RESEARCH PAPERS IN MANAGEMENT STUDIES

A Customer-Driven Model of Job Design: Towards a General Theory

Robert F Conti and Malcolm Warner

WP 2/2001

The Judge Institute of Management Studies
Trumpington Street
Cambridge CB2 1AG

Revision 23 March 2001

A Customer-Driven Model of Job Design: Towards a General Theory

Robert F Conti and Malcolm Warner *

Abstract

There has been considerable debate about the level of discretion that should be accorded workers in performing production tasks. Opposing views have been proposed without effective conceptual support. The authors develop a job discretion decision model based on customer preferences. They argue that the case for greater worker discretion is strengthened by this model. The model is empirically tested and used to resolve the discretion question and clarify relevant job design and human resource issues.

Introduction

The authors of "Designed to Work", Lund et al, have added an important insight to the job design body of knowledge. Based on nine case studies of manufacturing firms, they conclude that "engineers design jobs, not just machines". [1] The engineering decisions made in designing machines define the production jobs needed to build the machines. Lund, et al contend that engineers pursue economic and technical objectives and that job designs tend to evolve by default - leaving the compatibility of the job, product and process designs to chance. They urge firms to integrate job design into the total design process.

Fried, Cummings and Oldham describe the essence of job design: "At its most basic level job design is changing the social structure of jobs that people perform.

* Robert F Conti is Associate Professor of Operations Management, Bryant College, Rhode Island ,USA.
Malcolm Warner is Professor and Fellow, Wolfson College and a Faculty member of the Judge Institute of Management Studies, University of Cambridge

Unlike other change strategies that focus on training employees or altering the context of their work (for example, the payment system or managerial practices), job design focuses on the work itself – that is, on the tasks and activities that individuals complete in the organization on a daily basis" [2] Child uses two dimensions to define a job design: the extent of job specialization and the degree of job discretion. [3] There appears to be little question of the efficacy of enriching production jobs by expanding their scope - with benefits accruing to workers, the firm and customers. This is not the case with job discretion – particularly when worker changes in procedures can negatively affect product outcomes. Therefore, the focus of this article will be on determining the appropriate level of worker discretion in performing production tasks, its relation to the preceding debate on the topic and how the case for greater worker discretion can be advanced where this can be defended as feasible.

Lund, et al, propose a job discretion policy: "Although we found few examples where operators were encouraged to modify the process, these tend to indicate, where circumstances permit, it is a useful policy". [4] Their advice is diametrically opposite to that of Womak, et al: "Our advice to any company practicing craftsmanship of any sort…. Stamp it out." [5] Considering the wide range of existing products and processes, it is unlikely that either of these proposals is universally valid.

In a prior article, the authors support Womak's position, [6] Our analysis shows that the limits of human accuracy, when combined with large numbers of sequential production tasks, make low task discretion a statistically necessary condition for high reliability. We give an example of a product with 1000 assembly tasks, with skilled workers each exercising task discretion with only a .001 probability of making an error. Under these conditions, only about 37% of the products are shown to make an error-free pass through the entire process. Over 60% encounter the need for rework, creating the potential for reduced product reliability. Discretion must be eliminated in most of the assembly tasks to achieve globally competitive reliability levels. This is the position taken by Womack – that craft type discretion must be 'stamped out'.

Our supportive analysis was a particular solution to the job discretion decision – for highly complex products such as automobiles, with many parts, many interactions among the parts and with customers who value reliability. This article attempts to develop a 'model' that extends our prior analysis by suggesting a more general 'theory' of customer-driven job design – one that is able to reconcile the Lund and Womack differences and be applicable to a wider range of products.

Research Aims & Methodology

The major objective of the study is to model the factors that influence the appropriate level of production task discretion. A secondary objective is to assess the impact of discretion on human resource practices. These objectives are pursued through the following research questions:

1) What are the key internal and external factors that influence the appropriate levels of production task discretion and what is the relationship between these factors and appropriate discretion?

2) What human resource policies are consistent with the differing degrees of discretion?

To address these questions, a job discretion model was developed and tested through on-site studies of job designs and factor characteristics at ten manufacturing firms. The relevant human resource practices at each site were also surveyed. The model was evaluated and refined, preliminary conclusions were formulated and a future research agenda proposed.

Prior Research

For most of this century, job design has been one of the most frequently researched topics in the fields of management and organizational behaviour. Interest in job design was particularly *de rigueur in the* 1970s and 1980s, but it has fallen from intellectual fashion in the last decade. One reason has been the expansion of interest in business process re-engineering, to which we have turned a critical eye in earlier writings. [7] Part of the explanation for the reduced interest in job design and job satisfaction may be increased global competition, leading to a shift in interest to labour efficiency. Another factor may be the rise of service sector employment viv-a-vis manufacturing.

Dean and Snell reviewed the body of job design research, concluding that ".. although job design has long been a topic of organizational research, scholars have generally focused on its effects on employee satisfaction and motivation rather than on what influences job design in the first place". [8] Drucker defines the objective of the firm, and hence that of the manufacturing process, as the creation and satisfaction of customers. [9] Therefore, while prior job design research has largely emphasized the preferences of the workers, we argue here that primary consideration should be given to the preferences of the customer, who is at the end of the value-added chain. In doing so, we expand on the work of Hill.

The Voice of the Customer

Customer preferences can be defined by Hill's order winners, defined as the product characteristics that are crucial to a customer's purchase decision. [10] Hill incorporates Garvin's dimensions of quality into his model to enhance the order-winning characteristic of 'quality'.[11] A key outcome of manufacturing strategy is the choice of production processes - including job design. Hill links manufacturing strategy to customer needs as expressed by the order winners. His consideration of job design, however, is limited to a proposal for job enrichment. Our analysis extends Hill's model by considering the important question of the level of job discretion that is appropriate for meeting customer expectations.

Order Winners

The following order winners are used in our model:

1) Performance: how well the product performs to the customer's expectations

2) Reliability: the frequency with which the product performs as expected and does not require service. Low frequency of needed service equates to high reliability.

3) Aesthetics: the pleasurable look and 'feel' of the product

4) Craftsmanship: hand-generated uniqueness in the form and finish of the product

6) Delivery: the speed and reliability of the time from ordering to receiving the product.

7) Price: what the customer pays for the product.

8) Customization: the ability to tailor the product to specific customer desires. A measure of product variety.

The objectives of the product, process and job designs are to meet customer needs, as expressed by one or more order winners. Incorporating this reality into the design process adds a new dimension to the study of task discretion, since the customer is usually absent from this decision.

Boundaries of the Job Design Model

Our study considers manufacturers who build discrete-item products on a repetitive, though not necessarily continuous, basis - using either batch or flow production. Specialty or one-off job shops, which tend to employ high-discretion craft-skill job designs, are not considered. Process firms are also excluded since safety, health, environmental and regulatory constraints require operators to strictly adhere to established procedures without deviation. Emphasis of the study is on assembly tasks since they involve the majority of production workers and offer the greatest opportunity for exercising discretion.

Three types of job discretion are defined by Breaugh: [12]

1) Work method: amount of discretion operators have to change work methods or procedures.

2) Work criteria: discretion operators have in choosing or modifying criteria for evaluating their performance, including product specifications.

3) Work schedule: discretion in controlling the scheduling, sequencing and timing of job activities.

Work schedule discretion by workers can improve the speed and consistency of delivery – an order winner. More importantly, unlike discretion in work methods, it is not likely to unfavorably affect other order winners such as relia bility and performance, and this type of discretion should be encouraged. Therefore, we study the degree of workerdiscretion in setting product specifications and performing production tasks.

A Job Design Model

The proposed job design model is shown in Figure 1. Its driving force is the customer's utility function – a measure of what the customer values. Customers attempt to maximize their utility within the limits of their resources. Utility is increased by acquiring products with features that are of great value to the customer - features defined by the order winners. In the design of production systems, choices of job designs are a subset of the process choice, which includes the degree of automation, the choice of technology and the organization of production. The major determinants of process choice are product and process complexity, product volume, and the value that customers place on product craftsmanship and variety. We believe that this new combination of factors results in a model that is an improvement on earlier contributions to the field. The model is more market-led since it is more customer driven. The rationale for the model follows.

Job Discretion and Error

We have previously shown that increased discretion leads to increased errors in production tasks. [13] Therefore, the frequency of errors is reduced by reducing the number of discretionary tasks. The consequences of errors depend on whether they are detected and corrected, and the effect of uncorrected errors on order-winning characteristics.

Reason defines two types of human errors: “active errors, which are felt almost immediately and latent errors, whose adverse consequences may lie dormant within the system for a long time, only becoming evident when they combine with other factors to break the system’s defence” [14] Active errors can be detected and corrected through quality control – especially if ‘quality at the source’ checks are made by all workers. Also, there is usually a final inspection that can detect active errors and lead to rework. For competitive manufacturing, however, these inspection activities are forms of ‘waste’ that should be eliminated – by eliminating active errors. Latent errors present a more difficult challenge, since by their nature they are not detectable by quality control procedures.

Latent Errors

Latent errors have the potential to seriously degrade performance and reliability. Quality control is no substitute for preventing latent errors. As described by Reason, their negative consequences emerge only after the product is in use and influenced by environmental factors such as vibration or humidity - leading to potential field failures and product recalls. Product development engineers often employ sophisticated techniques such as statistical design of experiments (DOE) and failure mode and effects analysis (FMEA) to avoid latent errors. These techniques require that the products meet design specifications and engineers must approve all changes. This is necessary since a source of latent errors can be well intentioned ‘improvements’ made by workers exercising discretion. Their changes normally have favorable short-term effects, but may create serious latent consequences.

Car door assemblers at an auto plant in the USA participated in telephone surveys of recent purchasers. In response to complaints about the difficulty of closing heavy car doors on hills, they made modifications to reduce the closing force. The doors were much easier to close and complaints were reduced but reports of door leaks in heavy rain started to surface. A similar case occurred at a USA manufacturer of gas valves that gives broad discretion to workers. A machinist substituted an aluminium alloy for stainless steel in a flow nozzle. The aluminium was less expensive, easier to machine and easier to attach to connecting components. The aluminium nozzles passed all of the flow and pressure-drop tests and the change was made. The machinist was not aware that the design engineer had selected stainless steel to resist the corrosive effects of the high-speed gas flow. The aluminium nozzles failed after a few months in service, and several thousand valves had to be recalled. The potential consequences of latent errors in complex products are serious enough to warrant engineering control over employee-initiated changes.

Complexity, Discretion and Reliability

The effect of errors on reliability depends on the complexity of the product. Cooper, et al, define complexity as a combination of structural complexity - the number of parts in a product, and functional complexity - the number of functional interactions among the parts.[15] Both affect the impact of errors. As the number of parts increases, the number of production tasks, and hence the *exposure* to errors, increases. The human error probability

(HEP) is the probability that a worker exercising discretion will make a production task error. Studies have indicated that the minimum value of the HEP, under ideal conditions, is about one error per one thousand operations, or .001. [16] The probability of an operator performing correctly is .999 and the probability that a sequence of n operators on a production line will all avoid errors is .999 to the nth power. As a result, even for a product of modest structural complexity, with 200 tasks, only 82% of the units will experience an error-free pass through all tasks – unacceptable by world-class quality standards.

The *consequences* of errors depend on the functional complexity of the product, since more interactions create more opportunities for errors to cause failure. As a result, high task discretion can seriously lower reliability for complex products and appears to be incompatible with reliability as an order winner. Another form of complexity affects task discretion – process complexity. From a customer viewpoint, a process is deemed complex when its output cannot meet customer expectations without eliminating worker discretion, because the requirements exceed the limits of human skill and judgement. winner. If expected product performance requires a key component to be produced to tolerances attainable only by computerized technology, the process is considered complex. Total complexity is a combination of product and process complexity and high levels militate against the use of task discretion.

The Customer Utility of Product Variability

Product variability refers to differences in form, fit or function between successive products. For customers who value product uniqueness, the fact that no two hand-blown, hand-engraved Steuben crystal bowls are completely alike is a virtue. This craft-created variability has positive utility for these customers and they pay substantial premiums over the price of unvarying mass produced bowls. Rowley points out that for these products "What is important is perception, such as a craft and handmade image" [17] The low complexity of a bowl makes reliability unimportant, compatible with desirable variations.

A high degree of consistency has been shown to be necessary for reliable complex products, therefore the utility of variability is negative. Most owners of products such as cars will not be satisfied if the products need frequent repairs - regardless of performance. This is evidenced by the sharp market share losses of high perfomance, low reliability Porsche and Jaguar automobiles in the early 1990s.

The interaction between product complexity and the utility of variability appears to significantly affect the appropriate level of job task discretion. Applying the principle of Ockam's Razor, this simplified two-factor structure is pursued for our model.

The Variability Utility & Complexity Matrix

Figure 2 shows the matrix of the four combinations of variability utility and total complexity. Each quadrant lists the likely order winners that are consistent with the utility and complexity of the quadrant. Two viable quadrants are obvious: Quadrant I, with high discretion craft job designs for high variability utility and low complexity products, with craftsmanship and aesthetics as order winners; and Quadrant III, with low discretion designs for products with low variability utility and high total complexity, and with performance and reliability as order winners.

Quadrant IV products have both low utility of uniqueness and low complexity. These are often commodity products, with price and delivery as order winners. The low complexity affords considerable flexibility in the level of task discretion and this level will tend to be determined by the cost/volume relationships of the production technology options. Increased use of technology will lower costs and lower discretion. This discretion criterion is consistent with the high price elasticity of demand of the products and their low complexity and low sensitivity to errors.

Quadrant II customers " want it all" – performance, reliability, aesthetics and craftsmanship. This combination of high complexity and high craft utility can prove to be infeasible in the marketplace for products such as hand crafted luxury cars. The state of Florida in the USA has a 'lemon law' that allows car buyers to return unreliable cars for a refund. In 1998, the owner of a $250,000 Lamborghini Diablo invoked the law after a series of continual breakdowns. [18] Product proposals for this quadrant should be scrutinized for potential mismatches between customer wants and manufacturing reality. Mismatches can sometimes be resolved by a solution encountered in the empirical study – hybrid product and job designs.

A preliminary test of the model was made by an empirical study of job designs and influencing characteristics at ten manufacturing sites.

The Empirical Study

Ten production-sites in the United Kingdom, North America, Japan and Malta (ranging in size from small to large, employing from 120 to 4600 workers) were chosen for the empirical investigation of the above model. They were selected on the basis of the researchers' long-standing research associations with these firms and their long-term success in their markets to ensure that the witnessed job designs were supporting customer satisfaction. A secondary criterion was the selection of at least two sites in each of the three feasible quadrants. The observed levels of task discretion were compared to the levels of complexity and variability utility to determine the effectiveness of the model in identifying discretion levels appropriate to market needs. The characteristics of the sites are given in the Appendix in Table 1 and the results of the site studies are summarized in Table 3.

High Discretion Sites

The first two sites employ high discretion craft job designs. Beleek Pottery produces a broad range of china products – hand shaped and decorated by skilled craftsman. Stueben Glass emphasizes hand-blown, hand-engraved glass crystal objects. All products at Beleek and Steuben have very low complexity and the relevant order winners are craftsmanship and aesthetics. Customers pay substantial premiums over the price of comparable machine made items – to gain the high utility of craft variability. The high discretion, craft skill job designs are consistent with the quadrant I combination of desirable variability and low complexity.

Low Discretion Sites and Anomalies

The next four sites employ low task discretion job designs. The Toyota plant uses standard operating procedures (SOP) for line assembly of Corolla and Prizm cars and Tacoma trucks. Individual worker suggestions are encouraged, but all changes must be reviewed and the SOPs updated before implementation. The job design supports the customer desire for high reliability in a very complex product – a characteristic of Toyota vehicles. The Jaguar plant assembles XK8 convertibles and XJ8 sedans, using what is termed 'no-adjust build'. This non-discretionary assembly, instituted by Ford, has been instrumental in moving Jaguar cars from last place in the JD Powers quality league table in the early 1990s to first place in May 1999. Hoshizaki Electric is the market leader in Japan for commercial appliances such as complex automatic ice makers. Their use of foolproof, or 'poka-yoke', techniques is pervasive. Poka-yoke techniques remove discretion by either making it physically impossible for a production task to be performed in an unacceptable manner or signaling whenever an error is made. Consider an operation where non-magnetic aluminium screws must be used. If they are supplied to the worker on a magnetized chute any mislabeled steel screws will be detected and erroneous installation prevented. All Hoshizaki employees receive poka-yoke training and all participate in fool-proofing projects on company time. The UK plant of Company A produces highly reliable heating system controls. Their long-cycle, cellular assembly is aided by non-discretionary designs utilizing self-locating parts and colour coding. All four test sites build complex products for customers who value performance and reliability – hence product variability has negative customer utility and the low discretion job designs meet the Quadrant III market needs. .

There was an anomaly at Jaguar. Body and electro-mechanical assembly is performed without discretion but the wood trim shop is an island of craftsmanship. Skilled wood workers select matching wood veneers and cut, sand and finish the hand crafted interior trim for which Jaguar is renowned. Similarly, the leather hides for the seats are hand cut and sewn by ex-Jaguar craftsmen at their supplier. As a luxury car producer, Jaguar competes on the basis of aesthetics and craftsmanship as well as performance and reliability – placing their cars in Quadrant II. The Jaguar hybrid design fills customer craft needs without compromising customer reliability needs by hand crafting highly visible but low complexity components like interior trim and upholstery. Volkswagen will use this hybrid design for the planned new Bentley. It will be built in Germany and shipped to the UK where wood trim and leather seats will be hand crafted and installed to complete the car. [19]

An anomaly was also encountered at Martin Guitar, a leader in hand crafted acoustic guitars. Order winners are craftsmanship and aesthetics, achieved by the highly skilled craftwork used in fashioning the instruments. Customers also want outstanding sound - a need that encounters high process complexity in producing the guitar necks. Precisely formed necks are critical to guitar performance but even the most skilled craftsmen cannot consistently produce optimal shapes by hand. To overcome this undesired variability, an optimal neck was digitized and a computerized routing machine used to consistently duplicate the shape. The zero discretion neck routing, combined with the high discretion body construction, results in an effective hybrid process and job design. It appears that properly conceived hybrid designs can meet the diverse customer needs of quadrant II products.

Cost-Driven Discretion Sites

The final three sites use different discretion levels even though their products share the low complexity and low variability utility of quadrant IV. Company 'B' is a leading manufacturer of insulated ice storage cabinets. The cabinets have low complexity, with very few parts and only one that moves – the door. Order winners are price and delivery. Assembly is by hand, with considerable discretion given to workers to modify methods or processes. Hand assembly is consistent with the low volume that does not justify lower-discretion mechanization. Company 'C' is a market leader in medium-priced wood furniture, producing a broad line of standard items, using batch production. Order winners are price, delivery and aesthetics. Volume is low and the use of technology is limited to general- purpose woodworking machinery. Assembly and finishing is by hand, with workers having broad discretion in performing tasks. The work is semi-skilled. The desire for aesthetics is met by the product designs since customers are not expecting hand crafted bespoke items. The third site, Uvex, is a leader in industrial safety glasses. Volume is very high, the competition is intense and the products have low complexity. Assembly is totally automated, including the packaging of individual pairs of glasses, with the ability to assemble a broad range of models. Assembly workers load parts hoppers and manage the flow of parts replenishment containers. Uvex's customers value price and delivery and the high volume justifies a highly automated process choice with no operator task discretion. The job design choices of the three sites are consistent with the proposition that quadrant IV task discretion is cost-driven.

Empirical Study Results

Eight sites use discretion levels consistent with the model predictions. The other two use hybrid job designs. In both cases the dominant design is consistent with the model – high craft discretion for the guitar body at Martin and no-discretion assembly at Jaguar. The alternative designs used for the major components are also consistent with the model – high craft discretion for Jaguar trim and seats and no-discretion operation of the computerized guitar neck machine at Martin. The hybrid designs show the need to apply the discretion matrix separately to major components that have combinations of variability utility and complexity that are different from the main product.

The task discretion model emphasizes the shaded factors in Figure 1 – those argued to be the most significant. The secondary roles of product variety and product volume remain to be addressed. Volume was previously evaluated for quadrant IV.

Product Volume and Task Discretion

Annual production volume is a key to process choice and job design. In our model, however, volume is a direct determinant of job task discretion only in quadrant IV. In quadrant I volume is not a factor. The high volume Steuben factory and a low volume craft furniture shop can both validly use high discretion job designs. Using traditional cost/volume analysis, Steuben's high volume would undoubtedly justify programmeable computerization of their processes to duplicate the variability achieved by the glass blowers and engravers. The customers, however, would react negatively - they pay a premium for hand crafted variations, not those of an impersonal central processing unit. We see that the traditional process choice effect of high volume can become secondary to customer utility in a customer-driven model.

In quadrant III, task discretion must be minimized as a necessary condition for reliable complex products. This need is independent of volume. While volume may not affect the level of discretion, it does affect the means of achieving low discretion. At high volumes, extensive use of technology can be justified for eliminating discretion. In contrast, at low volumes, ‘poka-yoke’, or foolproof techniques must be used to reduce discretion in manual operations.

Quadrant II products tend to meet market needs only with the use of hybrids of quadrant I and quadrant III job designs. Therefore, volume and variety considerations cannot be applied directly to quadrant II. It can be seen that the role of product volume in job discretion choice is not deterministic. It is contingent upon the combined effects of product complexity and how customers value product variability – an important insight of the model.

Product Variety and Task Discretion

Just-in-time (JIT) production was hailed as ‘flexible mass production’ since JIT mixed model-scheduling permits several product models to be simultaneously built. Some firms, such as Dell Computer, have switched from mixed model scheduling to the more flexible ‘mass customization’ system. Pine defines mass customization as “developing, producing and delivering affordable goods and services with enough variety and customization that nearly everybody finds exactly what they need” [20] The task discretion model aids in selecting the appropriate means of customization.

Flexible job designs, with high levels of task discretion have been viewed as necessary for responding to wide varieties of customer demand. Our model shows that this approach is valid only for quadrant I and IV products, where low complexity makes them relatively insensitive to task discretion errors. For the complex, high reliability products of quadrant III customization must be achieved with low task discretion. Dell accomplishes this with modular assembly. Final products are customized by combining standard modular components to achieve large numbers of final configurations. If the modules and final assembly both use low discretion operations complex products can be customized without compromising reliability.

The effects of product volume and product variety on process choice are seen to be contingent upon customer needs and product complexity.

Input & Process Variability

High task discretion has been proposed as being necessary to cope with high input and process variability. See for example Buchanan and Boddy. [21] This prescription must be qualified to reflect the potential effects on order winners . For the low complexity products of quadrants I and IV, using discretionary skills to overcome variability in raw material inputs and variability in process outputs is appropriate since it is compatible with customer needs. This is not true, however, for the complex products of quadrant III. For these products, customer needs dictate that variability be controlled by non-discretionary technology and techniques such as statistical process control (SPC).

Human Resource Implications of the Model

To satisfy customers, human resource practices must be compatible with job designs. Several relevant human resource practices were empirically investigated at the ten sites by a structured questionnaire and open-ended interviews. The results are summarized in Table 2. The summary enables us to examine the pattern of practices in work relations, employee relations and employee involvement at the sites and evaluate their relationship to the corresponding job designs.

Training

Worker training is a vital human resource practice. Taylor points out that "Training is any systematic process used by an organization to develop employee's knowledge, skills, behaviour and attitudes in order to contribute to the achievement of the organizational goals". [22] Since a major organizational goal is satisfying customers, the training must be linked to the job designs and must also be market-driven. A key training decision is whether to emphasize the scope, or width of worker skills or the depth of their skills.

Training that increases the depth of skills is consistent with the craft skill job designs needed to satisfy customers who value craft-induced variations. Belleek and Steuben serve this market and both do emphasize depth of skill training. They achieve this through formal apprenticeship programs and with post-apprenticeship training where craftsmen produce increasingly demanding designs with the same basic skills. Jaguar and Martin also emphasize deepening skills in the craft-based portions of their hybrid designs. The wood workers at Jaguar are either graduates of the Jaguar apprentice program or journeymen cabinetmakers hired in by the firm. Martin Guitar's craftsmen do not serve an apprenticeship. The firm chooses to use a high division of labour in their handcrafted operations. Therefore, novice craftsman can be trained on the job by workers proficient in specific tasks, such as inlaying marble in guitar bodies.

Increasing the width of worker skills supports the use of multi-skilled workers, worker teams and job rotation. Training workers for wide ranges of individually shallow skills is appropriate for narrow, low discretion jobs in flow manufacturing. In this environment worker transfer flexibility and task sharing are necessary to maintain flow in the face of absenteeism and to achieve labour efficiency when model variations shift work loads. This environment is encountered in the firms of quadrant III and among the high volume, cost-sensitive firms of quadrant IV. All three of the low discretion, quadrant III sites – Toyota, Hoshizaki and Company A - do emphasize skill scope, or width, in their training, as does Uvex – a high volume quadrant IV site. Except for wood workers, Jaguar training also emphasizes skill scope. All five of the cited sites utilize work teams, multi-tasking, job rotation and low task discretion; and all employ flow-type JIT manufacturing.

Examination of Table 2 reveals that skill width training tends to be given on a 'just-in-time', or 'as required' basis. Only the skill depth sites have regularly scheduled job task training - as part of their apprenticeship programs. The need for broadening shop floor skills varies over time and ‘as required’ training improves efficiency by temporal linking of the training and its application. This is not the pattern, however, for training in process improvement skills. Nine of the ten sites provide training in process analysis and seven provide regularly scheduled training. They feel that continuous improvement programmes require continuous training. In general, the training programmes at the test sites appear to be appropriate for supporting their market-driven process choices and job designs.

High Performance Workplace Practices

Studies at the Institute for Work and Employment Research at MIT link high performance workplaces with more consensual employment practices such as quality circles/off-line problem solving groups, job rotation (implying multi-tasking), self-managed work teams and total quality management (including ‘quality at the source’ performed by workers). [23] Table 2 shows that nine of the ten sites practice multi-tasking, job rotation, and team working and all ten sites utilize worker quality control and employee process improvement programmes. The emphasis on team working is supported by the compensation at the sites, with group performance pay more prevalent than individual performance schemes. As expected, the Belleek and Steuben craft sites, with their emphasis on skill depth, have the lowest utilization of multi-tasking and job rotation. However, these are exceptions to the pervasive use of high performance practices at the test sites. Unlike job task discretion, these practices are being pursued regardless of the nature of product complexity and the customer value of product variability.

It appears that the structure of job designs for competitive manufacturing has two components - a *generic* set of worker activities that are independent of market and product characteristics, and a *product-specific* set determined by the model of Figure 1. A major decision for the product-specific activities is the choice of the level of job discretion. If production job design is a two-tiered process, each tier must be customer-driven. The objective of the high performance practices is to better serve the firm's customers. They seem to be customer-driven in all combinations of product complexity and variability utility and therefore are the foundation for competitive job design. We argue that these high performance practices must be combined with customer-driven, product-specific job designs and that the proposed model can aid these designs..

Customer-Driven Job Design and Job Satisfaction

In some markets, appropriate job designs will combine the high performance practices with zero task discretion, with implications for worker job satisfaction. Oldham and Hackman link job satisfaction among production workers to internal motivation. They describe five job attributes that lead to high motivation: the opportunity to exercise a variety of skills, task identity – the opportunity to complete an identifiable piece of work, task significance – the degree to which the job substantially impacts the lives of others, autonomy – the opportunity to exercise discretion in scheduling work and performing tasks, and job feedback – receiving clear and timely information about job performance. [24] In addition, Oldham and Hackman attribute high 'job content ' satisfaction to high degrees of job security.

The high performance practices appear to meet several of the attributes. The range of practices enables workers to utilize a variety of skills – in process improvement, multi-tasking and job rotation. Workers receive immediate feedback through 'quality at the source' inspecting of their work. Work teams tend to collaborate in building complete products or major assemblies, providing task identity. Work teams often have autonomy in the scheduling of their work. These favorable job satisfaction outcomes can potentially be diluted when they are combined with low levels of job discretion needed to meet customer needs. In these cases, little autonomy is possible, raising the question of whether the lack of discretion will significantly reduce job satisfaction. We argued in an earlier article that empirical and anecdotal evidence indicates that the outcome is not deterministic. [25] For some workers, a repetitive, consistent, predictable work cycle is viewed as desirable, creating a situation described by Baldamus as a "comfortable rhythm of work that pulls workers along. The experience is pleasant and may function as a relief from tedium." [26] DeSantis experienced this while working on an auto assembly line to research a book: "And one box (compartment of her mind) grooved on the robotic beauty of a repetitive physical task. I was Charlie Chaplin, Buster Keaton, Marcel Marceau….I was so good and so fast I became master of the line. I played it like a piano." [27] Emery supports this effect, observing that "things that break the continuity of work, i.e. poor tools and materials, and brief (interrupted) work cycles" cause much of the dissatisfaction in repetitive assembly. [28] DeSantis faced this when auto parts didn't fit, layers of concentric holes didn't line up and trim screws were too tiny to grasp. [29] Overcoming these conditions requires discretionary coping skills that can which lead to frustration, cynicism and de-motivation among workers. [30] In these circumstances the use of zero discretion through foolproof assembly can have a favorable impact on job satisfaction.

Schuring studied the influence of standard operating procedures (SOPs) on 'operational autonomy' – where operations are possible with "no need for online intervention, assistance or direct control of operators by the rest of the organization". [31] He concludes that SOPs make it possible for workers to perform their tasks with increased operational autonomy, free from the need to consult support or supervisory staff. It appears that the use of non-discretionary, standardized job designs for complex products can be a 'win-win' situation – for both customers and workers.

It should be recognized that high levels of job satisfaction do not necessarily lead to high quality, which presents a problem for many proponents of job design. Christian Berggren, a strong advocate of the Volvo 'reflective' production system, describes this condition at the innovative Uddevalla plant: "In terms of quality, Uddevalla reached the levels of the Gothenberg (traditional mass production) plant after one year, falling far short of expectations. Management had believed that the plant's combination of highly motivated and skilled workers and short feedback loops would "automatically" result in *excellent* quality. In order to build world class automobiles, however, consistency and systematic procedures are also critical"[32] Consistency is achieved by the use of product designs that make non-discretionary assembly possible, and by process and job designs that put it into practice. Non-discretionary 'systematic procedures' are a necessary condition for combining the job satisfaction attributes of long cycle assembly with the customer satisfaction attributes of highly reliable complex products.

Societal and Regulatory Job Design Influences

The emphasis thus far has been on job design factors *at the level of the firm and its markets*. There are, however, external societal and regulatory influences on job design decisions. Taguchi has identified several costs, or losses, to customers and society that result from undesirable product variability and the resulting low reliability. He has defined the effect in his ‘loss function’. [33] The customer costs include the direct costs of product failures and the opportunity costs of lost time and resources. The increased scrapping of poor products imposes environmental costs on society. In economic terms, the Taguchi societal loss represents a negative externality. Some of the external costs are ultimately internalized within the firms by the loss of dissatisfied customers. This can create lower job security and lower ‘job content’ satisfaction. Reducing the magnitude of variability is particularly important, since loss function costs increase exponentially with the size of the deviations from target values. While quantifying the actual costs is difficult, the loss function provides conceptual support for low discretion tasks in complex products.

The ISO 9000 series of quality standards were issued by the International Organization for Standardization in 1987. Meeting their requirements has increasingly become a competitive necessity, particularly in business-to-business (B2B) markets. ISO 9001 defines when standard operating procedures must be established to reduce production task discretion. Section 4.9, ‘Process Control’, states that “operating procedures must exist whenever the absence of such procedures has an impact on quality”. Procedures reduce discretion, variability and errors; therefore they affect quality and are necessary for complex products. Control of changes to these procedures is covered by Section 4.5, which states that "changes in documents require approval of authorized personnel prior to use". Pursuing ISO 9001 certification can influence job design policy for complex products by limiting on-line discretion in performing job tasks and restricting off-line discretion in making task improvements.

It is evident that decisions regarding job discretion should not be made by default or in the isolation of a single department. The call of Lund, et al, for integrating job design into the market and product planning processes should be heeded.

Conclusions and Limitations

The proposed job design model appears to be of value in making job discretion choices consistent with the market needs of the firm. Application of the model to the practices at the ten test sites yields the following job design policy proposal:

> *Production jobs should be designed to make maximum use of the worker's judgement, knowledge, skills, creativity, intelligence and initiative and thus broad discretion should be granted to workers to enable them to utilize these attributes in all tasks except those that can negatively impact on customer needs***.**

This policy can be implemented only by an integrative design process, particularly for complex products. For these products, design engineers must overlay their traditional functional and economic concerns with considerations for foolproof manufacturing. The resulting improved reliability and lower cost will enhance both the functional and economic performance of their designs. We feel that the above indented proposition constitutes the beginning of a nascent general theory of job design for the coming decade.

The proposed model can be applied to resolve the conflict between the positions of Lund, et al and Womak, et al. Lund and his co-authors propose the use of high levels of task discretion “Where circumstances permit…..” The model defines those circumstances as quadrant I and quadrant IV products, where low complexity ensures that high task discretion will not negatively affect customer needs. The model can also reconcile the zero- discretion prescription of Womack,et al, by restricting its validity to high complexity quadrant III products where task discretion can reduce performance, reliability and customer satisfaction. The appropriate level of discretion is not deterministic. It appears to be contingent on the particular combination of product complexity and customer values regarding product variability. This finding allows more scope for organizational choice than many preceding writers have imagined.

Conclusions regarding the model must be preliminary because of several limitations. The four-quadrant model with categorically sized variables has the advantage of simplicity but in reality both product complexity and variability utility are continuous variables, existing over a spectrum of values. While the two chosen variables adequately reconciled job designs at the test sites it is likely that additional factors would need to be included in the model to explain job design variations in a large population of firms. The test sample is very small and the sites were not randomly chosen. Future research should include a large-sample empirical study - to validly test a job discretion model and attempt to determine whether firm performance is positively correlated with appropriate job designs. The model structure should be enlarged for the study with an expanded set of independent variables that can subsequently be reduced through factor analysis.

A major breakthrough in quality management occurred with the recognition that the customer defines quality. This concept became the cornerstone of the Total Quality Management (TQM) movement. [35] The voice of the customer is frequently integrated into the product development process, aided by techniques such as ‘Quality Function Deployment” - a scheme for converting customer preferences into engineering specifications.[36] This systems approach integrates design engineering, marketing, and manufacturing and has been widely researched and reported. [37] Unfortunately job design has been largely excluded from the product development process, remaining the province of organiz ational behaviour researchers and human resource practitioners. As a result, job designs tend to evolve by default or be designed in isolation and the necessary customer-driven linkage to product and process design is seldom made.

Despite its limitations, we argue that this micro-level study is a valuable step in developing a model to enable job designs to be included in the product development process and to make it feasible to base job designs on the needs of a broader set of ‘stakeholders’ – customers, owners and society - as well as workers. We feel it strengthens the argument for expanding choice at the workbench or production line for a wider range of workers.

Acknowledgement: The authors wish to thank Dr Elizabeth Garnsey for pointing out the conflict between the positions of Lund and Womack and to Mr. Colin Gill [both of the University of Cambridge] for contributing to the discussion and clarification of the underlying issues. We are grateful to the Judge Institute of Management Studies and the Engineering Department at that university for their support in the writing-up of this study.

References

1. Lund, R., Bishop, A. and Salzman, H., *Designed to Work – Production Systems and People*, Englewood Cliffs, NJ, Prentice Hall, 1993, p.3

2. Fried, Y., Cummings, A. and Oldham, G., 'Training', in Poole, M. and Warner, M .(eds), *IEBM Encyclopedia of Human Resource Management*, London, Thomson, 1998, p.532

3. Child, J., Organization: *A Guide to Problems and Practices*, 2nd Edition, London, Harper and Row, 1984, p.25

4. Lund, R., Bishop, A. and Salzman, H., 1993, op. cit, p.198

5. Womack, J., Jones, D. and Roos, D., *The Machine That Changed the World*, New York, Rawson, 1990, p.91

6. Conti, R. and Warner, M., 'Technology, culture and craft: job tasks and quality realities', *New Technology, Work and Employment*, 12:2, September 1997, pp. 123-135

7. Conti, R. and Warner, M., 'Taylorism, teams and technology in 'reengineering' work-organization', *New Technology, Work and Employment*, 9:2, September 1994, pp. 93-102

8. Dean, J. and Snell, S., 'Integrated Manufacturing and Job Design: Moderating Effects of Organizational Inertia', *Academy of Management Journal*, 34:4, 1991, pp. 776-804

9. Drucker, P., *Management Tasks, Responsibilities and Practices*, New York, Harper and Row, 1974, p. 61

10. Hill, T., *Manufacturing Strategy: Text and Cases*, Burr Ridge, IL, Irwin, 1994, p.32

11. Garvin, D., 'Competing on the Eight Dimensions of Quality', *Harvard Business Review*, 65:6, November-December 1987, pp. 101-109

12. Breaugh, J., ‘The Measurement of Work Autonomy”, *Human Relations*, 38:6, 1985, pp. 551-570

13. Conti, R. and Warner, M., 1997, op. cit.

14. Reason, J., *Human Error,* Cambridge, Cambridge University Press, 1990, p.173

15. Cooper, W., Sinha, K. and Sullivan, R., ‘Measuring Complexity in High Technology Manufacturing’, *Interfaces,* 22:4, 1992, pp. 38-48

16. Ayres, R., ‘Complexity, Reliability and Design’, *Manufacturing Review,* March 1988, pp. 26-35

17. Rowley, C., ‘The illusion of flexible specialization: the case of the domesticware sector of the British ceramics industry’, *New Technology, Work and Employment*, 9:2, September 1994, pp. 127-139

18. State of Florida Attorney General Web Site, Retrieved from the World Wide Web 12 September 2000: http://legal1.firn.edu/resale.nsf

19. ‘Volkswagen plans to build new Bentley in Germany’, *The Times*, 9 July 2000

20. Pine II, B., *Mass Customization: The New Frontier in Business Competition,* Boston, Harvard Business School Press, 1993, pp.196

21. Buchanan, D., and Boddy, *Organizations in the Computer Age: Technological Imperatives and Strategic* Choice, Aldershot, Gower, 1983, pp.239-240

22. Taylor, P., ‘Training’, in Poole, M. and Warner, M., (eds) *IEBM Handbook of Human Resource Management*, London, International Thomson, 1998, p.643

23. Taylor, R., ‘A US Policy Vacuum’, *Financial Times*, 20 October 2000

24. Hackman, J. and Oldham, J., *Work Redesign*, Reading, MA, Addison Wesley, 1980, pp.77-80

25. Conti, R. and Warner, M., 1997, op. cit.

26. Baldamus, G., *Efficiency and Effort: An Analysis of Industrial Administration*, London, Tavistock, 1961, p.87

27. DeSantis, S., *Life on the Line,* New York, Doubleday, 1999, p.106

28. Emery, F., ‘Characteristics of Sociotechnical Systems’, in Davis, L. and Taylor, J., (eds), *Design of Jobs*, London, Penguin, 1972, p.184

29. DeSantis, S., op. cit., pp.58, 60, 92 and 142

30. Conti, R. and Warner, M., 1997, op. cit

31. Schuring, R., ‘Operational autonomy explains the value of group work in both lean production and reflective production’, *International Journal of Operations and Production Management*, 16:2, 1996, pp.171-182

32. Berggren, C., ‘NUMMI vs. Uddevalla’, *Sloan Management Review*, Winter 1994, pp.37-49

33. Taguchi, G., *Introduction to Quality Engineering*, Dearborn, MI, American Supplier Institute, 1986, p.33

34. Dean, J. and Evans, J., *Total Quality*, Minneapolis-St.Paul, MN, West, 1994, p.12

35. Hauser, J.and Clausing, D., ‘The House of Quality’, *Harvard Business Review*, 66:3, May-June 1988, pp.63-73

36. ReVelle, J., Frigon Sr., N., and Jackson Jr., H., *From Concept to Customer*, New York, Van Nostrand Reinhold, 1995

APPENDIX

TABLE 1. Test Site Characteristics

NO.	SITE	PRODUCTS	LOCATION	TRADE UNION	PRODUCTION WORKERS
S1	**Belleek**	Pottery	UK	Yes	180
S2	**Steuben**	Crystal Ware	USA	Yes	120
S3	**Toyota**	Cars & Trucks	USA	Yes	4600
S4	**Hoshizaki**	Ice Machines	Japan	Yes	1450
S5	**Company A**	Controls	UK	Yes	525
S6	**Jaguar**	Cars	UK	Yes	2200
S7	**Martin**	Guitars	USA	No	450
S8	**Company B**	Ice Storage Bins	USA	Yes	125
S9	**Company C**	Furniture	Malta	Yes	160
S10	**Uvex**	Safety Glasses	USA	No	270

TABLE 2. Human Resource Management at Test Sites

Dimension	Sites S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
JOB TASK DISCRETION MATRIX QUADRANT	I	I	III	III	III	II	II	IV	IV	IV
WORK RELATIONS										
Teamworking	%	%	P	P	P	P	P	%	%	X
Multi-tasking/ training	X	%	P	P	P	P	P	%	%	%
Job rotation	X	AR	P	%	AR	%	AR	%	AR	AR
Worker quality control	P	P	P	P	P	P	P	P	P	P
Just-in-time mfg.	X	X	P	P	P	P	X	P	%	P
High task discretion	P	P	X	X	X	%	%	P	P	X
EMPLOYEE RELATIONS										
Production craft apprentice program	P	P	X	X	X	%	X	X	X	X
Scheduled job task training	P*	P*	AR	AR	AR	AR	AR	AR	AR	AR
Individual performance pay	%	X	X	X	X	X	X	X	X	X
Group performance pay	X	%	P	P	P	X	X	X	X	P
Training emphasis	D	D	W	W	W	W/D	D/W W	W	W	W
EMPLOYEE INVOLVEMENT										
Quality circles, Kaizen improvement projects	P	P	%	P	%	P	P	%	%	P
Training for Kaizen & process improvement	X	P	P	P	AR	P	P	AR	AR	P

Key: P = practice widespread; % = practiced to some degree; X = practice not used;
AR = practice used as required; * = as part of apprentice program
D = skill depth emphasized; W= skill width, or scope emphasized (listed in priority order for dual emphasis hybrid design sites)

TABLE 3: Summary of Site Observations

SITE	PRODUCT	COMPLEX.	UTILITY Of VAR.	ORDER WINNERS	TASK DISCRETION
Belleek	Pottery	Low	High	Craft, aesthetic	High
Steuben	Crystal	Low	High	Craft, aesthetic	High
Toyota	Cars	High	Low	Perf, reliability	Low
Hoshizaki	Ice mach.	High	Low	Perf, reliability	Low
Company A	Controls	Med	Low	Perf, reliability	Low
Jaguar	Cars	High	Low	Perf, reliability	Low
	Trim,Seats	Low	High	Craft, aesthetic	High
Martin	Guitars	Low	High	Craft, aesth, perf	High
	Neck	High*	Low	Perf, reliability	Low
Co. B	Ice bins	Low	Low	Price, delivery	High
Co. C	Furniture	Low	Low	Price, delivery, aesthetics	Low
Uvex	Safety glasses	Low	Low	Price, delivery	Low

* Process complexity

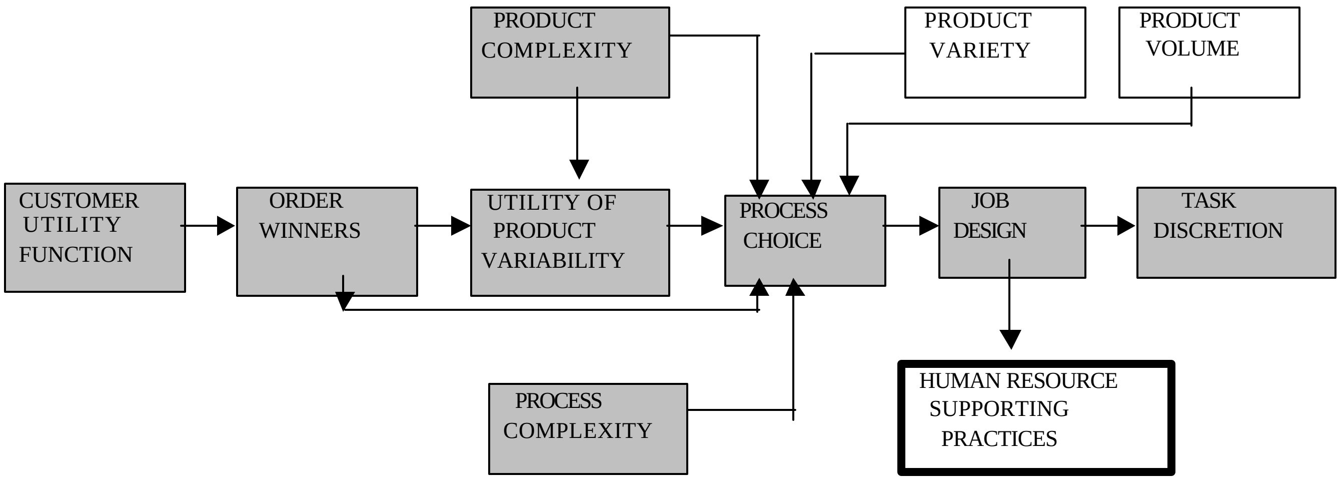

Figure 1

Job Task Discretion Model

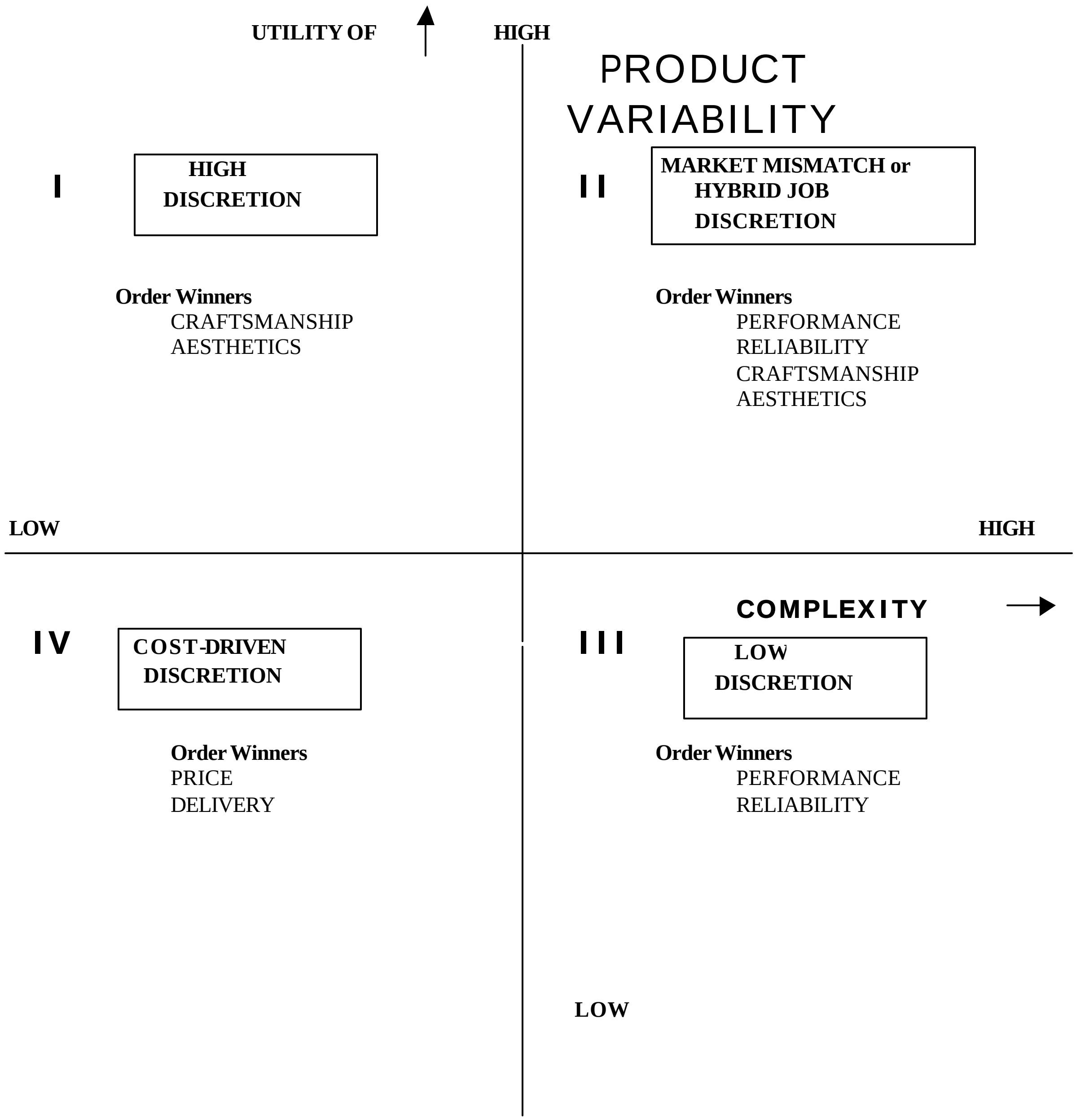

Figure 2
Job Task Discretion Matrix