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The Impact of Information Technologies and World Class Manufacturing Practices on Managerial Control

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Abstract

This study investigates the relationship between the use of specific information technologies and team-oriented practices and six measures of shop-floor control in a manufacturing setting. We investigate how use of 3 different types of ITs used in high tech manufacturing (product tracking, process automation, inter-firm IT linkages) are correlated with use of 3 types of world class manufacturing practices (process review and control, continuous improvement, and JIT), and how these patterns of use are associated with two very different managerial approaches to controlling workers. One is traditional, emphasizing top-down monitoring and pay-based rewards, the other participative, emphasizing social needs and team based work structures. Hypotheses linking technologies and practices to the specific control mechanisms underlying these two views are developed using control theory, agency theory, and concertive control theory. These hypotheses are empirically tested using data from a survey of manufacturing plants in the highly dynamic and competitive disk drive industry. Our results indicate that both views are used in practice, though we find that technologies and practices are associated with quite different patterns of control. Product tracking technologies' are associated with a top-down, managerial command and control approach which is best explained by agency theory supplemented with a recognition of the social implications of performance measurement which provide a basis for peer pressure. Inter-firm IT linkages and practices' relationship to control are associated with a more participatory team-based approach.

Introduction

Research relating control to organizational performance has long recognized that the key challenge in competitive settings is to achieve the highest possible level of control using a variety of mechanisms (Storey, 1985, Merchant, 1988). The drive towards higher total levels of control and more efficient control mechanisms is explained by microeconomic theory: as product markets become more competitive due to global trade and international capital markets, firms must become more efficient to survive. Control is not a unitary concept. A large body of research has examined when different types of control are appropriate. Both control theory (Thompson, 1967; Ouchi, 1977) and agency theory (Holmstrom and Milgrom, 1991) provide guidance on the relative effectiveness and efficiency of various types of control. Task measurability is a key variable determining the type of controls to be used in various theories of organizational control. March and Simon (1958) first described how predictability of the task determines the appropriate control system to be used. Thompson (1967) added that the appropriate focus of any control system should be determined by the measurability of two things: the relationship between task behaviors and outcomes ("knowledge of cause/effect relations" per Thompson); and, outcomes ("standards of desirable performance"). Ouchi (1977;1979) expanded this typology to address situations when measurement of both dimensions is either straightforward or problematic. Ritual control is used when both are problematic. It is implemented by selecting and socializing individuals so that their propensity to act against the interests of the organization is reduced. In this study, we investigate both formal selection and training processes (using the term "input control" suggested by Jaeger and Baliga (1985)), and informal peer pressure. While these control theories address when alternative mechanisms are appropriate based on task characteristics, agency theory (Eisenhardt, 1989) focuses on which combination of pay-based monitoring mechanisms represents the optimal control strategy. Agency theory suggests that if outcome and behavior based measures together provide more information about the agent's effort than either one alone, then both should be used in an optimal employment contract (Sappington, 1991). It also predicts that IT will be purchased to the extent that improved measurement of production work, when directly linked to compensation, reduces agency costs. So long as the reduced agency costs exceed the cost of the IT, total costs are minimized. A limitation of agency theory is that it assumes that individuals are motivated only by pay-based incentives. This ignores the need for affective, emotional attachments which provide a basis for commitment, social norms, and the infusion of social structures with value and political action (Parsons,

1951). Popular works by Ouchi (1981), Peters and Waterman (1982) and others in the early 1980's highlighted the opportunities available for harnessing these social needs via strong performance-focused corporate cultures. A substantial amount of research has been done on more team-oriented, participative modes of control. Tompkins and Cheney (1985) use "concertive control" to describe an ideologically-based form of control in which workers control themselves based on values which have been agreed upon with management. Although management's control activities are reduced, predictability and performance is increased as individuals accept managerial performance demands in return for increased discretion. Barker (1993) investigates this form of control in self-managing work teams, finding that the total level of control rises as workers create and emotionally invest in a value consensus, then develop a set of rational rules which they enforce on each other as no single supervisor ever could. Just as in a bureaucracy, team members look for rational measures they can use to make individual performance highly visible.

Hypotheses

In terms of the technologies examined in this study (see Table), product tracking technologies (comprised of MRP systems and bar coding) should enhance measurability of outcomes. Material requirements planning systems dramatically improve firms' ability to measure outcomes at all stages of the production process. Bar coding of individual products, when combined with computer aided test and inspection and warranty data, enable management to assess the quantity and quality of work done at each production task, often to the individual worker level. Inter-firm linkages often support tracking of individual products across firm boundaries and are expected to be positively related to outcome focused control. A major focus of process review and control and continuous improvement is to increase the inherent measurability of process outcomes and analyze this information effectively, thus a positive impact is hypothesized. The reduced slack associated with use of JIT makes inventory shortages and excesses more immediately apparent: either production shuts down, or stacks of inventory become obvious through line-of-sight management. Thus, JIT is expected to support outcome focused control. Theory does not suggest whether technologies will be associated with individual or team outcome monitoring, while the literature on practices strongly suggests that they will be implemented along with a pay scheme which recognizes team, rather than individual, outcomes.

H1: Extent of use of product tracking and inter-firm linkage technologies, and all management practices is positively related to the use of outcome control. Zuboff (1988) suggests that implementation of process automation AMTs requires significant new worker skills to fully exploit its potential benefits. Repetitive tasks become automated, creating more complex, intellectually demanding jobs. Similarly, process review and control practices require significantly different skills due to the statistical concepts required to understand it. Ensuring workers are capable of performing tasks is generally accomplished through selection and training practices.

H2: Extent of use of process automation technologies, and process review and control and continuous improvement practices is positively related to use of input control. Technologies and practices provide a plethora of measures to support increased measurability, thus technologies and practices which support task measurement are also expected to provide a basis for peer control. Product tracking technologies support increased monitoring of outcomes or behaviors, thus they are expected to be associated with higher levels of peer control. Inter-firm linkages are not relevant to this hypothesis because they extend outside the firm and would not involve a 'peer' group applicable to production workers. Process review and control, continuous improvement and JIT practices are expected to enhance measurability of outcomes or behaviors, supporting the informational requirements of peer control. These MPs are also associated with use of teams, providing a mechanism for development of shared values and therefore higher levels of peer control.

H3: Extent of use of product tracking technologies, and all management practices is positively related to the level of peer control. Traditional conceptions of control implicitly assume that increasing levels of managerial and peer control necessarily result in a lower levels of individual control. Industrialization and the rise of bureaucracy at the turn of the century drove Marx (1905), and Weber's (1968) dire predictions of class-based domination and entrapment in bureaucracy's 'iron cage', respectively. Subsequent research in

control theory, sociotechnical systems (Trist, 1981) and concertive control called this fixed sum perspective into question, arguing that high levels of worker self-control can coexist with high levels of managerial control, providing a greater total level of control and productivity. In general, this research found that low levels of self control are associated with traditional top-down managerial monitoring structures, while high levels of self control are associated with self-managing work teams. Based on this, interventions which are associated with individualized performance mechanisms are expected to be related to lower levels of individual control.

H4: Extent of use of product tracking and inter-firm linkage technologies is negatively related to an individual's degree of control over work.

Approach and Results

The field work for this research was completed in 1994 as part of the NSF sponsored Advanced Integrated Manufacturing Environments (AIME) project. Fifty one executives and 17 plant managers were interviewed on-site. All completed survey instruments for subsequent quantitative analysis. Contrary to organizational and emergent perspectives on the relationship between technology and control which are grounded at the firm level, both technology and practices do have significant effects on control across firms. The strong relationships found between technologies, practices and control mechanisms are evidence of this. This is in contrast to previous studies which emphasize emergent phenomena. The total level of control which workers are subject to appears to be affected by technological interventions by management. This has obvious implications for efficiency and quality in highly competitive industries. Specific technologies and practices have quite distinct patterns of control associated with them. Intra-firm product tracking technologies are associated with top-down managerial control. There is less emphasis on selection and training; individual productivity is managed through the measurement capabilities of IT, linked to individual pay schemes. Interdependent individuals use this information as a basis and focal point for peer pressure. This high level of monitoring reduces workers' sense of autonomy. Practices and inter-firm IT linkages are associated with a team-focused control approach which emphasizes selective hiring, higher levels of training, and team focused pay schemes. These interventions foreground the higher levels of skill and interdependence required in advanced manufacturing environments. Importantly, this divergence is mitigated at the firm level, as use of some technologies and practices is correlated. Management appears to be using technology and practices in tandem to achieve complementary increases in control at the individual and team level. This highlights the importance of considering both technologies and practices when investigating the effect of either on the production process. Considering either in isolation provides an incomplete picture of their impact and likely effectiveness. Similarly, focusing attention on whether the primary means of control should be outcome, behavioral, or social has limited value. Bringing ITs and practices together provides options for attaining a total level of control not possible with either one alone.

	Type of Control		Outcome		Input	Peer	Individual
			Individual	Team			
	Hypothesis		H1	H1	H2	H3	H4
ITs			.65	.76	.69	.97	.91
Product Tracking			.40**	.06	.00	.37*	-.49**
Process Automation			.05	.19	.04	-.27	.19
Supplier-Firm Linkages			.13	.42*	.09	.16	.07
Customer-Firm Linkages			-.03	.49**	.24	-.09	.13

Practices									
Process Review & Control				-.01	.32	.40**	.18		-.02
Continuous Improvement				-.05	.34*	.29	.11		.13
JIT				.26	.47**	.39**	.31		-.08
Notes: Legend:		*.10>p>.05		** p<.05					
Non-parametric tau-b correlations									

References available upon request from author