to the design of management accounting control systems. More specifically, the second contribution lies in the integration of cooperation theory, which was developed primarily in the psychology literature, with the Input Process Output (IPO) model of Hackman and Morris (1975). The more extensive model developed in this thesis, resulting from an integration of the two models, permits the formulation of more detailed expectations about how interaction among group members is affected by group and individualistic rewards.

The third contribution expands current understanding of the difference between performance contingent rewards, such as, group, individualistic and fixed-rate rewards. Prior theory has primarily dealt with differences in effort, or how hard individual group-members work at the task, without consideration of how they coordinate their work. This thesis provides a theoretical framework for understanding coordination effects resulting from the provision of fixed-rate rewards when compared to group and individualistic rewards. The understanding provided by these final two contributions is particularly useful in deciding which reward system to employ to facilitate group-interaction.

1.3.2 Methodological Contributions

The major methodological contribution made by this thesis is the development of an experimental task which, based on the simulation of a production line, unequivocally represents high task interdependence. High task interdependence has been argued to result from the introduction of new manufacturing technologies such as TOC. Yet, to date, high task interdependence had not been successfully introduced into the experimental domain. With the successful introduction of a highly interdependent task, it is now possible to examine some results in prior literature which have been surprising (e.g. Young et al., 1993), as well as opening up the possibility of testing research questions that were not relevant in the low task interdependence context.

1.3.3 Importance to Practitioners

Management accountants involved in organisations interested in setting up self-managing (autonomous) groups, in the first instance, are concerned with the value that the group structure vis-a-vis other coordination mechanisms such as aggregated feedback. In the second instance they are concerned with the type of support these groups need in terms of feedback and reward systems to obtain their full potential.

This thesis concludes that interaction provided by groups operating in highly interdependent tasks is beneficial, which makes the group structure an appropriate way to organise work. It is, further, concluded that the effectiveness of feedback aggregation in organisations depends on the work structure (i.e. whether these individuals are in group or not). Where groups are used in organisations, feedback aggregation is of little consequence, as group members are able to disseminate the incremental information provided by aggregated feedback during group-interaction. However, where groups are not in existence, aggregated feedback is of consequence to individuals and results in higher performance than with only local feedback.

Finally it was concluded that switching existing individualistic reward systems to group reward systems is of direct benefit to group cooperation and performance. Fixed-rate rewards were found to result in better cooperation than individualistic rewards, however, no such performance difference was found. Compared to group rewards, fixed-rate rewards resulted in a similar level of cooperation but inferior performance. This leads to the conclusion that group rewards are the superior way of rewarding groups under high task interdependence.

1.4 Structure of the Thesis

In order to address the issues raised above, the next chapter overviews the background literature on group-interaction models as well as cooperation theory. A chapter developing hypotheses with regard to group structure, feedback, as well as reward systems follows. Chapter 4 outlines the methods used in the two experiments. The results, along with issues arising from these results are presented in Chapter 5. The final chapter summarises the findings, discusses the limitations to the thesis and considers implications for future research and practice.

Chapter 2

Models of Group Behaviour

2.1 Introduction

The basis to a theory of organisations is the premise that all organisations need coordination (Van de Ven et al., 1976), where coordination is defined as a means of integrating or linking together different parts of the organisation to accomplish a collective set of tasks. Many studies in the organisational behaviour literature have examined the need for coordination at the organisational level (e.g. Blau, 1968, Meyer, 1972). Studies at that level have not sufficiently looked at the process of coordination. Following the lead of March and Simon (1958), authors such as Galbraith (1973) have started to look at the process of coordination at the departmental and individual level. Organising individuals into groups has been recognised as an important coordination mechanism in this literature (Galbraith, 1973).

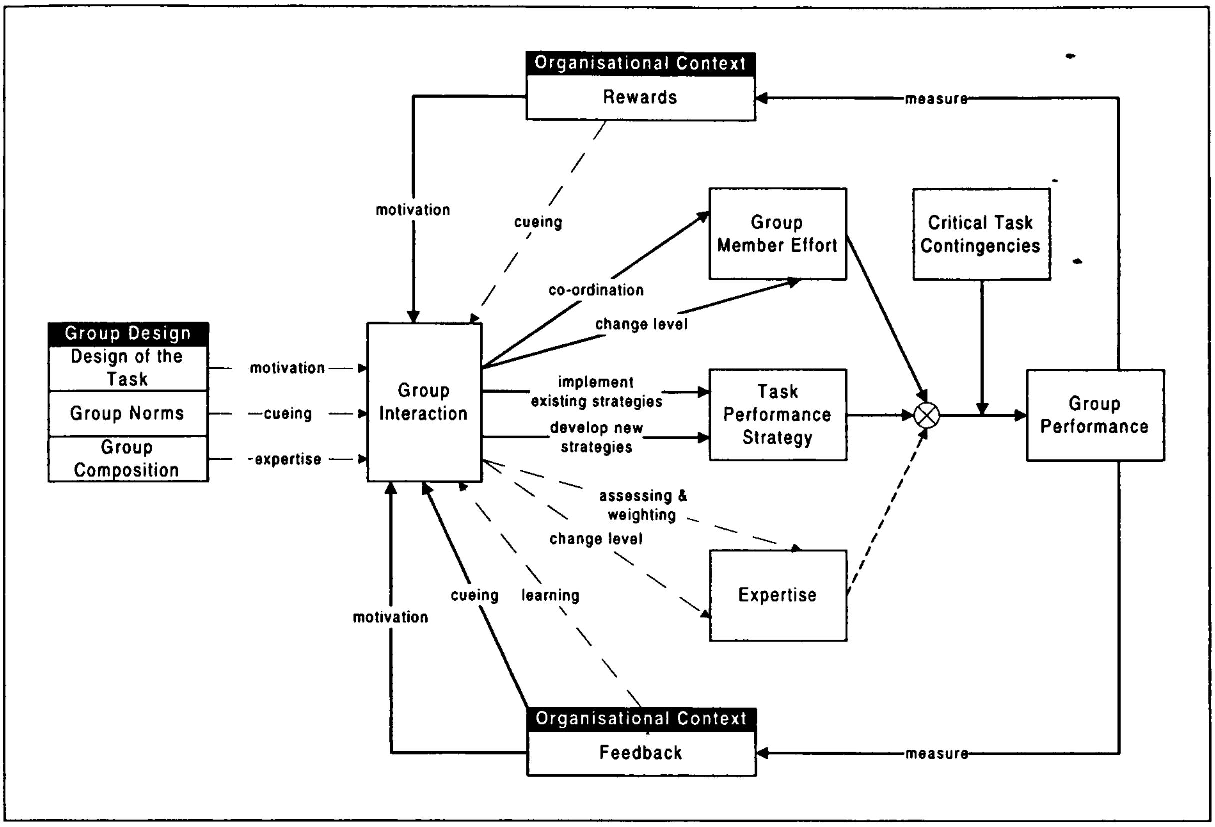
One purpose of this chapter is to review key group models that deal with group-interaction (e.g. Hackman and Morris, 1975) and provide a theoretical framework for understanding the importance of group-interaction to overall performance. Specific elements of this theory dealing with effort and task strategy will be used in Chapter 3 to develop the first hypothesis concerned with performance in situations with high task interdependence.

Another purpose of this chapter is to review feedback and rewards as two key factors impacting on the effectiveness of group-interaction on task performance. Feedback provided by the information system to groups is discussed using Nadler's (1979) theoretical group feedback model. Of particular interest here is the impact feedback has on the motivation of the group members and their ability to coordinate their decisions. Nadler's model provides a framework for predicting the impact different levels of feedback aggregation have on group performance, where there is high task interdependence. Insights gained from Nadler's model will be used in both the second and third hypotheses, discussed in Chapter 3.

Also of interest is the impact reward systems have on group-interaction. Deutsch's (1949a) theory of cooperation has been used extensively in the psychology literature to examine motivational effects of rewards systems (e.g. Miller and Hamblin, 1963; Okun and Di Vesta, 1975). As such, cooperation theory is used to examine motivational effects of rewards on group-interaction, which forms the basis of the fourth, fifth and sixth hypotheses.

Together, the elements of these individual theoretical modes can be combined in a comprehensive model (see Figure 2-1), which has been constructed specifically to guide discussion in this chapter. Not all the relationships will be of subsequent interest for the development of the hypotheses in Chapter 3. Relationships which are included for completeness of the model but of no further interest are represented by broken lines, while all other relationships are represented by solid lines. For example, group-interaction assists in assessing and weighting as well as changing the level of expertise in individual group members. Yet, the focus in this thesis is on task interdependence (defined in Chapter 3), which places critical demands on both effort and performance strategy where individuals have sufficient expertise to perform their individual tasks.

Figure 2-1 Summary Group Model



With the focus centred on task interdependence as the critical task contingency, it is of particular interest to examine how group-interaction assists in coordinating interdependent tasks. In order to a build a more detailed account of group-interaction assisting in coordination, it is of interest how group-interaction affects both the level of effort and the nature of the strategy of each individual group member. The effect of effort on coordination represents a motivational aspect of group-interaction, while the effect of strategy on coordination represents a learning aspect of group-interaction. Learning in turn increases the ability of individuals to coordinate and perform the task successfully. Also of interest to this thesis is the motivational and cueing functions of feedback, as well as the motivational effects of rewards. These represent mechanisms over which the organisation has direct control. It is also acknowledged that group design has a direct effect on group-interaction. However, it is assumed here that organisations are using groups to coordinate pre-existing tasks (the flow of which is determined by the existing technology), and in doing so, employ groups that know how to interact (e.g. group norm) and have the right amount of expertise (e.g. group composition). As such, group design itself is not of interest in this thesis.

The remainder of this chapter is structured as follows. First, a section outlining some well-respected approaches to modelling group-interaction processes is presented. The next section examines subsequent extensions to these models made by other authors, which include feedback and rewards. The final section outlines cooperation theory in more detail.

2.2 Group-interaction Models

2.2.1 Introduction

Throughout history, people have joined together in groups to accomplish tasks. Janis (1951) has estimated that there are four to five million groups in existence at any given time, and the number has probably increased rather than decreased since the 1950s given recent emphasis on groups.

There have been a number of different approaches taken to understanding groups over the time research has been conducted in this area. Approaches to group-interaction have varied from Bion's (1961) view of the "group as a whole"[8] to Homans' (1950) perspective of the group as a social system[9] and the socio-technical theory[10] which began in the early 1950's in conjunction with the Tavistock Institute projects in the British coal mining industry. Guzzo and Shea (1992) provided a summary of these perspectives along with empirical studies based upon them. Despite the variety of perspectives, the most dominant way of thinking about group performance has been represented by the Input-Process-Output (IPO) framework. This has been the case historically and continues today (Guzzo and Shea, 1992). IPO models are explicitly causal and particularly useful as they depict group-interaction contingent on various input factors (such as group member skill level and rewards) and enable predictions about outputs based on the nature of the group-interaction. The remainder of this section examines some of the IPO models in more detail.

Central to the IPO models is the notion of group-interaction, and it is therefore useful to provide a brief definition of group-interaction. Shaw (1981, p.445) defined interaction as follows:

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[8] Key to Bion's (1961) work are the assertions that the group as a whole is an appropriate and powerful level of analysis. Further, primary tasks occasion the creation of all groups, and in addition to primary tasks powerful unconscious forces exist within groups that influence behaviour as well.

[9] Key ideas in Homan's (1950) work are the assertions that groups are made up of two sub-systems, the external and the internal. The external sub-system is conditioned by the environment and impacts on the internal sub-system, whilst the external sub-system is also influenced by the internal sub-system. This makes Homan's model a mutual causation model.

[10] At the core of the socio-technical theory is the assertion that any group, organisation or other social aggregate contains technical and social systems, and that attempts to optimise either system alone will result in sub-optimisation of the whole (Trist, 1981).

> "An interpersonal exchange in which each person emits behavior in the presence of others, with at least the possibility that the behavior of each person affects the other person."

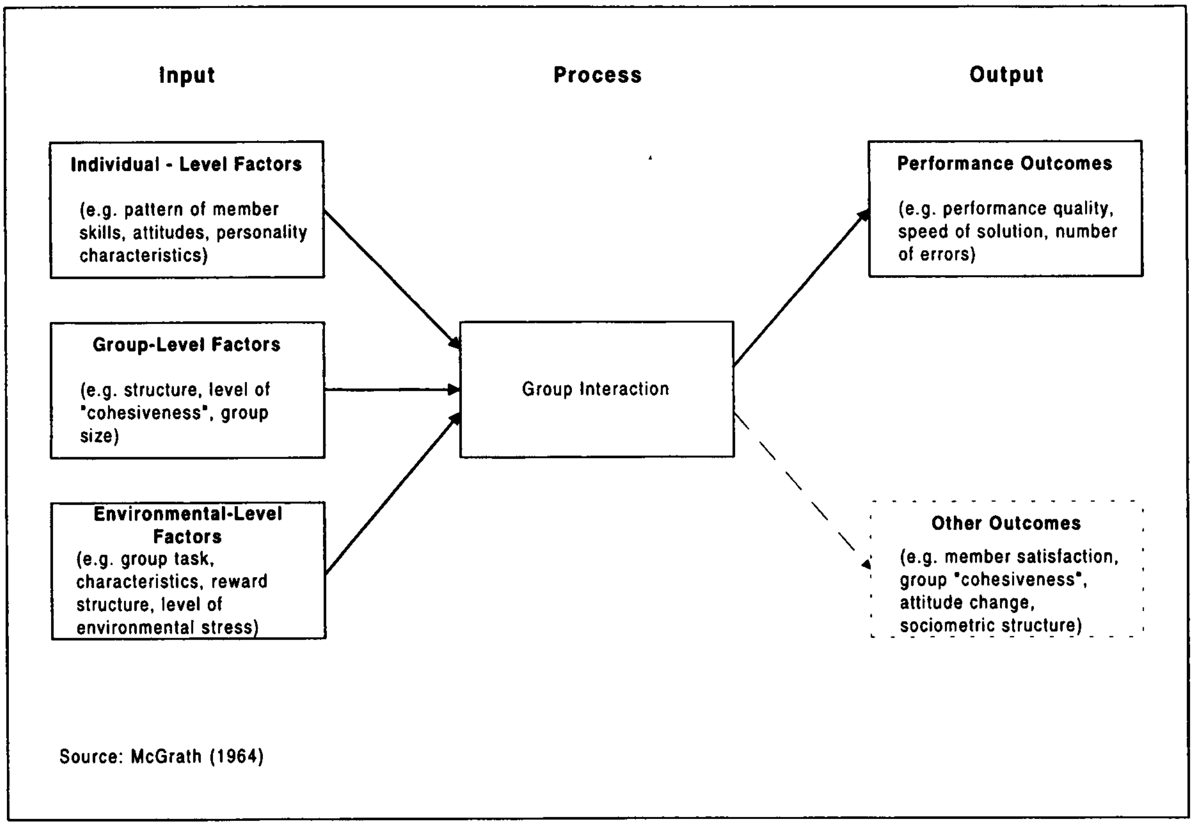
This definition is fairly broad and includes verbal communication and non-verbal interaction, such as the physical assistance by one group member to another. An example of the latter may be that of one group member holding a ladder, while another group member climbs the ladder to reach a box.

2.2.2 Core Input-Process-Output Models

Although IPO models provide the dominant framework for understanding group processes, various models exist, which describe the relationship between input variables, process and output variables (Hackman and Morris, 1975; Hackman and Oldham, 1980; Gladstein, 1984; Hackman, 1987; Shea and Guzzo, 1987; Sundstrom, DeMeuse and Futrell 1990). One limitation that has been raised is that none of these models completely captures the complexity of group dynamics (Hackman and Morris, 1975). Nevertheless, the work by Hackman and Morris (1975) and Hackman (1987) constitutes one of the most elaborate and widely accepted models of group-interaction (Kiggundu, 1983).

Prior to Hackman and Morris' (1975) research in the IPO framework depicted group-interaction as a general moderator between various levels of input (such as individual factors, group factors and environmental factors) and group output (refer Figure 2-2 for McGrath's (1964) model). This early work was rather simplistic, and lacked theoretical development dealing with specific links between group-interaction and group performance. For example, frequency of communication (a dimension of group-interaction) during group-interaction was incorrectly associated with group performance. To illustrate this, Hackman and Morris compared this association to identifying a good chess player by examining the number of times he or she moved his or her chess piece. Empirical work based on the early framework, which included Morris (1966) and Hackman (1968) found some support for the model, yet it was impossible to draw parsimonious explanations from the results because of inconsistencies within and across studies due to the lack of theoretical development.

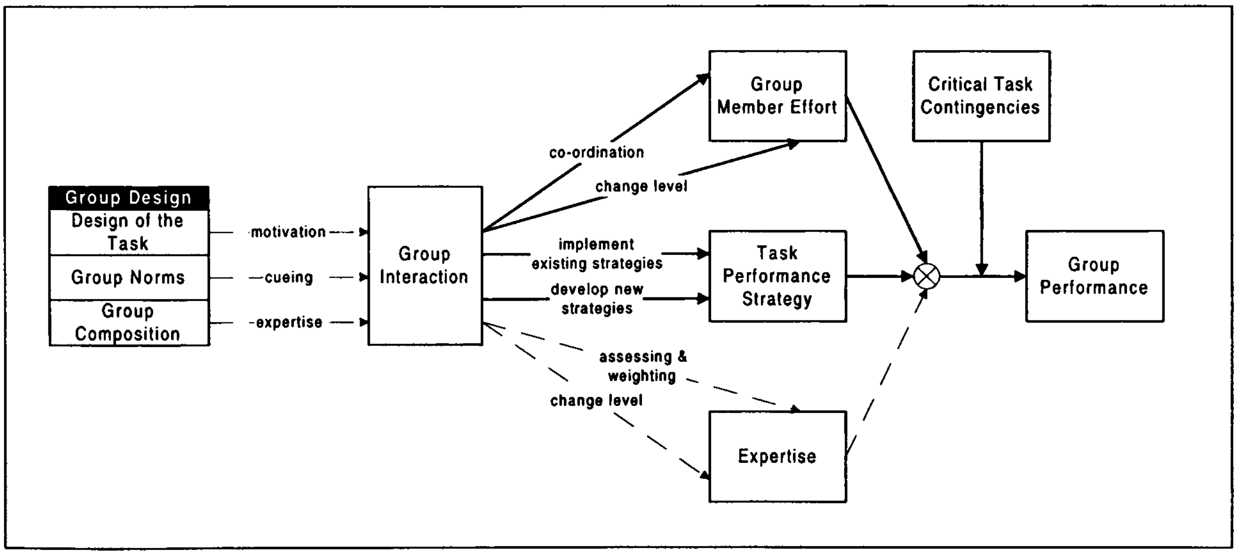
Figure 2-2 Summary of Early Group Models



In contrast, Hackman and Morris' (1975) model is more comprehensive. The model still retains the characteristics pertaining to McGrath (1964) in terms of proposing a relationship between group inputs and group performance, which is mediated by group-interaction. However, its difference is found in the introduction of three "summary variables" (effort, strategy and knowledge), which determine the effectiveness of group-interaction.

Hackman and Morris' (1975) model forms the core of the general group-interaction model depicted in Figure 2-3. The model proposes that dimensions of group-interaction (i.e. verbal communication and non-verbal interaction) are directly affected by group design. Task design affects individual group members' desires to interact, while group norms provide guidance on the appropriate form of interaction for the task. Group composition on the other hand determines the amount of expertise group members bring to the group.

Figure 2-3 Core Group Model



Group-interaction, in turn, directly affects group member effort by coordinating and/or changing the level of effort. As individual group members exert a particular amount of effort, their effort needs to be coordinated with that of other group members; otherwise there is a potential for duplication of work and the potential of conflict that can have dysfunctional effects on task performance. Group-interaction can be used to coordinate individual effort, therefore reducing process loss (Steiner, 1972) of total (i.e. group) effort resulting from uncoordinated individual effort. Group-interaction can also be used to raise the absolute level of effort individual group members put into the task at a given time. This can occur as group members spur each other on to do better or simply by being in the presence of other hard working group members.

Task performance strategies are also affected by group-interaction, through implementation of existing strategies and/or the development of new strategies. Given that individual group members will have a particular way of thinking about the task at hand, interaction can assist with implementing that strategy either through physical interchange (such as jointly lifting a box) or through verbal interchange (such as exchanging sales figures for the quarter). Interaction can also help develop new strategies, as individual group members jointly think about the task.

Finally, group-interaction provides an opportunity for group members to assess and weight the amount of expertise in the group, as well as, changing the level of expertise as group members share their individual expertise with other group members. Assessing and weighting can take the form of members looking at each individual level of expertise and taking arithmetic weights, or it can be a non-verbal interchange by simply observing other group members at work. Similarly learning (i.e. changing the level of expertise) can occur through communication or observation of other group members.

The form in which group-interaction will affect each of the three summary variables, be that verbal or non-verbal, will depend on the group task. Communication might not be very important in a physical task, such as manual clearing of snow, while it might be of utmost importance in cognitive tasks such as production scheduling. Hackman and Morris' (1975) model does not address this match explicitly, but rather implicitly asserts that incorrect matches between group-interaction and the three summary variables will simply lead to a less effective change in either effort, strategy or expertise.

Hackman and Morris (1975) also included the task as a final moderator between the three summary variables (effort, strategy and expertise) and group performance. Termed "critical task contingency" in their model, it sees task itself as crucial to determining the effect of group-interaction on group performance. For example, group-interaction may be extremely beneficial to changing the level of expertise as group-members share individual experience with fellow group members. If, however, the task does not require much expertise this essentially positive attribute of group-interaction may not translate into any great group performance difference.

In summary, the value of group-interaction on task performance is determined by its effect on the three summary variables, which in turn are moderated by the critical task contingencies. Group performance is, therefore, a function of the level of each summary variable resulting from group-interaction, and the relative weight each of the summary variables carries based on the critical task contingencies. This relationship can also be expressed in the following form:

$$\text{Group Performance} = S_1 \begin{bmatrix} \text{Level of} \\ \text{effort} \end{bmatrix} + S_2 \begin{bmatrix} \text{Amount of} \\ \text{expertise} \end{bmatrix} + S_3 \begin{bmatrix} \text{Level of} \\ \text{task performance} \\ \text{strategy} \end{bmatrix}.$$

where weights S_1, S_2 and S_3 are determined by the critical task contingency. As such, critical task contingencies inherent in task attributes (such as task interdependence discussed in Chapter 3) determine the extent to which effort, strategy and expertise are necessary for successful group performance. Group-interaction, in turn, is then beneficial in coordinating and changing the level of effort, strategy and expertise brought to bear on the task by the group.

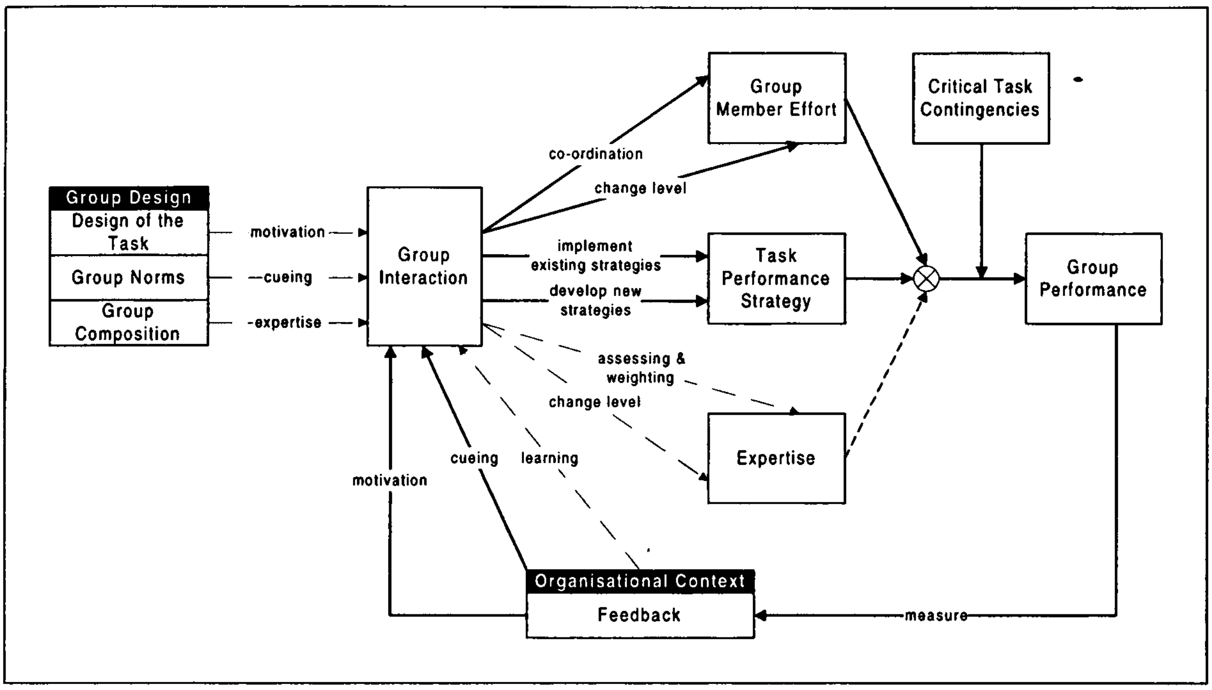
2.2.3 Extended IPO Models - Feedback

Both Nadler (1979) and Hackman (1987) have subsequently extended Hackman and Morris' (1975) model. Nadler's model examined the role of feedback on group-interaction, while Hackman (1987) included effects of rewards on group-interaction. Nadler's feedback extension forms the basis for the review in this section and Hackman's reward extension will be discussed in the next section.

Nadler (1979) modelled feedback as having motivational, cueing and learning effects (Figure 2-4 depicts an extended model, which includes the role of feedback). According to Nadler's model, feedback has motivational effects primarily on the amount of group effort exerted by group members. As group members receive information about their performance, it affects the way in which these group members interact. Feedback information was argued by Nadler to affect motivation of the group by affecting group member effort. As information becomes available about the performance of the group,

group members can adjust the coordination and levels of individual group member effort, which in turn affects group performance.

Figure 2-4 Extended Group Model - Feedback



Similarly, feedback was seen as affecting strategy and expertise by providing cues about the correct response. As group members receive information about the correct or desirable performance, they are able to change the implementation of existing strategies as well as developing new strategies. Furthermore, they can change their assessment and weighting of expertise in the group as well as change the level of expertise. Nadler distinguished learning from cueing based on the latter dealing with the probability of activating a correct response and the former relating to the strength of the correct response. This distinction is not helpful to this thesis, as both cueing and learning have the same effect on strategy and expertise.

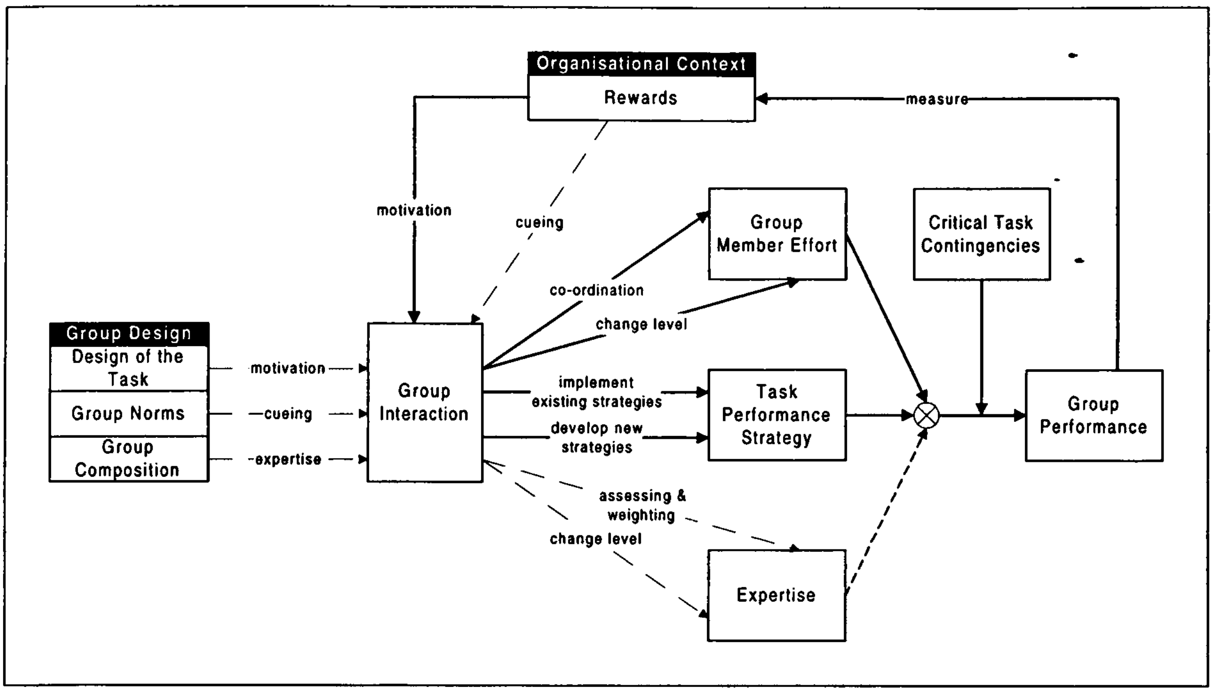
There are many aspects of feedback, which have received empirical attention, such as, the sign of the feedback and the level of feedback aggregation (Ilgen, Fisher and Taylor, 1979; Luckett and Eggleton, 1991). Feedback aggregation deals specifically with the level to which the feedback information relates. One comparison that has received attention in the psychology literature is whether information received about a more aggregated level (e.g. the group as a whole) leads to better group performance than information returned about a less aggregated level (e.g. the level of the individual group member). Studies such as Saavedra et al. (1993) will be reviewed in Chapter 3, as feedback aggregation is of particular interest to this thesis. It is sufficient to say at this point that current debate about the value of feedback aggregation has not reached closure.

In summary, feedback is argued to have a direct effect on group performance. Firstly, by increasing the level of effort exerted by group members in performing the task. Secondly, feedback provides additional direction (cueing and learning) which assist group members' strategies in performing the task.

2.2.4 Extended IPO Models - Rewards

A second extension to the core IPO models, which is of interest in this thesis is the effect of reward systems on group-interaction. Hackman (1987) has theorised that performance contingent reward system have direct effects on both the level effort exerted by individual group members and the task performance strategy used by each group member (refer Figure 2-5).

Figure 2-5 Extended Group Model - Rewards



Similar to feedback, performance contingent rewards provide information about the performance of the group back to each group member. Performance contingent reward systems effectively provide individual group members with a direct signal about the appropriate performance, as only appropriate performance (i.e. desired by the organisation) is rewarded. As most individuals prefer more rewards than less (Baiman, 1982) they provide motivation for individuals to change their effort levels and strategy to maximise their rewards. As a result, individual group members are expected to change either the coordination of their effort, or the actual level of their individual effort or both. Similarly, they either change the implementation of a current strategy or they develop a new strategy. Improvements from the use of performance-based rewards have been found empirically by Young, Shields and Wolf (1988). They found that rewards contingent on group performance increased group member effort above levels exhibited by group members receiving fixed-rate rewards.

Performance contingent rewards, however, also have the potential of impeding group performance by introducing incongruent goals between group members (Hackman and Oldham, 1980). Where rewards are not based on a common group goal, the potential exists for group members to feel competitive, which can have detrimental effects on their motivation to interact. In the Young et al. (1988) study both treatments groups (fixed-rate and group-rate) had similar goals, and performance contingent group rewards increased group performance as individuals were more highly motivated to achieve this common goal. In contrast, studies in psychology, which have looked at performance contingent rewards that are based on competitive goals have generally found that they lead to performance at a lower level to those that are based on cooperative or group goals. A comprehensive literature review of the comparison between cooperative and competitive rewards is provided in the meta study by Johnson, Johnson, Nelson and Skon (1981). The relative importance of fixed-rate rewards as well as performance contingent rewards based on individual rewards (which are not necessarily competitive) remains unclear.

Finally, rewards may also provide cueing signals, as individual group members find out how they should be performing the task in order to maximise their rewards. Cueing then assists the group to coordinate and change the level of group member effort along with changing the implementation of existing strategies and the development of new strategies.

Cooperation theory, developed in the psychology literature by Deutsch (1949a) provides some further theoretical guidance about the relationship between the performance base used to reward groups and group members motivation to interact. Cooperation theory specifically deals with the effects rewards have on individual group members' goals and how this translates into motivation to work together. A general review of cooperation theory is provided in the next section, while more detailed hypotheses regarding group-performance-based, individualistic-performance-based and fixed-rate rewards are examined in Chapter 3.

2.3 Cooperation Theory

2.3.1 Introduction

Cooperation theory aims to explain how group members work together to accomplish shared goals. Cooperation theory is ideally suited to the examination of reward systems, as even Deutsch (1949b) himself used a reward manipulation to test his theory empirically.

In cooperation theory, a cooperative situation is defined as one where individuals perceive that they can reach their individual goals if, and only if, other group members are able to reach their goals (Deutsch and Krauss, 1962). Similarly researchers prior to Deutsch (1949a), such as May and Dobbs (1937), defined cooperation as the behaviour of two individuals towards the same end. However, it was Deutsch (1949a) who had the major influence on research into cooperation. He developed cooperation theory further to view cooperation and competition respectively as relating to compatible and incompatible goals between group members. Deutsch's (1949a) initial framework stimulated a great deal of research interest, with early studies reporting conflicting results. For example Miller (1959) and Mintz (1951) found a negative relationships between differential (competitive) rewards and group performance, whereas studies such as Phillips (1954) and Sims (1929) found positive results. These inconsistencies prompted extension to the original framework by authors such as Miller and Hamblin (1963) who incorporated the level of task interdependence into the framework.

Deutsch's (1949a) framework has subsequently been extended to include independent rewards, in addition to cooperative and competitive rewards (Johnson and Johnson, 1989). Cooperation theory has also been applied to areas beyond the educational context in which in which it was first developed (such as the organisational context by Tjosvold, 1984; 1986; 1993; and Schmitt, 1981).

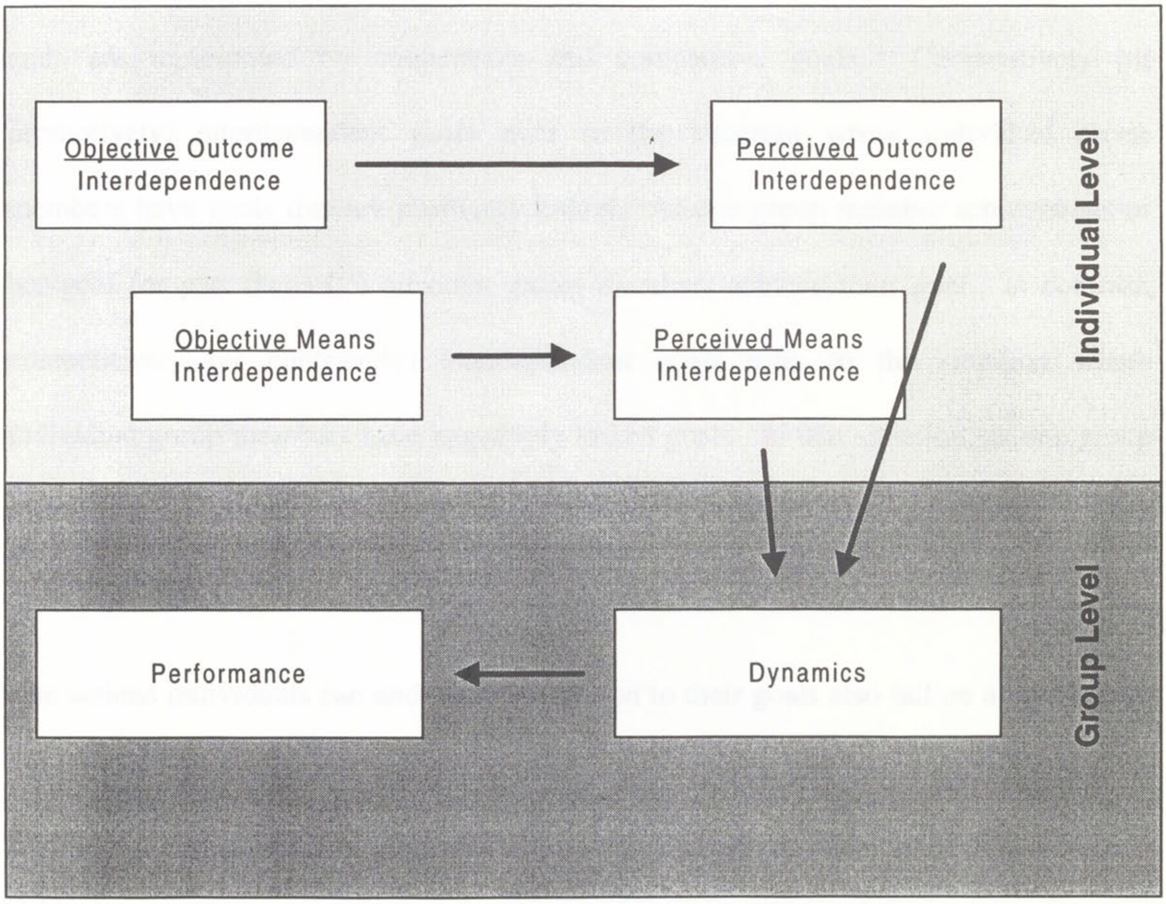
The following review of cooperation theory focuses on an overall framework. It does not intend to provide an exhaustive review of all the studies in the psychology literature, as good reviews are available in the meta study by Johnson et al. (1981) as well as the more recent review by Johnson and Johnson (1989). In the accounting literature studies have only recently introduced cooperation theory as a basis for understanding the effects of cooperation (Young et al., 1993) and rewards (Ravenscroft and Haka, 1996) on group performance, and a comprehensive review will be provided of these studies.

2.3.2 Initial Development by Deutsch

Deutsch (1949a) developed a theory of cooperation and competition that was based on Lewin's (1935) theory of intrinsic motivation. In his theory, Lewin stated that intrinsic motivation was a state of tension, in which the individual is motivated to move towards the accomplishment of desired goals. Deutsch (1949a) built on this theory and focused on the relationship between group members.

Deutsch's (1949a) theory dealt with two phases of analysis. The first phase theorised how the individual group members perceive their own goals and the type of responses anticipated from these individuals. The second phase dealt with group-interaction resulting from the individual responses and group performance. This is illustrated in Figure 2-6.

Figure 2-6 Amended Deutsch's Framework



The first phase deals with the individual's perceptions of goal interdependence and resulting actions. Deutsch (1949a) started with an objective view of goal interdependence, which is distinct from a perceived interdependence in that the individual does not have to be aware of the objective interdependence to be subject to it. However, Deutsch did theorise that the objective interdependence is interpreted by the individual through learning, and ends up approximating the objective interdependence. As such, Deutsch treated the link between objective outcome interdependence and perceived outcome interdependence as highly correlated, and therefore non-problematic.

Goal interdependence, objective and perceived, falls on a continuum. The two extreme ends are represented by cooperative and competitive goals. Cooperatively (or promotively) interdependent goals refer to the situation where individual group members have goals that are positively linked. As one group member achieves his or her goal (or part thereof[11]) all other group members achieve their goal. In contrast, competitively (or contriently) interdependent goals refer to the situation where individual group members have negatively linked goals. In that situation, as one group member achieves his or her goal, he or she prevents all other group members from achieving their goals.

The actions individuals can undertake in relation to their goals also fall on a continuum. On the one end of the continuum individuals can cooperate and interact effectively with fellow group members, which promotes the other individuals' chances of obtaining their goals. On the other end of the continuum individuals can opt not too cooperate, or even sabotage interaction with fellow group members, in an attempt to decrease the other individuals' chances for obtaining their goals.

Deutsch (1949a) theorised that goal interdependence has a direct effect on the individual's motivation to cooperate. By drawing on three social psychological processes (substitutability, cathexis[12], and inducibility[13]) he theorised that cooperative goals have positive motivation for group members to substitute their actions for other group members (i.e. assist other group members). Cooperative goals also provide positive motivation for group members to care about actions taken by other group members (i.e. positive cathexis) as well as being receptive to other group members' actions (i.e. positive inducibility). Competitive goals have the opposite effect on group member motivation. Hence cooperative goals, through substitutability, positive cathexis and positive inducibility result in cooperation between group members, whilst competitive goals, through non-substitutability, negative cathexis and negative inducibility results in non cooperative behaviour between group members.

In the second phase, Deutsch (1949a) specifically theorised how the motivation to cooperate would manifest itself in group behaviour. The specific aspects dealt with were organisation, motivation and communication.

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[11] The theory developed by Deutsch deals not only with fully achieved goals, but also deals with achievement of part of the goals. He referred to this in terms of goal regions. In the remainder of this chapter whenever the term goal is used the term partial goal can also be inferred.

[12] Cathexis refers to the investment of psychological energy in objects and events outside oneself.

Utilising the relationship between effective group member action and goal interdependence, Deutsch proposed that coordination in groups is more effective when the goals are cooperative rather than competitive. Group members in the cooperative groups are interested in other group members performing well, as it furthers their own interests. As such, they are more likely to coordinate their effort to ensure overall group performance.

In terms of communication, Deutsch proposed that whilst competitive groups communicate more, they do so less effectively. The argument for an increase in communication for competitive groups, over cooperative groups, was based on the benefits group members of competitive groups derive from communicating. When communication is only seen in terms of producing a sign (e.g. talking, Morris, 1946), then group members in competitive groups will engage in more talking than group members in cooperative groups, as they benefit from being heard. The decline in effectiveness in communication in competitive groups, when compared to cooperative groups, in terms of reaching a common understanding, follows on from this line of argument. As competitive group members attempt to talk as much as possible, they do so at the expense of listening to their fellow group members. This is consistent with the argument that a common understanding is not important to competitive group members, as they do not expect to benefit from other group members' communication.

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[13] Inducibility refers to the openness to influence.

Deutsch's final link extended differences in group-interaction to group performance. In particular, cooperative groups were argued to either have a higher level of productivity or take less time to produce an equal amount compared to the competitive groups. Further, where lack of group orientation is negatively related to group productivity, cooperative groups will have higher productivity compared to competitive groups.

Deutsch's (1949a) theory on cooperation and competition has received considerable research attention in psychology over the last 40 years and has since been modified in two principal ways (Johnson and Johnson, 1989). First, a number of authors have introduced moderating variables, such as task interdependence (which started with Miller and Hamblin, 1963), and second, others have adapted the theory to other research areas different to the educational area in which it was developed (such as Tjosvold 1984, 1986 in organisational behaviour literature). More recently, in management accounting, cooperation theory has provided a theoretical framework for studies by Young et al. (1993) and Ravenscroft and Haka (1996) concerned with the role of feedback and performance-based-rewards in work-groups.

2.3.3 Task Interdependence Extension to Cooperation Theory

Significant extensions to the original cooperation theory (Deutsch 1949a) have been made, which mirror the task demand characteristics described in the Hackman (1987) IPO model. Whilst the psychology literature has not utilised the three summary variables in the IPO model, it has incorporated task demands, with particular reference to task interdependence, into the model. By dichotomising task demands into high and low task interdependence, authors such as Miller and Hamblin (1963) theorised that cooperation only resulted in increased group performance when the task was high in interdependence.

In conclusion, Deutsch's (1949a) theory of cooperation is a useful framework for understanding the direct implications of goals and rewards on individual group member action first and groups member interaction with other group members second. The importance of high task interdependence for cooperation to result in performance differences is particularly relevant and will be discussed further in Chapter 3.

2.4 Conclusion

Of the group models introduced previously, a series of IPO models developed by Hackman, Morris and Oldham are of particular interest to this thesis as they provide a theoretical foundation for anticipating benefits from group-interaction. These models have stipulated that group-interaction (both verbal and non-verbal) has direct effects on the level of effort, strategy and expertise present in the group. Differences in interaction will affect any or all of these three "summary variables", and group performance differences are expected to the extent that these three summary variables are moderated by the task.

Nadler's (1979) feedback-model forms an important basis for theoretical development in Chapter 3, as it represents a well-established view of how feedback assists group-interaction by providing greater motivation to interact in conjunction with an increased understanding of the task. Hackman's (1987) extended group model, as well as Deutsch's (1949a) cooperation theory, are also important in this thesis as they provide an understanding of how rewards impact on group-interaction. It is theorised that rewards have direct effects on the individual group member's motivation to work with their fellow group members. This represents a difference in the level of cooperation between group members. Both feedback and rewards directly impact on the relative effectiveness of group-interaction, which affects the level of effort, strategy and expertise in the group. Together these models form the basis for deriving a set of testable hypotheses in the next chapter.

Chapter 3

Literature Review and Hypothesis Development

3.1 Introduction

The need for coordination has been one of the key foundations of organisational design (Galbraith, 1973; Van de Ven et al., 1976,). With recent changes occurring in production technologies (such as JIT and TOC), interdependence between organisational participants has increased, resulting in a greater need for coordination, as the individual's decisions and actions have a more direct effect on other individuals in the organisation. The relationship between task interdependence and coordination requirements is the first focus of this chapter. It is argued that as task interdependence reaches a sufficiently high level (e.g. reciprocal or team interdependence), a high degree of coordination of the individual contributions to the task is required.

Organisations facing high levels of interdependence have at least two additional coordination mechanisms available to them in addition to traditional coordination mechanisms (such as plans and procedures) used under lower levels of task interdependence (Galbraith, 1973). Coordination mechanisms in general have been shown to be additive, as organisations adopt additional coordination mechanisms without getting rid of previously existing mechanisms (Van de Ven et al., 1976). The first of these coordination mechanisms of interest is the use of groups. As discussed in Chapter 2, groups provide the opportunity for individuals to interact, which provides individuals with the motivation and ability to coordinate their actions. The second coordination mechanism involves providing individuals with more aggregated feedback in addition to their local (individual) feedback. Global feedback, which comprises of both local feedback and feedback about the overall process, also enhances motivation and the ability to coordinate. The salience of each of these coordination mechanisms in isolation, as well as their combined effect, constitute the second and third focus in this chapter.

Once an organisation has chosen to adopt a group coordination mechanism, consideration about the appropriateness of the incentive system needs to be addressed. Performance advantages from choosing appropriate incentive systems have been extensively documented at the individual level. Yet at the group level these advantages are less clear. Of particular interest, and the fourth focus of this chapter, is the importance of incentives on individual group member's motivation to coordinate their individual decisions with those of their group members. Three commonly available incentive systems (group, individual and fixed-rate) are examined. These particular incentive systems were chosen to address the current debate surrounding the importance of using group rewards instead of individual rewards for group coordination (Saunier and Hawk, 1994), as well as the relevance of fixed-rate rewards for group coordination[14].

[14] The effectiveness of rewards on the motivation of individuals was only examined in the context of interacting groups. This was a result of the two separate experiment approach adopted in this thesis. The first experiment established the superiority of interacting groups, which then shifted the focus of motivation, in the second experiment, to the group context.

3.2 Coordination with High Task Interdependence

Recent changes in production technologies have increased the level of interdependence between individuals in organisations. As individuals find themselves working more closely together, their individual decisions start to have direct consequences for other individuals in the organisation. In an effort to understand interdependence between individuals several different types of interdependencies have been investigated. Johnson and Johnson (1989) distinguished between resource interdependence, role interdependence and task interdependence. Resource interdependence refers to cases where each individual has particular resources, which need to be shared to complete the task. In contrast, role interdependence refers to cases where individuals are assigned roles, which need to be combined in order to complete the task. Task interdependence on the other hand refers to the direct effect one individual has on the decision and performance of others and vice versa. As such, task interdependence is directly relevant to this thesis, as it is the context in which coordination mechanisms become critical to effective system or organisational performance.

Thompson's (1967) definition of task interdependence in terms of work-flow or task sequencing is well established and has been used extensively in subsequent empirical testing (e.g. Van de Ven et al., 1976; Saaverdra et al., 1993; Hirst and Yetton, 1995). Thompson's typology is based on work-flows resulting from technologies inherent in the organisation. As such, the path taken by work as it flows through the organisation has a direct impact on the degree of dependence between individual participants. Based on the nature of work-flow Thompson proposed a hierarchy of tasks. Pooled interdependence, which represents the lowest level, refers to the case where individuals render a mostly discrete contribution to the work-flow (refer Figure 3-1). A commonly used example of pooled interdependence is a typing pool, where word-processing operators process individual typing jobs without affecting the output of other operators. Further up the hierarchy is sequential interdependence (refer Figure 3-2) and followed by reciprocal interdependence (refer Figure 3-3). Sequential interdependence refers to work-flows where the input of one individual becomes the input of another individual. An assembly line is a common example used to describe sequential interdependence. Reciprocal interdependence refers to work-flows where the output of one individual becomes the input of another, whose output in turn becomes the input of the former. A commonly used example to describe reciprocal interdependence is an aircraft maintenance crew. Each member of the crew executes a distinct function, which depends on other crew members, while his or her functions is also crucial for others' function. Finally the highest level of interdependence, team interdependence (see Figure 3-4), refers to situations where individuals jointly and simultaneously diagnose, problem solve and collaborate to complete the overall process (Van de Ven et al., 1976). This is indicated by the arrows in the diagram (see Figure 3-4), where all three individuals are directly dependent on each other. An example of team interdependence is a group of doctors performing a surgical procedure. Unlike the aircraft maintenance crew, the team of surgeons has to attend the patient simultaneously as the procedure unfolds, illustrating the simultaneous nature of team interdependence, which is crucial in distinguishing it from reciprocal interdependence. As the flow of work increases in interdependence, more demands are placed on individuals to coordinate their decisions carefully and, therefore, integrate them with the other individuals (Selto et al., 1992).

Figure 3-1 Pooled Interdependence

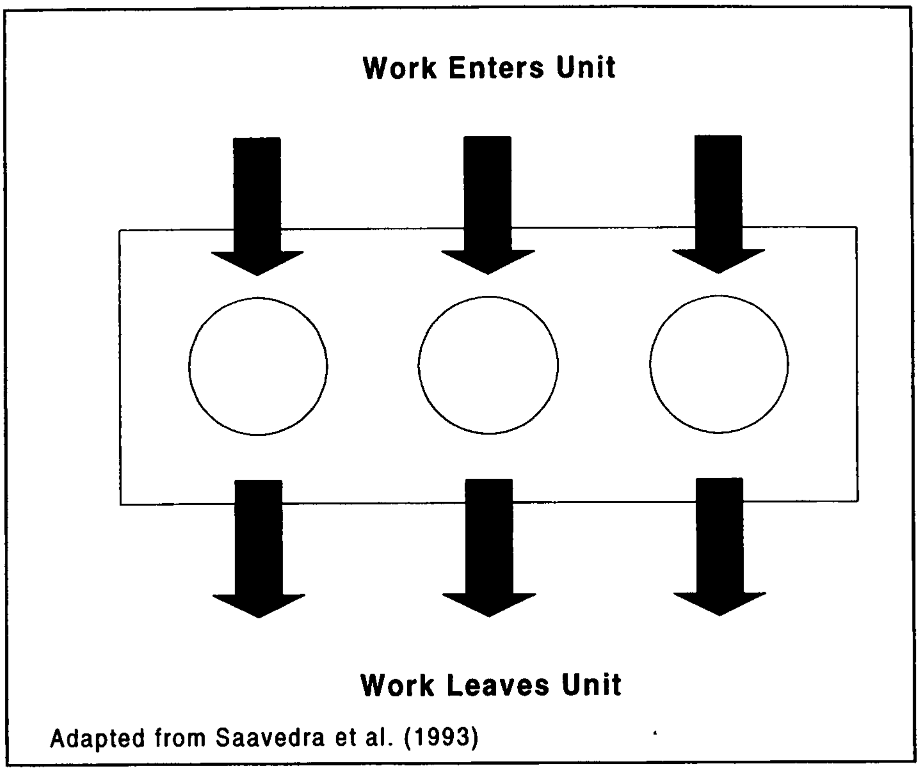


Figure 3-2 Sequential Interdependence

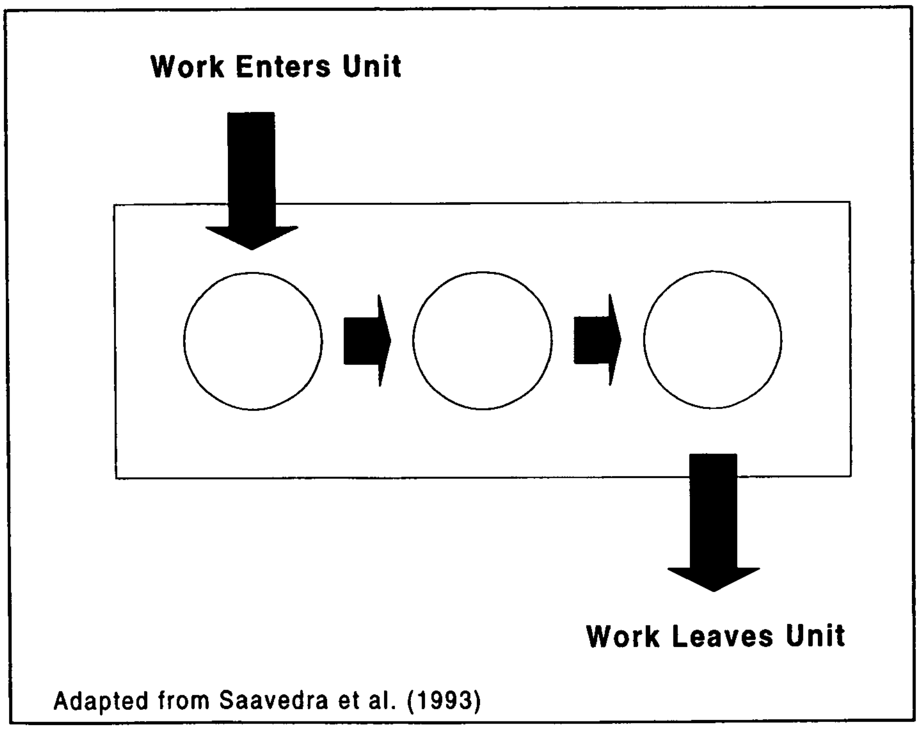


Figure 3-3 Reciprocal Interdependence

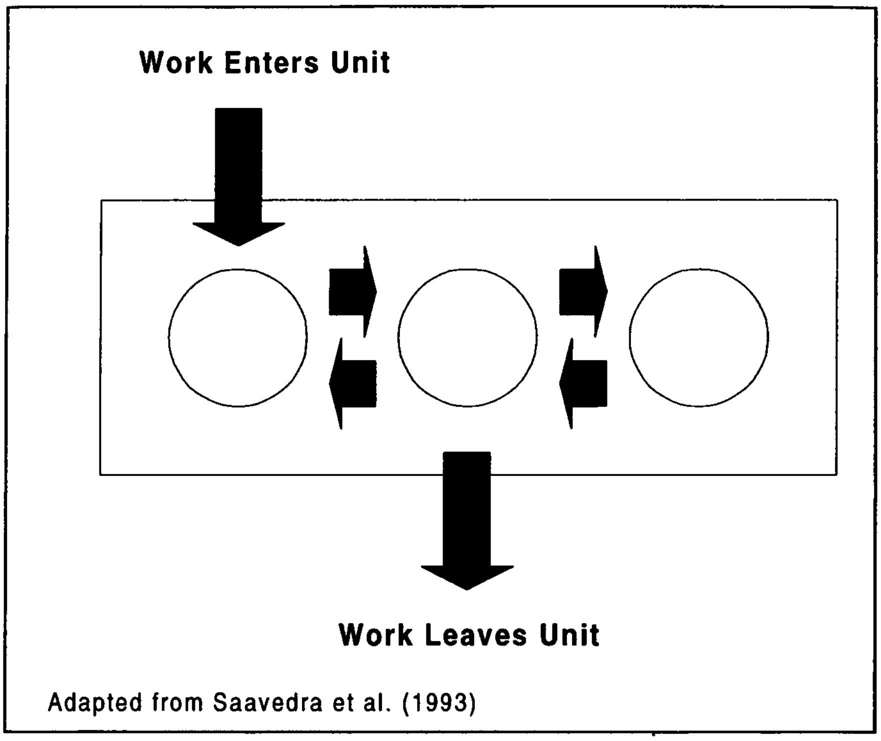
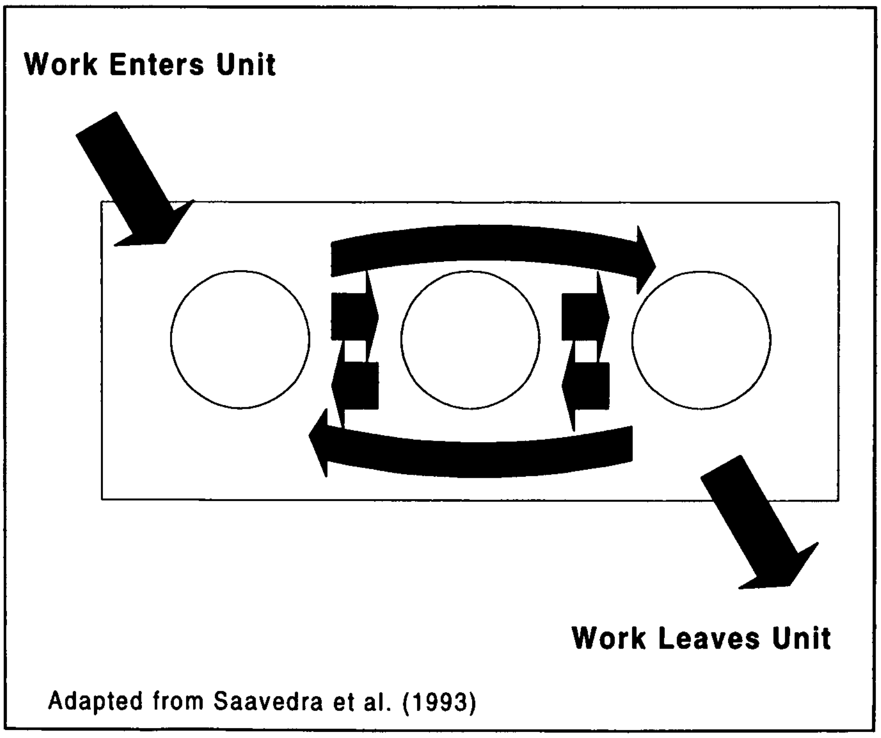


Figure 3-4 Team Interdependence



An example of changes in task interdependence, as discussed in Chapter 1, is the recent trend in the manufacturing industry from traditional push manufacturing systems to pull manufacturing systems. As buffer inventories are reduced or disappear, interdependence increases and individuals face increased demands to integrate their individual decisions and actions to keep production flowing (Selto et al., 1995).

Complementary to the hierarchy of interdependence, both Thompson (1967) and Van de Ven et al. (1976) theorised a hierarchy of coordination mechanisms. Both have argued that the level of interdependence needs to be matched to an appropriate level of coordination. A hierarchy of coordination mechanisms, based on the organisations ability to process information, traditionally starts with programs followed by plans and schedules, and, finally goal setting (Galbraith, 1973).

As the level of coordination requirements increases beyond the scope of these traditional coordination mechanisms, the organisation can take further steps to either reduce the need for information processing or increase the capacity of the organisation to process information. Reducing the need for information processing commonly involves either the creation of slack resources, or the creation of self contained jobs. Both effectively are attempts to reduce interdependence, but is most likely contrary to the objectives in the organisation that increased task interdependence in the first place. The introduction of groups and more aggregated feedback, on the other hand, are examples of increasing the capacity of the organisation to process information. Increasing the organisation's ability to process information is more likely to be in line with the objectives of the organisation that has resulted in increased interdependence. This is reflected by advocates of the new manufacturing technologies, such as Helms (1990), calling for more personal relations between individual participants.

3.3 Task Coordination Mechanisms

Both coordination mechanisms of interest to this thesis (group-interaction and feedback aggregation) are examples of increasing the organisation's ability to process more information (Thompson, 1967; March and Simon, 1967). More specifically, the use of groups as a coordination mechanism provides individuals with the opportunity to interact with each other during the execution of their own contribution to the task. Discussions in Chapter 2 dealt with the effectiveness of group-interaction on individuals' motivation and ability to perform the task. A key to successful performance of highly interdependent tasks is the appropriate coordination of individual contributions to the task.

Feedback aggregation provided to individuals was only discussed in the context of group-interaction in Chapter 2. Feedback aggregation, in general, is similar yet different to group-interaction in affecting individual's motivation and ability to perform the task. The similarity lies in feedback aggregation providing relevant information, similar to group communication, to individuals about their effort and strategies. Yet feedback aggregation lacks some of the richness of group-interaction as it only provides the information component of group-interaction without all of the verbal elements and some additional non-verbal elements (such as physical assistance during task execution) of group-interaction. It is however argued that, over time, the information provided by feedback aggregation will have similar effects on the individual's motivation and ability to coordinate the task as group-interaction. Discussion of both group-interaction and feedback aggregation as coordination mechanisms forms the content of the next three sections.

3.3.1 Group-interaction as a Coordination Mechanism

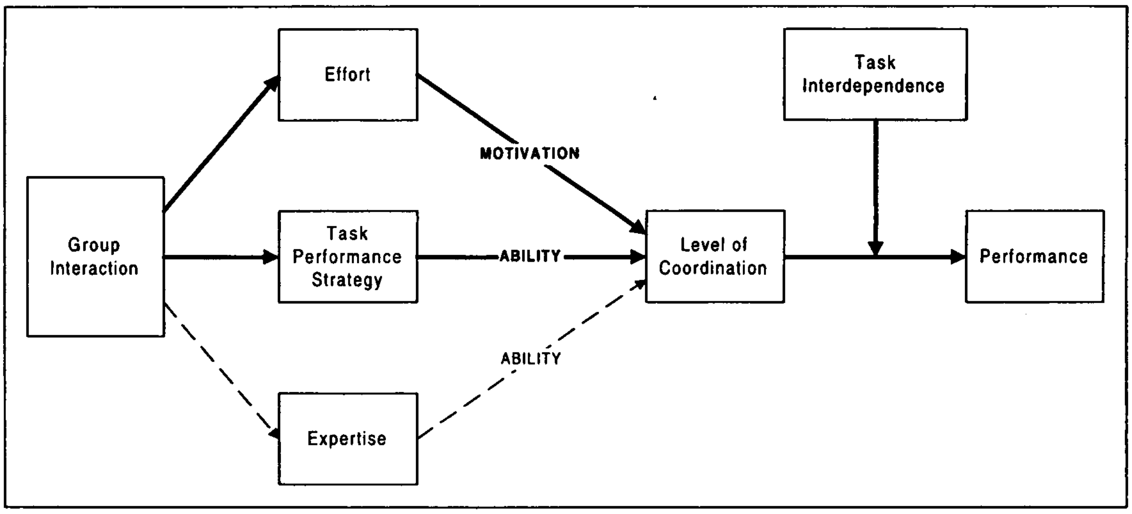
Several studies in both the organisational behaviour literature (Van de Ven et al., 1976), and the accounting literature (Scott and Tiessen, 1997; Young et al., 1993) have looked at group coordination in organisations. Findings in these studies indicate both anecdotally (Young et al., 1993) and empirically (Van de Ven et al., 1976) that organisations increasingly use groups as task interdependence increases. Increased use of groups in organisations has spawned further interest in their effects on organisational performance, reflected in recent review studies (such as Atkinson et al., 1997) calling for more research in this area.

The process by which groups assist coordination of highly interdependent tasks in organisations is less clear. Normative models, such as Hackman (1987), Hackman and Oldham (1980) and Hackman and Morris (1975) provide guidance to the link between group-interaction and performance. These models, discussed in greater detail in Chapter 2, proposed that group-interaction has direct effects on an individual's level of effort on the task, the level of understanding of the task performance strategy and expertise[15] (refer Figure 3-5[16]). Changes in the level of individual effort are considered

[15] As stated in Chapter 2, expertise is not of direct interest in this thesis, as the focus is on work-flow interdependence, where consequences of decisions affect outcome rather than a diversity in expertise. This will be the case throughout this Chapter.

to be motivational effects, as they reflect the way in which group interaction affects the willingness of individuals to work at the task. Motivational effects, in turn, impact the level of coordination - that is, the way in which coordination of the task takes place. On the other hand changes in performance strategy and expertise are considered to be learning effects, as they relate to the process by which the individual attains an understanding of the task. Learning effects impact the ability of individuals to coordinate and hence the level of coordination. The level of task interdependence then moderates the effectiveness of the level of coordination on task performance itself.

Figure 3-5 Group-interaction Model



Empirical research has examined the importance of interacting groups from at least three perspectives. The first perspective has examined differences between an interacting group and an individual (or mathematical composite of individuals). A large body of work psychology (e.g. Janis, 1971), auditing (e.g. Solomon, 1987; Trotman,

[16] Similar to the diagrams in Chapter 2, only solid lines are of interest to this Chapter.

1996) and management accounting (e.g. Young et al., 1993) has examined these differences on a variety of performance attributes such as accuracy, consistency and, more recently, time efficiency. It was not possible for these studies to examine coordination of task interdependence because of their focus on differences between groups and the individual. However, they have provided insight into the importance, or in some cases problems, with group-interaction.

Studies falling into a second perspective have examined effectiveness of group coordination directly, usually, by varying the level of task interdependence as opposed to group members' ability to interact (Saaverdra et al., 1993; Wageman and Baker, 1995). A limitation of varying task characteristics rather than group-interaction is that it precludes a discussion of the importance of group-interaction at any given level of task interdependence. The extent to which conclusions are possible regarding the importance of group-interaction is to state that as interdependence increases (and the task becomes more difficult due to increased demands on coordination), group-interaction assists in coordination and performance remains the same.

The most relevant perspective, in terms of testing the theoretical model in Figure 3-5, has included studies that have directly examined the importance of group-interaction as a coordination mechanism in the context of task interdependence (Young et al., 1993; Straus and McGrath, 1994). Of particular interest is the study by Young et al., as the authors raised the relevance of high task interdependence to interacting groups. Young et al., manipulated group members' ability to interact in a production line context (which they regarded as high in interdependence based on field visits to a number of *Fortune 500* manufacturing companies). Yet the authors failed to find significant differences between the interacting and non-interacting groups[17]. Young et al. acknowledged that one potential reason for the lack in performance differences between the groups could be attributed to the level of interdependence inherent in their sequential production line task. This raises the interesting question of whether a higher level of task interdependence is needed before differences in the level of coordination possible with interacting groups has any bearing on overall performance.

Research into groups has shown that organisations are using groups to coordinate highly interdependent tasks. Yet, studies that have examined performance improvements from group-interaction have been limited and, in some cases, have resulted in findings contradictory to normative expectations. Difficulties encountered in examining the relevance of group-interaction in coordinating interdependent tasks has been the lack of tasks used which exhibit a higher level of interdependence than the sequential (production line) variety. Sequential interdependence, using Thompson's (1967) typology of task interdependence, is a moderate level of interdependence at best. The normative expectation of performance gains from group-interaction remains where task interdependence is high.

Under high task interdependence the prediction remains that group-interaction results in higher task performance. This superior performance is based on group-interactions facilitating higher levels of effort and better strategies to individual contributing to the task. The resulting increases in motivation and ability increase the level of task

[17] The authors actually found a marginally significant effect in the opposite direction.

coordination, which results in better performance of highly interdependent tasks. The testing of this proposition is subject of hypothesis H1. Stated more formally:

H1: Groups outperform individuals when the task is high in interdependence.

3.3.2 Feedback Aggregation as a Coordination Mechanism

Information is provided by management accounting systems to individuals in the organisation on the belief that it will assist these individuals to detect and correct errors (Argyris, 1971; Luckett and Eggleton, 1991). Traditionally this type of feedback has consisted of information focused on individual efficiency and effectiveness (Kaplan, 1990; Abernethy and Lillis, 1995). The terms *local* feedback and *individual* feedback are used interchangeably from this point forward to refer to this type of information focused on individual performance (individual outcome). Local feedback has come under increased criticism by authors such as Kaplan (1990) for its failure to provide information relevant for individuals to coordinate their individual tasks under high task interdependence. By not providing this type of information, local feedback limits both the individual's ability and motivation to consider how his or her decision impacts, and, is impacted by other interdependent decision-makers in the organisation.

One avenue open to designers of management accounting systems is to provide individuals with more aggregated feedback. Nadler (1979) has modelled the implications of providing individuals with more aggregated information in the context of interacting groups (refer to discussion in Chapter 2). The model proposed effects of feedback on both group member effort (motivation) and strategy (ability) to perform the task.

Empirical testing of the effects that feedback aggregation has on coordination of interdependent tasks has primarily occurred in the context of interacting groups. This empirical literature, predominantly in psychology, has examined the effects of feedback aggregation mainly by comparing group feedback with individual feedback. In these studies group feedback is concerned with providing individual group members with information about the performance of the group. Nadler (1979) provided an overview of prior literature in this area. Early studies in this area (Zander and Wolf, 1964; Zajonc, 1962; Rosenberg and Hall, 1958) arrived at conflicting results regarding the effectiveness of group feedback. Based on his review of the literature, Nadler proposed as part of his contingency model that task interdependence was critical in determining the importance of group feedback. Group feedback was held to be particularly important to groups operating under high task interdependence.

Two subsequent studies by Pritchard, Jones, Roth, Stuebing and Ekeberg (1988) and Saavedra et al. (1993) further examined the importance of group feedback under high task interdependence. Pritchard et al. used a field experiment (the study was set in an Air Force base), where group feedback, goals and incentives were sequentially administered to work units. Each new treatment was administered in addition to the existing treatments (e.g. feedback was administered first followed by feedback plus goals, followed by feedback plus goals plus incentives). Pritchard et al. found that the introduction of group feedback increased productivity in the five Air Force branches when compared to the "no-feedback" provided before. While the study did not specifically test Nadler's (1979) model, it did lend support for the proposed importance of group feedback to group performance.

Saavedra et al. (1993) failed to find significant difference in performance between groups receiving group and individual feedback. Saavedra et al. used a controlled laboratory experiment, in which undergraduate student subjects were required to conduct an employee performance appraisal task. The lack of significant findings could be attributed to the use of undergraduate students who could potentially lack some of the experiences necessary to perform the evaluation task. However, evidence against that explanation is the observation that subjects were affected differently by the nature of the feedback (in terms of perceived conflict) and, more importantly, performed significantly differently when provided with a group goal in addition to group feedback. This points to the more plausible conclusion, which is discussed by Saavedra et al., that group feedback by itself may not be enough under high task interdependence. Rather, it is the combined effect of group goals and group feedback that provides groups with the ability to coordinate their decisions and achieve superior performance.

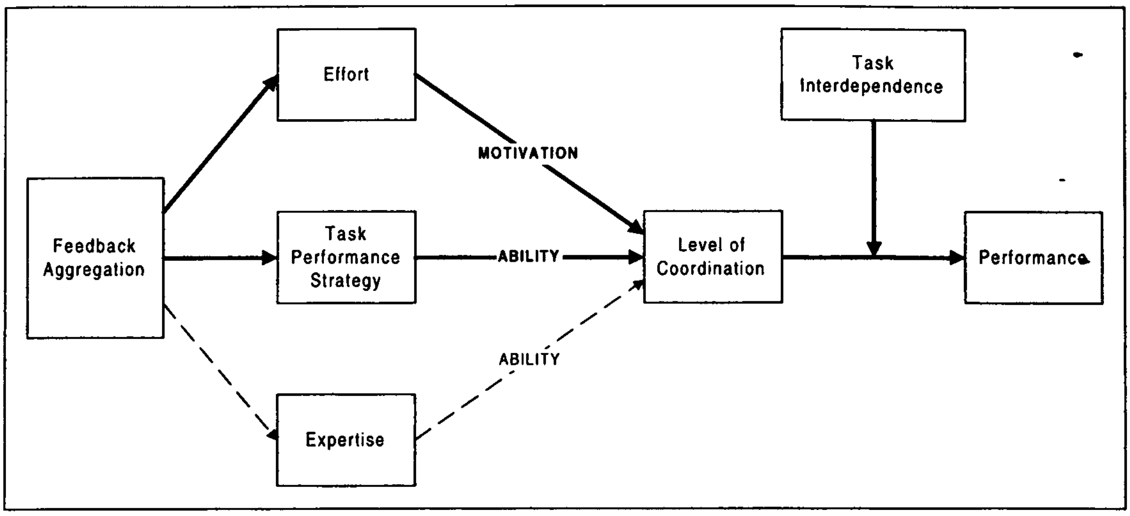
The majority of literature dealing with feedback aggregation reviewed has focused on the effectiveness of group feedback against individual feedback (apart from Pritchard et al., 1988, who compared group feedback with no feedback). However, designers of management accounting systems face additional considerations of individuals requiring individual feedback, in addition to, more aggregated feedback to make individual decisions. For example, production workers need to know individual production information (such as the capacity and inventory levels) to make production decisions, regardless of whether they also know how much production workers upstream or downstream are willing to produce. Aggregated feedback without the accompanying individual feedback is, therefore, less likely to be an option to designers of management accounting systems.

Another consideration for designers of management accounting systems is the possibility that interdependent individual decision-makers are not necessarily interacting in a group context. In order to reflect a more aggregated view of the overall task management accounting information needs to include information about the performance of other individual decision-makers (which is traditionally communicated in the group context) as well as the overall performance of the task.

A response to these two considerations is captured by the provision of *global feedback*. Global feedback is defined to include individual feedback as well as more aggregated information about the performance of other individuals in the system, as well as, the overall performance of the system. The incremental information provided by global feedback over local feedback has not been theorised or tested directly to date.

A theoretical model illustrating the effects feedback aggregation has on individuals is presented in Figure 3-6. Similar to group-interaction (refer in Figure 3-5), feedback aggregation provides additional information to individuals which impacts their effort levels (a motivational effect) and task performance strategy (an ability effect) as well as expertise (an ability effect). Similar to group-interaction, changes in individual effort and performance strategy, in particular, have direct effects on the level of individual coordination. The level of task interdependence subsequently moderates the importance of coordination on task performance.

Figure 3-6 Feedback Aggregation Model



Based on this theoretical model it is proposed that under high task interdependence increased individual motivation and ability, resulting from more aggregated feedback, results in higher task performance. As global feedback contains more aggregated feedback than local feedback it is further proposed that providing individual participants, under high task interdependence, with global feedback will result in higher task performance than providing them with local feedback. This proposition has not been subject to empirical testing and is the subject of hypothesis H2. Stated more formally:

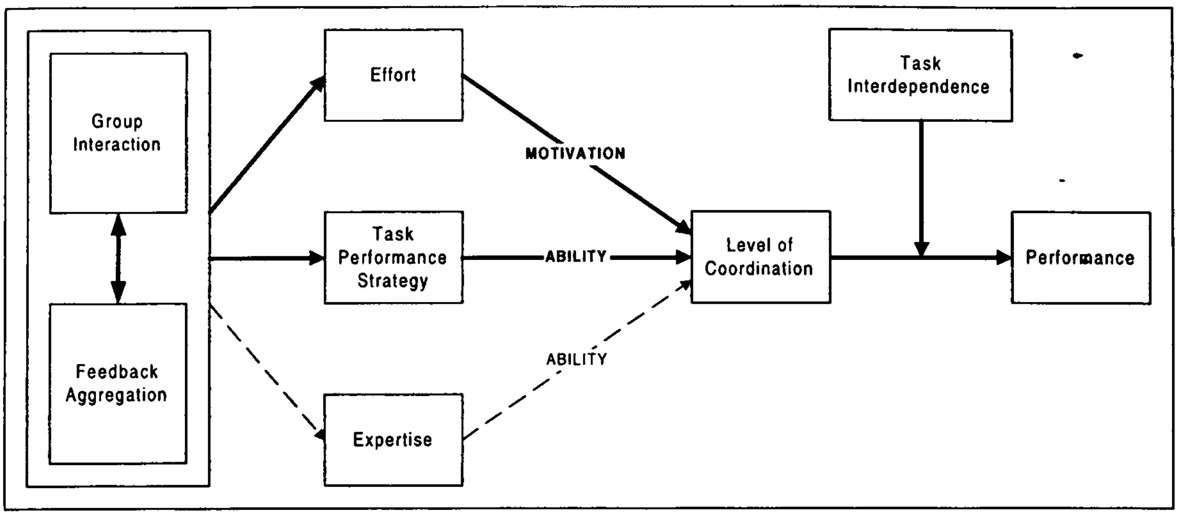
H2: Providing individuals with global feedback leads to higher task performance than providing them with local feedback, when the task is highly in interdependent.

3.3.3 Group-interaction and Feedback Aggregation

With an increased use of group-interaction as a coordination mechanism under high task interdependence (Van de Ven et al. 1976), designers of management accounting systems need to consider the role of feedback aggregation in groups. Previous group feedback literature, predominantly in psychology, has established the importance of feedback aggregation for groups operating under high task interdependence. Previous group feedback literature has not, however, examined the interaction between feedback aggregation and group-interaction. Whether additional feedback aggregation provided by global feedback over local feedback is equally important in interacting groups and non-interacting individuals has not been theorised or empirically tested.

The relative importance of global feedback in interacting groups, as opposed to non-interacting individuals, has not previously been addressed in a theoretical model. The model presented in Figure 3-7 illustrates the theoretical relationships between global feedback and interacting groups proposed in this thesis. Both group-interaction and feedback aggregation have been argued, in previous section, to be individual methods open to organisations to coordinate highly interdependent tasks. However, as coordination mechanisms, feedback aggregation and group-interaction provide some of the same assistance to individuals in terms of their individual effort levels, task performance strategies and expertise. For example, information provided by feedback aggregation can be ascertained (to some degree) from group-interaction, as group members share their individual information and perform their own aggregation. Conversely some of the information provided by group-interaction can be communicated in more formal form through feedback aggregation. Because of the overlap between these two coordination mechanisms, the relative effect of each on performance is moderated by the presence of the other.

Figure 3-7 Group and Feedback Interaction Model



Using this model, it is proposed that under high task interdependence, the relative salience of feedback aggregation depends on whether or not groups are used in conjunction with the feedback. It is further proposed that feedback aggregation has a stronger, positive effect on both motivation and the ability of individuals to coordinate, which results in increased performance under high task interdependence. As global feedback provides individuals with more aggregated information than local feedback, it is proposed that providing global feedback to participants leads to a relatively higher improvement in performance compared to local feedback, where group-interaction is absent than where group-interaction is present. As no prior literature has examined the relative salience of global feedback in interacting groups and non-interacting individuals, it will be tested in hypothesis H3. Stated more formally:

H3: Performance differences between global and local feedback, will be relatively greater where group-interaction is absent than when group-interaction is present and the task is high in interdependence.

3.4 Incentive Systems Role of Motivator

The importance of incentive systems on an individual's motivation and performance has long been recognised (refer Young and Lewis (1995) for experimental work; Merchant (1989) for control system design and Baiman, (1982, 1990) for agency theory). In their conclusion Young and Lewis also call for more research into incentive systems used to reward groups. Subsequent research has started to address some of the issues surrounding group incentive systems, such as group member incentive systems preferences (Awasthi, Chow and Wu, 1996), relative percentage of total individual rewards allocated on the basis of group performance (Scott and Tiessen, 1997) and cooperation/competition resulting from incentive systems (Ravenscroft and Haka, 1996). Despite increased research interest in group-incentive systems, many issues surrounding these systems remain.

One of the important issues is how incentive systems affect interaction between group members. This is particularly relevant, as discussion in previous sections has hypothesised effective group-member interaction as a viable coordination mechanism for highly interdependent tasks. While the accounting literature has not directly examined this issue, authors in the practitioner literature, such as Saunier and Hawk (1994), have started to discuss possible implications of using traditional individual incentives in groups. Whether incentive systems need to be tied to group performance is another related issue, which has not received much attention in the group literature.

3.4.1 Individual vs Group Rewards

In providing rewards for group member performance, management accounting has an important role to play in the success of groups (Scott and Tiessen, 1997). Management accounting provides the mechanism for performance measurement, which is essential for rewarding individual group members and hence the type of reward system will influence the type of performance measures. Some practitioners have already sounded alarm bells about perceived incompatibilities between traditional individualistic incentives[18], which are based on individualistic performance, being applied to group work (Sauner and Hawk, 1994). This concern is based on potential negative effects on both the motivation and ability of individuals to coordinate their decisions, resulting from the individualistic goals set by these incentives.

Incentive systems have a direct effect on an individual group member's motivation and ability to coordinate by affecting his or her goals. This relationship has been recognised as far back as Deutsch (1949b). *Group incentives* are monetary returns to group members based on group performance and, subsequently, distributed equally among group members. As such, they are a form of piece rate scheme and ensure that all group members share the same goal. *Individual incentives*, on the other hand, are monetary returns to group members based on their individual performance. As such, they are also a form of piece rate scheme, and focus the individual on their own goals, which may not be compatible with fellow group members' goals.

Empirical studies in both psychology and the organisational behaviour literature have examined the different effects individualistic and group rewards have on group goals, coordination and performance. Both Miller and Hamblin (1963) and Johnson et al. (1981) have reviewed early research in this area in two separate studies. While one of the more robust findings from these reviews is the clear indication that in the context of high task interdependence, cooperation (resulting from incentives) is better than competition, the effects of individualistic rewards on group coordination is less clear.

A subsequent study by Rosenbaum et al. (1980) has been the only study that has solely focused on the effects of group and individualistic rewards on group coordination and group productivity. The study involved high task interdependence in the form of building a single tower with wooden blocks. As all group members had the same expertise and all actions by group members were directly observable by all group members, group-interaction was the main driver of coordination and performance. As such, the key to group productivity was for individual group members to coordinate their individual contribution of individual pieces so as not to knock over the tower. The results showed that group rewards[19] led to more equal contributions by group members (measured in the amount of turns taken by each group member).

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[18] The term incentive and reward will be used interchangeably in this section. Traditionally the incentives terminology has been used in economics and accounting, whereas studies in psychology have used the rewards terminology.

[19] Rosenbaum et al. (1980) actually used the term cooperative rewards to refer group rewards. The two terms are used interchangeably from this point forward.

There was, however, no significant difference in overall performance between groups receiving group and individualistic rewards. The authors did not explain this finding as their main focus was on the difference in performance between competitive rewards and group/individualistic rewards. One possible explanation for no performance difference between groups receiving groups and individual rewards is that coordination was not as crucial to task performance differences as "sabotage". That is, as long as group members did not purposefully set out to hinder each other (which was the case with competitive rewards) groups could produce similar number of towers[20]. It also suggests that the level of interdependence, which was not directly measured in this study, was not high enough for coordination differences that were not sabotage related, to result in performance differences.

In contrast Abdel-Hamid, Sengupta and Hardebeck (1994) reported quite a different result. Abdel-Hamid et al. used a role-playing project simulation game in which two participants had to manage two interdependent real-life software development projects. Unlike Rosenbaum et al. (1980), the study by Abdel-Hamid et al. also included information asymmetry, as individual group members could not see each other's private projects[21]. Results reported showed that groups receiving group rewards outperformed groups receiving individualistic rewards, as they were more motivated to coordinate their individual projects with other group members. It was unclear, however, whether

[20] This explanation is consistent with similar number of tower falls observed for group rewards and individualistic rewards.

these results were due to the information asymmetry, the difference between reward systems or the presence of both.

Both Wageman and Baker (1995) and Wageman (1995) found further support for the superiority of group rewards over individualistic rewards. The former study used a task that required the correction of errors in a series of written articles, while the second study used a field setting (a customer service division of the Xerox Corporation). In both studies, however, coordination of decisions was not the only variable affecting performance. In both studies subjects also possessed different task specific expertise which could be shared during group-interaction. It is, therefore, difficult to assess whether performance differences were due to differences in coordination of high task interdependence or differences in coordination differential expertise requirements of the task (which is an example of resource interdependence; refer Section 3.2). As discussed previously in Section 3.2, only the former is of direct interest to this thesis.

Finally, Doer, Mitchell, Klastorin and Brown (1996) investigated group rewards and individualistic rewards at a fish processing plant located in the United States[22]. Two types of production systems (push and pull manufacturing), provided the context in which these incentive systems were studied. Results confirmed that in the context of high task interdependence (pull manufacturing) group rewards yielded a higher level of

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[21] Another minor difference was that both the cooperative and individualistic rewards were not completely "pure" in the sense that the cooperative reward was 80% group and 20% individual, and the individualistic reward was 80% individualistic and 20% group.

[22] The study was conducted as a goal setting study. However, as achievement of goals was accompanied by rewards it is included as part of the review.

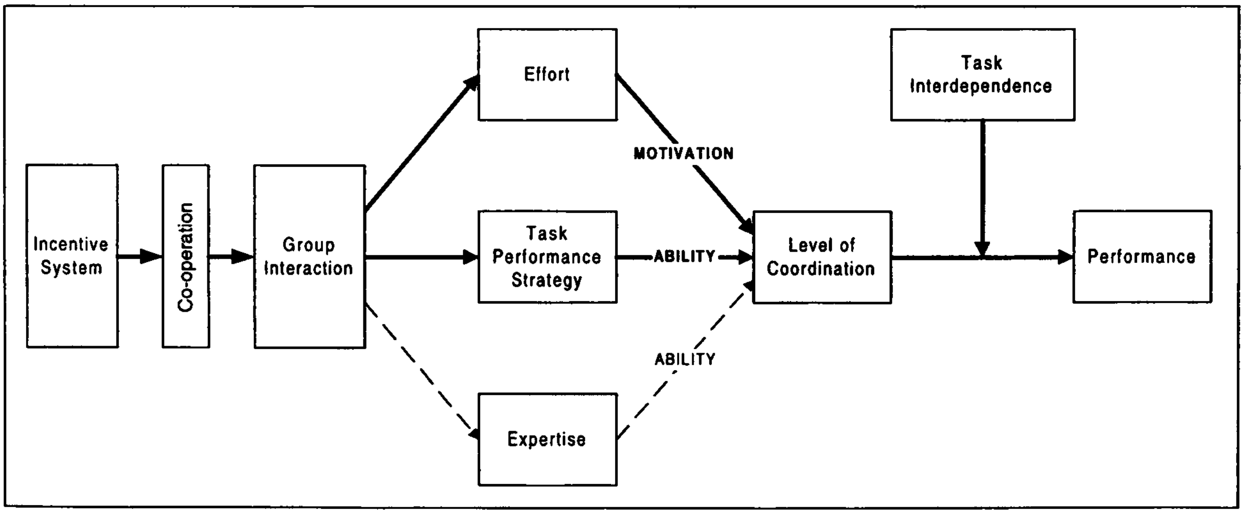
productivity than individualistic rewards. Differences in productivity were, however, difficult to attribute to coordination differences as group rewards yielded higher productivity regardless of the level of interdependence. One potential explanation offered by the authors was in terms of the difference in the total amount of money provided to groups receiving group rewards due to the difference in goal attainment. That is, group members receiving group rewards met group targets, for which they were rewarded, more frequently than groups receiving individualistic rewards based on individual targets.

In summary empirical studies examining differences between group and individualistic rewards have shown performance advantages resulting from the former over the latter in the context of high interdependence. Results for task interdependence, which represents one particular form of interdependence are more ambiguous. Where studies have examined coordination differences, resulting from different rewards systems and task interdependence, results have either not supported performance differences under high task interdependence (Rosenbaum et al., 1980), or they have supported performance differences independent of the level of interdependence (Doer et al., 1996).

Deutsch (1949a) on the other hand, has theorised a direct relationship between the level of cooperation resulting from rewards and the level of coordination. In his theory (reviewed in Chapter 2), reward systems have a direct effect on how individual group members view their individual goals and affect their motivation to interact in the group. Under group rewards, individuals share in the same common reward and hence perceive their goals as common, whereas, under individualistic rewards individuals do not share the same common purpose.

Combining Deutsch's (1949a) theory of cooperation and Hackman and Morris' (1975) theory of group-interaction (both reviewed in Chapter 2) results in the theoretical model developed in this thesis and presented in Figure 3-8. In this model, reward systems have direct consequences to the level of cooperation in the group based on the type of goals they create for the individual group member. Where goals between group members are compatible, the level of cooperation is higher than where goals are not compatible between group members. Cooperation, in turn, has direct effects on the level of group-interaction, which can be thought of in terms of how well group members are interacting with each other. The level of group-interaction then affects both effort (a motivational effect), task strategy (an ability effect) and expertise (an ability effect) of individual group members, which results in different levels of coordination. The final moderator of this difference in coordination is the level of task interdependence, which is the key to whether or not coordination is necessary for successful task performance.

Figure 3-8 Incentive System Model



As coordination of highly interdependent tasks was presented previously as one of the primary reasons for using groups as coordination mechanisms, it is important to examine whether group rewards affect task performance differently to individualistic rewards. Based on the model presented in Figure 3-8, it proposed that group incentives result in more common goals, which have a direct and positive effect on both the level of cooperation in the group and the level of group-interaction. This in turn will increase individual's motivation and ability to coordinate their individual contributions, which in the context of high task interdependence, results in higher task performance. Testing the effect that group rewards have on performance compared to individualistic rewards is the subject of hypothesis H4. Stated more formally:

H4: Groups receiving group rewards will outperform groups receiving individualistic rewards, when the task is high in interdependence.

3.4.2 Fixed-Rate Rewards vs Group and Individualistic Rewards

Another concern to designers of management accounting systems is whether to use piece-rate systems, such as group rewards, or *fixed-rate* rewards to foster coordination necessary under high task interdependence. *Fixed-rate* rewards refer to monetary return to group members independent of either group or individual performance. Interest in this debate has existed in the accounting literature for a long period of time. Traditionally this debate has occurred at the individual level (e.g. Demski and Feltham, 1978; Baiman, 1982), but more recently it has been raised at the group level (Young et al. 1988; Scott and Tiessen, 1997).

At the individual level economists have demonstrated analytically that performance is better with contingent rather than fixed incentives (Demski and Feltham, 1978; Baiman, 1982). Empirical research based on economic theories has provided results consistent with analytic evidence (Chow, 1983; Waller and Chow, 1985). These findings were compatible with research in the organisational behaviour literature, where studies have found that motivation and performance are higher under contingent rewards (Lawler, 1973). Yet studies at the individual level are unable to examine coordination between individuals, which is reflected in the question raised by Young and Lewis (1995) as to whether these results could translate into the group context.

Two accounting studies have empirically examined differences between performance contingent (group rewards) and fixed-rate incentives (fixed-rate rewards). Young et al. (1988) used a castle building task, which required individual subjects to contribute sequentially (i.e. one after the other) to the production of a toy castle. Results from this study showed that group rewards lead to higher group performance than fixed-rate rewards. However, Young et al. also varied the level of interdependence from low (push-manufacturing system with work in process inventory permitted) to high (pull-manufacturing system with work in process inventory prohibited). Young et al. failed to find an interaction effect between task interdependence and the type of reward system used, which leads to the conclusion that group rewards are superior to fixed-rate rewards regardless of the level of task interdependence. It also suggests that increased performance resulting from the reward system was not due to increased coordination, as there was no difference observed across levels of task interdependence, but rather increased physical effort in the production of toy castles.

Scott and Tiessen (1997) took a different approach to Young et al. (1988). They examined group performance differences resulting from basing different proportions of an employee's total remuneration on group performance. The authors tested the relationship between the weight group performance is given in the compensation scheme and group performance through the use of a survey. Scott and Tiessen found this relationship statistically significant. These results are consistent with Young et al. (1988). They show that group performance contingent reward systems (or more precisely, the degree to which they are linked to group performance) have a positive effect on group performance over fixed-rate rewards. However, in contrast to Young et al., this study could not address task interaction with reward systems. Further, the authors did not specifically deal with reasons for increased performance, apart from a general motivational argument.

With the lack of studies focusing on coordination of task interdependence, questions still remain about the differential effect group and fixed-rate rewards have on group performance where the task is high in interdependence. Using the model developed in the previous section (refer Section 3.4.1, Figure 3-8), it is proposed that both group and fixed-rate rewards impact differently on the level of cooperation and group-interaction. Unlike group rewards, which promote goal congruence (as all group members are motivated to strive towards a common group rewards), fixed-rate rewards do not directly promote or detract from a common goal. As group members under fixed-rate rewards are not directly affected by the performance of the group, they have less motivation to cooperate with one another when compared to group members receiving group rewards. As such, fixed-rate rewards result in lower levels of group-interaction and there is less motivation and ability of individual group members to coordinate resulting in lower task performance under high task interdependence. Testing performance advantages from providing group rewards over fixed-rate rewards is the subject of hypothesis H5. Stated more formally:

H5: Groups receiving group rewards will outperform groups receiving fixed-rate rewards, when the task is high in interdependence.

Providing fixed-rate rewards to groups is also an alternative to traditional individualistic performance-based rewards. Group studies in general have not examined fixed-rate rewards as an alternative to individualistic rewards. There have been some studies in the related goal setting literature dealing with the comparison between no-specific goals and individualistic goals (Mitchell and Silver,1990; Crown and Rose, 1995). The goal setting literature is relevant, as both rewards and setting specific goals have direct effects on individuals goals.

In contrast to group rewards, both fixed-rate and individualistic rewards are not expected to promote a common goal among group members. However, fixed-rate and individualistic rewards are different to the degree to which they detract from a common purpose. Fixed-rate rewards, as discussed previously, do not promote or detract the group members' motivation to pursue common goals. In contrast individualistic rewards do detract individuals from pursuing common goals, to the extent that individuals maximising their own performance and therefore their individual reward are incompatible with other group members doing the same. Based on the model developed in the previous section (refer Section 3.4.1, Figure 3-8) it is proposed that fixed-rate rewards result in higher level of cooperation than individualistic rewards, as group members receiving the former type of reward are less likely to pursue goals incompatible with their fellow group members. Higher levels of cooperation in fixed-rate rewards results in higher levels of motivation and ability of individual group members to coordinate their individual contributions, which in the context of high task interdependence, results in higher task performance. Testing the difference between fixed-rate rewards and individualistic rewards on group performance is the subject of hypothesis H6. Stated more formally:

H6: Groups receiving fixed-rate rewards will outperform groups receiving individualistic rewards, when the task is high in interdependence.

3.5 Conclusion

The current chapter has focused on the importance of group structure and feedback, as well as, the importance of rewards on group performance. These factors were considered in the context of highly interdependent tasks. Six hypotheses were developed, which will be empirically tested in two separate experiments discussed in the next chapter.

Chapter 4

Research Method

4.1 Introduction

In order to test the six hypotheses discussed in the previous chapter two separate experiments were conducted. Both experiments were based on the same production-scheduling task. However, the first experiment focused on the effect of group-interaction and feedback aggregation on group performance, while the second experiment examined the effect of reward-linked performance measures on group performance.

The remainder of this chapter commences with a discussion of the common research task. This is followed by a separate discussion of the subjects used in Experiment 1 and 2, as well as, the research design and procedures.

4.2 Production Scheduling Task

4.2.1 Introduction

In designing the common production-scheduling task, three principal considerations were taken into account. First, consideration had to be given to the perceived reality of the task. This was important to ensure a base level of intrinsic motivation, which, was particularly necessary for the first experiment where subjects had to be willing to engage in group-interaction and use accounting feedback without being paid.

The second principal consideration was given to the level of task interdependence. It was theorised in Chapter 3 that the presence of high task interdependence is necessary for issues of coordination to pose a problem for organisations. For this reason, task interdependence was designed to represent a high level of interdependence and was not manipulated.

The third principal consideration was given to the link between the level of coordination and production system performance. Of fundamental interest in this thesis is how coordination demands from high task interdependence are met by the two coordination mechanisms (i.e. groups and feedback aggregation). To ensure that differences in coordination are reflected in task performance (i.e. the dependent variable) noise introduced by other potential factors (such as physical effort exerted to perform the task) had to be controlled. This resulted in the choice of a decision task where subjects did not actually have to exert physically effort. And, further, task performance was a direct function of how well individual subjects coordinated their individual contributions.

Meeting all of the principal considerations is the production-scheduling task that was used in this thesis. The task ensured that, *a priori*, subjects were expected to engage in a highly interdependent task and any changes in the level of coordination resulting from the experimental treatments (discussed later) would result in task performance differences. Each of the three principal considerations and their effects on the form of the production scheduling task will now be examined in more detail, starting with a task description that shows how the task was constructed to be as realistic as possible. This is followed by a description of task interdependence and concludes with a discussion to show how the design permitted the direct relationship between coordination and performance.

4.2.2 Task Description

The overall research task was to schedule production of a complete product in order to maximise the total output of the production system. As production of the product was separated into various production stages, so too, the production scheduling was separated into three individual, but related production scheduling tasks. Each subject participating in the two experiments was assigned to complete the production-scheduling task for one of the production stages. To make the scheduling task more realistic, each separate scheduling task was described as relating to either cutting of raw materials into the shape of the product (manufacturing cell 1), painting the product (manufacturing cell 2) or drying paint on the product (manufacturing cell 3).

Each individual production scheduling task required the subjects to set production targets for two machines (refer Figure 4-1, Figure 4-2, and Figure 4-3). Each machine was dedicated to one part of the product flow, and had to be considered in the context in which it was located. Subjects could not change the position of their machines, as machines were deemed specific to a particular part of the manufacturing process. For example, in each manufacturing cell, machine XA was dedicated to the first pass-through of the product, while machine XB was dedicated to the second pass-through of the product. The first pass-through of the product was described to subjects as consisting of "primary operations" (such as first cutting, painting and drying of the product), while the second pass-through was described as consisting of "secondary operations" (such as final cutting, painting and drying of the product). Each production machine had a specific maximum capacity level, as well as, an associated level of inventory, which determined the amount of production possible for any given period (refer Figure 4-1, Figure 4-2, and Figure 4-3). For example, in manufacturing cell 1, machine 1A has an associated level of inventory as depicted by inventory 1A.

Figure 4-1 Manufacturing Cell 1

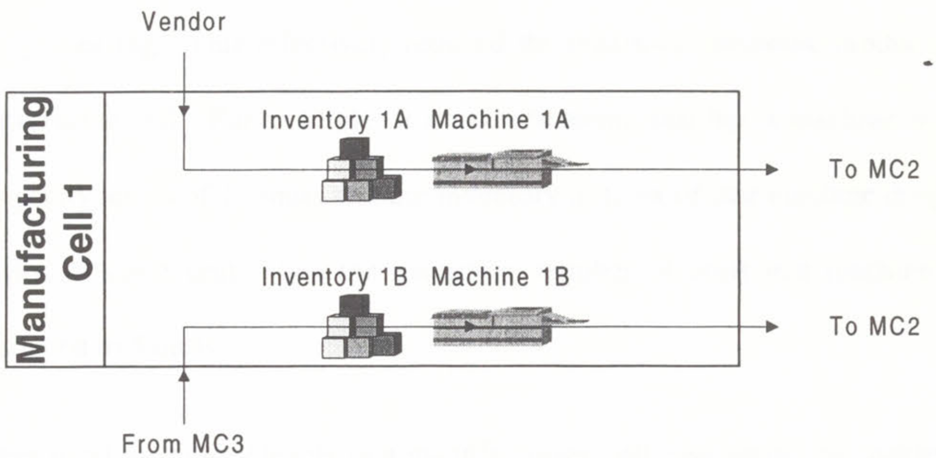


Figure 4-2 Manufacturing Cell 2

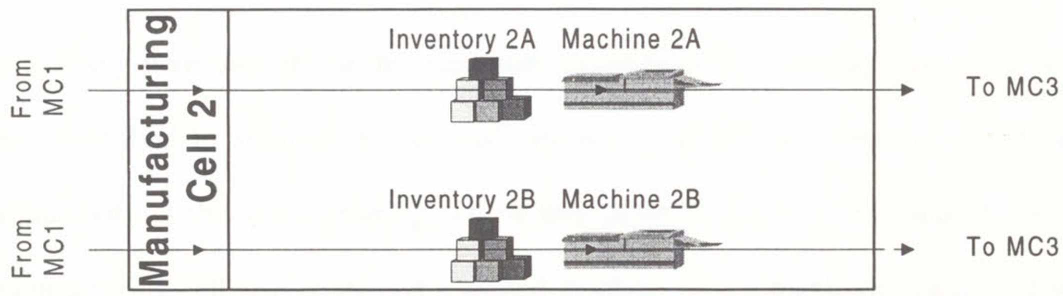
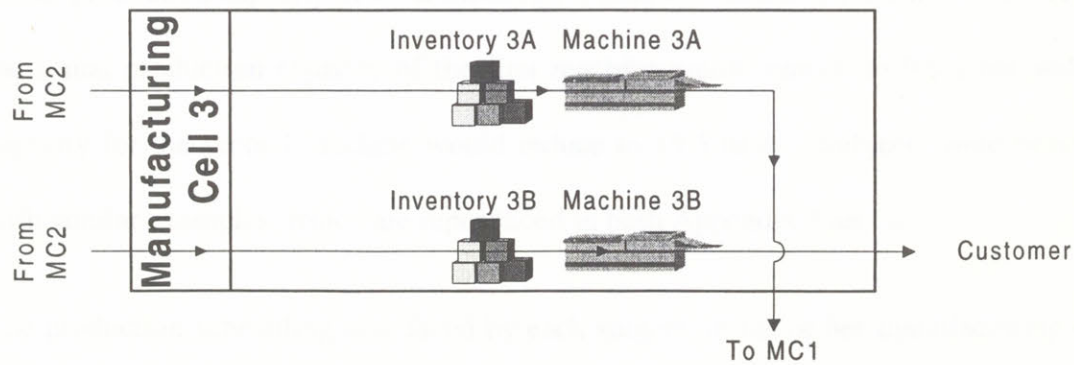


Figure 4-3 Manufacturing Cell 3



Inventory had two types of implications for the potential production levels in each manufacturing cell for each period. For each manufacturing cell, if the inventory for either machine dropped below its maximum capacity of the associated machine, then the associated machine's maximum capacity effectively reduced to the level of inventory available for processing. This effectively reduced the maximum potential productivity of the manufacturing cell. For example, if a manufacturing cell has a machine with a maximum capacity levels of 10 units and the inventory in front of that machine dropped below 10 units, to say 5 units, then the maximum number of units that machine can produce is reduced to 5 units.

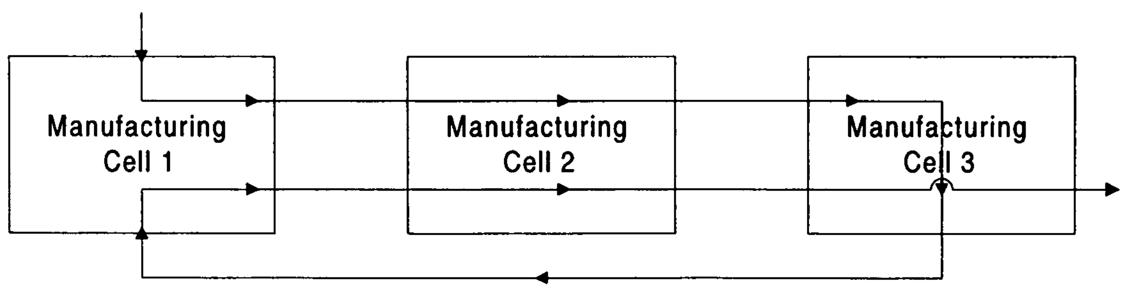
If, on the other hand, inventory levels in a manufacturing cell rose above the maximum capacity for that machine, the maximum capacity of both machines in the manufacturing cell were reduced by a factor of 0.1 for every one unit of inventory above the maximum level. Any inventory above the maximum capacity of the associated machine was, in fact, described to subjects as "excess" inventory, which was deemed to reduce the productivity of the manufacturing cell by this factor of 0.1. For example if that same manufacturing cell also contained a second machine with a maximum capacity level of 20 units and the inventory in front of that machine rose above 20 to 25 units, then the actual production capacity of both machines would be reduced by 0.1 x 5. As a result, the actual production capacity of the first machine would reduce to 9.5 units and the capacity for the second machine would reduce to 19.5 units. Subjects were provided with similar examples, which are reproduced in both Appendix 1 and 2.

The production scheduling task faced by each subject, in his or her manufacturing cell, required a consideration of both current capacity levels of each machine as well as current inventory levels in order to set a specific production level for each of their machines for the period. As such, the production scheduling task involved both capacity and inventory considerations, which the subjects would be familiar with from their studies of organisations and recognise as part of production scheduling. This ensured that they would engage by the task, which was confirmed by observations during the experiment.

4.2.2 Task Interdependence

Consistent with the definition in Chapter 3, task interdependence was created based on decision-flow (i.e. work-flow) resulting from the sequence of individual production scheduling decisions. As illustrated in Figure 4-4, decision flow started with the decision made by subject 1 (in manufacturing cell 1) for the first machine, and ended with the decision made by subject 3 (in manufacturing cell 3) for the second machine. Using Thompson's (1967) work-flow framework, the decision-flow inherent in the current task was of a reciprocal (high interdependence) nature.

Figure 4-4 Reciprocal Work-flow Interdependence



Further, to ensure that the task had a very high level of interdependence, different maximum capacity levels were set for each machine and the location of a bottleneck machine capacity in the final manufacturing cell. By constraining actual production levels of the overall process, it placed demands on individual decision-makers to consider (to the best of their ability) the maximum capacity of the production system as a whole, as any production above that level only increased excess inventory levels at some point or points in the system. These considerations required individual decision-makers to diagnose the decision flow both jointly and simultaneously in order to optimise the production system as a whole. By introducing a joint and simultaneous requirement into the task, the level of task interdependence was elevated above reciprocal interdependence to that of "team" interdependence, as described by Van de Ven et al. (1976).

A final design choice was made to make the implications of high interdependence for overall system performance immediate as soon as subjects started the main task. This choice involved the use of a production line that already contained excess inventory. By doing this, any decision had the immediate potential of either increasing excess inventory and, hence, decreasing the overall production level of the production system or decreasing excess inventory and, hence, increasing overall production levels. This choice was justified to subjects by describing their mission to take over an existing production line, which had been operating for a few periods. The starting point was, in fact, the outcome of a three period simulation using maximum production levels for each manufacturing cell (this leads to an immediate accumulation of inventory as the bottleneck, which sets the production pace, is ignored).

4.2.3 Performance Link

The final principal consideration in designing the production-scheduling task was the link between coordination and performance. Two steps were taken to ensure that the differences in the level of coordination between individual scheduling decisions were reflected in performance differences of the production system. The first step involved the removal of physical effort relating to any actual production, and the second step involved simulations performed to anticipate differences in outcomes based on two extreme levels of coordination (perfect vs imperfect coordination).

Prior studies that have examined differences in coordination resulting from particular coordination mechanisms (such as groups in Young et al., 1993) have often used tasks that, not only demanded coordination (like task interdependence), but also required physical effort in producing an actual product. By including physical effort in task performance these studies have run the risk of drawing conclusions about the effectiveness of coordination mechanisms based on performance differences (or lack thereof) that are potentially driven by differences in physical effort, or a trade-off between physical effort and coordination. As this thesis is only concerned with differences in coordination, physical effort was removed from the task. As a result of this design step, subjects were only required to set production levels without subsequently being required to physically produce a product at that level.

In addition to the removal of physical effort from the task, the second design step centred on the potential for a sufficiently large variation in performance. Potential variation is important, as power in any subsequent statistical test rests on a combination of potential variation (i.e. effect size) and sample size (Cohen, 1988). Sample size considerations were constrained by the number of students in the course (and hence available) and the number of treatments necessary. With a fixed sample size, increases in anticipated effect size increases the power of subsequent statistical tests (Lindsay, 1993). Maximum power in the statistical test is desirable, to avoid the probability of failing to reject the null when it is false (Type IV error). Simulations were run using different capacity and inventory levels in order to calculate anticipated effect sizes. Final capacity and inventory levels used in this task reflected a sufficiently large effect size resulting from potential differences in the level of coordination. In other words, where systematic differences in the level of coordination resulted from the treatments, associated production levels were anticipated to be large enough to be detected by statistical tests.

Taken together, these two design steps ensured that the production performance reflected differences in the level of coordination, and further that these differences were anticipated to be large enough to be detected by subsequent statistical analysis.

4.2.4 Summary

With the three principal design choices taken into account, the production scheduling task was anticipated to provide sufficient inherent motivation for subjects to engage in the task, while ensuring a high level of task interdependence and an appropriate performance measure in production output. With the task being the only commonality between the two experiments, each experiment will now be discussed separately in terms of the subjects used, its treatments and the experimental procedure.

4.3 Experiment 1

Experiment 1 was designed to investigate structural responses to high task interdependence. The role of group-interaction and feedback aggregation was of particular interest. This section details how the experiment was set up and administered to enable direct testing of these two coordination responses.

4.3.1 Subjects

Two hundred and four subjects participated in the experiment. Of the 204 subjects, six participated in the two-stage pilot tests (one primary and one secondary pilot test each). Of the remaining 192 subjects, 12 subjects were eliminated during the running of the experiment due to printer problems (two groups), sickness (one group) and failure to understand the experiment (one group). That left a total of 180 useable subjects in 60 groups. The average age of the subject was 21 years and ranged from 19 to 32 years. All subjects were enrolled in the same third-year management accounting subject at the time of the experiment, which ensured a homogeneous level of expertise (refer footnote 15).

4.3.2 Experimental Design

The experiment involved a 2 x 2 completely crossed research design. Each cell contained 15 groups. Two independent between-subject variables were group structure (group-interaction vs non-interacting individuals) and feedback (local vs global). The dependent variable was output performance in the eighth (final) production period. The rationale behind using final period output as the performance measure, is found in the common output starting point. Regardless of the treatment, all groups started from the same production output point, which was determined by the initial production capacity of the bottleneck machine. Over subsequent periods, group members could improve, stabilise or decrease the production performance of the system through their individual decisions. Using the final period output potentially maximises the variation induced by both the interaction and feedback treatments.

In terms of the experimental manipulation, group-interaction was operationalised by providing group members with an opportunity to interact. In contrast, non-interacting individuals who had to complete the task on their own were not permitted to interact[23].

As to feedback aggregation, local performance feedback was operationalised by providing each subject with an individual feedback report reflecting his or her own individual performance. This consisted of one column indicating the individual's own output-performance, as well as the inventory levels and production capacity available (refer Appendix 1 for a sample of this type of feedback). Global feedback, on the other hand, was operationalised by providing each individual with a more comprehensive feedback report. This report contained four columns, with the first three columns containing the performance information relating to the three individuals in the production systems, as described above, and the final column containing information about the overall output performance of the group. Information provided also reported inventory levels and the overall production capacity for the group.

[23] Absence of interaction in treatments where individuals were not permitted to interact was achieved by seating subjects behind each other and prohibiting them from talking during the experiment. Group-interaction on the other hand was achieved by seating the group members together at one table and expressly allowing them to talk during the experiment.

All treatment groups performed the same task, which was designed to exhibit high task interdependence. The design considerations, which ensured high task interdependence, have been discussed previously in this chapter in Section 4.2.2. Finally, subjects in all treatments received maximisation of production system output as a specific goal. Such a global goal was necessary, as the focus of the first experiment was on the facilitation of coordination (through group-interaction and feedback aggregation) rather than the motivation, which drives individuals to interact or use feedback. The motivation to interact is more specifically examined in Experiment 2, where the effect of reward systems on group-interaction is examined in more detail. In order to provide motivation for individuals to engage in group-interaction (where permitted) and use the additional information provided by global feedback (where available) the global goal was set. That is not to say, and indeed the opposite has been theorised in Chapter 3, that once individuals in the interacting-groups and global feedback treatments make use of these coordination methods their motivation levels will not be affected.

A series of manipulation check questions were included in the post-test questionnaire (these questions are reproduced in Appendix 1 along with all of the materials subjects received during the experiment). A further series of checks dealing with the perceived level of task interdependence, the common goal, and the general understanding of machine capacities, were also included. A discussion of these manipulation checks is included in the discussion of results in Chapter 5 (Section 5.2.1).

4.3.3 Experimental Procedures

Subjects were asked to sign up for a two-hour time block at the beginning of the semester. They were, subsequently, randomly allocated to one of four treatment cells. Each subject was contacted and informed about his or her particular time block. Overall, three time blocks were run per day for four days a week over a period of four weeks. In the majority of cases two groups completed the experiment in each time block. The treatment condition for the two groups in any time block was always the same to facilitate easier administration of the task, as some of the instructions were simultaneously provided to each group. Some of the time blocks consisted of only one group.

Upon arrival at the dedicated experimental room, the researcher assigned each subject to a particular group and a particular manufacturing cell within that group. The room was set up in such a fashion that a screen separated the two groups from each other. However, the screen did not prevent both groups from seeing the researcher. Once seated, the researcher introduced the research assistant and proceeded to read through a detailed script, which remained consistent throughout the four weeks. The script outlined the general instructions and background information. Then the researcher proceeded to read through the specific treatment instructions of the experiment with the subjects. This was done to ensure all subjects were exposed to all the information. The same procedure was followed across all experimental sessions to maintain consistency and control for researcher expectancy effects (Rosenthal, 1966).

Subsequent to receiving all relevant instructions, subjects in all treatment conditions completed a training session. The training session involved three production-scheduling decisions and lasted for 15 minutes. The sequencing of decisions was as follows. Groups initially received information necessary to make the first production decision, and were allowed a 5 minute period to make the decision. Upon completion, decision sheets were collected by the researcher and keyed into a spreadsheet package only visible to the researcher and the research assistant. A computer printout of the relevant feedback was returned. The previous feedback sheet was also returned to subjects for reference purposes. Printing of the feedback report took approximately two minutes. Subjects were then given another three minutes to make their next decision. During the training period individuals made all decisions in isolation, all individuals were prohibited from interacting and only local feedback was provided to each individual. This procedure was repeated for the three decision periods. Mechanics of the task used in the training session were identical to the ones later used in the main experiment. However, all numbers used for capacities, inventories and output were changed to avoid over sensitising subjects for the main part of the experiment. Another difference between the training session and the actual experiment, was the use of a balanced line for the training session. A balanced line was chosen to simplify the task and assist learning. Subjects were told that their training was conducted at a sister company, and would be similar to the production scheduling they had to undertake at the actual company.

The training session was conducted to avoid potential learning biases with the task. Duration of the training session was judged to be sufficient given observations from the pilot test. In addition, other studies have found that subjects can learn their task after the first period in a 3 period experimental task (Waller 1988) or after 15 minutes (Young, 1985; Young et al., 1988; Young, et al. 1993).

Upon completion of the training session, all training materials were collected. Post-training questionnaires were distributed, and subjects were asked to identify whether the capacity of each of the two machines under their control could drop in capacity (yes or no). They were also required to indicate whether the inventory in front of each machine could have an effect on the production capacity of the machines (yes or no). These questions were asked to ensure subjects understood the key concepts of machine capacity and inventory and the relationship between the two. Post-training questionnaires were collected and immediately corrected by the researcher or the research assistant. In cases where the subject responded incorrectly, he or she was informed, and attention was drawn to the appropriate passage in the material. Once this process was completed the researcher was satisfied that the subjects had sufficient understanding of the experimental material to undertake the main experiment.

The main experiment consisted of eight decisions. Subjects received a new set of task descriptions, which varied only in terms of the inventory and capacity figures. The main experiment started with the production line unbalanced and subjects were told that it was unbalanced as it had been operating for a few periods prior, and that they were replacing the previous production schedulers. At the start of the main experiment all groups were assigned to one of the four treatments.

Upon completion of the main experiment, a post-test questionnaire was distributed, which contained questions about the demographics of the subjects and manipulation checks. The relevance of the post-test questionnaire is discussed in Section 4.5

4.4 Experiment 2

The second experiment was conducted specifically to test for differences in reward systems. Of particular interest here were differences in performance resulting from group, individual and fixed-rate rewards. This section details how the second experiment was set up to test for these differences.

4.4.1 Subjects

One hundred and fifty subjects enrolled in the second year management-accounting course participated in the experiment. Of those 150 subjects, nine participated in a pilot test of the instrument. Of the remaining 141 subjects six (two groups of three) were eliminated due to computer failure[24]. This left 135 useable subjects in 45 groups (15 groups in each treatment cell) for the experimental part of the study. The average age of the subjects was 20 years and ranged from 18 to 32 years.

4.4.2 Experimental Design

The design involved three reward treatment cells with subjects randomly assigned to groups of three members in each treatment cell. One reward treatment consisted of group rewards, in which each group member received an equal share of the group

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[24] The computer simulation collapsed without providing saved information. As all entries were made via the computer, the responses for these subjects were lost.

reward based on group performance. The second treatment consisted of individualistic rewards, where each group member received a reward based on their own performance. And finally, a third treatment consisted of a fixed-rate reward, where each group member received a fixed amount regardless of his or her individual performance or the group's performance.

The reward systems for each treatment group was structured so as to ensure that all treatment groups had the same potential of earning approximately the same amount of total rewards for the entire experiment. This was an important consideration, as the focus of this thesis centres on the link between performance and rewards. As the aim of this experiment was to permit conclusions about performance differences resulting from different performance criteria (i.e. group, individualistic and fixed-rate), it was necessary to rule out potential performance differences based on simply proving one treatment group with more money for the same level of performance. The latter is always assumed to lead to greater effort and performance, as individuals always prefer more rewards to fewer rewards.

Balancing the earning potential between treatments was based on several production line simulations. Optimal production strategies for coordinating the task were simulated and actual pay-offs were calculated for each strategy. Optimal production strategies were based on the assumption that individuals, where permitted, would maximise their own wealth. Based on alternative strategies available to group members total pay-offs to the group were calculated and rates were adjusted to balance the total earned by each group under these strategies.

In contrast to the first experiment, the second experiment used a computer-based task. The program was written to run under Windows 95 and subjects had to enter all information into the computer. Reasons for using a computer-based task were fourfold. First, it permitted quicker feedback of information relating to the decision at hand (i.e. production capacities, inventory levels etc.). In the previous experiment these reports had to be manually printed between each decision. The delay caused by printing was eliminated, as reports were immediately available after each decision. Second, the amount of information returned to subjects was greater, as reward information had to be included in addition to all the other information returned to subjects in the first experiment. Printing the extra information manually would have caused further delays between decisions. Third, it was a conscious choice to permit subjects to proceed at their own pace, to ensure they were comfortable with the decision point. With a computerised task, it was possible to run several groups concurrently as each group could proceed at its own pace. Finally, using a computer-based task reduced some potential problems associated with manually printing large quantities of information (such as paper jams etc.).

The dependent variable in the experiment was total group output over all production periods. Total production was chosen as the dependent variable for two reasons. Subjects' ability to self-pace was the first reason. Because of self-pacing, not all treatment groups ended up with the maximum of 12 decisions. It was therefore not possible to use the final period output as in Experiment 1. The second related reason for choosing total production was the relationship between time and ending production level. Subjects had to balance time to think with the decision to act. Too much time spent on thinking about the optimal decision could potentially lead to a lack of production decisions. Optimal output in this system is achieved with careful, yet, fast decisions. This makes total output more feasible than final period output, as total output takes both the number of decisions and the decision quality into account.

Similarly to the first experiment, all treatment groups received the same task, which was designed to exhibit high task interdependence. The design considerations, which ensured high task interdependence, have been discussed previously in this chapter in Section 4.2.2. Unlike the first experiment, subjects in all treatments did not receive a specific goal. The rationale was that, contrary to the first experiment, the reward system treatment was a goal setting technique in itself. Setting another specific goal had the potential of confounding two types of goals. Whether organisational goals set explicitly can interact with goals derived from the reward system is beyond the scope of this thesis.

To ensure the treatment manipulation worked, a series of manipulation checks were built into the computerised experimental task. The post-test questionnaire contained further checks on task interdependence and task understanding (refer Appendix 2).

4.4.3 Experimental Procedures

Subjects were asked to sign up for a two hour time block at the beginning of the semester. Then, they were randomly allocated into one of the three treatment cells. Each subject was contacted and informed about his or her particular time block. An average of three time blocks was run over five days a week for two weeks. In the majority of cases three groups completed the experiment in each time block. The treatment condition for the three groups in any one block was always the same to facilitate easier administration of the task, as some of the instructions were simultaneously provided to each group. Some of the blocks consisted of only one or two groups.

Upon arrival at the dedicated experimental room, the experimenter randomly assigned each subject to a particular group and a particular manufacturing cell within that group. Each group was seated at a computer terminal, from which they could retrieve information about the production process and reward system. All group decisions were input into the same terminal for all experimental groups. The room was set up in such a fashion that a screen separated the three groups from each other. However, the screen did not prevent groups from seeing the experimenter. Once seated, the experimenter introduced the research assistant and proceeded to read through a detailed script, which remained constant throughout the two weeks of the experiment. The script outlined general instructions about the procedure of the experiment and some background information. The researcher then proceeded to read through the treatment specific information with the subjects. This was done to ensure all subjects were aware of all the information. The same procedure was followed across all experimental sessions to maintain consistency and control for researcher expectancy effects (Rosenthal, 1966).

After completion of the instructions, subjects in all conditions received a brief introduction on how to interact with the computer program that simulated the production environment. Subjects were informed that the computer program was self paced and they were reminded that they would be paid the amount earned during the experiment. The training period was conducted at the group level and excluded from payment. After these instructions, subjects received further detailed information on their training-manufacturing cell and commenced the training period. While the training period was excluded from payment, subjects did receive information about the amount they would have earned. The structure of their reward system during the training period was consistent with that in the main part of the experiment (i.e. subjects receiving group rewards did so both in the training period and the main part of the experiment). The training period involved a maximum of two production decisions. The average training period was twenty-eight minutes[25], ranging from fifteen minutes to thirty-four minutes. Subjects were reminded that this was only a training-run after twenty-five and thirty minutes. However, they were not forced to make a decision.

Upon completion of the training session, all training materials were collected. Subjects undertook a self scored post training questionnaire (at the group level), which asked subjects to identify whether the capacity of each of the two machines under their control could drop in capacity (yes or no). It also asked whether the inventory in front of each machine could have an effect on the production capacity of the machines (yes or no). These questions were asked to ensure subjects understood the key concepts of machine capacity and inventory and the relationship between the two. A further question was asked as to whether their reward was linked to the output of the individual manufacturing cell, the company as a whole or neither. This question was asked to ensure subjects understood the reward system in place. In the instance of a wrong

[25] Studies have found that subjects can learn their task after the first period in a three period experimental task (Waller 1988) or after 15 minutes (Young 1985; Young et al. 1988; Young et al. 1993). As such, we are satisfied that the training period was adequate for the subjects to learn the task.

response, the computer program prompted the subjects to reconsider and gave the reason for reconsidering. Groups were only permitted to continue when all questions were correctly answered.

The main experiment consisted of a maximum of 12 production decisions within a time limit of 60 minutes. The average time taken by groups in the main experiment was 47 minutes with a range between 25 and 56 minutes. The main experiment started with the production line unbalanced and subjects were told that it was unbalanced as it had been operating for a few periods prior, and that they were replacing the previous production schedulers. Subjects received further material relating to the operation of their particular manufacturing cell in the main part of the experiment. Upon completion of the main experiment, a post-test questionnaire was distributed, which contained manipulation check questions, as well as exploratory questions.

4.5 Post Test Questionnaire

Post-test questionnaires for both experiments, which are reproduced in Appendix 1 (Experiment 1) and Appendix 2 (Experiment 2), contained primarily manipulation check questions, as discussed previously in this Chapter in Sections 4.3.2 and 4.4.2. In addition, both post-test questionnaires contained a series of questions relating to the underlying psychological differences resulting in the variation of coordination and ultimately task performance. For the first experiment these questions (reproduced in Appendix 1) specifically examined the motivation and ability of subjects to coordinate. For the second experiment these questions centred specifically on variation in conflict resulting from differences in cooperation (refer Appendix 2 for these questions). These additional questions were used to support the primary analysis based on task performance.

Approaches to the post-test questionnaire varied between the two experiments. Reasons for the variations between the two post-test questionnaires are fourfold. First, additional questions were included in the second post-test questionnaire which dealt specifically with cooperation (measured in terms of conflict due to earlier difficulties experienced by Deutsch (1949b) in trying to measure cooperation directly). Second, some of the earlier questions on motivation and effort were omitted to keep the post-test questionnaire more manageable. The rational for omitting these questions was that results from the first post test questionnaire already established the relationship between interaction and motivation/effort. Third, the second post-test questionnaire reverted back to a traditional 7-point Likert scale, as the continuous scale used in the first post-test questionnaire did not benefit the analysis as much as anticipated. Significantly different responses tended to be larger than one interval on a Likert scale. Finally, multiple questions were used for some of the variables of interest (such as conflict) to increase construct validity (also some of these questions were drawn directly from prior literature such as the conflict questions which originated in a study by Jehn (1995)). The benefits gained from these variations permitted better testing of the relationships of interest in the second experiment, and thus outweighed benefits from keeping a consistent post-test questionnaire across both experiments.

4.6 Conclusion

This chapter has outlined the nature of the production-scheduling task, which was utilised in both experiments. It further described the experimental design of each of the two experiments along with a detailed account of the subjects involved and the experimental procedures. Taken together the two separate experiments form the basis for testing the six hypotheses developed in the Chapter 3.

Chapter 5

Results and Discussion

5.1 Introduction

Due to the sequential nature in which the two experiments were conducted, the results of each experiment are dealt with separately in this chapter. The remainder of this results and discussion section is structured as follows. First, manipulation checks are presented, followed by descriptive statistics and hypothesis testing for each experiment. Second, a discussion of the results is presented, along with further analysis using post-test questionnaire responses.

5.2 Experiment 1

The first experiment investigated the individual effects as well as joint effects of using group-interaction and feedback aggregation to coordinate highly interdependent tasks. Although subjects were randomly allocated to treatment cells, demographic data relating to the age, gender and status of study program was analysed to test for potential systematic differences in subjects between treatments. Tests for age and status of study program differences were conducted to ensure that subjects in each treatment group had similar levels of experience both in their personal and professional lives, which potentially affects how they approach the experimental task. Tests for gender differences were conducted to make sure each treatment group contained similar numbers of males and females. Systematic differences in gender make up of groups have the potential of affecting group communication due to differences in communication style between males and females (Ahn, 1996). Table 5-1 and Table 5-2 contain the descriptive demographic data. Results from statistical analysis of the data indicated no significant differences across treatment cells. As such, it is concluded that the random assignment to treatment cells was effective on the basis of age, gender and status of study program.

Table 5-1 Experiment 1 - Descriptive Statistics (Demographic Data)

	Age
Mean	21.011
S.D.	1.677
Minimum	19
Maximum	32

Table 5-2 Experiment 1 - Descriptive Statistics (Demographic Data)

	Sex
Female	91
Male	89
	Study Program
Full Time	175
Part Time	5

5.2.1 Manipulation checks

The relevance to the research hypotheses of the first experiment rested on four underlying conditions, which will be examined separately. The first condition related to the level of task interdependence. The task was designed to be highly interdependent (refer Chapter 4), and for the purpose of this experiment it was necessary that subjects also perceived this to be the case. The first manipulation check examines subjects' perceived level of interdependence. Second, subjects had to be aware of the common goal set explicitly in this experiment. The relevance of this common goal on motivation was discussed in Chapter 4. Third, subjects had to be aware of the nature of the treatment to which the were allocated. Finally, subjects had to understand the important relationship between excess capacity and actual capacity of their machines (refer Chapter 4).

Interdependence

The importance of high task interdependence was discussed in Chapter 3. Task interdependence itself was not manipulated in this experiment (i.e. the nature of the task was exactly designed so to ensure a high level of task interdependence as described in Chapter 4). Two questions in the post-test questionnaire (refer Appendix 2) examined subjects' perception of the task interdependence level directly. Responses to "To what extent did your production decision affect the production decision of the other manufacturing cells?" and " To what extent did other manufacturing cells' decisions affect the production decision of your manufacturing cell?" are reported in Table 5-3 and Table 5-4 respectively. The mean responses for all treatment groups for both questions were well above the mid-point of the scales indicating an overall perception of high task of interdependence. However, statistical analysis also showed that subjects in interacting groups perceived a significantly greater level of interdependence ($F_{1,176} = 32.559$, $p = 0.001$ and $F_{1,176} = 5.133$, $p = 0.024$ respectively) than subjects in non-interacting groups.

Table 5-3 Experiment 1 - Mean (SD) of Perceived Impact of Own Decision on Other Manufacturing Cells' Decisions

	NI	IG	Average
LF	86.244	105.556	95.900
	(28.673)	*(20.791)*	
GF	80.422	106.556	93.489
	(36.906)	*(22.264)*	
Average	83.333	106.056	**94.695**

NI = Non-Interacting Individuals, IG = Interacting Groups
LF = Local Feedback, GF = Global Feedback
Theoretical Range 1 (Not at all)- 127 (To a Great Extent)
N = 180

Table 5-4 Experiment 1 - Mean (SD) of Perceived Impact of Other Manufacturing Cells' Decisions on Own Decision

	NI	IG	Average
LF	86.489	97.289	91.889
	(35.433)	*(31.463)*	
GF	90.800	100.867	95.834
	(33.736)	*(20.822)*	
Average	88.645	99.078	**93.861**

NI = Non-Interacting Individuals, IG = Interacting Groups
LF = Local Feedback, GF = Global Feedback
Theoretical Range 1 (Not at all)- 127 (To a Great Extent)
N = 180

Common Goal

As discussed in Chapter 4 (Section 4.3.2), a common goal was set to ensure subjects had the initial motivation to make use of the group-interaction and aggregated feedback. Subjects' understanding of this goal was assessed by their response to the following post-test questionnaire item "To what extent were you motivated to act in the best interest of Advac (i.e. maximise the output of the final product) as a company?". Responses are reported in Table 5-5, and show that on average all subjects had a fairly high level of understanding of the group goal (96.28, with the mid-point of the scale being 63.50). It is, therefore, concluded that the setting of common goal was successful in experiment 1.

Table 5-5 Experiment 1 - Mean (SD) of Perception of a Group Goal

	NI	IG	Average
LF	82.711	99.978	91.345
	(33.762)	*(28.537)*	
GF	96.333	106.133	101.233
	(25.579)	*(18.479)*	
Average	89.522	103.056	

NI = Non-Interacting Individuals, IG = Interacting Groups
LF = Local Feedback, GF = Global Feedback
Theoretical Range 1 (Not at all)- 127 (To a Great Extent)
N = 180

Group-interaction and Feedback Aggregation Treatments

The first experiment involved two manipulations (work structure and feedback aggregation). Looking first at the work structure manipulation (interacting groups vs non-interacting individuals), which was enforced by the researcher at the time the experiment was conducted. Subjects in the non-interacting individual treatment were prohibited from interacting during the experiment, while interaction was expressly encouraged in the case of interacting groups. Non-interacting individual treatment groups were prohibited from interacting (e.g. they were seated separately one behind the other) and observed to abstain from interacting during the experiment, while interacting groups engaged in active interaction. The level of interaction and the cooperation, which results from interaction, was assessed by subjects' responses to the following statement "To what extent was there cooperation between the members of your group?" Responses are reported in Table 5-6 and show that subjects in interacting groups perceived a significantly higher level of cooperation ($F_{1,175} = 206.173$, $p = 0.001$) than subjects in the non-interacting individual treatments. It is, therefore, concluded that the group-interaction manipulation was successful.

Table 5-6 Experiment 1 - Mean (SD) of Extent of Interaction between Individuals in Manufacturing Cells

	NI	IG	Average
LF	38.067	105.489	71.778
	(39.064)	*(22.428)*	
GF	36.295	102.489	69.392
	(29.869)	*(30.850)*	
Average	37.181	103.989	

NI = Non-Interacting Individuals, IG = Interacting Groups
LF = Local Feedback, GF = Global Feedback
Theoretical Range 1 (Not at all)- 127 (To a Great Extent)
N = 180

Turning next to the feedback aggregation manipulation, this was achieved by providing either local or global feedback. Subjects in all treatment groups used the information supplied and perceived it to be of value, as reflected in their responses to the following post-test questionnaire question "How useful was the accounting report in setting your production target?" (refer Table 5-7). Overall, the average response for all groups was above the mid-point of the scale while global feedback was perceived to be significantly more useful than local feedback ($F_{1,176} = 12.293$, $p = 0.001$). It is therefore concluded that the feedback manipulation was successful, as it was both useful and perceived to be relatively more useful by individuals receiving global feedback.

Table 5-7 Experiment 1 - Mean (SD) of Perceived Usefulness of Feedback

	NI	IG	Average
LF	64.156	93.267	78.712
	(36.389)	*(31.949)*	
GF	93.333	95.822	94.578
	(30.037)	*(22.264)*	
Average	78.745	94.545	

NI = Non-Interacting Individuals, IG = Interacting Groups
LF = Local Feedback, GF = Global Feedback
Theoretical Range 1 (Not at all)- 127 (To a Great Extent)
N = 180

Capacity Considerations

An important aspect of the main task was the unbalanced nature of the production line. In order to test the subjects' understanding of the scope for balancing the line two questions were asked to see first, if subjects were aware of potential increases in their machine capacities when inventory decreased, and second, if subjects attempted to control the amount of excess inventory in the system. The first question asked subjects the following: "Under circumstances where there is no excess inventory in the manufacturing cell, what is the maximum production capacity of Machine XA (units) and Machine XB (units)?". For this first question, five subjects failed to respond to the question (refer Table 5-8). Of the remainder six (3%) incorrectly stated one of their machines' capacity whilst 18 (10%) incorrectly stated both of their machine's capacities. There were no statistically significant differences between treatment groups. As the number of subjects responding with the incorrect production capacity was fairly high, each incorrect answer was further investigated to determine the reason behind the deviation.

Table 5-8 Experiment 1 - Descriptive Statistics (Validity Checks)

	Production Capacity NI/ LF	NI/ GF	IG/ LF	IG/ GF
Correct answer	41	40	37	33
Incorrect answer	4	5	7	8
Missing answer	0	0	1	4
Total number of subjects	45	45	45	45
Pre-test max	0	0	0	2
Actual cell max with no inv.	1	0	0	0
Final period cell max	1	0	2	1
Final period cell/system max	0	0	2	0
First period cell max	0	2	0	0
Total system max	0	2	0	2
Initial equilibrium max	0	0	0	2
Mistake	1	0	0	1
Unexplained	1	1	3	0
Total incorrect answers	4	5	7	8

NI = Non-Interacting Individuals, IG = Interacting Groups
LF = Local Feedback, GF = Global Feedback

Of the incorrect answers, subjects interpreting the question differently to the original intent of the researcher, could explain 19 (79%) errors. The eight categories of deviations that took place were as follows: Two subjects answered in terms of the pre-test maximum production capacity of their manufacturing cell. One subject interpreted the question to mean the actual capacity of the manufacturing cell when there was no inventory in the cell. Four subjects answered with the maximum capacity of their manufacturing cell in the final production period, whilst two subjects answered with the maximum capacity possible given the aim to maximise the total system output. Two subjects answered with the maximum capacity of their manufacturing cell in the first production period. A further four subjects interpreted the maximum as the total system maximum capacity. Two subjects answered with the first period maximum capacity of the total system. And finally two subjects made mistakes in omitting zero's from their answer and reading from the wrong column in the report. This left a final 5 subjects (2.8%) for which the incorrect answer given could not be interpreted. The distribution of the final 5 unexplained answers along with the explained answers is illustrated in Table 5-8. A Wald Chi-Square analysis was conducted to test for differences in distribution between treatment groups for the final 5 unexplained incorrect answers. No significant difference was found ($\chi^2_3 = 2.68$, $p = 0.446$).

For the second question, subjects had to respond to the statement "in setting production targets, to what extent did you attempt to control excess inventory". The average response was 98.11 (refer Table 5-9) , which was well above the mid-point of the scale. Subjects in the interactive group treatments perceived their attempts significantly higher ($F_{1,175} = 16.110$, $p = 0.001$) than those in the non-interactive individual treatments. All groups responded relatively high to this statement.

Table 5-9 Experiment 1 - Mean (SD) of Attempt to Control Excess Inventory

	NI	**IG**	**Average**
LF	92.089	103.600	97.845
	(31.230)	*(21.589)*	
GF	90.889	105.889	98.389
	(29.025)	*(16.332)*	
Average	91.489	104.745	

NI = Non-Interacting Individuals, IG = Interacting Groups
LF = Local Feedback, GF = Global Feedback
Theoretical Range 1 (Not at all)- 127 (To a Great Extent)
N = 180

5.2.2 Descriptive Statistics

Statistical Tests

In order to test the first three hypotheses discussed in Chapter 3, a number of statistical procedures using SYSTAT (1994) were employed. The overall analysis was conducted using a 2 x 2 ANOVA (Hayes, 1988; Tabacknick and Fidell, 1989; Harsha and Knapp, 1990). The analysis was conducted on the eighth[26] (final) period output of the manufacturing system, as discussed in Chapter 4.

Descriptive Statistics

The descriptive statistics are presented in Table 5-10 and Figure 5-1. Several general patterns can be observed from the descriptive data. The performance of interacting groups was on average higher ($\bar{X} = 7{,}700$) than the performance of non-interacting individuals ($\bar{X} = 2{,}272$). Further subjects receiving global feedback ($\bar{X} = 5{,}365$) performed on average higher than subjects receiving local feedback ($\bar{X} = 4{,}608$). Thus from Figure 5-1 it appears that there is an interaction between group-interaction and feedback aggregation, with global feedback assisting non-interacting individuals, but not interacting groups.

[26] Due to the common starting point of all groups, there was less chance in the earlier period to reflect the differences in output caused by the treatments.

Figure 5-1 Interaction between Structure and Feedback

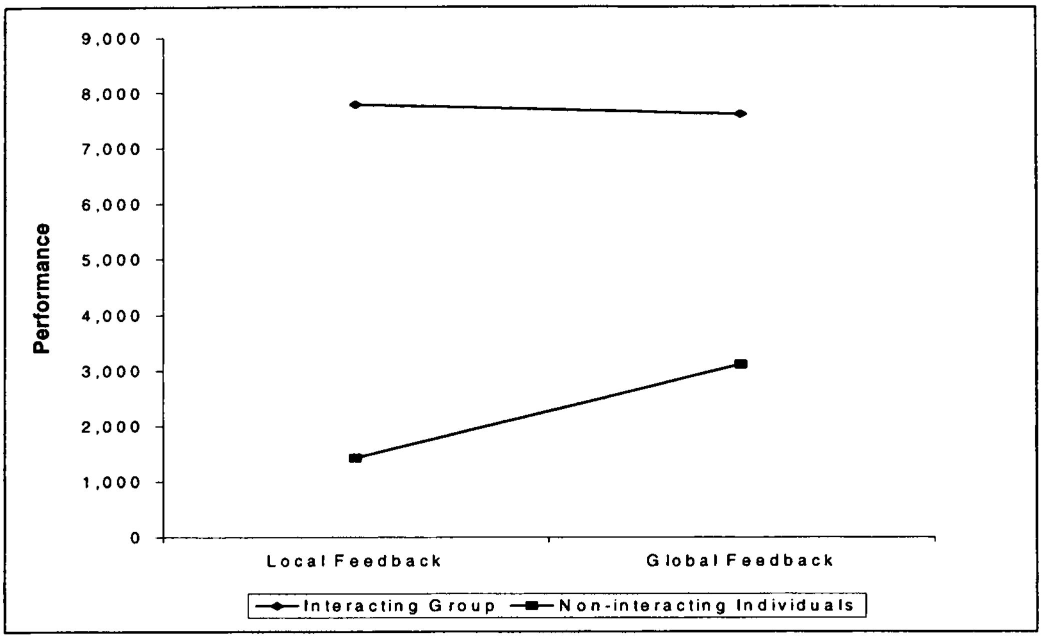

Table 5-10 Means (SD) of Group Performance in Period 8 (n=15 Groups per Cell with Three Subjects per Group

	Structure/ Performance Feedback Manipulation			
	IG		NI	
Group Output	*LF*	*GF*	*LF*	*GF*
Mean	7,786.80	7,612.87	1,428.33	3,116.40
S.D.	1,675.82	1,370.84	1,581.45	2,368.29

5.2.3 Hypothesis Testing

Hypothesis H1: The first hypothesis proposed a performance advantage for interacting groups over non-interacting individuals, when the task is high in interdependence. The main effect for work-structure was found to be significant ($F_{1,56} = 133.924$, $p = 0.000$, refer Table 5-11). This significant difference was due to interacting groups outperforming non-interacting individuals. A total of 47% of group performance variation was explained by this difference ($\hat{\omega}^2 = 0.47$, refer Table 5-12). Thus Hypothesis 1 was supported.

Table 5-11 Analysis of Variance of Production System Performance in Period 8

Summary of ANOVA					
Source	SS	df	MS	F	p
Structure	441,861,000	1	441,861,000	133.924	0.000
Feedback	8,597,249	1	8,597,249	2.606	0.112
Structure x Feedback	13,001,400	1	13,001,400	3.941	0.052
Error	184,764,000	56	3,299,349		

Table 5-12 Percentage of Variance Explained by Each Variable

Source	$\hat{\omega}^2$
Structure	0.47
Feedback	0.06
Structure x Feedback	0.11

Support of Hypothesis 1 shows that the use of interacting groups provides a performance advantage over non-interacting individuals. Performance advantages in this task are directly attributable to the level of coordination by each individual as discussed in Chapter 4. Support for Hypothesis 1 therefore shows that group-interaction assists individuals with coordinating their individual contributions to the task. The advantage of group-interaction in assisting coordination was theorised in Chapter 2 and 3 to result from providing group members with both a better motivation and ability to integrate their individual decisions. Motivation of individuals to coordinate their contributions to the production scheduling task were assessed in the following two post-test questionnaire questions "To what extent were you motivated to act in the best interest of Advac (i.e. maximise the output of the final product) as a company?" and "As a production manager what was your overall goal?". Responses are reported in Table 5-5 and Table 5-13 respectively. Results reported in Table 5-5 show that interacting group members perceived a significantly higher motivation ($\bar{X} = 103.06$)

to pursue the interest of the production system as a whole when compared to ($\bar{X} = 89.52$) non-interacting individuals ($F_{1,176} = 11.175$, $p = 0.001$). This is consistent with results reported in Table 5-13, where in the interacting group treatments individuals perceived their goals as group goals 97% of the time, compared to 71% of the time for individuals in the non-interacting individual treatments. This difference is statistically significant ($\chi_3^2 = 23.32$, $p = 0.000$). Results show that group-interaction increases individual participants' motivation to perform the task correctly (i.e. maximise the production of the production system). Motivation to perform the task correctly was previously theorised to result in higher levels of coordination necessary under high task interdependence and, therefore, better task performance.

Table 5-13 Experiment 1 - Goal Perception

	Group Goal	Individual Goal
NI/ LF	32	18
NI/ GF	39	11
IG/ LF	44	1
IG/ GF	43	2

NI = Non-Interacting Individuals, IG = Interacting Groups
LF = Local Feedback, GF = Global Feedback

Apart from motivation, discussed previously, group-interaction was theorised to increase group members' ability to coordinate their individual contributions to the task. The following post-test questionnaire item was used to assess this "To what extent were you able to set production targets that were consistent with your motivation?". Results to this question are reported in Table 5-14 and show that individuals in interacting groups perceive themselves to be better able to set production targets in accordance with their motivation ($\bar{X} = 80.23$) than individuals in non-interacting treatment groups

($\bar{X}$ = 54.56). This difference was statistically significant ($F_{1,176} = 27.867$, $p = 0.001$). It is, therefore, concluded that similar to motivation, group-interaction assists individuals in coordinating their individual decisions, which directly increase the performance of highly interdependent tasks.

Table 5-14 Experiment 1 - Mean (SD) of Ability to Set Production Targets in Accordance with Group Goals

	NI	IG	Average
LF	52.267	78.867	65.567
	(34.090)	*(34.337)*	
GF	56.844	81.600	69.222
	(34.482)	*(26.996)*	
Average	54.556	80.234	
Theoretical Range 1 (Not at all)- 127 (To a Great Extent)			

In summary, support for Hypothesis 1 confirms the value of group-interaction to organisations facing the challenge to coordinate highly interdependent tasks. Increased levels of motivation and ability to integrate individuals' contributions resulting from group-interaction were identified as the drivers of better coordination. Young et al. (1993) also observed increased levels of motivation and ability to coordinate, however, contrary to Young et al., the level of interdependence in this study was sufficiently high for superior coordination to translate into better overall task performance.

Hypothesis 2: The second hypothesis proposed an advantage for global feedback over local feedback, when the task is high in interdependence. The main effect for structure was not significant ($F_{1,56} = 2.606$, $p = 0.112$, refer Table 5-11), indicating that individuals receiving global feedback performed at a similar level to individuals receiving local feedback. Thus Hypothesis 2 was not supported.

In Chapter 2 and 3, feedback aggregation was theorised to affect the quality of group-interaction by increasing or decreasing the level of motivation as well as the ability to coordinate individual contributions to the task. As the production task in this experiment was designed specifically to reflect changes in coordination, the absence of a performance effect indicates that task coordination did not differ sufficiently between individuals receiving local and global feedback. Further analysis into individual's motivation and ability to set production targets, based on the same questions used in the previous section, is presented in Table 5-5, Table 5-13 and Table 5-14. Individuals in both feedback conditions perceived their goals as group goals to a similar extent (80% for local feedback and 86% for global feedback). However, subjects receiving global feedback expressed a significantly higher motivation to act in the best interest of the production system, which represents the task ($\bar{X} = 91.34$ for local feedback and $\bar{X} = 101.23$ for global feedback, $F_{1,176} = 5.967$, $p = 0.016$). On the other hand, the perceived ability to set production targets did not vary between feedback treatment groups. Taken together this analysis suggests that while global feedback had a positive effect on the individual's motivation to contribute to the task, it did not increase the individual's ability to do so. This resulted in a lack of difference in coordination and task performance.

In summary, providing individuals in a highly interdependent production system with global feedback over local feedback does not lead to greater production performance. Nevertheless, while it does provide these individuals with a higher motivation to act in the best interest of the production system, it does not provide them with an increased ability to do so. The rejection of Hypothesis 2 represents a caution against some recent criticism of traditional local information in highly interdependent situations. The perceived failure of traditional local information to provide individuals with the opportunity to better develop and implement better coordinating strategies may not be overcome by global information in general. The usefulness of global information may well depend on the work structure in place. This possibility is pursued further in Hypothesis 3.

Hypothesis 3: The third hypothesis proposed a relatively greater performance difference between global and local feedback where group-interaction is not present. Results reported in Table 5-11 and Table 5-12 show a marginally significant interaction ($F_{1,56} = 3.941$, $p = 0.052$, $\hat{\omega}^2 = 0.11$) between feedback (global vs local) and work-structure (interacting groups vs non interaction individuals), which supported Hypothesis 3. Further analysis of the group means (refer Table 5-10) revealed the interaction between structure and feedback to be primarily due to increased performance achieved by the non-interacting individuals receiving global feedback over non-interacting individuals with local feedback (simple effect $F_{1,56} = 6.478$, $p = 0.013$). Interacting groups receiving global feedback did not differ in performance from interacting groups receiving local feedback ($F_{1,56} = 0.069$, $p = 0.794$).

Results for Hypothesis 3 indicate that coordination was only affected by the increased information provided by global feedback over local feedback in non-interacting groups. Subject's perceptions of feedback usefulness reported in Table 5-7 confirm that the difference between local and global feedback in non-interacting groups ($\bar{X} = 64.16$ and $\bar{X} = 93.33$ respectively) is relatively large (simple effect $F_{1,176} = 20.786$, $p = 0.000$), while this difference in interacting groups ($\bar{X} = 93.27$ and $\bar{X} = 95.82$ respectively) is not very large (simple effect $F_{1,176} = 0.159$, $p = 0.691$)[27].

Further analysis of the motivation of non-interacting individuals to coordinate their contributions revealed that global feedback had a positive effect on the motivation of the individual to act in the best interest of the production system as a whole (refer Table 5-5). This difference ($\bar{X} = 82.71$ and $\bar{X} = 96.33$ respectively) was significant ($F_{1,176} = 0.5.661$, $p = 0.018$). No difference in motivation was observed between global and local feedback in interacting groups. Similar to the overall feedback scenario presented with respect to the previous hypothesis, ability to set production targets was not affected by differences in feedback aggregation.

In summary, rejecting Hypothesis 3 showed that feedback aggregation has a beneficial performance effect only in the context of non-interacting individuals. Where individuals are already structured as interacting groups, the perceived usefulness of feedback aggregation disappears. To non-interacting individuals, global feedback increased task performance, which was attributed to higher levels of coordination. Further for these non-interacting individuals, global feedback also increased the motivation but not the ability to coordinate their individual contributions.

In conclusion, results from Experiment 1 showed that group-interaction is a viable coordination mechanism resulting in higher performance of highly interdependent tasks.

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[27] A further post-test question was asked of subjects in the interacting groups treatments "How useful was the accounting report in developing a strategy to produce as much of Delta as possible, while keeping

Feedback aggregation, on the other hand, is only relevant to coordination where group-interaction is not present.

5.3 Experiment 2

The second experiment investigated the effects of three specific reward systems (group, individualistic and fixed-rate) on group performance. Allocation to treatment groups was random. Three demographic attributes (age, gender and study program) were captured by the computer program (refer to screen shots in Appendix 2) and are reported in Table 5-15 and Table 5-16. These demographic attributes were analysed for systematic differences across treatment groups for reasons already discussed in the context of the first experiment (refer Section 5.2). Results from the statistical analysis indicated no significant differences across treatment cells. As such, it is concluded that the random assignment to treatment cells was effective.

Table 5-15 Experiment 2 - Desriptive Statistics (Demographic Data)

	Age
Mean	19.948
S.D.	1.627
Minimum	18
Maximum	32

Advac's inventories as low as possible?". Responses for global and local feedback did not differ ($\bar{X} = 80.31$ and $\bar{X} = 87.53$ respectively) significantly ($t_{87} = 1.044$, $p = 0.299$).

Table 5-16 Experiment 2 - Descriptive Statistics (Demographic Data)

	Sex
Female	61
Male	74
	Study Program
Full Time	129
Part Time	6

5.3.1 Manipulation Checks

The success of the second experiment rested on three aspects, which are examined separately. As for Experiment 1, it was important that subjects perceived the task to be highly interdependent. Also, subjects had to understand the nature of the reward treatment to which they were allocated, and finally, subjects had to understand the requirements of the task, which involved bringing a production system back into balance.

Interdependence

The importance of high task interdependence was discussed in Chapter 3. Similar to the first experiment, interdependence itself was not manipulated. As discussed in Chapter 4 (refer Section 4.5) the post test questionnaire questions used for the second experiment differed from those used in the first experiment. A confirmatory factor analysis showed three questions loading on the interdependence factor (refer Table 5-17). These three questions asked subjects to respond to the following statements on a 7 point Likert scale: "To what extent did your group's members work together to discuss how to do the task better?"; "To what extent did the task you performed as a group require the group members to assist each other?"; "To what extent were you assisted by your coworkers when you encountered difficulties in performing the task?". The construct validity of this variable was assessed using Cronbach's (1951) alpha, which was acceptable at 0.751 (Nunnally and Bernstein, 1994). The average response for interdependence was 16.07, which was well above the mid-point of the scale (ranging from 3 - 21).. It is, therefore, concluded that subjects perceived the decision context to be high in interdependence.

Table 5-17 Experiment 2 - Post-Test Variables

	Cronbach Alpha	Mean	Median	Standard Deviation	Theoretical Range	Actual Range
<u>Interdependence</u> • To what extent did your group's members work together to discuss how to do the task better? • To what extent did the task you performed as a group require the group members to assist each other? • To what extent were you assisted by your coworkers when you encountered difficulties in performing the task?	0.751	16.067	16.000	3.042	3 - 21	4 - 21
<u>Relationship Conflict</u> • To what extent was there tension among the members of your group? • To what extent was there emotional conflict among the members of your group?	0.694	4.452	4.000	2.695	2 - 14	2 - 12
<u>Task Conflict</u> • To what extent were there differences of opinions about the task in your group? • To what extent were there conflicts about the task you performed as a group?	0.648	5.852	6.000	2.358	2 - 14	2 - 12
<u>Perceived Understanding</u> • To what extent did you feel you did the task properly? • To what extent did your group develop a good strategy for performing the task?	0.750	9.141	9.000	2.724	2 - 14	2 - 14
N = 135						

Treatments

Subjects were tested for their understanding of the reward system in the post-training questionnaire (administered by the computer after the training period). Subjects were asked to respond to the following question "Was your wage influenced by the output of: a) The Individual's Manufacturing Cell, b) Advac or c) Neither?". The computer program only allowed subjects to progress where the correct answer was provided. This ensured subjects clearly understood the implications of the reward systems they were using.

Frequency of reward screen access was examined to ascertain the importance subjects placed on the reward system. All groups in all reward cells accessed the reward screen at least once. The average percentage of time spent on the wage screen was 2.69% of the total time spent on the task. This percentage is fairly high given that the reward screen was only accessible by itself and group members were able to transfer payment figures onto paper. Frequency of access and time of access both lend further support to the fact that the reward manipulation was both understood and taken seriously.

Task Understanding

As for Experiment 1, an important aspect of the main task was the unbalanced nature of the production line. Instead of asking subjects specifically about the potential capacity of their machines, which some subjects had difficulties in interpreing in the first experiment, they were asked two more general questions about their perceived understanding of the task. Subjects were asked to respond to the following two questions "To what extent did you feel you did the task properly?" and "To what extent did your group develop a good strategy for performing the task?". A confirmatory factor analysis found that these two items loaded on the same dimension. Structural validity of this variable was assessed using Cronbrach's (1951) alpha, which was acceptable at 0.750 (Nunnally and Bernstein, 1994). The means score for all subjects was 9.141 (refer Table 5-17), which is above the mid-point of the scale. Also, no significant differences were found between treatment groups, confirming that subjects in all treatment groups perceived they had an above average understanding of the task.

5.3.2 Descriptive Statistics

Statistical Tests

All post-test questionnaire items, including those used in the manipulation check questions, were factor analysed using SYSTAT. Questions loading on the same factor were further tested for reliability using Cronbach (1951) alpha scores.

The analysis of all hypotheses was conducted using a one-way ANOVA and Tukey (1-tailed) follow-up group comparisons for directional hypotheses and Tukey (2-tailed) follow-up comparisons for non-directional hypotheses. All analyses were conducted at an alpha level of 0.05.

Descriptive Statistics

The descriptive statistics are presented in Table 5-18. Several general patterns emerge from the descriptive data. The performance of treatment groups receiving group rewards performed the highest ($\bar{X} = 62,785$) followed by treatment groups receiving fixed-rate rewards ($\bar{X} = 60,597$) and individualistic rewards ($\bar{X} = 56,950$).

Table 5-18 Descriptive Statistics: Total Sample - Mean Performance Score (Standard Deviation)

	Group	Individualistic	Fixed-Rate
*Output**			
Mean	62,785	56,950	60,597
S.D.	27,749	26,475	25,003
n	15	15	15
* Total Output			

5.3.3 Hypothesis Testing

The overall ANOVA test statistic reported in Table 5-19 showed no significant overall difference in performance. These results show no support for Hypothesis 4, 5 and 6. Regardless of the reward system implemented, all groups performed at a similar level.

Table 5-19 Overall ANOVA on Total Output

		Analysis of Variance			
Source	SS	DF	MS	F-Ratio	P (two tailed)
Reward	260,686,000	2	130,343,000	0.187	0.831
Error	29,346,324,000	42	698,722,000		

5.3.4 Further Analysis

Introduction

During the analysis of results, it became evident that subjects within each treatment group ranged widely in their performance, as indicated by the large standard deviation in Table 5-18. This variation did not appear to be related to the reward treatments. In order to understand this variation better, a post-hoc examination of the correlations between post-test questionnaire items (level of interdependence, relationship conflict, task conflict, and perceived task understanding), and actual performance was conducted. It revealed only one significantly positive relationship (refer Table 5-20). This was between the level of task understanding and performance ($r = 0.556$, $p = 0.001$). In addition, perceived task understanding ranged from very low to very high with a wide disparity (refer Table 5-17). However, means of perceived task understanding did not differ across treatment groups ($F_{2,66} = 0.198$, $p = 0.821$). This suggests that the task may have simply been too difficult for some group members negating any behavioural effects resulting from the reward treatments as group members struggled to understand the task. As this was not anticipated, and as this thesis is primarily concerned with examining reward effects on groups that understand the task, a median split of the overall sample was undertaken on the basis of the understanding of the task[28]. The split was undertaken by aggregating the scores for perceived understanding of the three members for each group. Only groups whose aggregate exceeded the median value for all groups were subsequently included in the sub-sample. The resulting sub-sample contained groups that reported an above average level of task understanding[29].

[28] The following analysis was also conducted using a mean split without a change in the results.

[29] The following analysis was also conducted on the sub-sample that reported a below average level of task understanding. No significant results were found in this sub-sample, which further supports the assertion that in this sub-sample the lack of task understanding overwhelmed any reward treatment effects. The noise created by this sub-sample in the overall analysis is the most likely explanation for the lack of performance differences observed in the total sample.

Table 5-20 Pearson Correlation Matrix

	Inter-dependence	Relationship Conflict	Task Conflict	Perceived Understanding	Actual Performance
Inter-dependence	1.000				
Relationship Conflict	-0.310	1.000			
Task Conflict	-0.046	0.639**	1.000		
Perceived Understanding	0.334	-0.037	-0.232	1.000	
Actual Performance	0.162	-0.211	-0.158	0.556**	1.000
** Significant at the 0.01 level N = 135					

Descriptive Statistics (Sub-Sample)

Descriptive statistics are reported in Table 5-21. The sub-sample[30] reported in Table 5-21 consisted of 5 group rewards, 11 individualistic rewards and 7 fixed-rate rewards[31]. For the sub-sample, groups receiving group rewards achieved the highest performance followed by groups receiving fixed-rate rewards and individualistic rewards.

Table 5-21 Descriptive Statistics: Sub-Sample - Mean Performance Score (SD)

	Group	**Individualistic**	**Fixed-Rate**
*Output**			
Mean	97,087	67,829	68,819
S.D.	11,628	21,587	19,872
N	5	11	7
* Total Output			

[30] Discussion from this point forward is centred on the sub-sample only. As such, the term sub-sample will not be repeated except for section and table headings.

[31] Due to the unequal cell distribution and the small sample size, Levene's test for equal variance was used to test for differences in variances between the three treatment groups. No significant difference was found. In addition non-parametric tests were conducted in addition to the parametric tests reported. Results remained consistent across both types of tests.

Hypothesis Testing

Hypothesis H4: The fourth hypothesis proposed a performance advantage for groups receiving group rewards over groups receiving individualistic rewards, when the task is high in interdependence. The overall Analysis of Variance (ANOVA) was significant ($F_{2,20} = 4.314$, $p = 0.028$), indicating an overall difference between treatments, which explained 38% ($\hat{\omega}^2 = 0.384$) of the variation in the sample. The follow-up Tukey means comparison tests (refer Table 5-22) supported Hypothesis 4. Groups receiving group rewards significantly outperformed groups receiving individualistic rewards ($p < 0.05$).

Table 5-22 Overall ANOVA on Total Output - Sub Sample

		Analysis of Variance			
Source	SS	DF	MS	F-Ratio	P (two tailed)
Reward	3,266,069,004	2	1,633,034,502	4.314	0.028
Error	7,570,860,000	20	378,543,000		
$\hat{\omega}^2 = 0.384$					

Mean Comparisons	
Group	$97{,}087_a$
Individualistic	$67{,}829_b$
Fixed-Rate	$68{,}819_b$

Note: Means in each group of three that share a common subscript are not significantly different by Tukey, $p < 0.05$, (1-tailed)

Support for Hypothesis 4 indicated that the use of group rewards leads to performance advantages where group members have an above average understanding of the task. It was theorised in Chapter 3 that the performance advantage for groups receiving group rewards is due to superior coordination of individual decisions. It was further theorised that, based on cooperation theory, superior coordination in these groups was due to group members being better motivated (due to the group reward) to coordinate their individual decisions and pursue a common goal.

To assess the proposed differences in cooperation resulting from the reward systems, Jehn's (1995) two dimensions of conflict were used. These measures were used because changes in conflict are directly associated with changes in motivation to pursue common goals[32]. Jehn's two dimensions of conflict were made up of *relationship conflict* and *task conflict*. The former relates to conflict created by disagreements relating to the interaction within the group, while the latter deals with disagreements relating to the execution of the task itself. The two variables (i.e. dimensions) are reported in Table 5-17. Relationship conflict contained two questions "To what extent was there tension among the members of your group?" and "To what extent was there emotional conflict among the members of your group?" Both questions loaded on the same dimension in the confirmatory factor analysis. The validity was assessed using Cronbach's (1951) alpha (0.649). Task conflict also contained two questions "To what extent were there differences in opinions about the task in your group?" and "To what extent were there conflicts about the task you performed as a group?". Cronbach's alpha was used again (0.648) to assess the validity, which was acceptable.

Task conflict was the only variable that differed significantly between group rewards and individualistic reward treatments. As reported in Table 5-23, group rewards

[32] Deutsch (1949b) reported difficulties with measures of competition, as subjects had difficulties in interpreting when they felt competitive. This problem has been overcome with Jehn's conflict measures.

resulted in lower levels of task conflict than individualistic rewards. This difference was statistically significant (refer Table 5-24, Tukey $p < 0.05$). It is, therefore, concluded that group rewards resulted in higher levels of cooperation (i.e. less task conflict) and as a result of the higher levels of cooperation, group members were better at coordinating their individual decisions resulting in higher overall performance.

Table 5-23 Descriptive Statistics: Sub-Sample - Mean Conflict Score (Standard Deviation)

	Group	**Individualistic**	**Fixed-Rate**
Task Conflict			
Mean	4.667	6.303	4.714
S.D.	2.024	2.616	2.194
Actual Range	2 – 8	2 – 12	2 - 10
N	15	33	21

Table 5-24 Overall ANOVA on Task Conflict - Sub Sample

Analysis of Variance					
Source	SS	DF	MS	F-Ratio	P (two tailed)
Reward	44.571	2	22.285	3.948	0.024
Error	372.589	66	5.645		
$\hat{\omega}^2 = 0.776$					

Mean Comparisons	
Group	4.667_b
Individualistic	6.303_a
Fixed-Rate	4.714_b

Note: Means in each group of three that share a common subscript are not significantly different by Tukey, $p < 0.05$, (1-tailed)

In summary, support for Hypothesis 4 confirmed the importance of choosing a group reward system to support group coordination. Where groups are used to coordinate highly interdependent tasks, group rewards ensure higher levels of cooperation than individualistic rewards, which translate into higher levels of coordination and higher performance for groups receiving group rewards.

Hypothesis H5: The fifth hypothesis proposed a performance advantage for group rewards over fixed-rate rewards, when the task is high in interdependence. Descriptive statistics reported in Table 5-21 support this hypothesis, as group rewards resulted in significantly higher performance to fixed-rate rewards (refer Table 5-22, Tukey < 0.05). It is, therefore, concluded that groups receiving group rewards outperform groups receiving fixed-rate rewards.

It was theorised in Chapter 3 that the differences in performance is due to cooperation differences, with members of groups receiving group rewards experiencing higher levels of cooperation resulting in higher levels of coordination and increased performance. Similar to the testing of Hypothesis 4, Jehn's (1995) conflict variables were used to test for differences in cooperation. Neither relationship conflict or task conflict differed significantly between groups receiving group rewards and those receiving fixed-rate rewards. It is, therefore, concluded that the difference in performance between the two treatments was not due to differences in willingness to cooperate. Possible alternatives include a better understanding of the goal, and are subject to further development in a future study (refer Section 6.4 for a discussion of future research).

In summary, support for Hypothesis 5 shows that fixed-rate rewards are not a viable alternative to group based rewards, when the task is high in interdependence. However, it is not possible with the constraints of the current research instrument to ascertain the reasons for the superiority of group based rewards over fixed-rate rewards. Further discussions of potential reasons are presented in Chapter 6 (refer Section 6.4) as part of the recommendations for future research.

Hypothesis H6: The sixth hypothesis proposed a performance advantage for groups receiving fixed-rate rewards over groups receiving individualistic rewards, when the task is high in interdependence. The follow-up Tukey means comparison test did not support this hypothesis (refer Table 5-22). Both groups performed at about the same level (refer Table 5-21). It is interesting to note that task conflict did differ significantly between these two groups (Tukey < 0.05, refer Table 5-24). As reported in Table 5-23, members of groups receiving individualistic rewards perceived a higher degree of task conflict ($\bar{X} = 6.303$) than members of groups receiving fixed-rate rewards ($\bar{X} = 4.714$). Differences in the level of task conflict are consistent with the cooperation theory reviewed in Chapter 2 and 3. In contrast to individualistic rewards, fixed-rate rewards were theorised not to detract from the group's purpose, and hence result in higher levels of cooperation (i.e. lower levels of conflict). Understanding why this did not result in performance differences cannot be isolated in this study and will require further theoretical development in a later study (refer Section 6.4 for a further discussion of future research).

In summary, the lack of support for Hypothesis 6 indicates that fixed-rate rewards and individualistic rewards result in similar performance levels. Individualistic rewards appear to create more conflict around the task, which was not found to be detrimental to the performance of the group relative to fixed rate rewards.

In conclusion, results from Experiment 2 showed that group rewards are superior to both individualistic and fixed-rate rewards. That makes group rewards the best of the alternative studied for rewarding groups under high task interdependence.

5.4 Conclusion

This section has tested the six hypotheses set out in Chapter 3. Support was found for group structure as an appropriate way to organise highly interdependent tasks. Global feedback only resulted in superior performance when individuals in the production system did not have the benefit of group-interaction. Further support was found for the importance of supporting groups with group rewards. Group rewards were found to result in superior performance to both fixed-rate and individualistic rewards.

Chapter 6

Summary and Conclusions

6.1 Introduction

This thesis has addressed six research questions relating to the importance of group-interaction and feedback aggregation as coordination mechanisms, as well as, the effect of three types of reward systems (group, individualistic and fixed-rate) on group cooperation. The context in which these six research questions were addressed was high task interdependence. In addressing these six research questions, this thesis makes a number of contributions to prior theory, as well as, research methodology. A contribution is also made to practitioners interested in coordinating highly interdependent tasks.

The first aim of this chapter is to present the major conclusions to the six research questions with reference to the contributions where appropriate. This is followed by a discussion of the inherent limitations of this thesis and the implications for future research. Some concluding remarks will be made in the final section.

6.2 Summary and Conclusions

The motivation for this thesis was drawn from new developments in the manufacturing and service industries, which have resulted in different demands on the individual working within these industries. One dimension of these new developments (e.g. JIT, TQM, TOC) is a change in work-flow from one of low to medium interdependence to one of high task interdependence. Accompanying this change has been an increased demand on individuals to coordinate and integrate their individual decisions with other individuals in the organisation. Two important coordination mechanisms (group-interaction and feedback aggregation) have been examined in this thesis as well as the implications of three types of reward schemes (group, individualistic and fixed-rate) on group cooperation. As this thesis is one of the first forays into the context of high task interdependence, a major methodological contribution has been the successful introduction of a highly interdependent experimental task making it now possible to re-examine some of the surprising results in prior studies (e.g. Young et al. 1993) as well as opening up new possibilities for testing research questions relevant in the high task interdependence context.

Within the context of high task interdependence, six research questions were investigated. Each research question will now be summarised along with the relevant findings and implications for practitioners.

6.2.1 Group-interaction

The first research question was concerned with the relevance of group-interaction as a coordination mechanism under high task interdependence. Experimental results showed that under these conditions, performance was higher where group-interaction was permitted. This higher performance was attributed to better coordination of individual decisions, as individuals considered the mutual relationship with other individuals when arriving at their own decisions.

The theoretical reasons underlying the relationship between group-interaction and the level of coordination were developed in Chapters 2 and 3 based on several of Hackman's IPO models (e.g. Hackman and Morris, 1975) and constitute a major theoretical contribution in this thesis. In this theory, both motivation and the ability of individuals to coordinate were argued to increase as a result of group-interaction. Motivation and ability in turn were proposed to lead to higher levels of coordination. Further analysis of the post-test questionnaire supported this theory.

As such, results for the first research question confirmed the value of group-interaction to organisations facing high task interdependence. This is consistent with Young et al.'s (1993) observations of better motivation and ability to coordinate. Contrary to Young et al., however, coordination differences resulted in performance differences[33].

Based on the empirical findings it is concluded that organisations primarily concerned with coordinating tasks high in interdependence should consider the implementation of groups as an efficient coordination mechanism.

6.2.2 Feedback Aggregation

The value from providing individuals in organisations with more aggregated information in addition to their local information constituted the second research question. Experimental results for the second research question did not provide support for coordination advantages resulting from providing individuals with more aggregated information in addition to their local information (the combination of which was termed global feedback) over just providing local feedback.

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[33] It is beyond the scope of this thesis to propose that the difference was solely due to the different level of interdependence, as task interdependence was not manipulated in this thesis. Also the trade-off faced by subjects in the Young et al. (1993) study between physical production and coordination is not replicated here, as subjects did not face a production trade-off for their coordination. Nevertheless, the findings are important to organisations facing coordination as a major determinant of performance.

Nadler's (1979) group feedback formed the basis for the theoretical development in Chapter 3. Prior feedback work, which includes Nadler's model, however were confined to group-interaction. The amended model developed in Chapter 3 overcomes this limitation and constitutes another major theoretical contribution of this thesis. The theory developed in Chapter 3 also proposed that feedback aggregation increases both the level of motivation and ability of individuals to coordinate their decisions. Results from the post-test did support a motivation increase resulting from global feedback, but without a corresponding increase in the ability to coordinate. One potential explanation is that this comparison between global and local feedback included both interacting groups and non-interacting individuals. It is quite possible that feedback has differential effects based on the level of interaction (which is another form of sharing information). This explanation is pursued further in the third research question (Section 6.2.3).

In conclusion, it is not possible to recommend to organisations the wholesale adoption of more aggregated feedback for highly interdependent tasks. While it does appear to raise motivation levels it was not sufficient to affect coordination levels and hence task performance.

6.2.3 Group and Feedback Interaction

The third research question examined the relative importance of feedback aggregation in the context of interacting groups versus non-interacting individuals. Results from the empirical testing found that increased information provided by global feedback was only of direct consequence to coordination differences where group-interaction was not possible. Where group-interaction was possible, individuals were able to do some of the feedback aggregation themselves during group-interaction. As such, receiving aggregated feedback became less salient to interacting groups than non-interacting individuals. However where group-interaction was absent, global information increased performance by increasing individuals coordination, as global feedback provided the overview missing from local feedback.

Results from the post-test questionnaire into differences in motivation and ability to coordinate found that, similar to the overall feedback results, only motivation was significantly different and only for non-interacting individuals. Moreover increases in motivation due to global feedback was sufficient for non-interacting individuals to achieve a higher level of coordination and, hence, better performance than those non-interacting individuals receiving only local feedback.

As the interaction between feedback aggregation and group-interaction has not been examined in either psychology or accounting to date, the theoretical development constitutes another contribution in this thesis.

Based on the empirical results, outlined previously, it is concluded that global feedback is particularly relevant in organisations where group-interaction is not possible. Organisations which have not adopted groups (for example for cost or goegraphical reasons) should consider designing their management accounting system to ensure individuals are receiving information about the overall organisational flow and results (i.e. aggregated feedback provides the "big" picture to each participant). This will have a positive effect, not so much in their understanding of task interdependence, but in their motivation to consider the impact of their decisions on other parts of the system.

6.2.4 Reward Systems

The final three research questions were concerned with the relative impact of three types of reward systems (group-rewards, individualistic rewards and fixed-rate rewards) on cooperation between group members. Cooperation was theorised to affect coordination and, hence, performance of highly interdependent tasks. Empirical results showed that all three rewards systems were equally ineffective where individual group members did not have an above average understanding of the task[34]. Where an above average understanding of the task did prevail, group rewards lead to superior coordination, and hence, performance, while individualistic and fixed-rate rewards lead to approximately equal levels of performance.

The theoretical basis for examining differences in group-interaction resulting from these three reward systems involved the amalgamation of two existing theoretical models based on Hackman's IPO model and Deutsch's cooperation theory (refer Chapter 3). Accordingly, it was proposed that group rewards would lead to higher levels of cooperation, group-interaction and coordination than both fixed-rate and individualistic rewards. Fixed-rate rewards in turn were proposed to lead to higher levels of cooperation, group-interaction and coordination than individualistic rewards. As the two theories have not previously been integrated, this amalgamation constitutes the final theoretical contribution in this thesis.

[34] For groups with a below average understanding of the task, the lack of understanding was the major cause of sub-optimal performance.

Results from the post-test questionnaire showed that the difference between group and individualistic rewards was accompanied by relatively higher levels of cooperation in the former. This confirms prior speculation in the literature that rewarding individual performance in the context of high task interdependence is detrimental to coordination and performance, as individuals focus on maximising their own performance potentially at the expense of the performance of the group. Organisations that have traditionally used individualistic rewards systems need to reconsider this choice where the groups have been implemented to coordinate high task interdependence. While cooperation differences were not found between group rewards and fixed-rate rewards, group rewards did result in higher performance making it the superior form of remuneration.

6.3 Limitations of the Thesis

The extent to which conclusions, summarised in the previous section, can be generalised are subject to a number of limitations, which need to be taken into account. The first limitation of this thesis is its focus on coordination. While it has been argued previously that coordination is very important to organisations facing high task interdependence, group-interaction may also provide other benefits, such as building of employee morale and reducing employee turnover, which have not been investigated here. Such effects, however, suggest an investigation spanning a longer time horizon and would be ideally examined in a field study.

A second related limitation is the exclusion of physical effort from the task used in both experiments. Physical effort has become less important to organisations where many manual tasks are now performed by machines, and coordination of these activities is of primary concern. However, with the omission of physical effort the investigation of a trade-off between effort exerted from physically executing a manufacturing task and the coordination required to integrate the physical effort is precluded. It is not possible to draw insights into whether coordination advantages gained from group-interaction will translate into production differences where coordination activity has a cost of reduced physical activity. This is best pursued in a further study.

A third limitation is the relative ease in which global feedback was ascertainable from combining local feedback received by members of interacting groups. The level of cognitive effort necessary to combine local feedback of each group's members was relatively low, as global feedback consisted, in the main, of simple aggregation of production capacity as well as inventory numbers. As such, the lack of an overall difference between local and global feedback was attributed to a lack of difference in global feedback to add extra ability to coordinate. In organisations this may not always be the case, particularly where there is an extensive amount of information available about the production flow. In such a context, management accounting systems have an important role to play in providing aggregate information and reports necessary to coordinate the production flow.

A fourth limitation to the current thesis is the relatively low level (in absolute terms) of conflict induced across all reward systems. Overall, even the individualistic group members did not perceive an overwhelming level of competition and conflict, which could be due to the learning required by the task and the group cohesiveness brought about by the management accounting feedback being provided on a group basis. That is, individual group members are less likely to pursue their own self-interest (and create conflict) when they do not have a full understanding of how the task affects their self-interest. Furthermore, individuals are less likely to pursue their own self-interest where information about consequences from their decisions is commonly available to their fellow group members. A further possibility is the relative importance of the reward and the relative short duration of the task in the laboratory. One would expect the salience of the reward to increase in an organisational setting, and this is expected to exacerbate the effect on cooperation and performance. In practice differences in the level of conflict are anticipated to be stronger, as individuals are more familiar with their tasks and group members are less likely to be aware of all the consequences stemming from each decision. This would be expected to lead to stronger results in practice.

Despite these limitations, conclusions summarised in this chapter are important to organisations facing the job of coordinating highly interdependent tasks, as well as, issues surrounding selection of an appropriate reward system given the adoption of a group coordination mechanism. The limitations do not directly invalidate these conclusions, but rather expose some potential considerations that need to be addressed prior to generalising from these conclusions.

6.4 Implications for Future Research

Conclusions drawn in this thesis provide detail about the process by which group-interaction, feedback aggregation and reward systems affect the performance of highly interdependent tasks. In the process of drawing these conclusions, several new avenues for future research have presented themselves.

This thesis established that the context of high task interdependence is a relevant context when evaluating group-interaction. In the context of high task interdependence, variations in group-interaction translate into group performance differences. Coordination differences resulting from group-interaction have been the main focus in this thesis. Yet group-interaction can also be beneficial in other areas, such as sharing of expertise. While differences in expertise (or resources) have been present in previous studies (e.g. Ravenscroft and Haka, 1996), none have used the models developed in this thesis to explore group-interaction processes in greater detail. Future research needs to look more closely at some of the relationships raised in the models developed in this thesis, which have not been directly tested here.

Further, results from the current thesis indicate that aggregation of feedback is particularly relevant to coordination where group-interaction is absent. Future research is needed here to explore the level of aggregation further. One possible avenue would be to investigate a context where the ability to aggregate information through group-interaction is either very difficult or very costly. The expectation would be that as difficulty and cost of aggregation increase, providing this information systematically through the accounting system even to interacting groups becomes more important.

A related point of interest would be whether the ability to coordinate is affected once this difficulty level increases. As the task difficulty level increases, individual group members are likely to find it more difficult, both in time and cognitive effort, to process and interpret the information needed to perform the task. Management accounting systems and reports can assist group decision making and it is therefore anticipated that management accounting information has an important role to play in providing groups' informational support where task difficulty levels are higher.

The results from the current thesis provide further insight into the effects of reward systems on cooperation, coordination and performance. Yet despite the significant performance differences between treatment groups, the overall range in conflict was relatively small and absolute levels relatively low (refer discussion in previous Sections 6.3). As the relatively low levels of conflict are partially due to the experimental setting, and higher levels are anticipated in an organisational setting, future research needs to explore the context where conflict is more pronounced. Two potential avenues to explore higher levels of conflict are by either providing more monetary incentive in absolute terms (i.e. pay them more money), or by exploring a context where reward levels (which could include both monetary and non-monetary rewards) are more long term (e.g. a field study in an organisation).

A further avenue for future research is to tease out differences between fixed-rate rewards and both group and individualistic rewards. As discussed in Chapter 5, fixed-rate rewards resulted in similar levels of cooperation to group rewards, yet groups receiving fixed-rate rewards performed at a significantly lower level than group rewards. In contrast, fixed-rate rewards resulted in higher levels of cooperation than individualistic rewards but similar performance to the latter. It was not possible, within the constraints of the research instrument, to ascertain why similar cooperation levels between group and fixed-rate rewards did not translate into similar levels of coordination. A potential explanation is that group members receiving fixed-rate rewards are willing to cooperate but lack motivation to execute the task or learn the task.

Group rewards, on the other hand, not only motivate group members to cooperate, but also provide additional motivation for group members to exert effort and learn how to perform the task more effectively. Individualistic rewards, on the other hand, prevent group members from cooperating in the first place, which lowers their motivation and ability to coordinate. Given the results in this thesis, it is evident that reward systems can impact levels of cooperation positively without the desired increase in motivation and effort to coordinate the task. Future research needs to examine more closely the differences between fixed-rate rewards and group rewards in particular, in terms of motivation and effort. It appears that cooperation itself is desirable, but not sufficient, to ensure individual group member motivation and ability to coordinate highly interdependent tasks. The model developed in Chapter 3 provides a starting point, but in itself is not sufficient and requires both refinement and subsequent validation in a laboratory experiment.

6.5 Concluding Remarks

This thesis has been concerned with the effectiveness of group-interaction and feedback aggregation as coordination mechanisms for highly interdependent tasks. It has also examined the importance of group, individualistic and fixed-rate rewards in facilitating group coordination mechanisms. Detailed models have been developed in this thesis to facilitate specific hypotheses that have been subsequently tested empirically. Results have been presented and conclusions drawn, which are important to both researchers and practitioners.

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Appendix 1

Experimental Material - Experiment 1

Content	Page	IG/LF*	IG/GF*	NI/LF*	NI/GF*
Company Background	155	✓	✓	✓	✓
P.O. Instructions - Trainvac 1	162	✓	✓	✓	✓
P.O. Instructions - Trainvac 2	165	✓	✓	✓	✓
P.O. Instructions - Trainvac 3	169	✓	✓	✓	✓
P.O. Instructions - Advac 1	173	✓	✓	✓	✓
P.O. Instructions - Advac 2	176	✓	✓	✓	✓
P.O. Instructions - Advac 3	180	✓	✓	✓	✓
Production Report - Trainvac 1	184	✓	✓	✓	✓
Production Report - Trainvac 2	185	✓	✓	✓	✓
Production Report - Trainvac 3	186	✓	✓	✓	✓
Production Report - Advac 1	187	✓		✓	
Production Report - Advac 1	188		✓		✓
Production Report - Advac 2	189	✓		✓	
Production Report - Advac 2	190		✓		✓
Production Report - Advac 3	191	✓		✓	
Production Report - Advac 3	192		✓		✓
Post-test Questionnaire	193	✓	✓	✓	✓

* Treatment Abbreviations:

IG/LF = Interacting Group/ Local Feedback

IG/ GF = Interacting Group/ Global Feedback

NI/ LF = Non-interacting Individuals/ Local Feedback

NI/ GF = Non-interacting Individuals/ Global Feedback

Advac Ltd

Company Profile

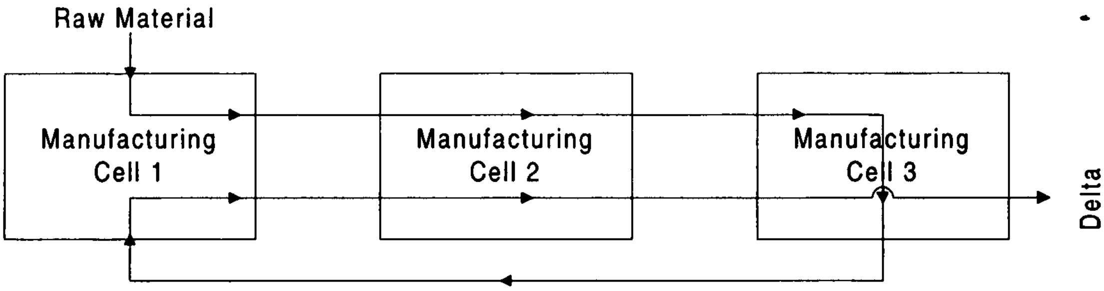
Name: ______________________

Student Number: ______________________

Company Background

Advac is a manufacturing company located in the west of Sydney. Advac is involved in the manufacture of Delta. Three manufacturing cells (or departments) are involved in the manufacture of Delta. The manufacturing flow of Delta through the three manufacturing cells is illustrated in figure 1.

Figure 1



Manufacturing cell 1 is involved primarily in cutting raw materials into the shape of Delta. The raw materials initially enter manufacturing cell 1 from the vendor and manufacturing cell 1 uses machine 1A to perform some preliminary cutting. Upon completion of the cutting, work in process (WIP) is passed on to manufacturing cell 2. Manufacturing cell 2 performs primarily painting operations. The WIP received from manufacturing cell 1 is painted using machine 2A. Upon completion of the painting operation the WIP is passed on to manufacturing cell 3. Manufacturing cell 3 performs primarily drying operations. The WIP received from manufacturing cell 2 is dried using machine 3A and is then passed on to manufacturing cell 1 for some final cutting. This final cutting is performed in manufacturing cell 1 using machine 1B. Upon completion of the final cutting the WIP is then passed on to manufacturing cell 2 for final painting. This final painting is performed in manufacturing cell 2 using machine 2B. Upon completion of the final painting the WIP leave manufacturing cell 2 for final drying in manufacturing cell 3. This final drying is performed in manufacturing cell 3 using machine 3B. After the final drying stage Delta is completed and leaves the manufacturing process to be assembled by the final customer.

Top management has indicated that customer demand for Delta is at an all time high, and that all of the production output of Delta can be sold. Top management has indicated that as much of Delta should be produced as possible. Further, top management has indicated that it is concerned about the levels of work in process inventories in Advac. Top management has issued a directive to keep work in process inventories as low as possible.

Job Description

Production Scheduling

You are the production manager of one of the manufacturing cells. As the production manager you have to schedule production for each machine in your manufacturing cell, at the beginning of each production period. Once you have made your decision about how much to produce on each machine your manufacturing cell is committed to those production figures for the period. However, you are free to change your decision in the next production period.

Machine Operation

The capacity of your two machines are not equal. They differ due to the nature of the task performed by each machine. However, each of your machines has a maximum capacity which limits your production. Production capacity of your machines may decrease below the maximum production capacity as a result of excess inventory as outlined in the next paragraph. You will be made aware of decreases in production capacities at the beginning of the production period before you make your production decision for the period. Your production decision can never be in excess of the production capacity of the machines for the period.

Inventory Management

Inventory accumulates in front of each machine. This is illustrated in figure 2 (on page 5). Inventory which does not exceed the maximum production capacity of the particular machine is considered to be "working inventory" and does not affect the capacity of the particular machine. However, any inventory which exceeds this "working inventory" level poses a problem to the manufacturing cell. This "excess inventory" has to be administered and decreases the capacity of the machines in the manufacturing cell by diverting time away from production. For every one unit of excess inventory at the beginning of the production period for a particular machine, the production capacity of both machines in the manufacturing cell is decreased by 0.1 units for the period. Further increases in excess inventory at the beginning of the production period for a particular machine lead to further decreases in manufacturing cell capacity, at the 0.1 rate, until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory at the beginning of the production period for a particular machine has no further effect on the manufacturing cell's machine capacities, as emergency procedures will maintain the 1,000 unit minimum capacity of each machine.

Subsequent decreases in excess inventory levels will result in restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of your machines. In cases where your production capacity is less than maximum capacity, due to excess inventory, your production decision <u>cannot exceed this capacity</u>.

An example illustrating the previous points on inventory management follows. Assume that the maximum production capacity of both of your machines is 100 units. Further assume that the total inventory at the beginning of the current period for machine A was 120 units and for machine B 100 units. The nature and effects of this inventory for the current period would be as follows.

Inventory in front of machine A	
Working inventory	100
Excess inventory	20
Total inventory in front of machine A	120

Inventory in front of machine B	
Working inventory	100
Excess inventory	0
Total inventory in front of machine B	100

Total working inventory in manufacturing cell (both machines)	200
Total excess inventory in manufacturing cell (both machines)	20
Productivity loss in manufacturing cell due to excess inventory in manufacturing cell (both machines) [0.1 x 20]	2

Capacity of machine A	
Maximum capacity	100
Less capacity loss due to excess inventory in the manufacturing cell	2
Actual capacity of machine A	98

Capacity of machine B	
Maximum capacity	100
Less capacity loss due to excess inventory in the manufacturing cell	2
Actual capacity of machine B	98

Figure 2

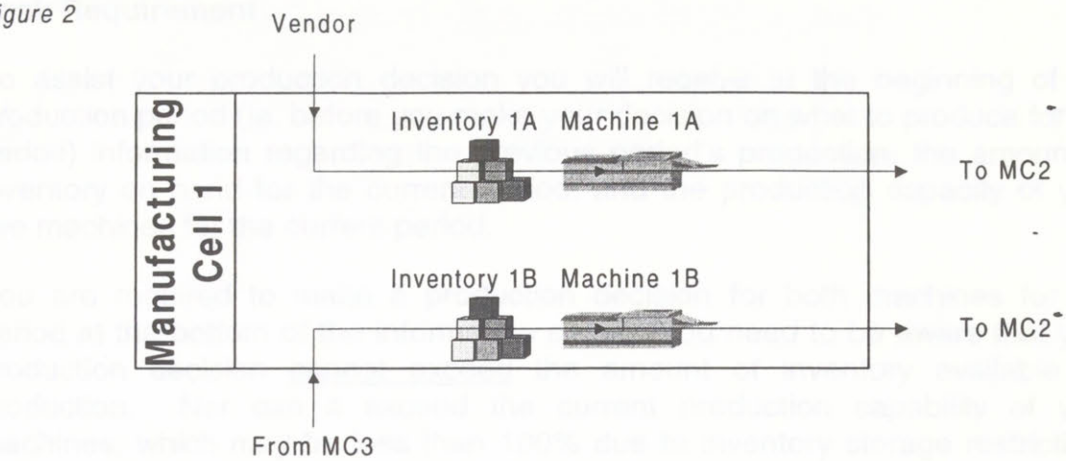


Figure 2 (cont.)

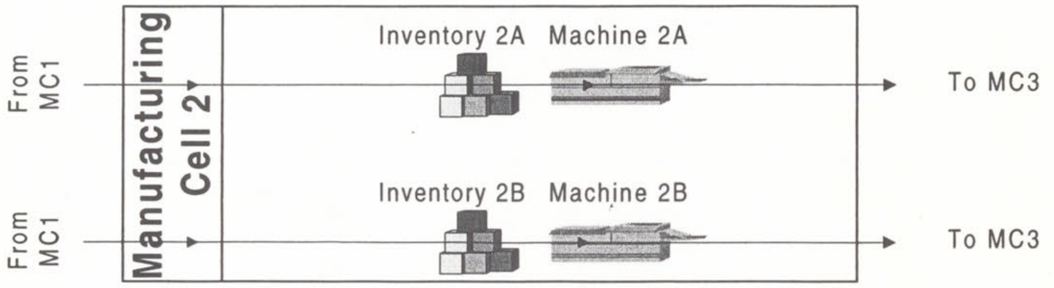
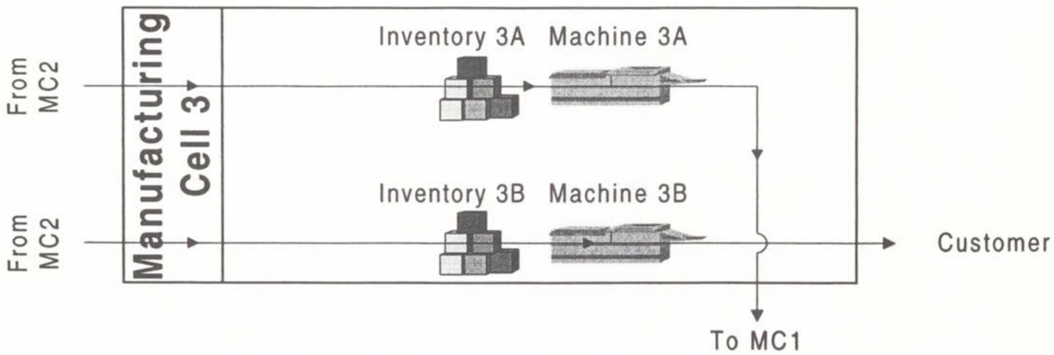


Figure 2 (cont.)



Task Requirement

To assist your production decision you will receive at the beginning of the production period (ie. before you make your decision on what to produce for the period) information regarding the previous period's production, the amount of inventory on hand for the current period, and the production capacity of your two machines for the current period.

You are required to make a production decision for both machines for the period at the bottom of the information sheet. You need to be aware that your production decision cannot exceed the amount of inventory available for production. Nor can it exceed the current production capability of your machines, which may be less than 100% due to inventory storage restrictions discussed above.

Production Operating Instructions

Trainvac

Manufacturing Cell 1

Training Period

Before commencing your job at Advac, top management has assigned you to a training division Trainvac. Trainvac manufactures a similar product to Delta called Zeta, which has no commercial value.

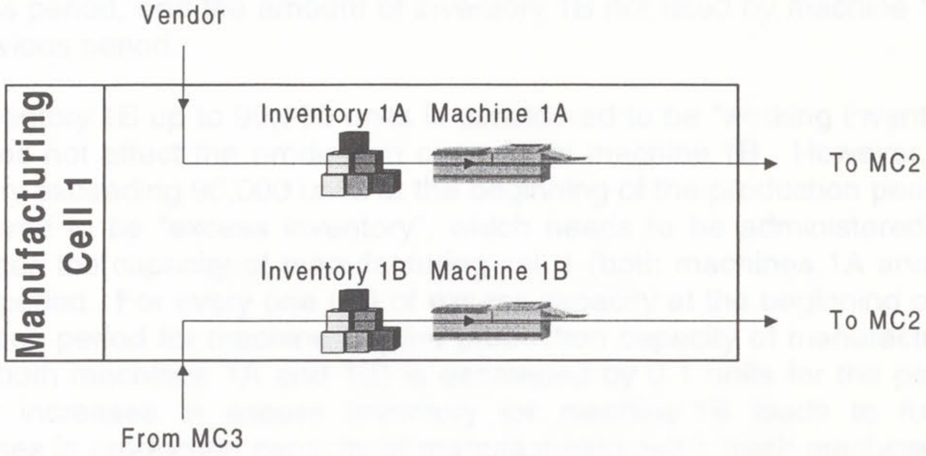
You have been assigned to manufacturing cell 1 at Trainvac, whose operating characteristics are equivalent to your final job at manufacturing cell 1 at Advac.

The only difference between your training manufacturing cell at Trainvac and your final manufacturing cell at Advac is in regard to the capacities of your two machines in each cell. They differ significantly as the training cell is a much larger manufacturing cell than your final manufacturing cell.

Manufacturing Responsibility

- You are the production manager of manufacturing cell 1. Manufacturing cell 1 is one of three manufacturing cells involved in the manufacture of Zeta within Trainvac Ltd. Your manufacturing cell is primarily concerned with cutting the raw material for Zeta.

Figure 1



- As the manager of manufacturing cell 1, you are required to set the production level for the two machines (machine 1A and machine 1B) under your control.

Machine Operations

- <u>Machine 1A</u> performs a cutting operation on the raw materials received from the vendor (refer figure 1). It has a maximum capacity of 225,000 units per production period. Once the raw materials have been cut, they are passed as work in process (WIP) to manufacturing cell 2 (MC2) for paint work.

- <u>Machine 1B</u> performs a further refinement cutting operation on the WIP received from manufacturing cell 3 (MC3, refer figure 1). It has a maximum capacity of 90,000 units per production period. Once the refinement to the WIP has occurred, it is passed on to manufacturing cell 2 (MC2) for final paint work.

Inventory Management

- Machine 1A has inventory 1A associated with it (refer figure 1). This inventory is supplied by the vendor to your manufacturing cell. You have negotiated an agreement with the vendor to supply enough to replenish inventory 1A up to 225,000 at the start of every production period.

- Machine 1B has inventory 1B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 3 in the previous period, and the amount of inventory 1B not used by machine 1B in the previous period.

- Any inventory 1B up to 90,000 units is considered to be "working inventory", and does not affect the production capacity of machine 1B. However, any inventory exceeding 90,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 1 (both machines 1A and 1B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 1B, the production capacity of manufacturing cell 1 (both machines 1A and 1B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 1B leads to further decreases in production capacity of manufacturing cell 1 (both machines 1A and 1B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 1B beyond that point has no further effect on the production capacity of manufacturing cell 1, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 90,000 units per production period for machine 1B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Production Operating Instructions

Trainvac

Manufacturing Cell 2

Training Period

Before commencing your job at Advac, top management has assigned you to a training division Trainvac. Trainvac manufactures a similar product to Delta called Zeta, which has no commercial value.

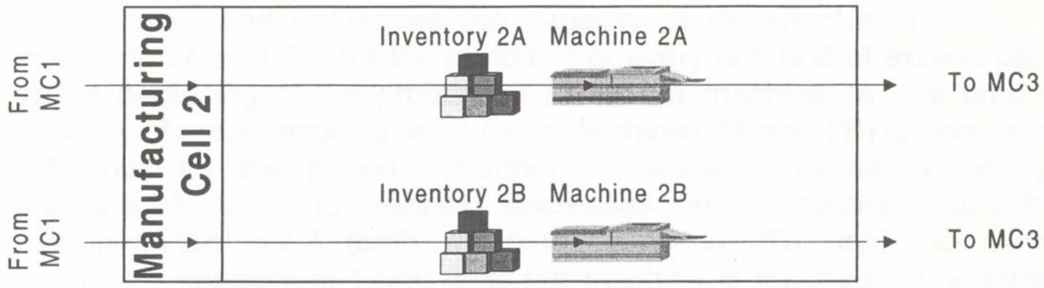
You have been assigned to manufacturing cell 2 at Trainvac, whose operating characteristics are equivalent to your final job at manufacturing cell 2 at Advac.

The only difference between your training manufacturing cell at Trainvac and your final manufacturing cell at Advac is in regard to the capacities of your two machines in each cell. They differ significantly as the training cell is a much larger manufacturing cell than your final manufacturing cell.

Manufacturing Responsibility

- You are the production manager of manufacturing cell 2. Manufacturing cell 2 is one of three manufacturing cells involved in the manufacture of Zeta within Trainvac Ltd. Your manufacturing cell is primarily concerned with painting the raw material for Zeta.

Figure 1



- As the manager of manufacturing cell 2, you are required to set the production level for the two machines (machine 2A and machine 2B) under your control.

Machine Operations

- <u>Machine 2A</u> performs a painting operation on the work in process (WIP) received from manufacturing cell 1 (MC1, refer figure 2). It has a maximum capacity of 187,500 units per production period. Once the WIP has been painted, it is passed on to manufacturing cell 3 (MC3) for drying work.

- <u>Machine 2B</u> performs a further refinement painting operation on the WIP received from manufacturing cell 1 (MC1, refer figure 2). It has a maximum capacity of 82,500 units per production period. Once the refinement to the WIP has occurred, it is passed on to manufacturing cell 3 (MC3) for final drying work.

Inventory Management

- Machine 2A has inventory 2A associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 1 in the previous period, and the amount of inventory 2A not used by machine 2A in the previous period.

- Any inventory 2A up to 187,500 units is considered to be "working inventory", and does not affect the production capacity of machine 2A. However, any inventory exceeding 187,500 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 2 (both machines 2A and 2B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 2A, the production capacity of manufacturing cell 2 (both machines 2A and 2B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 2A lead to further decreases in production capacity of manufacturing cell 2 (both machines 2A and 2B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 2A beyond that point has no further effect on the production capacity of manufacturing cell 2, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 187,500 units per production period for machine 2A.

- Machine 2B has inventory 2B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 1 in the previous period, and the amount of inventory 2B not used by machine 2B in the previous period.

- Any inventory 2B up to 82,500 units is considered to be "working inventory", and does not affect the production capacity of machine 2B. However, any inventory exceeding 82,500 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 2 (both machines 2A and 2B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 2B, the production capacity of manufacturing cell 2 (both machines 2A and 2B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 2B lead to further decreases in production capacity of manufacturing cell 2 (both machines 2A and 2B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 2B beyond that point has no further effect on the production capacity of manufacturing cell 2, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate.

However, production can never exceed the maximum capacity of 82,500 units per production period for machine 2B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Production Operating Instructions

Trainvac

Manufacturing Cell 3

Training Period

Before commencing your job at Advac, top management has assigned you to a training division Trainvac. Trainvac manufactures a similar product to Delta called Zeta, which has no commercial value.

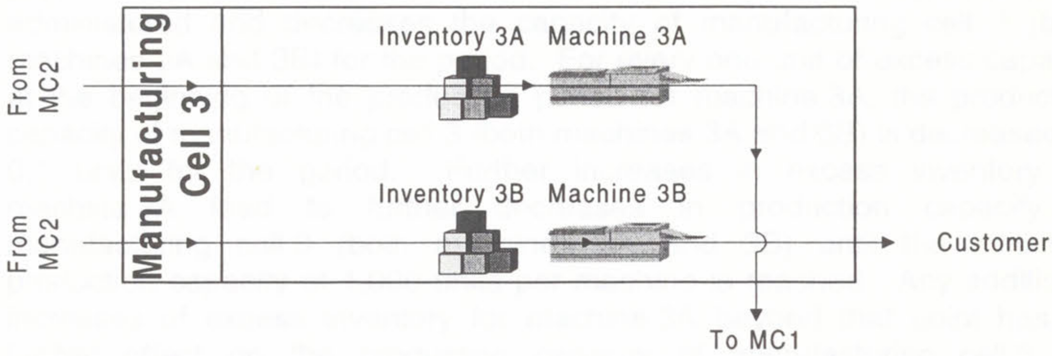
You have been assigned to manufacturing cell 3 at Trainvac, whose operating characteristics are equivalent to your final job at manufacturing cell 3 at Advac.

The only difference between your training manufacturing cell at Trainvac and your final manufacturing cell at Advac is in regard to the capacities of your two machines in each cell. They differ significantly as the training cell is a much larger manufacturing cell than your final manufacturing cell.

Manufacturing Responsibility

- You are the production manager of manufacturing cell 3. Manufacturing cell 3 is one of three manufacturing cells involved in the manufacture of Zeta within Trainvac Ltd. Your manufacturing cell is primarily concerned with drying the raw material for Zeta.

Figure 1



- As the manager of manufacturing cell 3, you are required to set the production level for the two machines (machine 3A and machine 3B) under your control.

Machine Operations

- Machine 3A performs a drying operation on the work in process (WIP) received from manufacturing cell 2 (MC2, refer figure 1). It has a maximum capacity of 127,500 units per production period. Once the WIP has been dried, it is passed on to manufacturing cell 1 (MC1) for final cutting work.

- Machine 3B performs a final drying operation on the WIP received from manufacturing cell 2 (MC2, refer figure 1). It has a maximum capacity of 75,000 units per production period. Once the refinement to the WIP has occurred, it leaves the manufacturing process as Zeta to be assembled by the customer.

Inventory Management

- Machine 3A has inventory 3A associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 2 in the previous period, and the amount of inventory 3A not used by machine 3A in the previous period.

- Any inventory 3A up to 127,500 units is considered to be "working inventory", and does not affect the production capacity of machine 3A. However, any inventory exceeding 127,500 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 3 (both machines 3A and 3B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 3A, the production capacity of manufacturing cell 3 (both machines 3A and 3B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 3A lead to further decreases in production capacity of manufacturing cell 3 (both machines 3A and 3B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 3A beyond that point has no further effect on the production capacity of manufacturing cell 3, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 127,500 units per production period for machine 3A.

- Machine 3B has inventory 3B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 2 in the previous period, and the amount of inventory 3B not used by machine 3B in the previous period.

- Any inventory 3B up to 75,000 units is considered to be "working inventory", and does not affect the production capacity of machine 3B. However, any inventory exceeding 75,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 3 (both machines 3A and 3B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 3B, the production capacity of manufacturing cell 3 (both machines 3A and 3B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 3B lead to further decreases in production capacity of manufacturing cell 3 (both machines 3A and 3B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 3B beyond that point has no further effect on the production capacity of manufacturing cell 3, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate.

However, production can never exceed the maximum capacity of 75,000 units per production period for machine 3B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Production Operating Instructions

Advac

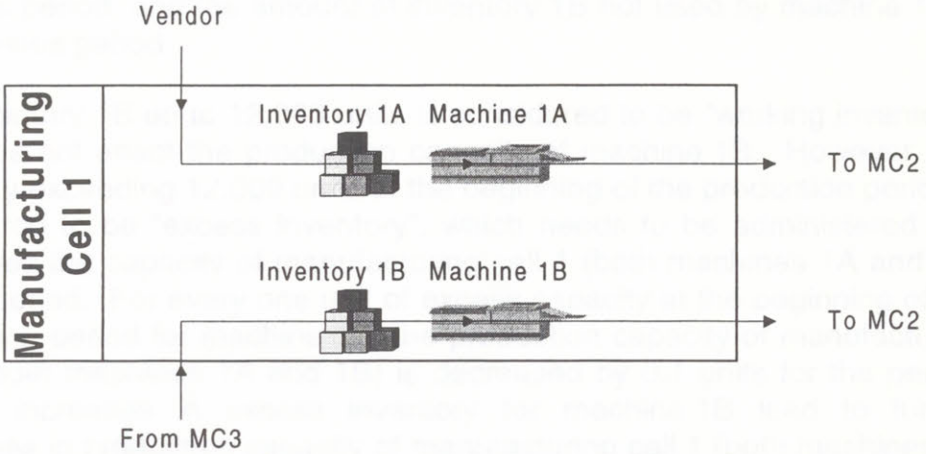
Manufacturing Cell 1

Having completed your training period, top management has now deemed you ready to commence your task in manufacturing cell 1 at Advac. Your manufacturing cell has been operating for several period, and you are replacing your predecessor at the end of one of the production periods.

Manufacturing Responsibility

- You are the production manager of manufacturing cell 1. Manufacturing cell 1 is one of three manufacturing cells involved in the manufacture of Delta within Advac Ltd. Your manufacturing cell is primarily concerned with cutting the raw material for Delta.

Figure 1



- As the manager of manufacturing cell 1, you are required to set the production level for the two machines (machine 1A and machine 1B) under your control.

Machine Operations

- Machine 1A performs a cutting operation on the raw materials received from the vendor (refer figure 1). It has a maximum capacity of 30,000 units per production period. Once the raw materials have been cut, they are passed as work in process (WIP) to manufacturing cell 2 (MC2) for paint work.

- Machine 1B performs a further refinement cutting operation on the WIP received from manufacturing cell 3 (MC3, refer figure 1). It has a maximum capacity of 12,000 units per production period. Once the refinement to the WIP has occurred, it is passed on to manufacturing cell 2 (MC2) for final paint work.

Inventory Management

- Machine 1A has inventory 1A associated with it (refer figure 1). This inventory is supplied by the vendor to your manufacturing cell. You have negotiated an agreement with the vendor to supply enough to replenish inventory 1A up to 30,000 at the start of every production period.

- Machine 1B has inventory 1B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 3 in the previous period, and the amount of inventory 1B not used by machine 1B in the previous period.

- Any inventory 1B up to 12,000 units is considered to be "working inventory", and does not affect the production capacity of machine 1B. However, any inventory exceeding 12,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 1 (both machines 1A and 1B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 1B, the production capacity of manufacturing cell 1 (both machines 1A and 1B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 1B lead to further decreases in production capacity of manufacturing cell 1 (both machines 1A and 1B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 1B beyond that point has no further effect on the production capacity of manufacturing cell 1, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 12,000 units per production period for machine 1B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Production Operating Instructions

Advac

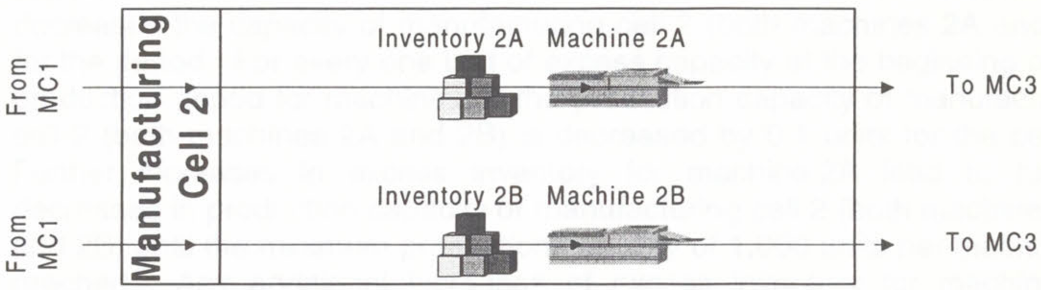
Manufacturing Cell 2

Having completed your training period, top management has now deemed you ready to commence your task in manufacturing cell 2 at Advac. Your manufacturing cell has been operating for several period, and you are replacing your predecessor at the end of one of the production periods.

Manufacturing Responsibility

- You are the production manager of manufacturing cell 2. Manufacturing cell 2 is one of three manufacturing cells involved in the manufacture of Delta within Advac Ltd. Your manufacturing cell is primarily concerned with painting the raw material for Delta.

Figure 1



- As the manager of manufacturing cell 2, you are required to set the production level for the two machines (machine 2A and machine 2B) under your control.

Machine Operations

- Machine 2A performs a painting operation on the work in process (WIP) received from manufacturing cell 1 (MC1, refer figure 2). It has a maximum capacity of 25,000 units per production period. Once the WIP has been painted, it is passed on to manufacturing cell 3 (MC3) for drying work.
- Machine 2B performs a further refinement painting operation on the WIP received from manufacturing cell 1 (MC1, refer figure 2). It has a maximum capacity of 11,000 units per production period. Once the refinement to the WIP has occurred, it is passed on to manufacturing cell 3 (MC3) for final drying work.

Inventory Management

- Machine 2A has inventory 2A associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 1 in the previous period, and the amount of inventory 2A not used by machine 2A in the previous period.

- Any inventory 2A up to 25,000 units is considered to be "working inventory", and does not affect the production capacity of machine 2A. However, any inventory exceeding 25,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 2 (both machines 2A and 2B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 2A, the production capacity of manufacturing cell 2 (both machines 2A and 2B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 2A lead to further decreases in production capacity of manufacturing cell 2 (both machines 2A and 2B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 2A beyond that point has no further effect on the production capacity of manufacturing cell 2, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 25,000 units per production period for machine 2A.

- Machine 2B has inventory 2B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 1 in the previous period, and the amount of inventory 2B not used by machine 2B in the previous period.

- Any inventory 2B up to 11,000 units is considered to be "working inventory", and does not affect the production capacity of machine 2B. However, any inventory exceeding 11,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 2 (both machines 2A and 2B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 2B, the production capacity of manufacturing cell 2 (both machines 2A and 2B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 2B lead to further decreases in production capacity of manufacturing cell 2 (both machines 2A and 2B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 2B beyond that point has no further effect on the production capacity of manufacturing cell 2, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate.

However, production can never exceed the maximum capacity of 11,000 units per production period for machine 2B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Production Operating Instructions

Advac

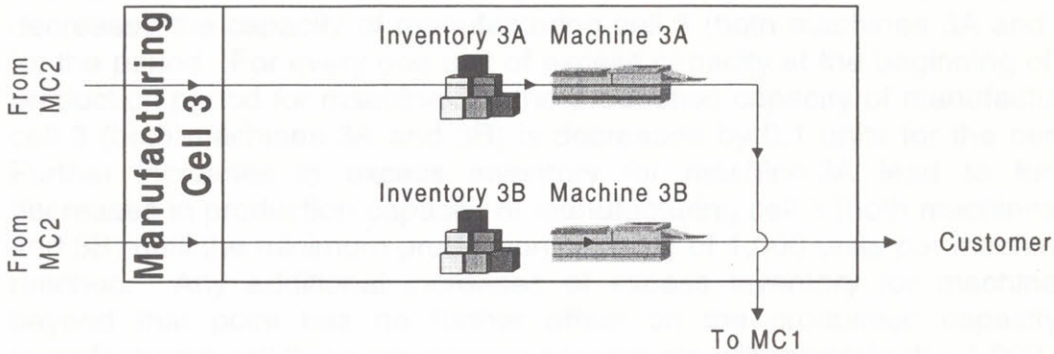
Manufacturing Cell 3

Having completed your training period, top management has now deemed you ready to commence your task in manufacturing cell 3 at Advac. Your manufacturing cell has been operating for several period, and you are replacing your predecessor at the end of one of the production periods.

Manufacturing Responsibility

- You are the production manager of manufacturing cell 3. Manufacturing cell 3 is one of three manufacturing cells involved in the manufacture of Delta within Advac Ltd. Your manufacturing cell is primarily concerned with drying the raw material for Delta.

Figure 1



- As the manager of manufacturing cell 3, you are required to set the production level for the two machines (machine 3A and machine 3B) under your control.

Machine Operations

- <u>Machine 3A</u> performs a drying operation on the work in process (WIP) received from manufacturing cell 2 (MC2, refer figure 1). It has a maximum capacity of 17,000 units per production period. Once the WIP has been dried, it is passed on to manufacturing cell 1 (MC1) for final cutting work.

- <u>Machine 3B</u> performs a final drying operation on the WIP received from manufacturing cell 2 (MC2, refer figure 1). It has a maximum capacity of 10,000 units per production period. Once the refinement to the WIP has occurred, it leaves the manufacturing process as Delta to be assembled by the customer.

Inventory Management

- Machine 3A has inventory 3A associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 2 in the previous period, and the amount of inventory 3A not used by machine 3A in the previous period.

- Any inventory 3A up to 17,000 units is considered to be "working inventory", and does not affect the production capacity of machine 3A. However, any inventory exceeding 17,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 3 (both machines 3A and 3B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 3A, the production capacity of manufacturing cell 3 (both machines 3A and 3B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 3A lead to further decreases in production capacity of manufacturing cell 3 (both machines 3A and 3B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 3A beyond that point has no further effect on the production capacity of manufacturing cell 3, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the reversal of such decreases at the same rate. However, production can never exceed the maximum capacity of 17,000 units per production period for machine 3A.

- Machine 3B has inventory 3B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 2 in the previous period, and the amount of inventory 3B not used by machine 3B in the previous period.

- Any inventory 3B up to 10,000 units is considered to be "working inventory", and does not affect the production capacity of machine 3B. However, any inventory exceeding 10,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 3 (both machines 3A and 3B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 3B, the production capacity of manufacturing cell 3 (both machines 3A and 3B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 3B lead to further decreases in production capacity of manufacturing cell 3 (both machines 3A and 3B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 3B beyond that point has no further effect on the production capacity of manufacturing cell 3, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the reversal of such decreases at the same

rate. However, production can never exceed the maximum capacity of 10,000 units per production period for machine 3B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Manufacturing Cell Number: 1 **Period: 1**

Production Report 1 (Last Period)	**Last Period (units)**
Output	
Machine 1A	-
Machine 1B	-

Production Report 2 (This Period) (A) Inventory on Hand	**This Period (units)**
Inventory 1A	
Working Inventory	225,000
Excess Inventory	0
Inventory 1B	
Working Inventory	90,000
Excess Inventory	0
(B) Machine Capacity	**This Period**
Maximum	
Machine 1A	225,000
Machine 1B	90,000
Actual	
Machine 1A	225,000
Machine 1B	90,000

Please use the following space to submit production targets for each of your machines for the current period.

Remember that your goal is to submit production targets to enable Trainvac to produce as much of Zeta as possible. Also remember that top management has issued a directive to keep work in process inventories in Trainvac as low as possible.

Please note that the production target cannot exceed the lower of inventory available for production or the capacities currently available for the machines.

Production

Machine 1A ______________________________ (units)

Machine 1B ______________________________ (units)

Manufacturing Cell Number: 2 **Period: 1**

Production Report 1 (Last Period)	**Last Period (units)**
Output	
Machine 2A	-
Machine 2B	-

Production Report 2 (This Period) (A) Inventory on Hand	**This Period (units)**
Inventory 2A	
Working Inventory	187,500
Excess Inventory	0
Inventory 2B	
Working Inventory	82,500
Excess Inventory	0
(B) Machine Capacity	**This Period**
Maximum	
Machine 2A	187,500
Machine 2B	82,500
Actual	
Machine 2A	187,500
Machine 2B	82,500

Please use the following space to submit production targets for each of your machines for the current period.

Remember that your goal is to submit production targets to enable Trainvac to produce as much of Zeta as possible. Also remember that top management has issued a directive to keep work in process inventories in Trainvac as low as possible.

Please note that the production target cannot exceed the lower of inventory available for production or the capacities currently available for the machines.

Production

Machine 2A ______________________________ (units)

Machine 2B ______________________________ (units)

Manufacturing Cell Number: 3 **Period: 1**

Production Report 1 (Last Period)	**Last Period (units)**
Output	
Machine 3A	-
Machine 3B	-

Production Report 2 (This Period) **(A) Inventory on Hand**	**This Period (units)**
Inventory 3A	
Working Inventory	127,500
Excess Inventory	0
Inventory 3B	
Working Inventory	75,000
Excess Inventory	0
(B) Machine Capacity	**This Period**
Maximum	
Machine 3A	127,500
Machine 3B	75,000
Actual	
Machine 3A	127,500
Machine 3B	75,000

Please use the following space to submit production targets for each of your machines for the current period.

Remember that your goal is to submit production targets to enable Trainvac to produce as much of Zeta as possible. Also remember that top management has issued a directive to keep work in process inventories in Trainvac as low as possible.

Please note that the production target cannot exceed the lower of inventory available for production or the capacities currently available for the machines.

Production

Machine 3A ______________________________ (units)

Machine 3B ______________________________ (units)

Manufacturing Cell Number: 1 **Period: 1**

Production Report 1 (Last Period)	**Last Period (units)**
Output	
Machine 1A	29,040
Machine 1B	11,040

Production Report 2 (This Period) **(A) Inventory on Hand**	**This Period (units)**
Inventory 1A	
Working Inventory	30,000
Excess Inventory	0
Inventory 1B	
Working Inventory	12,000
Excess Inventory	13,700
(B) Machine Capacity	**This Period**
Maximum	
Machine 1A	30,000
Machine 1B	12,000
Actual	
Machine 1A	28,630
Machine 1B	10,630

Please use the following space to submit production targets for each of your machines for the current period.

Remember that your goal is to submit production targets to enable Advac to produce as much of Delta as possible. Also remember that top management has issued a directive to keep work in process inventories in Advac as low as possible.

Please note that the production target cannot exceed the lower of inventory available for production or the capacities currently available for the machines.

Production

Machine 1A ______________________________ (units)

Machine 1B ______________________________ (units)

Period: 1	Manufacturing Cell			Company
	Number 1	Number 2	Number 3	Total
Production Report 1 (Last Period)	**(units)**	**(units)**	**(units)**	**(units)**
Output				
Machine A	29,040	23,780	15,140	-
Machine B	11,040	9,780	8,140	
Total Output of Delta				8,140
Production Report 2 (This Period) **(A) Inventory on Hand**	**(units)**	**(units)**	**(units)**	**(units)**
Inventory A				
Working Inventory	30,000	25,000	17,000	
Excess Inventory	0	15,360	24,940	-
Inventory B				
Working Inventory	12,000	11,000	10,000	
Excess Inventory	13,700	3,360	3,940	
Total Working Inventory	42,000	36,000	27,000	105,000
Total Excess Inventory	13,700	18,720	28,880	61,300
(B) Machine Capacity	**(units)**	**(units)**	**(units)**	**(units)**
Maximum				
Machine A	30,000	25,000	17,000	
Machine B	12,000	11,000	10,000	
Maximum capacity of Advac				10,000
Actual				
Machine A	28,630	23,128	14,112	
Machine B	10,630	9,128	7,112	
Actual capacity of Advac				7,112

Please use the following space to <u>submit production targets</u> for each of your machines for the current period.

Remember that your goal is to submit production targets to enable Advac to produce as much of Delta as possible. Also remember that top management has issued a directive to keep work in process inventories in Advac as low as possible.

Please note that the production target <u>cannot exceed</u> the lower of inventory available for production <u>or</u> the capacities currently available for the machines.

Production

Machine 1A ______________________________ (units)

Machine 1B ______________________________ (units)

Manufacturing Cell Number: 2 **Period: 1**

Production Report 1 (Last Period)	**Last Period (units)**
Output	
Machine 2A	23,780
Machine 2B	9,780

Production Report 2 (This Period) **(A) Inventory on Hand**	**This Period (units)**
Inventory 2A	
Working Inventory	25,000
Excess Inventory	15,360
Inventory 2B	
Working Inventory	11,000
Excess Inventory	3,360
(B) Machine Capacity	**This Period**
Maximum	
Machine 2A	25,000
Machine 2B	11,000
Actual	
Machine 2A	23,128
Machine 2B	9,128

Please use the following space to <u>submit production targets</u> for each of your machines for the current period.

Remember that your goal is to submit production targets to enable Advac to produce as much of Delta as possible. Also remember that top management has issued a directive to keep work in process inventories in Advac as low as possible.

Please note that the production target <u>cannot exceed</u> the lower of inventory available for production <u>or</u> the capacities currently available for the machines.

Production

Machine 2A ________________________________ (units)

Machine 2B ________________________________ (units)

Period: 1	**Manufacturing Cell**			**Company Total**
	Number 1	**Number 2**	**Number 3**	
Production Report 1 (Last Period)	**(units)**	**(units)**	**(units)**	**(units)**
Output				
Machine A	29,040	23,780	15,140	-
Machine B	11,040	9,780	8,140	
Total Output of Delta				8,140
Production Report 2 (This Period) **(A) Inventory on Hand**	**(units)**	**(units)**	**(units)**	**(units)**
Inventory A				
Working Inventory	30,000	25,000	17,000	
Excess Inventory	0	15,360	24,940	-
Inventory B				
Working Inventory	12,000	11,000	10,000	
Excess Inventory	13,700	3,360	3,940	
Total Working Inventory	42,000	36,000	27,000	105,000
Total Excess Inventory	13,700	18,720	28,880	61,300
(B) Machine Capacity	**(units)**	**(units)**	**(units)**	**(units)**
Maximum				
Machine A	30,000	25,000	17,000	
Machine B	12,000	11,000	10,000	
Maximum capacity of Advac				10,000
Actual				
Machine A	28,630	23,128	14,112	
Machine B	10,630	9,128	7,112	
Actual capacity of Advac				7,112

Please use the following space to submit production targets for each of your machines for the current period.

Remember that your goal is to submit production targets to enable Advac to produce as much of Delta as possible. Also remember that top management has issued a directive to keep work in process inventories in Advac as low as possible.

Please note that the production target cannot exceed the lower of inventory available for production or the capacities currently available for the machines.

Production

Machine 2A ______________________________ (units)

Machine 2B ______________________________ (units)

Manufacturing Cell Number: 3 **Period: 1**

Production Report 1 (Last Period)	**Last Period (units)**
Output	
Machine 3A	15,140
Machine 3B	8,140

Production Report 2 (This Period) **(A) Inventory on Hand**	**This Period (units)**
Inventory 3A	
Working Inventory	17,000
Excess Inventory	24,940
Inventory 3B	
Working Inventory	10,000
Excess Inventory	3,940
(B) Machine Capacity	**This Period**
Maximum	
Machine 3A	17,000
Machine 3B	10,000
Actual	
Machine 3A	14,112
Machine 3B	7,112

Please use the following space to submit production targets for each of your machines for the current period.

Remember that your goal is to submit production targets to enable Advac to produce as much of Delta as possible. Also remember that top management has issued a directive to keep work in process inventories in Advac as low as possible.

Please note that the production target cannot exceed the lower of inventory available for production or the capacities currently available for the machines.

Production

Machine 3A ______________________________ (units)

Machine 3B ______________________________ (units)

Period: 1	Manufacturing Cell			Company
	Number 1	Number 2	Number 3	Total
Production Report 1 (Last Period)	**(units)**	**(units)**	**(units)**	**(units)**
Output				-
Machine A	29,040	23,780	15,140	
Machine B	11,040	9,780	8,140	
Total Output of Delta				8,140
Production Report 2 (This Period)				
(A) Inventory on Hand	**(units)**	**(units)**	**(units)**	**(units)**
Inventory A				
Working Inventory	30,000	25,000	17,000	
Excess Inventory	0	15,360	24,940	-
Inventory B				
Working Inventory	12,000	11,000	10,000	
Excess Inventory	13,700	3,360	3,940	
Total Working Inventory	42,000	36,000	27,000	105,000
Total Excess Inventory	13,700	18,720	28,880	61,300
(B) Machine Capacity	**(units)**	**(units)**	**(units)**	**(units)**
Maximum				
Machine A	30,000	25,000	17,000	
Machine B	12,000	11,000	10,000	
Maximum capacity of Advac				10,000
Actual				
Machine A	28,630	23,128	14,112	
Machine B	10,630	9,128	7,112	
Actual capacity of Advac				7,112

Please use the following space to <u>submit production targets</u> for each of your machines for the current period.

Remember that your goal is to submit production targets to enable Advac to produce as much of Delta as possible. Also remember that top management has issued a directive to keep work in process inventories in Advac as low as possible.

Please note that the production target cannot exceed the lower of inventory available for production or the capacities currently available for the machines.

Production

Machine 3A ______________________________ (units)

Machine 3B ______________________________ (units)

Post Test Questionnaire

1. General participant information

Age ______________________________

Sex (Male/ Female) ______________________________

Full-time/ Part-time Student ______________________________

The following questions relate to the task that you were required to perform at Advac. Please <u>ignore</u> the training period at Trainvac.

2. As the production manager what was your overall goal? (circle one)

   Maximise my own manufacturing cell production

   Maximise Advac's production

3. Under circumstances where there is no excess inventory in the manufacturing cell, what is the maximum production capacity of

   Machine XA ______________(units)

   Machine XB ______________(units)

For the following questions please indicate your response on the line as shown in the following line example:

Example:

Not at all | To a great extent

4. In setting production targets, to what extent did you attempt to control excess inventory? (indicate on the line)

Not at all | To a great extent

5. To what extent did your production decision affect the production decision of the other manufacturing cells? (indicate on the line)

Not at all | To a great extent

6. To what extent did other manufacturing cells' decisions affect the production decision of your manufacturing cells? (indicate on the line)

Not at all | To a great extent

7. To what extent was there cooperation between the members of your group? (indicate on the line)

Not at all | | To a great extent

8. To what extent were you motivated to act in the best interest of Advac (ie. maximise the output of the final product) as a company? (indicate on the line)

Not at all | | To a great extent

9. To what extent were you able to set production targets that were consistent with your motivation expressed in question 5? (indicate on the line)

Not at all | | To a great extent

10. How useful was the accounting report in setting your production target? (indicate on the line)

No use   Very useful

11. How useful was the accounting report in developing a strategy to produce as much of Delta as possible, while keeping Advac's inventories as low as possible? (indicate on the line)

No use   Very useful

Appendix 2

Experimental Material - Experiment 2

Content	Page	G*	I*	F*
Company Background	198	✓	✓	✓
P.O. Instructions - Trainvac 1	205	✓		
P.O. Instructions - Trainvac 2	208	✓		
P.O. Instructions - Trainvac 3	212	✓		
P.O. Instructions - Trainvac 1	216		✓	
P.O. Instructions - Trainvac 2	219		✓	
P.O. Instructions - Trainvac 3	223		✓	
P.O. Instructions - Trainvac 1	227			✓
P.O. Instructions - Trainvac 2	230			✓
P.O. Instructions - Trainvac 3	234			✓
P.O. Instructions - Advac 1	238	✓		
P.O. Instructions - Advac 2	241	✓		
P.O. Instructions - Advac 3	245	✓		
P.O. Instructions - Advac 1	249		✓	
P.O. Instructions - Advac 2	252		✓	
P.O. Instructions - Advac 3	257		✓	
P.O. Instructions - Advac 1	260			✓
P.O. Instructions - Advac 2	263			✓
P.O. Instructions - Advac 3	267			✓
Reward System Illustration	271		✓	
Reward System Illustration	272			✓
Post-test Questionnaire	273	✓	✓	✓
Screen Shots	277	✓	✓	✓

* Treatment Abbreviations:

G = Group Rewards, I = Individualistic Rewards, F = Fixed-rate Rewards

Advac Ltd

Company Profile

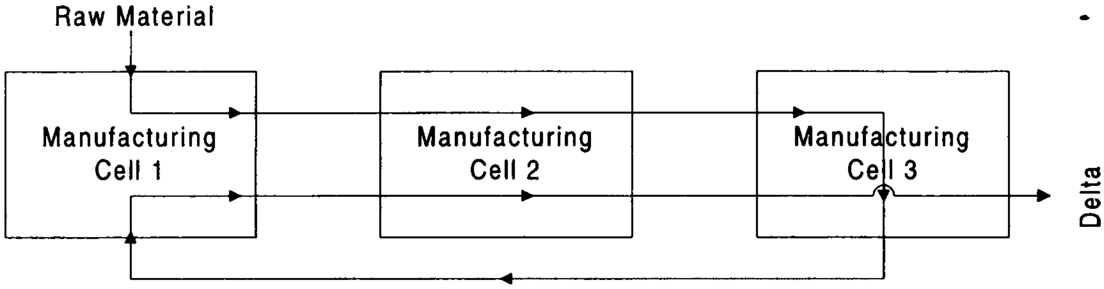
Name: ______________________________

Student Number: ______________________________

Company Background

Advac is a manufacturing company located in the west of Sydney. Advac is involved in the manufacture of Delta. Three manufacturing cells (or departments) are involved in the manufacture of Delta. The manufacturing flow of Delta through the three manufacturing cells is illustrated in figure 1.

Figure 1



Manufacturing cell 1 is involved primarily in cutting raw materials into the shape of Delta. The raw materials initially enter manufacturing cell 1 from the vendor and manufacturing cell 1 uses machine 1A to perform some preliminary cutting. Upon completion of the cutting, work in process (WIP) is passed on to manufacturing cell 2. Manufacturing cell 2 performs primarily painting operations. The WIP received from manufacturing cell 1 is painted using machine 2A. Upon completion of the painting operation the WIP is passed on to manufacturing cell 3. Manufacturing cell 3 performs primarily drying operations. The WIP received from manufacturing cell 2 is dried using machine 3A and is then passed on to manufacturing cell 1 for some final cutting. This final cutting is performed in manufacturing cell 1 using machine 1B. Upon completion of the final cutting the WIP is then passed on to manufacturing cell 2 for final painting. This final painting is performed in manufacturing cell 2 using machine 2B. Upon completion of the final painting the WIP leave manufacturing cell 2 for final drying in manufacturing cell 3. This final drying is performed in manufacturing cell 3 using machine 3B. After the final drying stage Delta is completed and leaves the manufacturing process to be assembled by the final customer.

Top management has indicated that customer demand for Delta is at an all time high, and that all of the production output of Delta can be sold. Top management has further indicated that each manufacturing cell has full autonomy and that the production manager of each manufacturing cell should manage to the best of his/ her ability.

Job Description

Production Scheduling

You are the production manager of one of the manufacturing cells. As the production manager you have to schedule production for each machine in your manufacturing cell, at the beginning of each production period. Once you have made your decision about how much to produce on each machine your manufacturing cell is committed to those production figures for the period. However, you are free to change your decision in the next production period.

Machine Operation

The capacity of your two machines are not equal. They differ due to the nature of the task performed by each machine. However, each of your machines has a maximum capacity which limits your production. Production capacity of your machines may decrease below the maximum production capacity as a result of excess inventory as outlined in the next paragraph. You will be made aware of decreases in production capacities at the beginning of the production period before you make your production decision for the period. Your production decision can never be in excess of the production capacity of the machines for the period.

Inventory Management

Inventory accumulates in front of each machine. This is illustrated in figure 2 (on page 5). Inventory which does not exceed the maximum production capacity of the particular machine is considered to be "working inventory" and does not affect the capacity of the particular machine. However, any inventory which exceeds this "working inventory" level poses a problem to the manufacturing cell. This "excess inventory" has to be administered and decreases the capacity of the machines in the manufacturing cell by diverting time away from production. For every one unit of excess inventory at the beginning of the production period for a particular machine, the production capacity of both machines in the manufacturing cell is decreased by 0.1 units for the period. Further increases in excess inventory at the beginning of the production period for a particular machine lead to further decreases in manufacturing cell capacity, at the 0.1 rate, until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory at the beginning of the production period for a particular machine has no further effect on the manufacturing cell's machine capacities, as emergency procedures will maintain the 1,000 unit minimum capacity of each machine.

Subsequent decreases in excess inventory levels will result in restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of your machines. In cases where your production capacity is less than maximum capacity, due to excess inventory, your production decision <u>cannot exceed this capacity</u>.

An example illustrating the previous points on inventory management follows. Assume that the maximum production capacity of both of your machines is 100 units. Further assume that the total inventory at the beginning of the current period for machine A was 120 units and for machine B 100 units. The nature and effects of this inventory for the current period would be as follows.

Inventory in front of machine A	
Working inventory	100
Excess inventory	20
Total inventory in front of machine A	120

Inventory in front of machine B	
Working inventory	100
Excess inventory	0
Total inventory in front of machine B	100

Total working inventory in manufacturing cell (both machines)	200
Total excess inventory in manufacturing cell (both machines)	20
Productivity loss in manufacturing cell due to excess inventory in manufacturing cell (both machines) [0.1 x 20]	2

Capacity of machine A	
Maximum capacity	100
Less capacity loss due to excess inventory in the manufacturing cell	2
Actual capacity of machine A	98

Capacity of machine B	
Maximum capacity	100
Less capacity loss due to excess inventory in the manufacturing cell	2
Actual capacity of machine B	98

Figure 2

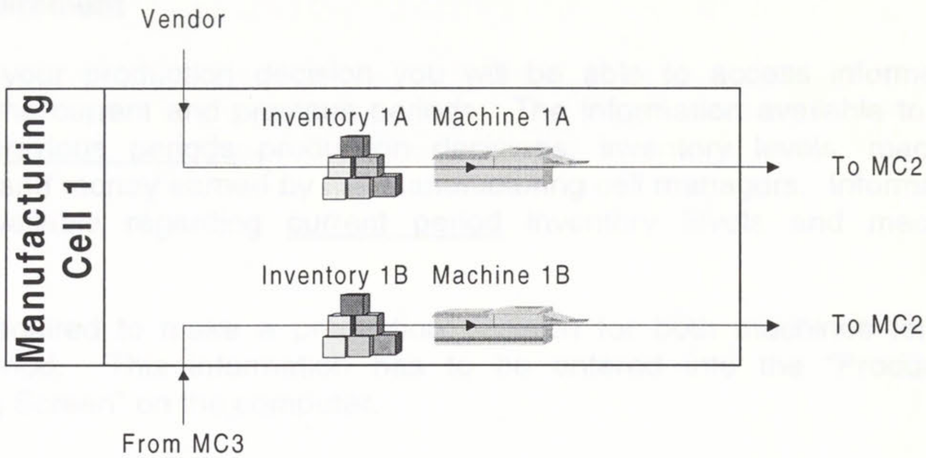


Figure 2 (cont.)

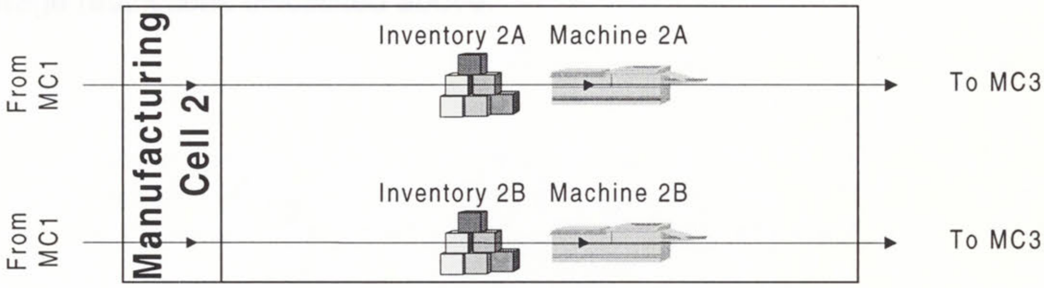
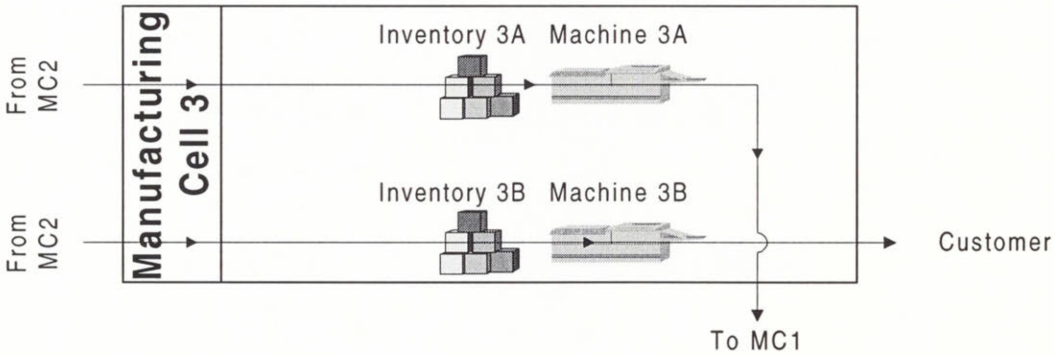


Figure 2 (cont.)



Task Requirement

To assist your production decision you will be able to access information regarding the current and previous periods. The information available to you includes previous periods production decisions, inventory levels, machine capacities and money earned by the manufacturing cell managers. Information is also available regarding current period inventory levels and machine capacities.

You are required to make a production decision for both machines for the current period. This information has to be entered into the "Production Scheduling Screen" on the computer.

You need to be aware that your production decision cannot exceed the amount of inventory available for production. Nor can it exceed the current production capability of your machines, which may be less than 100% due to inventory storage restrictions discussed above.

Production Operating Instructions

Training Camp

Manufacturing Cell 1

Training Period

Before commencing your job at Advac, top management has assigned you to a training division within Advac. The training division manufactures a similar product to Delta called Zeta, which has no commercial value.

You have been assigned to manufacturing cell 1, whose operating characteristics are equivalent to your final job at manufacturing cell 1 at Advac.

The only difference between your training manufacturing cell and your final manufacturing cell at Advac is in regard to the capacities of your two machines in each cell. They differ significantly as the training cell is a much larger manufacturing cell than your final manufacturing cell.

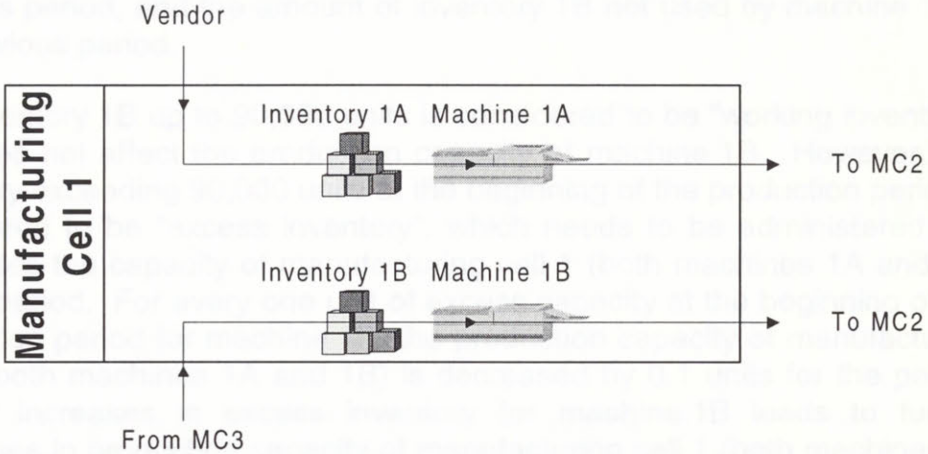
This booklet contains information about your specific:

Please take a moment to read this carefully!

Manufacturing Responsibility

- You are the production manager of manufacturing cell 1. Manufacturing cell 1 is one of three manufacturing cells involved in the manufacture of Zeta within the training division. Your manufacturing cell is primarily concerned with cutting the raw material for Zeta.

Figure 1



- As the manager of manufacturing cell 1, you are required to set the production level for the two machines (machine 1A and machine 1B) under your control.

Machine Operations

- <u>Machine 1A</u> performs a cutting operation on the raw materials received from the vendor (refer figure 1). It has a maximum capacity of 225,000 units per production period. Once the raw materials have been cut, they are passed as work in process (WIP) to manufacturing cell 2 (MC2) for paint work.

- <u>Machine 1B</u> performs a further refinement cutting operation on the WIP received from manufacturing cell 3 (MC3, refer figure 1). It has a maximum capacity of 90,000 units per production period. Once the refinement to the WIP has occurred, it is passed on to manufacturing cell 2 (MC2) for final paint work.

Inventory Management

- Machine 1A has inventory 1A associated with it (refer figure 1). This inventory is supplied by the vendor to your manufacturing cell. You have negotiated an agreement with the vendor to supply enough to replenish inventory 1A up to 225,000 at the start of every production period.

- Machine 1B has inventory 1B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 3 in the previous period, and the amount of inventory 1B not used by machine 1B in the previous period.

- Any inventory 1B up to 90,000 units is considered to be "working inventory", and does not affect the production capacity of machine 1B. However, any inventory exceeding 90,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 1 (both machines 1A and 1B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 1B, the production capacity of manufacturing cell 1 (both machines 1A and 1B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 1B leads to further decreases in production capacity of manufacturing cell 1 (both machines 1A and 1B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 1B beyond that point has no further effect on the production capacity of manufacturing cell 1, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 90,000 units per production period for machine 1B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Reward System

During the training period you will be paid a <u>variable wage</u> in Cook dollars per production period. A variable rate of 1.5 Cook dollars for every unit of production output for the training division will be paid less 0.01 Cook dollars for every unit of excess inventory in the training division. The payment of the wage is for illustration purposes only, and will not be convertible into Australian dollars at the end of your management contract.

Production Operating Instructions

Training Camp

Manufacturing Cell 2

Training Period

Before commencing your job at Advac, top management has assigned you to a training division within Advac. The training division manufactures a similar product to Delta called Zeta, which has no commercial value.

You have been assigned to manufacturing cell 2, whose operating characteristics are equivalent to your final job at manufacturing cell 2 at Advac.

The only difference between your training manufacturing cell and your final manufacturing cell at Advac is in regard to the capacities of your two machines in each cell. They differ significantly as the training cell is a much larger manufacturing cell than your final manufacturing cell.

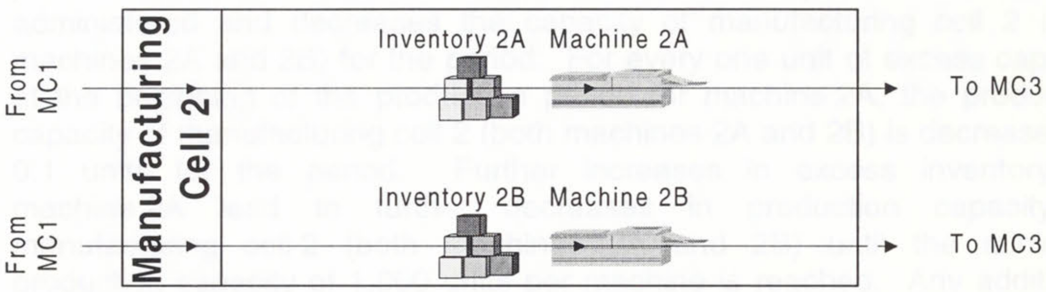
This booklet contains information about your specific:

Please take a moment to read this carefully!

Manufacturing Responsibility

- You are the production manager of manufacturing cell 2. Manufacturing cell 2 is one of three manufacturing cells involved in the manufacture of Zeta within the training division. Your manufacturing cell is primarily concerned with painting the raw material for Zeta.

Figure 1



- As the manager of manufacturing cell 2, you are required to set the production level for the two machines (machine 2A and machine 2B) under your control.

Machine Operations

- <u>Machine 2A</u> performs a painting operation on the work in process (WIP) received from manufacturing cell 1 (MC1, refer figure 2). It has a maximum capacity of 187,500 units per production period. Once the WIP has been painted, it is passed on to manufacturing cell 3 (MC3) for drying work.

- <u>Machine 2B</u> performs a further refinement painting operation on the WIP received from manufacturing cell 1 (MC1, refer figure 2). It has a maximum capacity of 82,500 units per production period. Once the refinement to the WIP has occurred, it is passed on to manufacturing cell 3 (MC3) for final drying work.

Inventory Management

- Machine 2A has inventory 2A associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 1 in the previous period, and the amount of inventory 2A not used by machine 2A in the previous period.

- Any inventory 2A up to 187,500 units is considered to be "working inventory", and does not affect the production capacity of machine 2A. However, any inventory exceeding 187,500 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 2 (both machines 2A and 2B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 2A, the production capacity of manufacturing cell 2 (both machines 2A and 2B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 2A lead to further decreases in production capacity of manufacturing cell 2 (both machines 2A and 2B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 2A beyond that point has no further effect on the production capacity of manufacturing cell 2, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 187,500 units per production period for machine 2A.

- Machine 2B has inventory 2B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 1 in the previous period, and the amount of inventory 2B not used by machine 2B in the previous period.

- Any inventory 2B up to 82,500 units is considered to be "working inventory", and does not affect the production capacity of machine 2B. However, any inventory exceeding 82,500 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 2 (both machines 2A and 2B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 2B, the production capacity of manufacturing cell 2 (both machines 2A and 2B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 2B lead to further decreases in production capacity of manufacturing cell 2 (both machines 2A and 2B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 2B beyond that point has no further effect on the production capacity of manufacturing cell 2, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate.

However, production can never exceed the maximum capacity of 82,500 units per production period for machine 2B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Reward System

During the training period you will be paid a variable wage in Cook dollars per production period. A variable rate of 1.5 Cook dollars for every unit of production output for the training division will be paid less 0.01 Cook dollars for every unit of excess inventory in the training division. The payment of the wage is for illustration purposes only, and will not be convertible into Australian dollars at the end of your management contract.

Production Operating Instructions

Training Camp

Manufacturing Cell 3

Training Period

Before commencing your job at Advac, top management has assigned you to a training division within Advac. The training division manufactures a similar product to Delta called Zeta, which has no commercial value.

You have been assigned to manufacturing cell 3, whose operating characteristics are equivalent to your final job at manufacturing cell 3 at Advac.

The only difference between your training manufacturing cell and your final manufacturing cell at Advac is in regard to the capacities of your two machines in each cell. They differ significantly as the training cell is a much larger manufacturing cell than your final manufacturing cell.

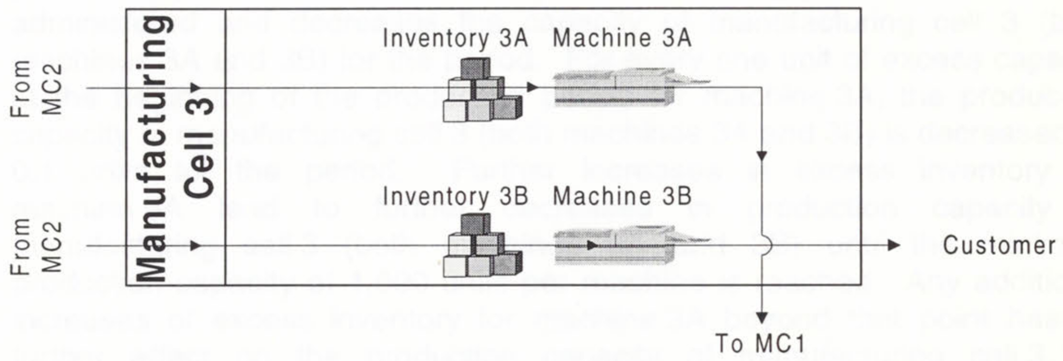
This booklet contains information about your specific:

Please take a moment to read this carefully!

Manufacturing Responsibility

- You are the production manager of manufacturing cell 3. Manufacturing cell 3 is one of three manufacturing cells involved in the manufacture of Zeta within the training division. Your manufacturing cell is primarily concerned with drying the raw material for Zeta.

Figure 1



- As the manager of manufacturing cell 3, you are required to set the production level for the two machines (machine 3A and machine 3B) under your control.

Machine Operations

- Machine 3A performs a drying operation on the work in process (WIP) received from manufacturing cell 2 (MC2, refer figure 1). It has a maximum capacity of 127,500 units per production period. Once the WIP has been dried, it is passed on to manufacturing cell 1 (MC1) for final cutting work.

- Machine 3B performs a final drying operation on the WIP received from manufacturing cell 2 (MC2, refer figure 1). It has a maximum capacity of 75,000 units per production period. Once the refinement to the WIP has occurred, it leaves the manufacturing process as Zeta to be assembled by the customer.

Inventory Management

- Machine 3A has inventory 3A associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 2 in the previous period, and the amount of inventory 3A not used by machine 3A in the previous period.

- Any inventory 3A up to 127,500 units is considered to be "working inventory", and does not affect the production capacity of machine 3A. However, any inventory exceeding 127,500 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 3 (both machines 3A and 3B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 3A, the production capacity of manufacturing cell 3 (both machines 3A and 3B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 3A lead to further decreases in production capacity of manufacturing cell 3 (both machines 3A and 3B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 3A beyond that point has no further effect on the production capacity of manufacturing cell 3, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 127,500 units per production period for machine 3A.

- Machine 3B has inventory 3B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 2 in the previous period, and the amount of inventory 3B not used by machine 3B in the previous period.

- Any inventory 3B up to 75,000 units is considered to be "working inventory", and does not affect the production capacity of machine 3B. However, any inventory exceeding 75,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 3 (both machines 3A and 3B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 3B, the production capacity of manufacturing cell 3 (both machines 3A and 3B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 3B lead to further decreases in production capacity of manufacturing cell 3 (both machines 3A and 3B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 3B beyond that point has no further effect on the production capacity of manufacturing cell 3, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate.

However, production can never exceed the maximum capacity of 75,000 units per production period for machine 3B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Reward System

During the training period you will be paid a variable wage in Cook dollars per production period. A variable rate of 1.5 Cook dollars for every unit of production output for the training division will be paid less 0.01 Cook dollars for every unit of excess inventory in the training division. The payment of the wage is for illustration purposes only, and will not be convertible into Australian dollars at the end of your management contract.

Production Operating Instructions

Training Camp

Manufacturing Cell 1

Training Period

Before commencing your job at Advac, top management has assigned you to a training division within Advac. The training division manufactures a similar product to Delta called Zeta, which has no commercial value.

You have been assigned to manufacturing cell 1, whose operating characteristics are equivalent to your final job at manufacturing cell 1 at Advac.

The only difference between your training manufacturing cell and your final manufacturing cell at Advac is in regard to the capacities of your two machines in each cell. They differ significantly as the training cell is a much larger manufacturing cell than your final manufacturing cell.

This booklet contains information about your specific:

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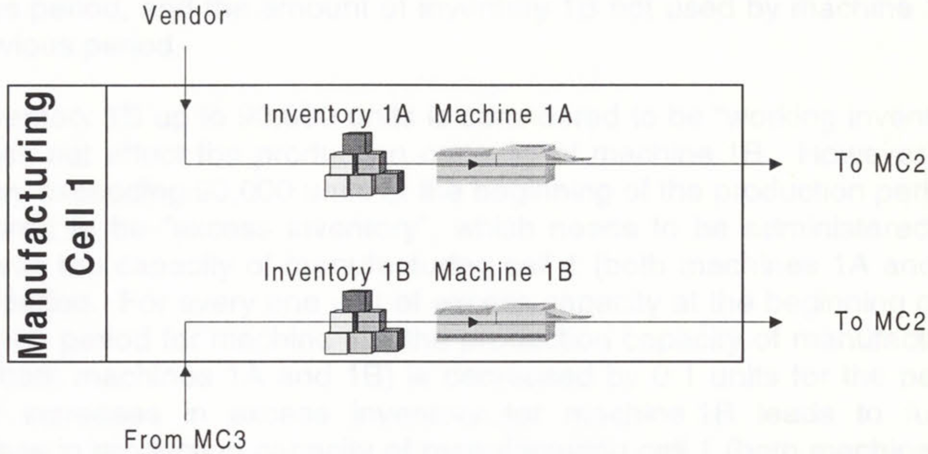
Manufacturing Responsibility

- You are the production manager of manufacturing cell 1. Manufacturing cell 1 is one of three manufacturing cells involved in the manufacture of Zeta within the training division. Your manufacturing cell is primarily concerned with cutting the raw material for Zeta.

Figure 1



- As the manager of manufacturing cell 1, you are required to set the production level for the two machines (machine 1A and machine 1B) under your control.

Machine Operations

- Machine 1A performs a cutting operation on the raw materials received from the vendor (refer figure 1). It has a maximum capacity of 225,000 units per production period. Once the raw materials have been cut, they are passed as work in process (WIP) to manufacturing cell 2 (MC2) for paint work.

- Machine 1B performs a further refinement cutting operation on the WIP received from manufacturing cell 3 (MC3, refer figure 1). It has a maximum capacity of 90,000 units per production period. Once the refinement to the WIP has occurred, it is passed on to manufacturing cell 2 (MC2) for final paint work.

Inventory Management

- Machine 1A has inventory 1A associated with it (refer figure 1). This inventory is supplied by the vendor to your manufacturing cell. You have negotiated an agreement with the vendor to supply enough to replenish inventory 1A up to 225,000 at the start of every production period.

- Machine 1B has inventory 1B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 3 in the previous period, and the amount of inventory 1B not used by machine 1B in the previous period.

- Any inventory 1B up to 90,000 units is considered to be "working inventory", and does not affect the production capacity of machine 1B. However, any inventory exceeding 90,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 1 (both machines 1A and 1B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 1B, the production capacity of manufacturing cell 1 (both machines 1A and 1B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 1B leads to further decreases in production capacity of manufacturing cell 1 (both machines 1A and 1B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 1B beyond that point has no further effect on the production capacity of manufacturing cell 1, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 90,000 units per production period for machine 1B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Reward System

During the training period you will be paid a flat wage in Cook dollars per production period. A flat wage of 112,500 Cook dollars will be paid per production period, regardless of the production output and excess inventory levels of your individual manufacturing cell and the training division. The payment of the wage is for illustration purposes only, and will not be convertible into Australian dollars at the end of your management contract.

Production Operating Instructions

Training Camp

Manufacturing Cell 2

Training Period

Before commencing your job at Advac, top management has assigned you to a training division within Advac. The training division manufactures a similar product to Delta called Zeta, which has no commercial value.

You have been assigned to manufacturing cell 2, whose operating characteristics are equivalent to your final job at manufacturing cell 2 at Advac.

The only difference between your training manufacturing cell and your final manufacturing cell at Advac is in regard to the capacities of your two machines in each cell. They differ significantly as the training cell is a much larger manufacturing cell than your final manufacturing cell.

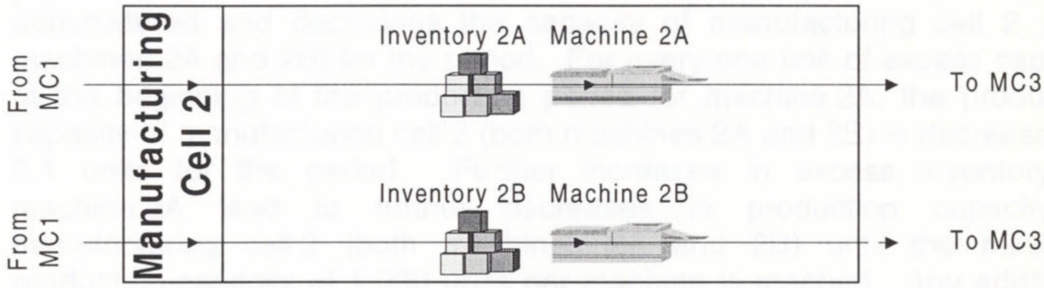
This booklet contains information about your specific:

Please take a moment to read this carefully!

Manufacturing Responsibility

- You are the production manager of manufacturing cell 2. Manufacturing cell 2 is one of three manufacturing cells involved in the manufacture of Zeta within the training division. Your manufacturing cell is primarily concerned with painting the raw material for Zeta.

Figure 1



- As the manager of manufacturing cell 2, you are required to set the production level for the two machines (machine 2A and machine 2B) under your control.

Machine Operations

- <u>Machine 2A</u> performs a painting operation on the work in process (WIP) received from manufacturing cell 1 (MC1, refer figure 2). It has a maximum capacity of 187,500 units per production period. Once the WIP has been painted, it is passed on to manufacturing cell 3 (MC3) for drying work.

- <u>Machine 2B</u> performs a further refinement painting operation on the WIP received from manufacturing cell 1 (MC1, refer figure 2). It has a maximum capacity of 82,500 units per production period. Once the refinement to the WIP has occurred, it is passed on to manufacturing cell 3 (MC3) for final drying work.

Inventory Management

- Machine 2A has inventory 2A associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 1 in the previous period, and the amount of inventory 2A not used by machine 2A in the previous period.

- Any inventory 2A up to 187,500 units is considered to be "working inventory", and does not affect the production capacity of machine 2A. However, any inventory exceeding 187,500 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 2 (both machines 2A and 2B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 2A, the production capacity of manufacturing cell 2 (both machines 2A and 2B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 2A lead to further decreases in production capacity of manufacturing cell 2 (both machines 2A and 2B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 2A beyond that point has no further effect on the production capacity of manufacturing cell 2, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 187,500 units per production period for machine 2A.

- Machine 2B has inventory 2B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 1 in the previous period, and the amount of inventory 2B not used by machine 2B in the previous period.

- Any inventory 2B up to 82,500 units is considered to be "working inventory", and does not affect the production capacity of machine 2B. However, any inventory exceeding 82,500 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 2 (both machines 2A and 2B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 2B, the production capacity of manufacturing cell 2 (both machines 2A and 2B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 2B lead to further decreases in production capacity of manufacturing cell 2 (both machines 2A and 2B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 2B beyond that point has no further effect on the production capacity of manufacturing cell 2, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate.

However, production can never exceed the maximum capacity of 82,500 units per production period for machine 2B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Reward System

During the training period you will be paid a flat wage in Cook dollars per production period. A flat wage of 112,500 Cook dollars will be paid per production period, regardless of the production output and excess inventory levels of your individual manufacturing cell and the training division. The payment of the wage is for illustration purposes only, and will not be convertible into Australian dollars at the end of your management contract.

Production Operating Instructions

Training Camp

Manufacturing Cell 3

Training Period

Before commencing your job at Advac, top management has assigned you to a training division within Advac. The training division manufactures a similar product to Delta called Zeta, which has no commercial value.

You have been assigned to manufacturing cell 3, whose operating characteristics are equivalent to your final job at manufacturing cell 3 at Advac.

The only difference between your training manufacturing cell and your final manufacturing cell at Advac is in regard to the capacities of your two machines in each cell. They differ significantly as the training cell is a much larger manufacturing cell than your final manufacturing cell.

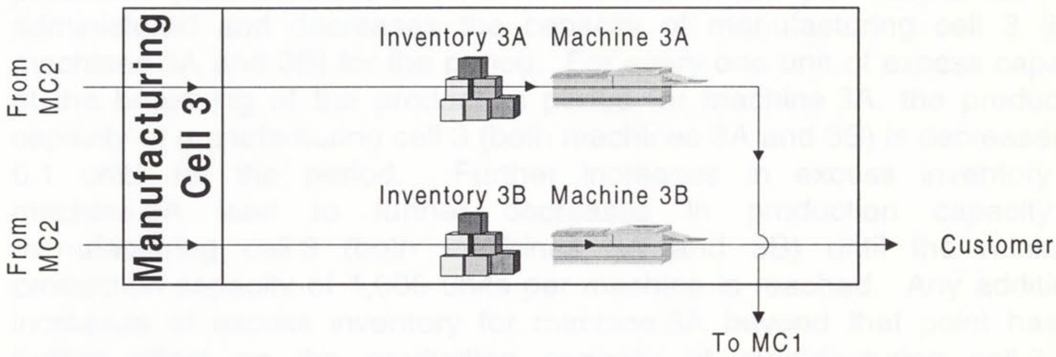
This booklet contains information about your specific:

Please take a moment to read this carefully!

Manufacturing Responsibility

- You are the production manager of manufacturing cell 3. Manufacturing cell 3 is one of three manufacturing cells involved in the manufacture of Zeta within the training division. Your manufacturing cell is primarily concerned with drying the raw material for Zeta.

Figure 1



- As the manager of manufacturing cell 3, you are required to set the production level for the two machines (machine 3A and machine 3B) under your control.

Machine Operations

- <u>Machine 3A</u> performs a drying operation on the work in process (WIP) received from manufacturing cell 2 (MC2, refer figure 1). It has a maximum capacity of 127,500 units per production period. Once the WIP has been dried, it is passed on to manufacturing cell 1 (MC1) for final cutting work.

- <u>Machine 3B</u> performs a final drying operation on the WIP received from manufacturing cell 2 (MC2, refer figure 1). It has a maximum capacity of 75,000 units per production period. Once the refinement to the WIP has occurred, it leaves the manufacturing process as Zeta to be assembled by the customer.

Inventory Management

- Machine 3A has inventory 3A associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 2 in the previous period, and the amount of inventory 3A not used by machine 3A in the previous period.

- Any inventory 3A up to 127,500 units is considered to be "working inventory", and does not affect the production capacity of machine 3A. However, any inventory exceeding 127,500 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 3 (both machines 3A and 3B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 3A, the production capacity of manufacturing cell 3 (both machines 3A and 3B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 3A lead to further decreases in production capacity of manufacturing cell 3 (both machines 3A and 3B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 3A beyond that point has no further effect on the production capacity of manufacturing cell 3, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 127,500 units per production period for machine 3A.

- Machine 3B has inventory 3B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 2 in the previous period, and the amount of inventory 3B not used by machine 3B in the previous period.

- Any inventory 3B up to 75,000 units is considered to be "working inventory", and does not affect the production capacity of machine 3B. However, any inventory exceeding 75,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 3 (both machines 3A and 3B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 3B, the production capacity of manufacturing cell 3 (both machines 3A and 3B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 3B lead to further decreases in production capacity of manufacturing cell 3 (both machines 3A and 3B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 3B beyond that point has no further effect on the production capacity of manufacturing cell 3, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate.

However, production can never exceed the maximum capacity of 75,000 units per production period for machine 3B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Reward System

During the training period you will be paid a flat wage in Cook dollars per production period. A flat wage of 112,500 Cook dollars will be paid per production period, regardless of the production output and excess inventory levels of your individual manufacturing cell and the training division. The payment of the wage is for illustration purposes only, and will not be convertible into Australian dollars at the end of your management contract.

Production Operating Instructions

Training Camp

Manufacturing Cell 1

Training Period

Before commencing your job at Advac, top management has assigned you to a training division within Advac. The training division manufactures a similar product to Delta called Zeta, which has no commercial value.

You have been assigned to manufacturing cell 1, whose operating characteristics are equivalent to your final job at manufacturing cell 1 at Advac.

The only difference between your training manufacturing cell and your final manufacturing cell at Advac is in regard to the capacities of your two machines in each cell. They differ significantly as the training cell is a much larger manufacturing cell than your final manufacturing cell.

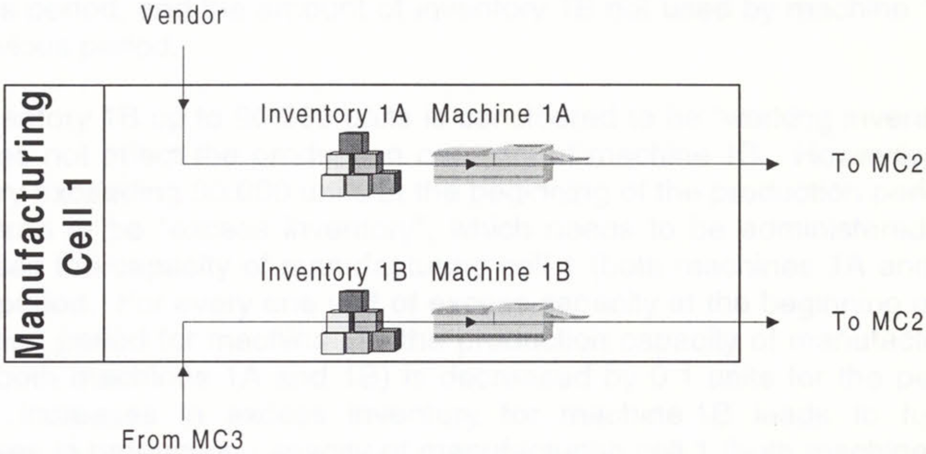
This booklet contains information about your specific:

Please take a moment to read this carefully!

Manufacturing Responsibility

- You are the production manager of manufacturing cell 1. Manufacturing cell 1 is one of three manufacturing cells involved in the manufacture of Zeta within the training division. Your manufacturing cell is primarily concerned with cutting the raw material for Zeta.

Figure 1



- As the manager of manufacturing cell 1, you are required to set the production level for the two machines (machine 1A and machine 1B) under your control.

Machine Operations

- Machine 1A performs a cutting operation on the raw materials received from the vendor (refer figure 1). It has a maximum capacity of 225,000 units per production period. Once the raw materials have been cut, they are passed as work in process (WIP) to manufacturing cell 2 (MC2) for paint work.
- Machine 1B performs a further refinement cutting operation on the WIP received from manufacturing cell 3 (MC3, refer figure 1). It has a maximum capacity of 90,000 units per production period. Once the refinement to the WIP has occurred, it is passed on to manufacturing cell 2 (MC2) for final paint work.

Inventory Management

- Machine 1A has inventory 1A associated with it (refer figure 1). This inventory is supplied by the vendor to your manufacturing cell. You have negotiated an agreement with the vendor to supply enough to replenish inventory 1A up to 225,000 at the start of every production period.

- Machine 1B has inventory 1B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 3 in the previous period, and the amount of inventory 1B not used by machine 1B in the previous period.

- Any inventory 1B up to 90,000 units is considered to be "working inventory", and does not affect the production capacity of machine 1B. However, any inventory exceeding 90,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 1 (both machines 1A and 1B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 1B, the production capacity of manufacturing cell 1 (both machines 1A and 1B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 1B leads to further decreases in production capacity of manufacturing cell 1 (both machines 1A and 1B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 1B beyond that point has no further effect on the production capacity of manufacturing cell 1, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 90,000 units per production period for machine 1B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Reward System

During the training period you will be paid a <u>variable wage</u> in Cook dollars per production period. As manufacturing cell 1 manager you will be paid 0.75 Cook dollars for every unit of production output from <u>manufacturing cell 1</u>, less 0.01 Cook dollars for every unit of excess inventory <u>in manufacturing cell 1</u>. The payment of the wage is for illustration purposes only, and will not be convertible into Australian dollars at the end of your management contract.

Production Operating Instructions

Training Camp

Manufacturing Cell 2

Training Period

Before commencing your job at Advac, top management has assigned you to a training division within Advac. The training division manufactures a similar product to Delta called Zeta, which has no commercial value.

You have been assigned to manufacturing cell 2, whose operating characteristics are equivalent to your final job at manufacturing cell 2 at Advac.

The only difference between your training manufacturing cell and your final manufacturing cell at Advac is in regard to the capacities of your two machines in each cell. They differ significantly as the training cell is a much larger manufacturing cell than your final manufacturing cell.

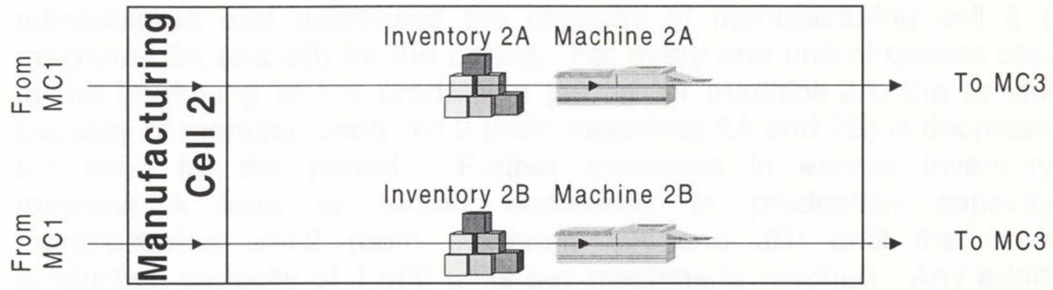
This booklet contains information about your specific:

Please take a moment to read this carefully!

Manufacturing Responsibility

- You are the production manager of manufacturing cell 2. Manufacturing cell 2 is one of three manufacturing cells involved in the manufacture of Zeta within the training division. Your manufacturing cell is primarily concerned with painting the raw material for Zeta.

Figure 1



- As the manager of manufacturing cell 2, you are required to set the production level for the two machines (machine 2A and machine 2B) under your control.

Machine Operations

- <u>Machine 2A</u> performs a painting operation on the work in process (WIP) received from manufacturing cell 1 (MC1, refer figure 2). It has a maximum capacity of 187,500 units per production period. Once the WIP has been painted, it is passed on to manufacturing cell 3 (MC3) for drying work.

- <u>Machine 2B</u> performs a further refinement painting operation on the WIP received from manufacturing cell 1 (MC1, refer figure 2). It has a maximum capacity of 82,500 units per production period. Once the refinement to the WIP has occurred, it is passed on to manufacturing cell 3 (MC3) for final drying work.

Inventory Management

- Machine 2A has inventory 2A associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 1 in the previous period, and the amount of inventory 2A not used by machine 2A in the previous period.

- Any inventory 2A up to 187,500 units is considered to be "working inventory", and does not affect the production capacity of machine 2A. However, any inventory exceeding 187,500 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 2 (both machines 2A and 2B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 2A, the production capacity of manufacturing cell 2 (both machines 2A and 2B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 2A lead to further decreases in production capacity of manufacturing cell 2 (both machines 2A and 2B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 2A beyond that point has no further effect on the production capacity of manufacturing cell 2, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 187,500 units per production period for machine 2A.

- Machine 2B has inventory 2B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 1 in the previous period, and the amount of inventory 2B not used by machine 2B in the previous period.

- Any inventory 2B up to 82,500 units is considered to be "working inventory", and does not affect the production capacity of machine 2B. However, any inventory exceeding 82,500 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 2 (both machines 2A and 2B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 2B, the production capacity of manufacturing cell 2 (both machines 2A and 2B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 2B lead to further decreases in production capacity of manufacturing cell 2 (both machines 2A and 2B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 2B beyond that point has no further effect on the production capacity of manufacturing cell 2, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate.

However, production can never exceed the maximum capacity of 82,500 units per production period for machine 2B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Reward System

During the training period you will be paid a variable wage in Cook dollars per production period. As manufacturing cell 2 manager you will be paid 0.915 Cook dollars for every unit of production output from manufacturing cell 2, less 0.012 Cook dollars for every unit of excess inventory in manufacturing cell 2. The payment of the wage is for illustration purposes only, and will not be convertible into Australian dollars at the end of your management contract.

Production Operating Instructions

Training Camp

Manufacturing Cell 3

Training Period

Before commencing your job at Advac, top management has assigned you to a training division within Advac. The training division manufactures a similar product to Delta called Zeta, which has no commercial value.

You have been assigned to manufacturing cell 3, whose operating characteristics are equivalent to your final job at manufacturing cell 3 at Advac.

The only difference between your training manufacturing cell and your final manufacturing cell at Advac is in regard to the capacities of your two machines in each cell. They differ significantly as the training cell is a much larger manufacturing cell than your final manufacturing cell.

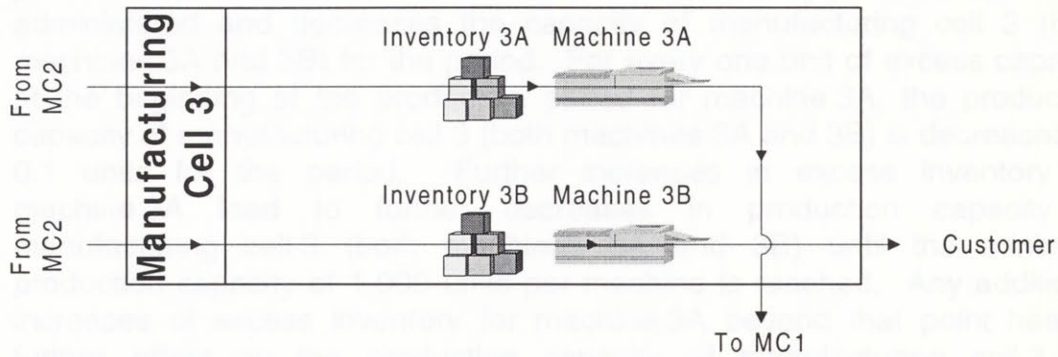
This booklet contains information about your specific:

Please take a moment to read this carefully!

Manufacturing Responsibility

- You are the production manager of manufacturing cell 3. Manufacturing cell 3 is one of three manufacturing cells involved in the manufacture of Zeta within the training division. Your manufacturing cell is primarily concerned with drying the raw material for Zeta.

Figure 1



- As the manager of manufacturing cell 3, you are required to set the production level for the two machines (machine 3A and machine 3B) under your control.

Machine Operations

- Machine 3A performs a drying operation on the work in process (WIP) received from manufacturing cell 2 (MC2, refer figure 1). It has a maximum capacity of 127,500 units per production period. Once the WIP has been dried, it is passed on to manufacturing cell 1 (MC1) for final cutting work.

- Machine 3B performs a final drying operation on the WIP received from manufacturing cell 2 (MC2, refer figure 1). It has a maximum capacity of 75,000 units per production period. Once the refinement to the WIP has occurred, it leaves the manufacturing process as Zeta to be assembled by the customer.

Inventory Management

- Machine 3A has inventory 3A associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 2 in the previous period, and the amount of inventory 3A not used by machine 3A in the previous period.

- Any inventory 3A up to 127,500 units is considered to be "working inventory", and does not affect the production capacity of machine 3A. However, any inventory exceeding 127,500 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 3 (both machines 3A and 3B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 3A, the production capacity of manufacturing cell 3 (both machines 3A and 3B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 3A lead to further decreases in production capacity of manufacturing cell 3 (both machines 3A and 3B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 3A beyond that point has no further effect on the production capacity of manufacturing cell 3, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 127,500 units per production period for machine 3A.

- Machine 3B has inventory 3B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 2 in the previous period, and the amount of inventory 3B not used by machine 3B in the previous period.

- Any inventory 3B up to 75,000 units is considered to be "working inventory", and does not affect the production capacity of machine 3B. However, any inventory exceeding 75,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 3 (both machines 3A and 3B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 3B, the production capacity of manufacturing cell 3 (both machines 3A and 3B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 3B lead to further decreases in production capacity of manufacturing cell 3 (both machines 3A and 3B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 3B beyond that point has no further effect on the production capacity of manufacturing cell 3, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate.

However, production can never exceed the maximum capacity of 75,000 units per production period for machine 3B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Reward System

During the training period you will be paid a variable wage in Cook dollars per production period. As manufacturing cell 3 manager you will be paid 1.406 Cook dollars for every unit of production output from manufacturing cell 3, less 0.019 Cook dollars for every unit of excess inventory in manufacturing cell 3. The payment of the wage is for illustration purposes only, and will not be convertible into Australian dollars at the end of your management contract.

Production Operating Instructions

Advac

Manufacturing Cell 1

Having completed your training period, top management has now deemed you ready to commence your task in manufacturing cell 1 at Advac. Your manufacturing cell has been operating for several period, and you are replacing your predecessor at the end of one of the production periods.

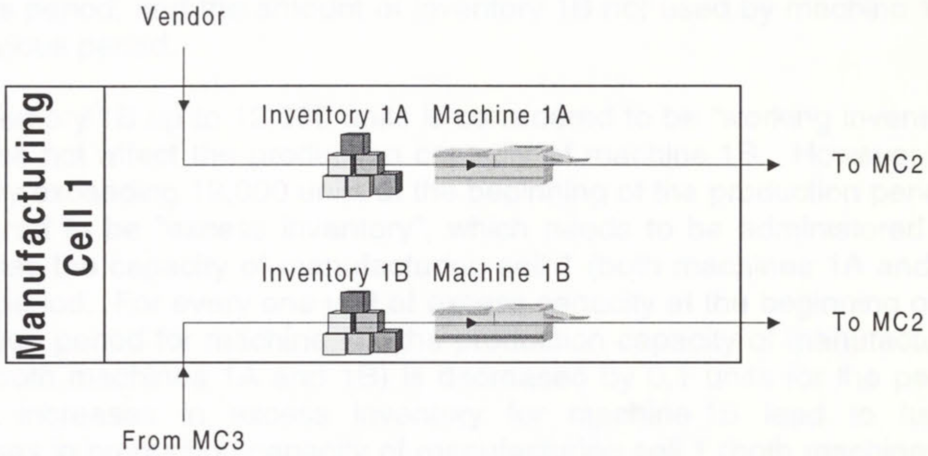
This booklet contains information about your specific:

Please take a moment to read this carefully!

Manufacturing Responsibility

- You are the production manager of manufacturing cell 1. Manufacturing cell 1 is one of three manufacturing cells involved in the manufacture of Delta within Advac Ltd. Your manufacturing cell is primarily concerned with cutting the raw material for Delta.

Figure 1



- As the manager of manufacturing cell 1, you are required to set the production level for the two machines (machine 1A and machine 1B) under your control.

Machine Operations

- <u>Machine 1A</u> performs a cutting operation on the raw materials received from the vendor (refer figure 1). It has a maximum capacity of 30,000 units per production period. Once the raw materials have been cut, they are passed as work in process (WIP) to manufacturing cell 2 (MC2) for paint work.

- <u>Machine 1B</u> performs a further refinement cutting operation on the WIP received from manufacturing cell 3 (MC3, refer figure 1). It has a maximum capacity of 12,000 units per production period. Once the refinement to the WIP has occurred, it is passed on to manufacturing cell 2 (MC2) for final paint work.

Inventory Management

- Machine 1A has inventory 1A associated with it (refer figure 1). This inventory is supplied by the vendor to your manufacturing cell. You have negotiated an agreement with the vendor to supply enough to replenish inventory 1A up to 30,000 at the start of every production period.

- Machine 1B has inventory 1B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 3 in the previous period, and the amount of inventory 1B not used by machine 1B in the previous period.

- Any inventory 1B up to 12,000 units is considered to be "working inventory", and does not affect the production capacity of machine 1B. However, any inventory exceeding 12,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 1 (both machines 1A and 1B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 1B, the production capacity of manufacturing cell 1 (both machines 1A and 1B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 1B lead to further decreases in production capacity of manufacturing cell 1 (both machines 1A and 1B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 1B beyond that point has no further effect on the production capacity of manufacturing cell 1, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 12,000 units per production period for machine 1B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Reward System

As a production manager of Advac, you are being paid for your management services. This payment is a a <u>variable wage</u> in Cook dollars per production period. A variable rate of 1.5 Cook dollars for every unit of production output for Advac will be paid less 0.01 Cook dollars for every unit of excess inventory in Advac. Cook dollars earned from this point on can be converted into Australian dollars at the end of your management contract. The exchange rate between Australian dollars and Cook dollars is 1 Australian dollar to 85,000 Cook dollars.

Production Operating Instructions

Advac

Manufacturing Cell 2

Having completed your training period, top management has now deemed you ready to commence your task in manufacturing cell 2 at Advac. Your manufacturing cell has been operating for several period, and you are replacing your predecessor at the end of one of the production periods.

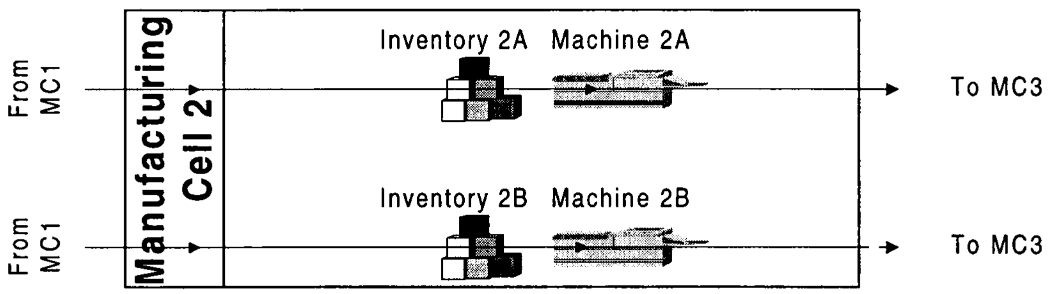
This booklet contains information about your specific:

Please take a moment to read this carefully!

Manufacturing Responsibility

- You are the production manager of manufacturing cell 2. Manufacturing cell 2 is one of three manufacturing cells involved in the manufacture of Delta within Advac Ltd. Your manufacturing cell is primarily concerned with painting the raw material for Delta.

Figure 1



- As the manager of manufacturing cell 2, you are required to set the production level for the two machines (machine 2A and machine 2B) under your control.

Machine Operations

- <u>Machine 2A</u> performs a painting operation on the work in process (WIP) received from manufacturing cell 1 (MC1, refer figure 2). It has a maximum capacity of 25,000 units per production period. Once the WIP has been painted, it is passed on to manufacturing cell 3 (MC3) for drying work.

- <u>Machine 2B</u> performs a further refinement painting operation on the WIP received from manufacturing cell 1 (MC1, refer figure 2). It has a maximum capacity of 11,000 units per production period. Once the refinement to the WIP has occurred, it is passed on to manufacturing cell 3 (MC3) for final drying work.

Inventory Management

- Machine 2A has inventory 2A associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 1 in the previous period, and the amount of inventory 2A not used by machine 2A in the previous period.

- Any inventory 2A up to 25,000 units is considered to be "working inventory", and does not affect the production capacity of machine 2A. However, any inventory exceeding 25,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 2 (both machines 2A and 2B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 2A, the production capacity of manufacturing cell 2 (both machines 2A and 2B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 2A lead to further decreases in production capacity of manufacturing cell 2 (both machines 2A and 2B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 2A beyond that point has no further effect on the production capacity of manufacturing cell 2, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 25,000 units per production period for machine 2A.

- Machine 2B has inventory 2B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 1 in the previous period, and the amount of inventory 2B not used by machine 2B in the previous period.

- Any inventory 2B up to 11,000 units is considered to be "working inventory", and does not affect the production capacity of machine 2B. However, any inventory exceeding 11,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 2 (both machines 2A and 2B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 2B, the production capacity of manufacturing cell 2 (both machines 2A and 2B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 2B lead to further decreases in production capacity of manufacturing cell 2 (both machines 2A and 2B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 2B beyond that point has no further effect on the production capacity of manufacturing cell 2, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate.

However, production can never exceed the maximum capacity of 11,000 units per production period for machine 2B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Reward System

As a production manager of Advac, you are being paid for your management services. This payment is a a variable wage in Cook dollars per production period. A variable rate of 1.5 Cook dollars for every unit of production output for Advac will be paid less 0.01 Cook dollars for every unit of excess inventory in Advac. Cook dollars earned from this point on can be converted into Australian dollars at the end of your management contract. The exchange rate between Australian dollars and Cook dollars is 1 Australian dollar to 85,000 Cook dollars.

Production Operating Instructions

Advac

Manufacturing Cell 3

Having completed your training period, top management has now deemed you ready to commence your task in manufacturing cell 3 at Advac. Your manufacturing cell has been operating for several period, and you are replacing your predecessor at the end of one of the production periods.

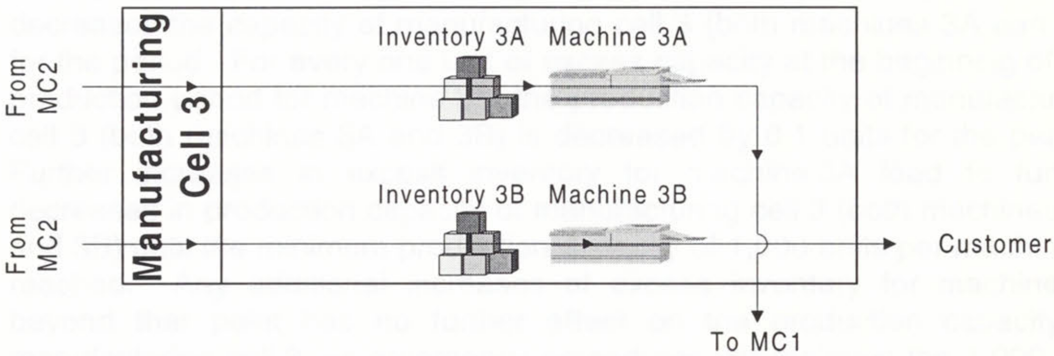
This booklet contains information about your specific:

Please take a moment to read this carefully!

Manufacturing Responsibility

- You are the production manager of manufacturing cell 3. Manufacturing cell 3 is one of three manufacturing cells involved in the manufacture of Delta within Advac Ltd. Your manufacturing cell is primarily concerned with drying the raw material for Delta.

Figure 1



- As the manager of manufacturing cell 3, you are required to set the production level for the two machines (machine 3A and machine 3B) under your control.

Machine Operations

- <u>Machine 3A</u> performs a drying operation on the work in process (WIP) received from manufacturing cell 2 (MC2, refer figure 1). It has a maximum capacity of 17,000 units per production period. Once the WIP has been dried, it is passed on to manufacturing cell 1 (MC1) for final cutting work.

- <u>Machine 3B</u> performs a final drying operation on the WIP received from manufacturing cell 2 (MC2, refer figure 1). It has a maximum capacity of 10,000 units per production period. Once the refinement to the WIP has occurred, it leaves the manufacturing process as Delta to be assembled by the customer.

Inventory Management

- Machine 3A has inventory 3A associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 2 in the previous period, and the amount of inventory 3A not used by machine 3A in the previous period.

- Any inventory 3A up to 17,000 units is considered to be "working inventory", and does not affect the production capacity of machine 3A. However, any inventory exceeding 17,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 3 (both machines 3A and 3B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 3A, the production capacity of manufacturing cell 3 (both machines 3A and 3B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 3A lead to further decreases in production capacity of manufacturing cell 3 (both machines 3A and 3B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 3A beyond that point has no further effect on the production capacity of manufacturing cell 3, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the reversal of such decreases at the same rate. However, production can never exceed the maximum capacity of 17,000 units per production period for machine 3A.

- Machine 3B has inventory 3B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 2 in the previous period, and the amount of inventory 3B not used by machine 3B in the previous period.

- Any inventory 3B up to 10,000 units is considered to be "working inventory", and does not affect the production capacity of machine 3B. However, any inventory exceeding 10,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 3 (both machines 3A and 3B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 3B, the production capacity of manufacturing cell 3 (both machines 3A and 3B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 3B lead to further decreases in production capacity of manufacturing cell 3 (both machines 3A and 3B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 3B beyond that point has no further effect on the production capacity of manufacturing cell 3, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the reversal of such decreases at the same

rate. However, production can never exceed the maximum capacity of 10,000 units per production period for machine 3B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Reward System

As a production manager of Advac, you are being paid for your management services. This payment is a a variable wage in Cook dollars per production period. A variable rate of 1.5 Cook dollars for every unit of production output for Advac will be paid less 0.01 Cook dollars for every unit of excess inventory in Advac. Cook dollars earned from this point on can be converted into Australian dollars at the end of your management contract. The exchange rate between Australian dollars and Cook dollars is 1 Australian dollar to 85,000 Cook dollars.

Production Operating Instructions

Advac

Manufacturing Cell 1

Having completed your training period, top management has now deemed you ready to commence your task in manufacturing cell 1 at Advac. Your manufacturing cell has been operating for several period, and you are replacing your predecessor at the end of one of the production periods.

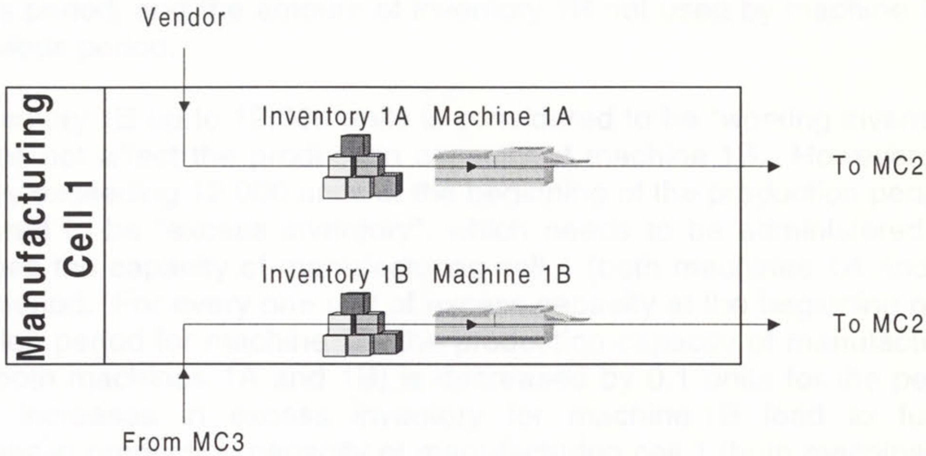
This booklet contains information about your specific:

Please take a moment to read this carefully!

Manufacturing Responsibility

- You are the production manager of manufacturing cell 1. Manufacturing cell 1 is one of three manufacturing cells involved in the manufacture of Delta within Advac Ltd. Your manufacturing cell is primarily concerned with cutting the raw material for Delta.

Figure 1



- As the manager of manufacturing cell 1, you are required to set the production level for the two machines (machine 1A and machine 1B) under your control.

Machine Operations

- Machine 1A performs a cutting operation on the raw materials received from the vendor (refer figure 1). It has a maximum capacity of 30,000 units per production period. Once the raw materials have been cut, they are passed as work in process (WIP) to manufacturing cell 2 (MC2) for paint work.

- Machine 1B performs a further refinement cutting operation on the WIP received from manufacturing cell 3 (MC3, refer figure 1). It has a maximum capacity of 12,000 units per production period. Once the refinement to the WIP has occurred, it is passed on to manufacturing cell 2 (MC2) for final paint work.

Inventory Management

- Machine 1A has inventory 1A associated with it (refer figure 1). This inventory is supplied by the vendor to your manufacturing cell. You have negotiated an agreement with the vendor to supply enough to replenish inventory 1A up to 30,000 at the start of every production period.

- Machine 1B has inventory 1B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 3 in the previous period, and the amount of inventory 1B not used by machine 1B in the previous period.

- Any inventory 1B up to 12,000 units is considered to be "working inventory", and does not affect the production capacity of machine 1B. However, any inventory exceeding 12,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 1 (both machines 1A and 1B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 1B, the production capacity of manufacturing cell 1 (both machines 1A and 1B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 1B lead to further decreases in production capacity of manufacturing cell 1 (both machines 1A and 1B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 1B beyond that point has no further effect on the production capacity of manufacturing cell 1, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 12,000 units per production period for machine 1B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Reward System

As the production manager of Advac, you are being paid for your management services. This payment is a <u>flat wage</u> in Cook dollars per production period. This flat wage of 25,000 Cook dollars will be paid per production period, regardless of the production output and excess inventory levels of your individual manufacturing cell and that of Advac's. Cook dollars earned from this point on can be converted into Australian dollars at the end of your management contract. The exchange rate between Australian dollars and Cook dollars is 1 Australian dollar to 85,000 Cook dollars.

Production Operating Instructions

Advac

Manufacturing Cell 2

Having completed your training period, top management has now deemed you ready to commence your task in manufacturing cell 2 at Advac. Your manufacturing cell has been operating for several period, and you are replacing your predecessor at the end of one of the production periods.

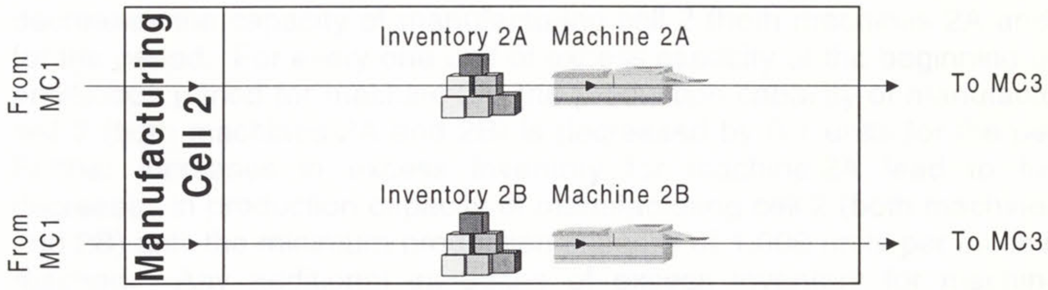
This booklet contains information about your specific:

Please take a moment to read this carefully!

Manufacturing Responsibility

- You are the production manager of manufacturing cell 2. Manufacturing cell 2 is one of three manufacturing cells involved in the manufacture of Delta within Advac Ltd. Your manufacturing cell is primarily concerned with painting the raw material for Delta.

Figure 1



- As the manager of manufacturing cell 2, you are required to set the production level for the two machines (machine 2A and machine 2B) under your control.

Machine Operations

- Machine 2A performs a painting operation on the work in process (WIP) received from manufacturing cell 1 (MC1, refer figure 2). It has a maximum capacity of 25,000 units per production period. Once the WIP has been painted, it is passed on to manufacturing cell 3 (MC3) for drying work.

- Machine 2B performs a further refinement painting operation on the WIP received from manufacturing cell 1 (MC1, refer figure 2). It has a maximum capacity of 11,000 units per production period. Once the refinement to the WIP has occurred, it is passed on to manufacturing cell 3 (MC3) for final drying work.

Inventory Management

- Machine 2A has inventory 2A associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 1 in the previous period, and the amount of inventory 2A not used by machine 2A in the previous period.

- Any inventory 2A up to 25,000 units is considered to be "working inventory", and does not affect the production capacity of machine 2A. However, any inventory exceeding 25,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 2 (both machines 2A and 2B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 2A, the production capacity of manufacturing cell 2 (both machines 2A and 2B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 2A lead to further decreases in production capacity of manufacturing cell 2 (both machines 2A and 2B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 2A beyond that point has no further effect on the production capacity of manufacturing cell 2, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 25,000 units per production period for machine 2A.

- Machine 2B has inventory 2B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 1 in the previous period, and the amount of inventory 2B not used by machine 2B in the previous period.

- Any inventory 2B up to 11,000 units is considered to be "working inventory", and does not affect the production capacity of machine 2B. However, any inventory exceeding 11,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 2 (both machines 2A and 2B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 2B, the production capacity of manufacturing cell 2 (both machines 2A and 2B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 2B lead to further decreases in production capacity of manufacturing cell 2 (both machines 2A and 2B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 2B beyond that point has no further effect on the production capacity of manufacturing cell 2, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate.

However, production can never exceed the maximum capacity of 11,000 units per production period for machine 2B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Reward System

As the production manager of Advac, you are being paid for your management services. This payment is a flat wage in Cook dollars per production period. This flat wage of 25,000 Cook dollars will be paid per production period, regardless of the production output and excess inventory levels of your individual manufacturing cell and that of Advac's. Cook dollars earned from this point on can be converted into Australian dollars at the end of your management contract. The exchange rate between Australian dollars and Cook dollars is 1 Australian dollar to 85,000 Cook dollars.

Production Operating Instructions

Advac

Manufacturing Cell 3

Having completed your training period, top management has now deemed you ready to commence your task in manufacturing cell 3 at Advac. Your manufacturing cell has been operating for several period, and you are replacing your predecessor at the end of one of the production periods.

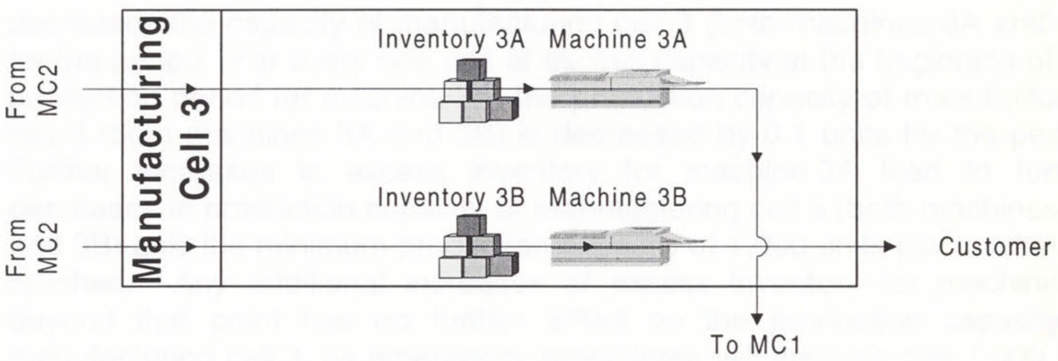
This booklet contains information about your specific:

Please take a moment to read this carefully!

Manufacturing Responsibility

- You are the production manager of manufacturing cell 3. Manufacturing cell 3 is one of three manufacturing cells involved in the manufacture of Delta within Advac Ltd. Your manufacturing cell is primarily concerned with drying the raw material for Delta.

Figure 1



- As the manager of manufacturing cell 3, you are required to set the production level for the two machines (machine 3A and machine 3B) under your control.

Machine Operations

- Machine 3A performs a drying operation on the work in process (WIP) received from manufacturing cell 2 (MC2, refer figure 1). It has a maximum capacity of 17,000 units per production period. Once the WIP has been dried, it is passed on to manufacturing cell 1 (MC1) for final cutting work.

- Machine 3B performs a final drying operation on the WIP received from manufacturing cell 2 (MC2, refer figure 1). It has a maximum capacity of 10,000 units per production period. Once the refinement to the WIP has occurred, it leaves the manufacturing process as Delta to be assembled by the customer.

Inventory Management

- Machine 3A has inventory 3A associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 2 in the previous period, and the amount of inventory 3A not used by machine 3A in the previous period.

- Any inventory 3A up to 17,000 units is considered to be "working inventory", and does not affect the production capacity of machine 3A. However, any inventory exceeding 17,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 3 (both machines 3A and 3B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 3A, the production capacity of manufacturing cell 3 (both machines 3A and 3B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 3A lead to further decreases in production capacity of manufacturing cell 3 (both machines 3A and 3B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 3A beyond that point has no further effect on the production capacity of manufacturing cell 3, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the reversal of such decreases at the same rate. However, production can never exceed the maximum capacity of 17,000 units per production period for machine 3A.

- Machine 3B has inventory 3B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 2 in the previous period, and the amount of inventory 3B not used by machine 3B in the previous period.

- Any inventory 3B up to 10,000 units is considered to be "working inventory", and does not affect the production capacity of machine 3B. However, any inventory exceeding 10,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 3 (both machines 3A and 3B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 3B, the production capacity of manufacturing cell 3 (both machines 3A and 3B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 3B lead to further decreases in production capacity of manufacturing cell 3 (both machines 3A and 3B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 3B beyond that point has no further effect on the production capacity of manufacturing cell 3, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the reversal of such decreases at the same

rate. However, production can never exceed the maximum capacity of 10,000 units per production period for machine 3B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Reward System

As the production manager of Advac, you are being paid for your management services. This payment is a flat wage in Cook dollars per production period. This flat wage of 25,000 Cook dollars will be paid per production period, regardless of the production output and excess inventory levels of your individual manufacturing cell and that of Advac's. Cook dollars earned from this point on can be converted into Australian dollars at the end of your management contract. The exchange rate between Australian dollars and Cook dollars is 1 Australian dollar to 85,000 Cook dollars.

Production Operating Instructions

Advac

Manufacturing Cell 1

Having completed your training period, top management has now deemed you ready to commence your task in manufacturing cell 1 at Advac. Your manufacturing cell has been operating for several period, and you are replacing your predecessor at the end of one of the production periods.

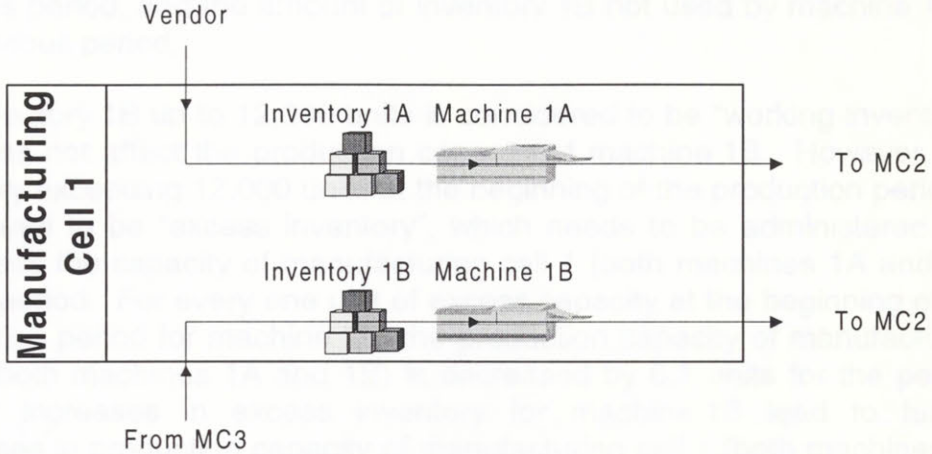
This booklet contains information about your specific:

Please take a moment to read this carefully!

Manufacturing Responsibility

- You are the production manager of manufacturing cell 1. Manufacturing cell 1 is one of three manufacturing cells involved in the manufacture of Delta within Advac Ltd. Your manufacturing cell is primarily concerned with cutting the raw material for Delta.

Figure 1



- As the manager of manufacturing cell 1, you are required to set the production level for the two machines (machine 1A and machine 1B) under your control.

Machine Operations

- <u>Machine 1A</u> performs a cutting operation on the raw materials received from the vendor (refer figure 1). It has a maximum capacity of 30,000 units per production period. Once the raw materials have been cut, they are passed as work in process (WIP) to manufacturing cell 2 (MC2) for paint work.
- <u>Machine 1B</u> performs a further refinement cutting operation on the WIP received from manufacturing cell 3 (MC3, refer figure 1). It has a maximum capacity of 12,000 units per production period. Once the refinement to the WIP has occurred, it is passed on to manufacturing cell 2 (MC2) for final paint work.

Inventory Management

- Machine 1A has inventory 1A associated with it (refer figure 1). This inventory is supplied by the vendor to your manufacturing cell. You have negotiated an agreement with the vendor to supply enough to replenish inventory 1A up to 30,000 at the start of every production period.

- Machine 1B has inventory 1B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 3 in the previous period, and the amount of inventory 1B not used by machine 1B in the previous period.

- Any inventory 1B up to 12,000 units is considered to be "working inventory", and does not affect the production capacity of machine 1B. However, any inventory exceeding 12,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 1 (both machines 1A and 1B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 1B, the production capacity of manufacturing cell 1 (both machines 1A and 1B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 1B lead to further decreases in production capacity of manufacturing cell 1 (both machines 1A and 1B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 1B beyond that point has no further effect on the production capacity of manufacturing cell 1, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 12,000 units per production period for machine 1B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Reward System

As a production manager of Advac, you are being paid for your management services. This payment is a <u>variable wage</u> in Cook dollars per production period. As manufacturing cell 1 manager you will be paid 0.75 Cook dollars for every unit of production output from <u>manufacturing cell 1</u>, less 0.01 Cook dollars for every unit of excess inventory <u>in manufacturing cell 1</u>. Cook dollars earned from this point on can be converted into Australian dollars at the end of your management contract. The exchange rate between Australian dollars and Cook dollars is 1 Australian dollar to 85,000 Cook dollars.

Production Operating Instructions

Advac

Manufacturing Cell 2

Having completed your training period, top management has now deemed you ready to commence your task in manufacturing cell 2 at Advac. Your manufacturing cell has been operating for several period, and you are replacing your predecessor at the end of one of the production periods.

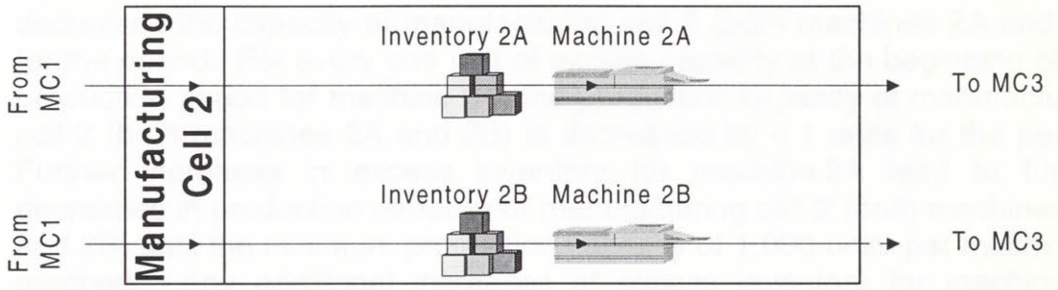
This booklet contains information about your specific:

Please take a moment to read this carefully!

Manufacturing Responsibility

- You are the production manager of manufacturing cell 2. Manufacturing cell 2 is one of three manufacturing cells involved in the manufacture of Delta within Advac Ltd. Your manufacturing cell is primarily concerned with painting the raw material for Delta.

Figure 1



- As the manager of manufacturing cell 2, you are required to set the production level for the two machines (machine 2A and machine 2B) under your control.

Machine Operations

- <u>Machine 2A</u> performs a painting operation on the work in process (WIP) received from manufacturing cell 1 (MC1, refer figure 2). It has a maximum capacity of 25,000 units per production period. Once the WIP has been painted, it is passed on to manufacturing cell 3 (MC3) for drying work.

- <u>Machine 2B</u> performs a further refinement painting operation on the WIP received from manufacturing cell 1 (MC1, refer figure 2). It has a maximum capacity of 11,000 units per production period. Once the refinement to the WIP has occurred, it is passed on to manufacturing cell 3 (MC3) for final drying work.

Inventory Management

- Machine 2A has inventory 2A associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 1 in the previous period, and the amount of inventory 2A not used by machine 2A in the previous period.

- Any inventory 2A up to 25,000 units is considered to be "working inventory", and does not affect the production capacity of machine 2A. However, any inventory exceeding 25,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 2 (both machines 2A and 2B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 2A, the production capacity of manufacturing cell 2 (both machines 2A and 2B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 2A lead to further decreases in production capacity of manufacturing cell 2 (both machines 2A and 2B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 2A beyond that point has no further effect on the production capacity of manufacturing cell 2, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate. However, production can never exceed the maximum capacity of 25,000 units per production period for machine 2A.

- Machine 2B has inventory 2B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 1 in the previous period, and the amount of inventory 2B not used by machine 2B in the previous period.

- Any inventory 2B up to 11,000 units is considered to be "working inventory", and does not affect the production capacity of machine 2B. However, any inventory exceeding 11,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 2 (both machines 2A and 2B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 2B, the production capacity of manufacturing cell 2 (both machines 2A and 2B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 2B lead to further decreases in production capacity of manufacturing cell 2 (both machines 2A and 2B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 2B beyond that point has no further effect on the production capacity of manufacturing cell 2, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the restoration of lost capacity at the same rate.

However, production can never exceed the maximum capacity of 11,000 units per production period for machine 2B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Reward System

As a production manager of Advac, you are being paid for your management services. This payment is a variable wage in Cook dollars per production period. As manufacturing cell 2 manager you will be paid 0.915 Cook dollars for every unit of production output from manufacturing cell 2, less 0.012 Cook dollars for every unit of excess inventory in manufacturing cell 2. Cook dollars earned from this point on can be converted into Australian dollars at the end of your management contract. The exchange rate between Australian dollars and Cook dollars is 1 Australian dollar to 85,000 Cook dollars.

Production Operating Instructions

Advac

Manufacturing Cell 3

Having completed your training period, top management has now deemed you ready to commence your task in manufacturing cell 3 at Advac. Your manufacturing cell has been operating for several period, and you are replacing your predecessor at the end of one of the production periods.

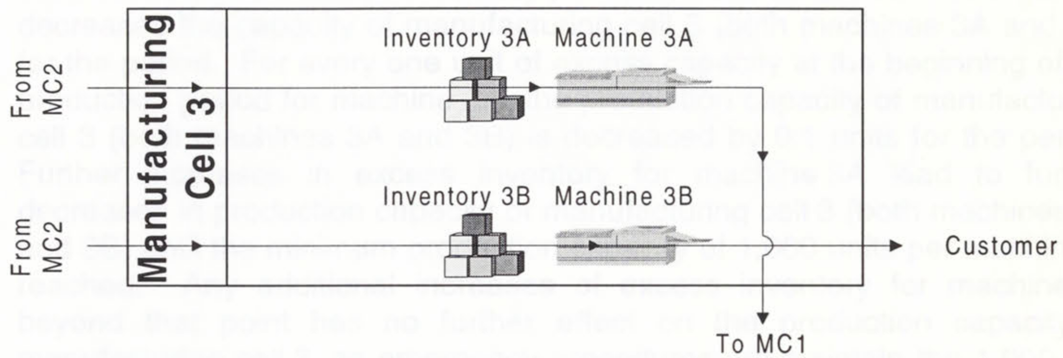
This booklet contains information about your specific:

Please take a moment to read this carefully!

Manufacturing Responsibility

- You are the production manager of manufacturing cell 3. Manufacturing cell 3 is one of three manufacturing cells involved in the manufacture of Delta within Advac Ltd. Your manufacturing cell is primarily concerned with drying the raw material for Delta.

Figure 1



- As the manager of manufacturing cell 3, you are required to set the production level for the two machines (machine 3A and machine 3B) under your control.

Machine Operations

- Machine 3A performs a drying operation on the work in process (WIP) received from manufacturing cell 2 (MC2, refer figure 1). It has a maximum capacity of 17,000 units per production period. Once the WIP has been dried, it is passed on to manufacturing cell 1 (MC1) for final cutting work.

- Machine 3B performs a final drying operation on the WIP received from manufacturing cell 2 (MC2, refer figure 1). It has a maximum capacity of 10,000 units per production period. Once the refinement to the WIP has occurred, it leaves the manufacturing process as Delta to be assembled by the customer.

Inventory Management

- Machine 3A has inventory 3A associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 2 in the previous period, and the amount of inventory 3A not used by machine 3A in the previous period.

- Any inventory 3A up to 17,000 units is considered to be "working inventory", and does not affect the production capacity of machine 3A. However, any inventory exceeding 17,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 3 (both machines 3A and 3B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 3A, the production capacity of manufacturing cell 3 (both machines 3A and 3B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 3A lead to further decreases in production capacity of manufacturing cell 3 (both machines 3A and 3B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 3A beyond that point has no further effect on the production capacity of manufacturing cell 3, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the reversal of such decreases at the same rate. However, production can never exceed the maximum capacity of 17,000 units per production period for machine 3A.

- Machine 3B has inventory 3B associated with it (refer figure 1). This inventory is a direct result from the production of manufacturing cell 2 in the previous period, and the amount of inventory 3B not used by machine 3B in the previous period.

- Any inventory 3B up to 10,000 units is considered to be "working inventory", and does not affect the production capacity of machine 3B. However, any inventory exceeding 10,000 units at the beginning of the production period is considered to be "excess inventory", which needs to be administered and decreases the capacity of manufacturing cell 3 (both machines 3A and 3B) for the period. For every one unit of excess capacity at the beginning of the production period for machine 3B, the production capacity of manufacturing cell 3 (both machines 3A and 3B) is decreased by 0.1 units for the period. Further increases in excess inventory for machine 3B lead to further decreases in production capacity of manufacturing cell 3 (both machines 3A and 3B) until the minimum production capacity of 1,000 units per machine is reached. Any additional increases of excess inventory for machine 3B beyond that point has no further effect on the production capacity of manufacturing cell 3, as emergency procedures will maintain the 1,000 unit minimum capacity for each machine. Subsequent decreases in excess inventory levels will result in the reversal of such decreases at the same

rate. However, production can never exceed the maximum capacity of 10,000 units per production period for machine 3B.

- In cases where your production capacity for the period is less than maximum capacity, due to excess inventory, your production decision for the period cannot exceed this capacity.

Reward System

As a production manager of Advac, you are being paid for your management services. This payment is a variable wage in Cook dollars per production period. As manufacturing cell 3 manager you will be paid 1.406 Cook dollars for every unit of production output from manufacturing cell 3, less 0.019 Cook dollars for every unit of excess inventory in manufacturing cell 3. Cook dollars earned from this point on can be converted into Australian dollars at the end of your management contract. The exchange rate between Australian dollars and Cook dollars is 1 Australian dollar to 85,000 Cook dollars.

Reward System Illustration

Assume that the production output for Advac for the period was 100,000 units. Further assume that the total number of excess inventory in Advac at the time that this decision was made was 500,000 units. This would have the following effects on the amount paid to each of the production managers.

Manufacturing Cell 1

Wage = 1.5 Cook dollars x Advac Output - 0.01 Cook dollars x Excess Inventory in Advac

Wage = 1.5 x 100,000 - 0.01 x 500,000

Wage = C$145,000

Manufacturing Cell 2

Wage = 1.5 Cook dollars x Advac Output - 0.01 Cook dollars x Excess Inventory in Advac

Wage = 1.5 x 100,000 - 0.01 x 500,000

Wage = C$145,000

Manufacturing Cell 3

Wage = 1.5 Cook dollars x Advac Output - 0.01 Cook dollars x Excess Inventory in Advac

Wage = 1.5 x 100,000 - 0.01 x 500,000

Wage = C$145,000

Reward System Illustration

Assume that the production output for each of the manufacturing cells was 100,000 units for the period. Further assume that the total number of excess inventory in each of the manufacturing cells was 500,000 units. As the variable rates differ for each manufacturing cell, the effect on the amount paid for each of manufacturing cell managers differ.

Manufacturing Cell 1

Wage = 0.75 Cook dollars x Manufacturing Cell 1 Output - 0.01 Cook dollars x Excess Inventory in Manufacturing Cell 1

Wage = 0.75 x 100,000 - 0.01 x 500,000

Wage = C$70,000

Manufacturing Cell 2

Wage = 0.915 Cook dollars x Manufacturing Cell 2 - 0.012 Cook dollars x Excess Inventory in Manufacturing Cell 2

Wage = 0.915 x 100,000 - 0.012 x 500,000

Wage = C$85,500

Manufacturing Cell 3

Wage = 1.406 Cook dollars x Manufacturing Cell 3 - 0.019 Cook dollars x Excess Inventory in Manufacturing Cell 3

Wage = 1.406 x 100,000 - 0.019 x 500,000

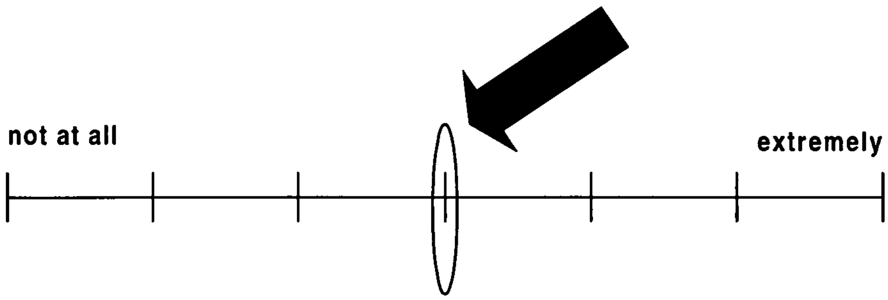
Wage = C$131,100

Post Test Questionnaire

The following questions relate to the task you were required to perform at Advac. Please <u>ignore</u> the training period at the Training-camp.

For the following questions please <u>to what extend</u> you agree with the following statements. Indicate your response by circling one of the seven points on the scale below each statement as illustrated in the following example:

Example:



1. To what extent did your group's members work on the task alone?

not at all — extremely

2. To what extent did you feel that you and your coworkers were a team?

not at all — extremely

3. To what extent was there tension <u>among the members</u> of your group?

not at all — extremely

4. To what extent was your group highly imaginative in thinking about how to do the task better?

not at all **extremely**

5. To what extent did your group's members work together to discuss how to do the task?

not at all **extremely**

6. To what extent were you assisted by your coworkers when you encountered difficulties in performing your task.

not at all **extremely**

7. To what extent was there emotional conflict <u>among the members</u> of your group?

not at all **extremely**

8. To what extent did your group experiment with ways to do the task.

not at all **extremely**

9. To what extent did one or more of your fellow group members' performance impact on your performance in the group?

not at all **extremely**

10. To what extent did you feel competitive with others in

not at all **extr**

11. To what extent were there differences of opinions <u>about the task</u> in your group?

not at all **extremely**

12. To what extent did you feel your group did the task properly?

not at all **extremely**

13. To what extent did <u>the task</u> you performed as a group require the group members to assist each other?

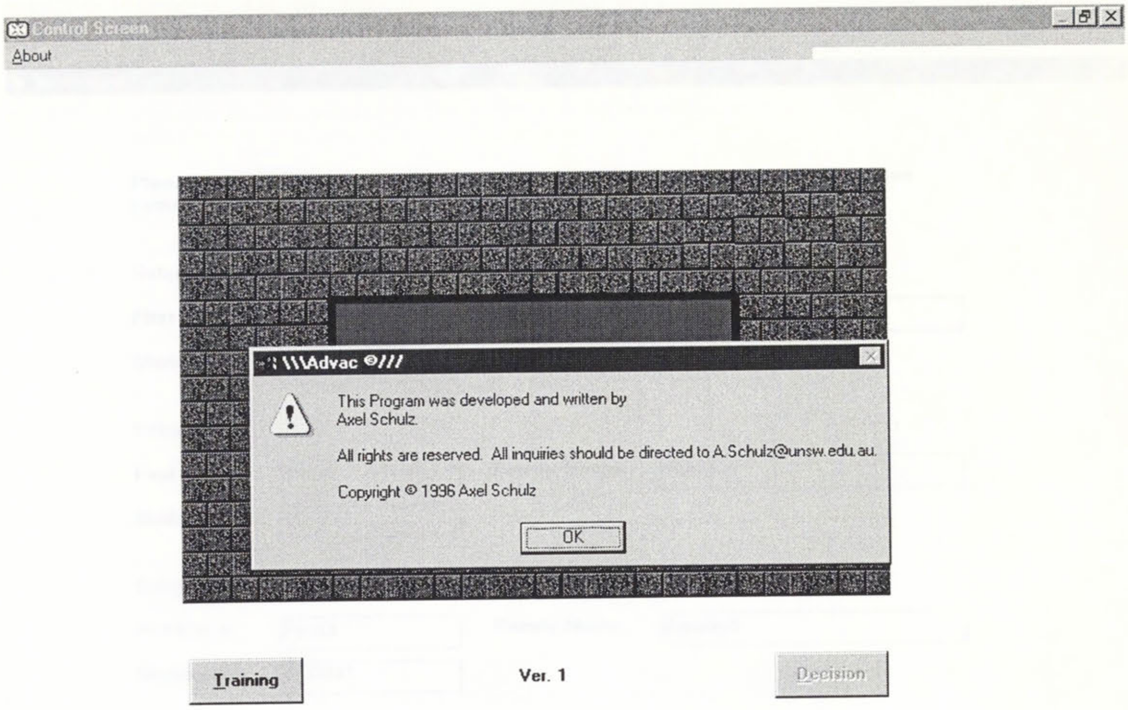
not at all **extremely**

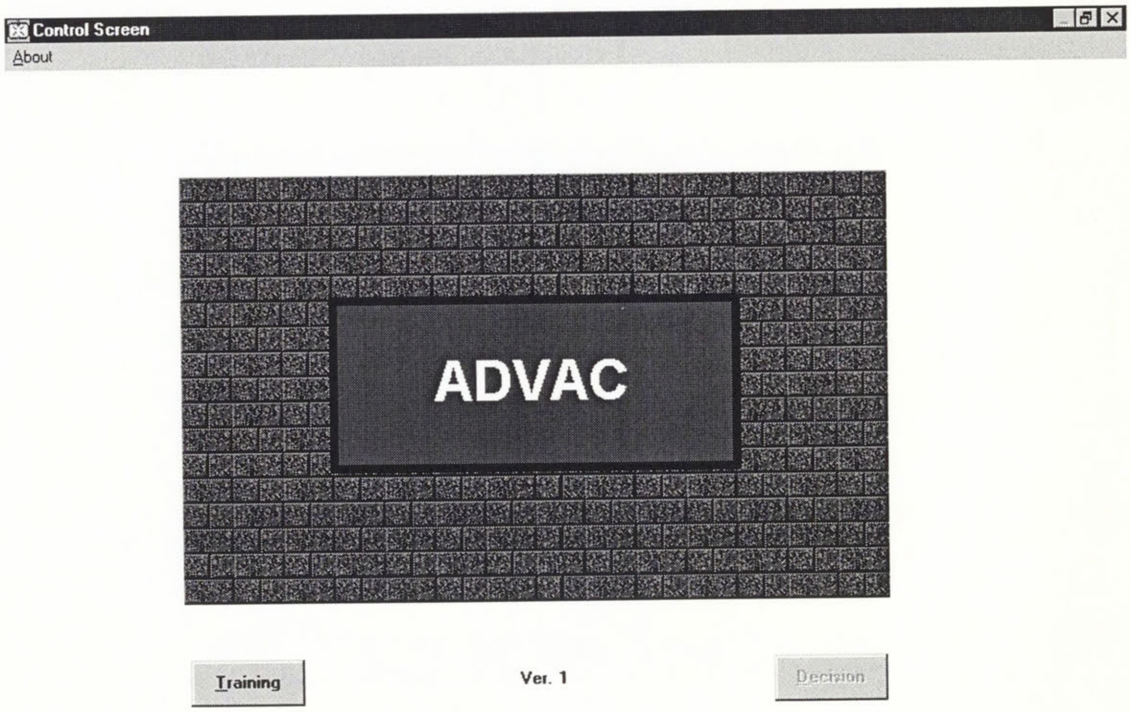
14. To what extent were there conflicts <u>about the task</u> you performed as a group?

not at all **extremely**

15. To what extent was your group develop a good strategy for performing the task?

not at all **extremely**


Control Screen
About
\\\Advac ©///
This Program was developed and written by
Axel Schulz.
All rights are reserved. All inquiries should be directed to A.Schulz@unsw.edu.au.
Copyright © 1996 Axel Schulz
OK
Training
Ver. 1
Decision


Control Screen
About
ADVAC
Training
Ver. 1
Decision

Name Input Form

Please enter the names of your three group members and then press the continue button.

Subject 1

First Name	First1	**Family Name**	Family1
Student No.	1111111		

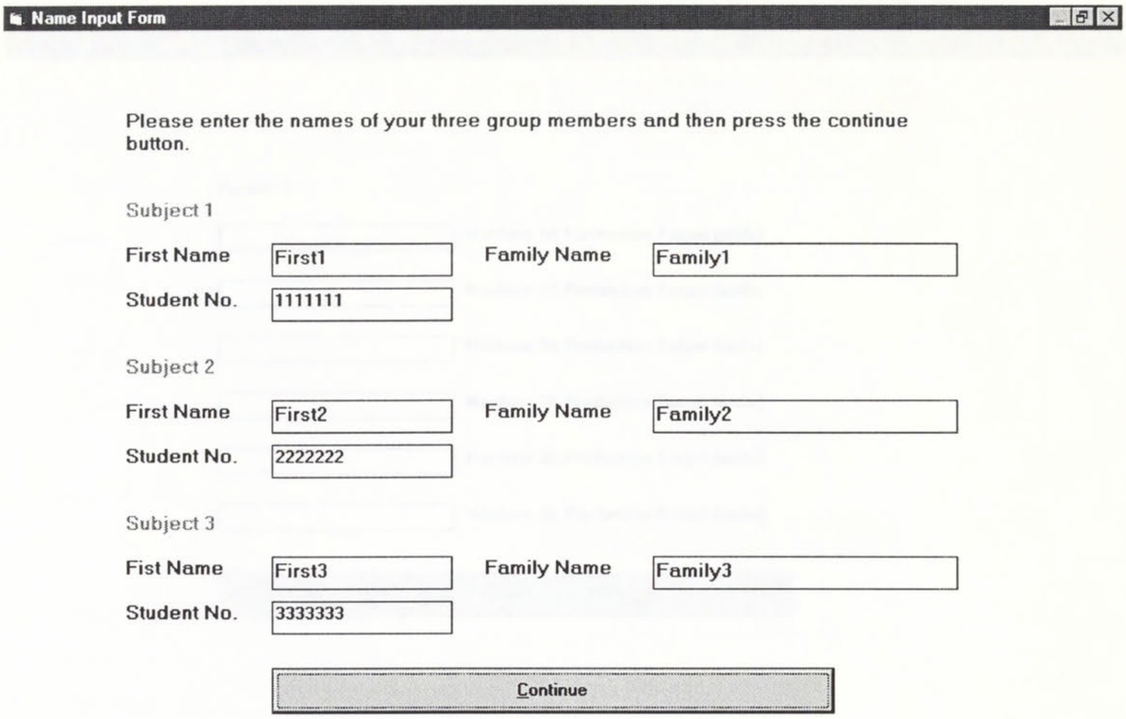
Subject 2

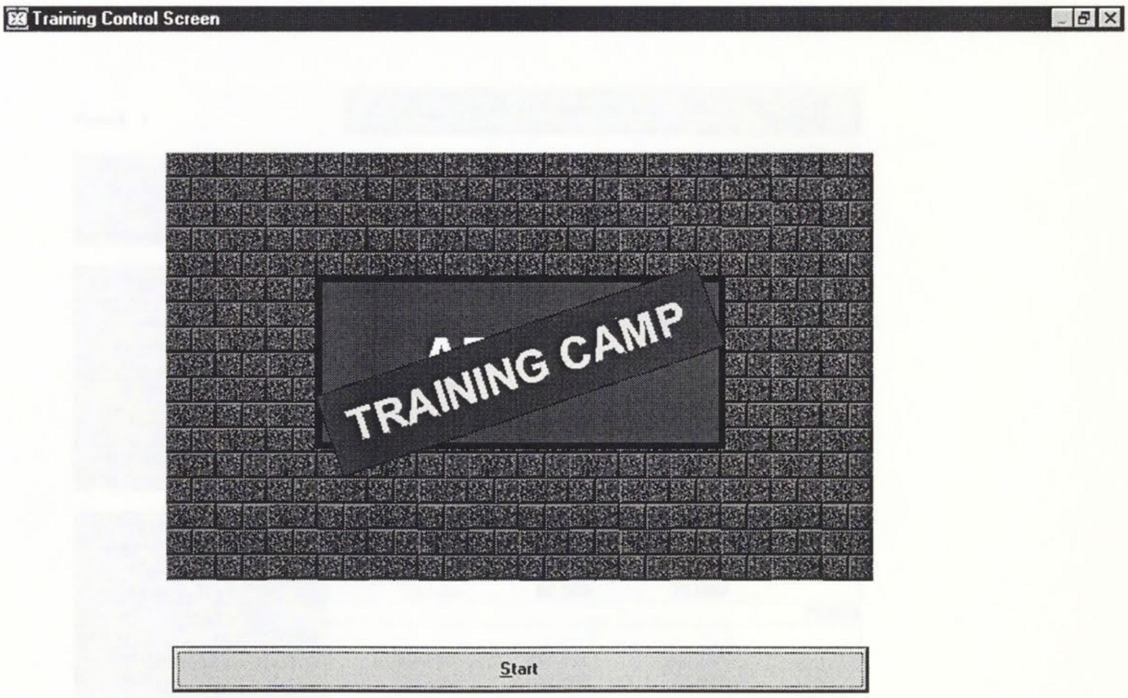
First Name	First2	**Family Name**	Family2
Student No.	2222222		

Subject 3

Fist Name	First3	**Family Name**	Family3
Student No.	3333333		

Continue


Name Input Form
Please enter the names of your three group members and then press the continue button.
Subject 1
First Name
First1
Family Name
Family1
Student No.
1111111
Subject 2
First Name
First2
Family Name
Family2
Student No.
2222222
Subject 3
Fist Name
First3
Family Name
Family3
Student No.
3333333
Continue


Training Control Screen
TRAINING CAMP
Start

Training Production Screen

Production Reports   Advac Pay Office

Period: 1

Machine 1A Production Target (units)

Machine 1B Production Target (units)

Machine 2A Production Target (units)

Machine 2B Production Target (units)

Machine 3A Production Target (units)

Machine 3B Production Target (units)

Submit

The Report Screen

Period: 1

Back to Production Input Screen

Last Period Output (units)	Manuf. Cell 1	Manuf. Cell 2	Manuf. Cell 3	Advac Total
Machine A	0	0	0	
Machine B	0	0	0	
Total Output of Delta				0

This Period Inventory (units)	Manuf. Cell 1	Manuf. Cell 2	Manuf. Cell 3	Advac Total
Inventory A				
Working Inventory	225,000	187,500	127,500	
Excess Inventory	0	0	0	
Inventory B				
Working Inventory	90,000	82,500	75,000	
Excess Inventory	0	0	0	
Total Working Inventory	315,000	270,000	202,500	787,500
Total Excess Inventory	0	0	0	0

This Period Mach. Cap. (units)	Manuf. Cell 1	Manuf. Cell 2	Manuf. Cell 3	Advac Total
Maximum				
Machine A	225,000	187,500	127,500	
Machine B	90,000	82,500	75,000	
Maximum Capacity of Advac				75,000
Actual				
Machine A	225,000	187,500	127,500	
Machine B	90,000	82,500	75,000	
Actual Capacity of Advac				75,000

Advac Pay Office

Back to Production Schedule Input Screen

First1 Family1

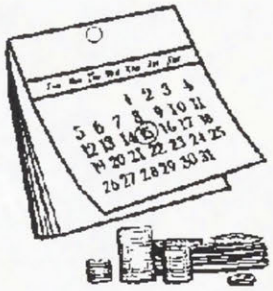
	$
Wage (Period 0)	Data Not Available
Cumulative	Data Not Available
% Increase in Wage	Data Not Available

First2 Family2

	$
Wage (Period 0)	Data Not Available
Cumulative	Data Not Available
% Increase in Wage	Data Not Available

First3 Family3

	$
Wage (Period 0)	Data Not Available
Cumulative	Data Not Available
% Increase in Wage	Data Not Available



ADVAC
Pay Office

Covering Production Period 0

Post Training Questionnaire

Post Training Questionnaire

To conclude your training period, top management has asked you to answer the following four questions. Answer by checking one box per question.

Q1 Was it be possible for the production capacities of machines 1A, 1B, 2A, 2B, 3A and 3B to drop below their maximum capacities?

☑ Yes ☐ No

Q2 Was it possible for 'working inventory' for a particular machine, at the beginning of the production period, to have an effect on the production capacity of that machine?

☐ Yes ☑ No

Q3 Was it possible for 'excess inventory' for a particular machine, at the beginning of the production period, to have an effect on the production capacity of that machine?

☑ Yes ☐ No

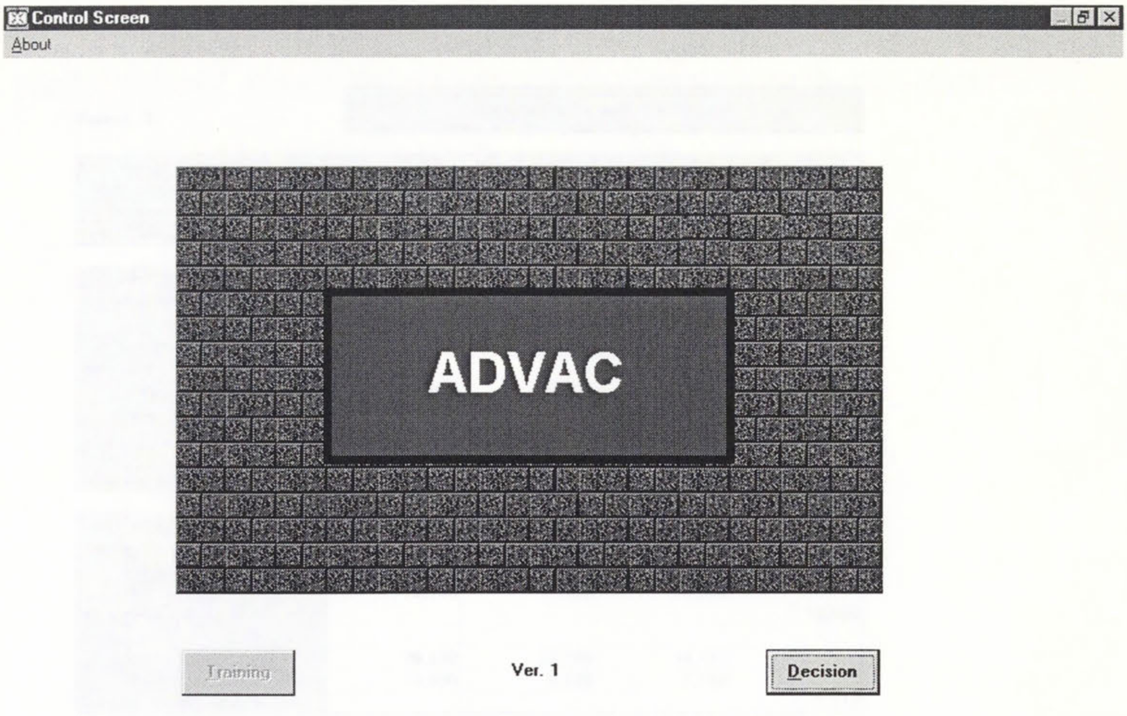
Q4 Were you wages influenced by the output of:

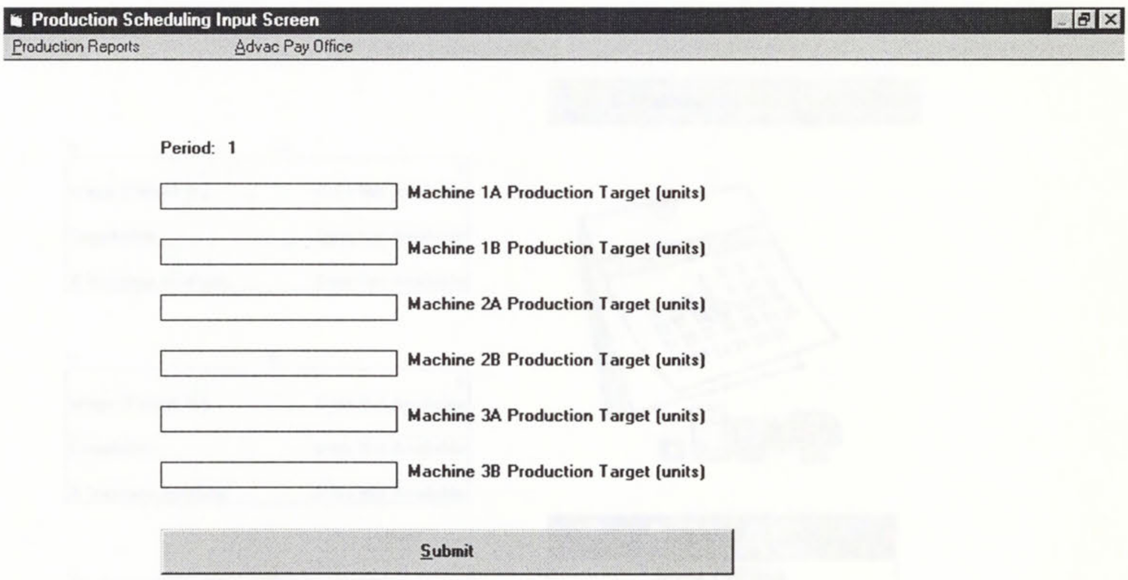
☐ The Individual Manufacturing Cells

☑ Advac

☐ Neither

Submit Answers


Control Screen
About
ADVAC
Training
Ver. 1
Decision


Production Scheduling Input Screen
Production Reports
Advac Pay Office
Period: 1
Machine 1A Production Target (units)
Machine 1B Production Target (units)
Machine 2A Production Target (units)
Machine 2B Production Target (units)
Machine 3A Production Target (units)
Machine 3B Production Target (units)
Submit

The Report Screen

Period: 1

Back to Production Input Screen

Last Period Output (units)	Manuf. Cell 1	Manuf. Cell 2	Manuf. Cell 3	Advac Total
Machine A	29,040	23,780	15,140	
Machine B	11,040	9,780	8,140	
Total Output of Delta				8,140

This Period Inventory (units)	Manuf. Cell 1	Manuf. Cell 2	Manuf. Cell 3	Advac Total
Inventory A				
Working Inventory	30,000	25,000	17,000	
Excess Inventory	0	15,360	24,940	
Inventory B				
Working Inventory	12,000	11,000	10,000	
Excess Inventory	13,700	3,360	3,940	
Total Working Inventory	42,000	36,000	27,000	105,000
Total Excess Inventory	13,700	18,720	28,880	61,300

This Period Mach. Cap. (units)	Manuf. Cell 1	Manuf. Cell 2	Manuf. Cell 3	Advac Total
Maximum				
Machine A	30,000	25,000	17,000	
Machine B	12,000	11,000	10,000	
Maximum Capacity of Advac				10,000
Actual				
Machine A	28,630	23,128	14,112	
Machine B	10,630	9,128	7,112	
Actual Capacity of Advac				7,112

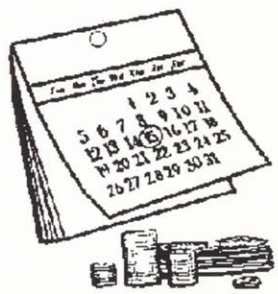
Advac Pay Office

Back to Production Schedule Input Screen

a	aa
	$
Wage (Period 0)	Data Not Available
Cumulative	Data Not Available
% Increase in Wage	Data Not Available

b	b
	$
Wage (Period 0)	Data Not Available
Cumulative	Data Not Available
% Increase in Wage	Data Not Available

c	c
	$
Wage (Period 0)	Data Not Available
Cumulative	Data Not Available
% Increase in Wage	Data Not Available



ADVAC
Pay Office

Covering Production Period 0

Post Test Questionnaire

Post Test Questionnaire

General participant information

First1

Age ☐

Sex ☐Male ☐Female

Study Program ☐Full-Time ☐Part-Time

First2

Age ☐

Sex ☐Male ☐Female

Study Program ☐Full-Time ☐Part-Time

First3

Age ☐

Sex ☐Male ☐Female

Study Program ☐Full-Time ☐Part-Time

Continue