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Japan's building industry: The new model

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Japan's *big five* general contractors – Kajima, Obayahi, Taisei, Takenaka and Shimizu – have developed efficient production systems for their construction site work. Earlier studies show that this has been achieved by applying a very standardized approach. Yet the Japanese building industry undertakes extensive research and development, the application of which could reasonably be expected to disrupt the efficient construction-site production systems. This paper describes a study undertaken in mid-1991 that began by exploring the relationship between the research institutes and the mainstream project work of the *big five*. This led to a review of established theories about the way that innovation takes place which in turn directed the study towards the interaction between the *big five* and their environments. Two major changes in these environments are currently under way. The first is growing demands by the *big five's* customers for higher standards and more fashionable design. The second is a serious labour shortage in the Japanese building industry. The *big five* have reacted in different ways to these two major environmental changes. This discovery finally led the study into a concern with the models that managers use in understanding their work. The paper suggest that a new model, based on using the human nervous system as a metaphor, is needed in order to understand the behaviour of the *big five*. It is also proposed that such a model will help in designing appropriate organizations for the *big five* as they face and seek to influence the rapid changes now resulting from the ambitions of Japan's increasingly affluent society.

Keywords: Japan, building industry, change, model building, fashionable design, labour shortage.

Introduction

This paper discusses processes of change within a standardized and reliable construction industry. It is based on an ongoing study of the Japanese building industry which the author began in 1985 and has continued intermittently ever since. Most recently the author spent 3 months in mid-1991 as a Visiting Professor at the Research Centre for Advanced Science and Technology (RCAST) at the University of Tokyo. Significant stages in the development of the author's understanding of Japanese building are marked by Bennett, Flanagan and Norman (1987), Hordyk and Bennett (1989) and Bennett (1991). The author's main interest is in construction project management and his studies of Japanese practice have concentrated on the work of the *big five* general contractors since they dominate the thinking of the Japanese building industry. The *big five* are Kajima, Obayashi, Taisei, Takenaka and Shimizu.

The *big five* are amongst the largest construction companies in the world. They each employ around 10 000 professional staff, most of whom are engineers. They provide a comprehensive range of construction services for their customers. They undertake all the design and management activities but subcontract the direct construction work. They carefully build up long-term relationships with customers and subcontractors. They invest in their own future by providing well designed, on-the-job training both for their own and for their subcontractors' staff and by undertaking large programmes of research and development. The overall result is that the *big five* have achieved standards of consistent, reliable quality in many aspects of their work that are unmatched elsewhere in the world.

The author's earlier reports of Japanese building practice contain some gaps and ambiguities. Perhaps the biggest unresolved issue is how the exciting innovations produced by the research institutes of the *big five* general contractors coexist with the consistent, reliable, standardized processes which the author has observed in operation on the 100 or so Japanese building sites that he has visited over the past 7 years. In attempting to understand how the apparent dichotomy between innovation and controlled

efficiency is resolved in practice, the author was led to look beyond project management and consider management at the level of the firm. This extension of the author's field of interest raised questions about practice in Japan. Resolving these questions has caused the author to adopt a new theoretical model in order to understand the behaviour of the *big five* at the level of the firm. That change is echoed in practice since at least some of the *big five* are adopting new organizational forms in order to cope with fundamental changes in the Japanese construction environment. Thus the title of this paper refers both to a new theoretical and a new practical model.

The research methods used throughout the author's 7-year attempt to understand Japanese building industry practice, given that the author neither speaks nor reads Japanese, are rather like those of a detective solving a mystery. First, a number of questions concerning the subject of current interest are framed. These are then discussed with many experienced managers at various levels of responsibility in different divisions of the *big five* companies. In most cases the discussions are conducted directly in English but in a minority of cases an interpreter is necessary. When something new and interesting emerges from these discussions, it is checked with several managers from different backgrounds. If there is broad agreement then the author looks for corroborating physical evidence on construction sites, in research institutes or in some other part of the Japanese building industry. Given some hard evidence, the interesting facts are incorporated in a formal paper and presented to an audience of Japanese building industry people. In exactly this way, the present paper, or rather earlier drafts of it, has been presented to and debated with three separate groups of Japanese construction managers. The comments and criticism raised in those discussions are taken into account in this version of the paper.

Planning and control

The distinctive strength of the Japanese building industry is its ability to plan work on site in exceptional detail and then put the plan into effect, on every project, with remarkable consistency. Construction projects are completed exactly on time by the *big five* with no exceptions. No other nation's big contractors achieve anything like this total reliability. It is also the case that when projects are handed over on the agreed contract completion date, they are completely finished and working properly.

The starting point for this consistency is construction plans that are unusually detailed and leave nothing to chance. The depth of planning that is routinely applied to the *big five*'s building projects has steadily increased over the 7 years that the author has been studying Japanese building practice. In other words, the Japanese approach is not static: it develops over time. The situation today is that, as a matter of course, in the *big five*'s building projects, design is complete in every detail before manufacturing and construction begin. The construction drawings and specifications produced by the *big five* use standardized details and specifications which are familiar to their subcontractors. The overall effect is that buildability, based on standardized methods, which draw on well practised skills, is designed into Japanese buildings by the *big five* during the detail design stage. Beyond this remarkably well ordered approach to detail design, the construction method is established and planned before manufacturing and construction begin. This planning is very detailed and allows for the construction method to be taken into account during manufacturing and preassemble. As a result construction workers find, in many cases, that access to their work places, the distribution of the materials and components they will use and their specific work activities are helped by brackets, lugs, safety provisions and other constuction aids incorporated into the structure of buildings during the off-site manufacturing or preassemble processes. Similarly, by thorough planning, the maximum possible use is made of each crane lift. So for example, as Hordyk and Bennett (1989) report, engineering service components and finishing components are lifted into place with preassembled structural steelwork elements.

The detail design and construction planning is carried out, before work begins on site, by specialists in the *big five*'s head offices or regional offices. In most cases the project manager who will subsequently be responsible for the construction process is involved in these preliminary stages. Consequently, he has a deep understanding of the task he will manage long before work begins on site. It is on site, though, that the project manager comes into his own. He is responsible for putting the detailed plans into effect. He will have a large, well educated and experienced team to help him. As far as humanly possible, nothing is left to chance. However, construction is inherently uncertain and this too is allowed for in the system of control used on Japanese building sites.

Control is achieved by means of a consistent sequence of daily meetings on site. The first meeting brings the whole site workforce together at the start of each day's work. At this meeting the subcontractors' teams, who undertake all the direct construction work, are briefed on the overall day's work by the *big five*'s project managers. They describe the main activities which will take place on site, major deliveries, safety priorities and any other points which need particular attention. Following the overall briefing, the subcontract teams move to their workplaces and hold what is called a toolbox meeting. This takes place around a chalkboard on which is written the tasks which their foreman has agreed that they will

complete in the day. This forms a kind of personal contract, which it is a matter of honour to perform. So the purpose of the toolbox meetings is to ensure that every man on site knows exactly what he is to do during the day and where this fits into the overall plan for the project.

Day-to-day coordination and control is planned at a short (usually about 20 min) coordination meeting which takes place every afternoon. All the subcontractors' foremen and the *big five*'s project management team meet to review progress and plan the next day's work. First, any problems which have arisen during the current day's work are discussed and resolved. Then the next day's work is considered. The starting point for this is the overall programme prepared before work began on site. Discussion is concentrated therefore on such issues as the flow of materials on to and around the site, the removal of rubbish, the use of cranes or the number of men in any one work area. When problems are raised, everyone present focuses absolutely on finding a solution. Possible answers may be suggested by anyone. All suggestions are taken seriously and carefully considered. When a consensus has been reached, the project manager announces the decision, which is then accepted by all. One of the project management team keeps a record on a chalkboard of decisions as they are made. At the start of the meeting, the chalkboard contains the current pattern of work as agreed at the equivalent meeting the previous day. As changes are agreed, the old information is rubbed out and the new written up. The main chalkboard is hung on site at the place where the workforce assembles at the start of each day. This allows everyone to see a short description of the current work plan. The foremen update their own workboards at the end of the day from notes taken at the afternoon coordination meeting and hang them in the relevant workplaces ready for the next day's toolbox meeting.

The inherent uncertainty of construction is recognized by incorporating slack into the construction plans. Work is planned to be undertaken by one subcontractor for each trade or specialism during 5 days a week, in one shift. In addition work is planned in discrete periods of time. So, for example, each two week programme is designed to be independent and to include some slack time. When problems arise, the slack is used to bring the project back on schedule by the end of the two week period. If necessary, men will work late into the night, 7 days a week. When problems are more serious, a second shift will be worked. This may involve introducing a second, or in an extreme case a third, subcontractor. The aim is to keep the project exactly on programme; when this proves impossible, the aim is to return it to the original programme as quickly as possible. The overall aim is to complete the project exactly on the completion date stated in the contract. It would be a matter of extreme dishonour and a great commercial embarrassment to any of the *big five* to complete a building even one day late.

Kaizen

The most important factor in developing and steadily improving the remarkable consistency in performance which characterizes the work of the *big five* is called *Kaizen* which means continual incremental improvements. *Kaizen* matters may be raised at any of the daily meetings on site as an integral part of normal work. Indeed many in the industry dislike the term *Kaizen* since it implies a special activity when they regard it as normal to look for the best way to do work and to solve problems as they arise. However considerable efforts are now being devoted by some companies to encouraging and publicizing *Kaizen* activities. Once a year all the groups within such companies and all their subcontractors are invited to make a formal report on interesting *Kaizen* activities. These begin locally and the best ideas are selected to go forward to branch and then to company-wide presentation meetings. Finally a large number of the reports are collected into a book, a copy of which is distributed to everyone in the company to ensure that good ideas are not wasted. The *Kaizen* book describing improvements on building projects produced by one of the *big five* general contractors for 1990 contains just over 500 pages each closely packed with information about good practical innovations. There are similar books for civil and heavy engineering. The formal *Kaizen* presentation meetings and the publications are intended to emphasize the importance of looking for improvements, to publicize good ideas and to help subcontractors improve their *Kaizen* procedures.

The author observed a *Kaizen* meeting in a branch office of one of the *big five* general contractors in which groups drawn from 10 different subcontractors made presentations. The presentations were each supported by a formal written report. The reports were made into a book of 76 pages. Each presentation described an interesting idea which had arisen out of a work-related problem. Typically a group of five or six men within a subcontractor's site-based team, faced with a problem, had decided to form a *Kaizen* group. The group would meet between 5 and 12 times over 2 to 5 months to find a solution. They began by carefully defining their problem, next they set targets for the improvements that they wished to achieve, and then they searched for possible answers using formal methods of process analysis, brainstorming, cost and time estimating, and technological innovation. One answer would be selected and applied. Any unforeseen difficulties would be tackled by further meetings of the group and the overall results recorded. Impressive savings in time, cost and site labour

were achieved by many of the groups. In several cases these were accompanied by significant improvements to safety and quality.

Kaizen activities take place in all firms as a normal part of everyday work. However, the support and publicity given to them varies from company to company. The *Kaizen* group play a role that is similar to that ascribed to quality circles in much of the literature on Japanese management. However, *Kaizen* groups are thought by many people in the industry to be more practical than formal quality circles since they are an *ad hoc* response to the real problems which arise during the course of projects.

Whether the process is called quality circles or *Kaizen*, the search for incremental improvements needs to be applied steadily and consistently so that quality and productivity continue to improve. To ensure that incremental improvement is sustained, the well-thought-out ideas that emerge from practice are embodied in company-wide standards. Standards control the details of what is built and the day-to-day working methods of operatives and managers. The standards are unusually well developed. In addition to the consistent patterns of daily meetings on construction sites, they include widely used standard specifications of materials and workmanship; widely used standard construction details; and well-developed check-lists for testing the quality of work. All of this is reinforced by long-term relationships between companies, that is, building owners, construction companies and subcontractors. Therefore, in a sense, human interactions become standardized or at least unusually predictable. The apparent dichotomy which provoked this paper is that alongside the wonderfully consistent, standardized and predictable approach of the *big five* are research institutes producing results which on the face of it ought to produce a series of major changes which would disrupt the well-ordered production system.

Research institutes

As mentioned in the introduction to this paper, the *big five* all have research institutes that are involved in leading-edge research. Currently highly publicized examples of research institutes work include: 1 km-high buildings, space under the ocean, underground space, construction in outer space, new materials, application of biotechnology, high-technology clean rooms and completely automated site-based construction systems. It might be expected that the application of such research would disrupt the smooth, orderly process of steady incremental improvement.

The earlier studies describe how the research institutes undertake planned programmes of research for their companies. A further important responsibility of the research institutes is to help solve problems that occur on the company's projects anywhere in the world. The earlier studies also found that staff in the research institutes are encouraged to spend up to 30% of their time in pursuing their own research ideas. The result is a rich mixture of fundamental and applied research and development work. A proportion of this work is done in collaboration with the research institutes of other construction companies or of companies from other industries.

The implicit assumption in the author's earlier published work on this subject is that the research institutes provide a vehicle for individuals with big new ideas to undertake long-term research remote from the established production system. In other words, the research institutes provide a proper outlet for the creative, original thinkers who emerge within the company. Natural researchers are not left in frustration to fiddle with the company's mainstream production system as occurs all too often in Western building industries. It was assumed in the earlier studies that the research institutes enabled big changes to be introduced to the site-based production system in a controlled and orderly manner.

The RCAST research confirmed that the consistent and reliable performance which charaterizes Japanese building does coexist with leading-edge research. However, the RCAST work showed that the research institutes do not play the central role in change which was implicitly assumed in earlier studies. The research institutes are given a very particular role by the *big five*.

The work undertaken by the research institutes of the *big five* is formally decided by senior management but their decisions may be influenced by people at any level and within any division of the company. In each company, research and development priorities are determined annually by a conference of senior managers. Everyone in the company is invited to propose ideas for research. Within this process, researchers in the research institutes can put forward ideas for research which they wish to pursue. Managers throughout the company sift through the ideas proposed by their own staff and the best are put forward to the conference. The ideas are further sifted and prepared for the conference by an administrative department in the research institute. A majority of the work authorized by the conference nowadays is essentially development work and a significant proportion is designed to attract the attention of the media. Most of the ideas which are supported by the conference come from the line divisions. Also a significant proportion of the actual development work is undertaken in the line divisions aided by experts in relevant subjects drawn from the research institutes.

As a consequence of this approach, the research institutes undertake a mixture of academic research,

development work in collaboration with the line divisions, and public relations work. The academic work serves to maintain a pool of experts within the company. An expert may be needed at any time to help with a problem which has arisen on a project or to contribute to some major new development. It takes time to develop effective and experienced researchers. Therefore companies recruit graduates who want to undertake research and to some extent allow them to pursue their own interests. Researchers can decide for themselves what research they do, but such work, if it is of any magnitude, has to be approved by the annual conference of senior managers. In practice this tends to restrict research to issues which apear to have some fairly obvious benefits in the not-too-distant future. Nevertheless the style of work in the research institutes allows researchers to write papers for academic journals, attend international conferences and undertake all normal academic activities. In this way some researchers develop major reputations in their own subjects and so, in practice, establish the *de facto* right to pursue their own interests.

Major developments, such as the automated building construction systems which are currently the focus of major development work by the *big five*, are directed not by the research institutes but by line managers. Researchers are seen by the line managers as insufficiently aware of the current realities of everyday practice. It is accepted that they develop good ideas but generally it is thought that they do not know how to develop them into techniques which can be applied in practice. In other words, researchers are seen as being academic rather than practical. Certainly in discussions with staff in the research institutes, the commercial potential of their work appeared to be given a low priority.

In an attempt to ensure that research has practical relevance, some companies have established a technological development division to coordinate the work of the research institutes with that of the line divisions. The technology development divisions' main responsibilities are to coordinate development and to initiate technology transfer. Their mission is to help site people to solve problems using the knowledge of the research institutes and other expert advice. The technical development divisions are organizationally half-way between site managers and the research institutes. Essentially they provide project co-ordinators who are committed to finding answers to practical problems which have arisen during the course of projects. Their work is organized into what are called development projects. A typical development project is based on a problem which has arisen on a number of projects. Thus there is a demand for help and so it is easier to get research ideas accepted. Most are initiated by line people near the bottom of the organization – that is, by 35–40 year-old site engineers or designers. They have seen a problem in their current project and thought of a way of solving it. Once an idea is accepted as being potentially useful, the technology development division help to find the people and ideas needed to develop it. This may involve people from universities as well as the research institutes. The view of senior managers interviewed on this subject in two of the *big five* companies is that, typically, 40% of development work is done by the managers and 60% by researchers who have relevant knowledge.

One consistent feature of the development projects observed was that they all involved ingenious uses of traditional forms of construction. It appears to be accepted that there is little point devoting effort to developments which involve new materials or require skills beyond those already available within the industry. This is because it is believed that the introduction of radical new ideas, at least in the present conditions of high demand, would be resisted by subcontractors.

The third category of research institutes' work can most accurately be described as public relations. In some cases, the institutes' buildings and grounds are kept in pristine condition to impress customers. The public relations work also includes producing very professional video films and glossy publications describing interesting ideas. In some cases, there is little serious research to support the statements made in such public relations materials. Normal academic standards of rigorous criticism are not applied. The driving force behind such work appears to be competition between the *big five* general contractors. It was explained to the author that directors of the *big five* general contractors do not like reports in newspapers or on television that one of their competitors has developed a new idea on which they are not already working. This kind of competition drives everyone in the company to search for new ideas and also to make sure that they know what the other *big five* companies are doing. As a result, the companies copy each other's research topics and on occasions make public statements on the basis of little or no real research.

So, overall, the research institutes have developed a sophisticated mixture of work. They have a major role in the development of new ideas but it tends to be a supporting one rather than the central one implied by the earlier studies. Major developments have many roots within the *big five* companies – the line divisions are probably the principal source. The annual conference of senior managers undoubtedly draws on ideas from many sources both inside and outside the company in deciding on the priority subjects. Thus it is probable that a major new development requires support from many sources over several years before it is given wholehearted support in the form of a large budget allocation. It is also probable that in many ways the day-to-day work of the research institute exerts an influence on these processes.

However the central role given to line managers,

schooled in *Kaizen*, in determining overall policy suggests the possibility that changes which would alter the established site-based production systems may be resisted. Clark and Staunton (1989) throw relevant light on this issue in making a distinction between entrenching innovations and altering innovations.

Innovation

Clark and Staunton provide a broad overview of theories about change in organizations. In doing so they build up a rich picture of innovation and the way it is introduced into organizations. They define an innovation as the application of new knowledge. In their view organizations use knowledge which is embodied in equipment, raw materials, their built environment and the organization's operating procedures. Operating procedures are derived from generalizations about past experience. They are taken for granted and are almost tacit in the way they activate networks of interlocking behaviours. Organizations' operating procedures make up what Clark and Staunton call structural repertoires, that is collections of actions, each of which suits a particular situation. An organization's structural repertoire typically includes basic operating cycles to control their core technology; strategic innovation cycles, which, as well as introducing new ideas, may require existing practices to be abandoned; and special routines to deal with crises and new opportunities. Organizations also need operating procedures for solving the puzzles or problems which they identify in undertaking their work and dealing with their environment.

In order to understand innovation, it is necessary to study the linkages among the elements that make up the organizations – Clark and Staunton recognize that these linkages are usually complex. They may comprise market relationships, clan relationships of trust and honour, and hierarchical, bureaucratic relationships centred on a focal unit imposing detailed rules. The linkages may therefore extend beyond the boundaries of a single legal entity and bring customers and suppliers into the organization who must be considered.

If follows that Clark and Staunton see the organizations which are relevant to understanding innovation as networks. The emphasis on networks rightly concentrates attention on the formation of the knowledge and expertise which flows through the organization. It directs attention to clan relationships based on trust and the building of lasting, stable relationships between firms committed to reciprocal exchanges of knowledge and resources. The modern model of networks focuses more on interactions rather than on the actors. This is because any given interaction will include only part of the time and attention of the actors involved. Thus consistent sequences of interacting actions are of primary interest. It is these sequences, that Clark and Staunton call operating procedures, which make up the structural repertoires. They see structural as a key part of an overall model which links events to actions. In their model, the work consists of streams of events which influence the cognitive inputs to organizations and give rise to puzzles or problems. In diagnosing answers, managers make choices from their structural repertoires which trigger networks of interlocking behaviours.

It follows that change in organizations results from decisions by managers who need continually to analyse their situation and diagnose from a repertoire of operating procedures, some of which will include a decision to innovate. An innovation is adopted when a manager perceives that it has some of the following characteristics: it provides a balance of advantages; it is compatible with the values and experience of the organization; it is not too complex to understand: it can be tried out on a limited scale; and the effects of the innovation are capable of being communicated to all those likely to be affected. Clark and Staunton see the process of innovating as consisting of at least the following stages: awareness, interest, evaluation, trial and adoption. They also recognize that the likelihood of an innovation being adopted depends on the availability of information about it, the cost of adopting it, likely profits and the potential for economies of scale and economies of scope.

Innovations may consist of blendings of new equipment and new raw materials with new forms of organization within new forms of built environment and thus involve changes to all the elements of embodied knowledge and to the linkages between them. In successful organizations there is an overall coherence in the elements and linkages and therefore following the introduction of an innovation, the elements and linkages evolve until a new overall coherence is achieved. The need to achieve a new coherence often provides the greatest difficulties in innovating and causes organizations to tend to resist change. The degree of difficulty and therefore the level of costs involved depends on the nature of the interaction between the innovation and the organization. In recognizing these interactions, Clark and Staunton draw a sharp distinction between entrenching innovations and altering innovations.

An entrenching innovation is one which makes an organization more effective in some aspect of its work but leaves it in essentially the same shape. It builds on existing methods so that equipment is modified and knowledge is extended and reinforced. It is concerned with improving efficiency and the network of actions it requires is given clear expression in the earlier description of *Kaizen*.

On the other hand, an altering innovation is likely to

reshape an entire organization, requiring markedly different equipment, raw materials, forms of knowledge and physical contexts. Existing competences become redundant and it seems likely that altering innovations will be resisted by Japanese construction managers since they have invested much time and effort in learning and improving the established ways of working.

Clark and Staunton take the view that organizations have to make choices between entrenching innovation which leads to greater efficiency and altering innovation. These choices are given expression in an organization's design decisions. Design is involved in products, services, production processes, channels of distribution, supply chains and the image of an organization. Design links customer wants, expressed in buying behaviour, to the immediate suppliers of goods. Influential designers can encourage or require suppliers to use new materials, new equipment and new methods. In these ways, designers have the power to exercise strategic management of innovation. Seen in this way, design is a crucial strategic activity which aims to internalize customer requirements and interests either by applying entrenching innovations to existing designs to achieve efficiency or by adopting new designs which require altering innovations.

Clark and Staunton suggest that entrenching innovations are suitable for organizations which give a high priority to efficiency and operate within stable markets. Altering innovations, on the other hand, are suitable for organizations which actively seek to exploit new ideas in response to rapidly changing markets. They open the way for new organizations.

Whilst there is a clear coincidence between the concept of entrenching innovations and the application of *Kaizen* in Japanese building, the earlier studies provide no evidence that the *big five* are equally adept at introducing altering innovations. It happens that Japan's building industry is at present facing two examples of the kind of changes to its environment which Clark and Staunton suggest require organizations to adopt altering innovations.

Fashionable design

The first of the two major environmental changes is that customers are now putting much greater emphasis on individual design. Bennett, Flanagan and Norman (1987) described Japanese buildings as solid and middle-class in that they were designed to fit in with their neighbours. The Japanese frequently describe the importance of conforming by quoting a well-known Japanese proverb: 'The proud nail is hammered flat.' Now individual design and arbitrary fashion are taken much more seriously in Japanese society generally, including amongst the ranks of the building industry's customers. Buildings are starting to appear in Tokyo that are clearly designed to be noticed. As Hisatomi (1990) reports, 'It is now fashionable to employ Western architects.' As well as demanding distinctive designs, the steadily growing wealth of Japan has enabled building customers to demand greater comfort and higher levels of control over their internal environments. These new demands have brought a number of new technologies, most significantly information technology including sophisticated electronic control systems, into the mainstream of Japanese building work. As a result of all these new demands, Japanese building projects, especially in the early design stages, are nowadays much more likely to be significantly different from each other.

The demands for fashionable design and greater comfort and control has placed more emphasis on the design stages of projects. It is now normal for a committee drawn from many parts of a *big five* company to be established at the start of major and unusual projects. Its tasks are to anticipate problems at the earliest possible stage, to ensure that people with relevant knowledge and experience are brought into the project committee, and then to find answers, so that problems do not arise on site. Unusual construction are thought about very carefully. Site staff with relevant experience are appointed early. The company's research institute may be asked to provide specialist advice. The company's in-house experts on information technology may be brought into the project committee. Feedback reports from previous similar projects are consulted.

An important aid to identifying problems is provided by formal design review meetings at key points in the overall project process. For example, when projects are handed from sales and marketing to the designers, the customer's brief is checked to determine what the customer really wants as opposed to what the salesman may have needlessly introduced. Also, when projects move from conceptual design to detail design, a review serves to ensure that *the face and feel of the building* as designed are properly reflected in the construction details. Also when projects are handed from designers to site managers, a review can help to ensure the buildability, time and cost.

The overall effect of all this preparatory work is that by the time projects reach the construction site they fit into the consistent, well-established pattern of the industry's work. In other words, the early demands for individual design have been handled by means of entrenching innovations as far as construction on site is concerned. However, there are also signs of a more fundamental change in response to customers' new demands.

Major organizational changes have taken place in recent years in the head offices of all the *big five* contractors. In some this has taken the form of creating

sales and marketing divisions, others have created technological development divisions, while yet others have formed separate and distinct design divisions. Also all of the *big five* companies have in one form or another created divisions to provide expertise and knowledge of current developments in the important field of information technology. In each of these different organizational changes, the aim is to foster specialized bodies of knowledge and skills and to encourage the development of the distinct culture associated with a particular specialism.

The emergence of separate sales and marketing divisions is especially interesting. They include staff responsible for handling relationships with major, long-established customers together with the sales and marketing staff responsible for finding or creating new projects. An example of the nature of this change and its effects is provided by the reorganization within one of the *big five*. It brought together staff from civil engineering and building divisions. This served to provide better links between these two distinct disciplines on, for example, major urban renewal projects. These projects are very complicated to set up. For examples they often have unusual clients which may involve both the public and private sectors (called Japan third-sector projects). They may also involve many small owners whose interests have to be coordinated. Previously the *big five* general contractors' response to such projects tended to add to the complexity by being divided between their civil engineering and building divisions. The sales and marketing divisions now provide a single coordinated approach to major urban renewal projects. They negotiate with local authorities over land-use changes, act as mediators between owners and local government and generally act as facilitators for new developments. In this and other ways the creation of integrated sales and marketing divisions has already led to new ways of creating projects. It is probable that the potential for these projects had existed for several years but the reorganization which created new relationships appears to have been needed to provide an effective response.

The sales and marketing divisions will inevitably become important feedback channels. They will be in touch with customers on a day-to-day basis and so provide an important source of new ideas about the function of the industry's products. Small developments in the work of several separate customers, perhaps from different sectors of the building market, may provide early signs of a major change of direction. It is interesting to speculate on whether a larger and more tightly co-ordinated marketing effort is likely to alter the direction of change in Japanese building. Will change in the future be driven by market opportunities rather than by technological development? How will this change of emphasis be received by the traditional, engineering-based line managers and subcontractors? Similar questions arise in respect of the separate and distinct design divisions formed by some of the *big five* companies.

Perhaps one sign of the answer is that some at least of the press announcements of exciting new constructions are based on very preliminary ideas. They are not backed up by fully developed and practical technologies. Some of the ideas for super high-rise buildings and construction in space or under the oceans are of this superficial nature. They are exciting and creative but the announcements are much more of a marketing activity than the serious and carefully developed engineering on which the big general contractors have previously built their reputations. So it is not unreasonable to conclude that external changes have caused the *big five* not only to adopt altering innovations in the organization of their head office activities but, at least to some extent, to alter their basic value systems. However, to date, their site-based construction activities have been insulated from such major changes.

Labour shortages

The second major environmental change has had a direct effect on the *big five*'s construction sites. At the time of the RCAST research, the Japanese building industry was facing a serious shortage of labour. Also the industry was in a period of high demand and, as a result, the difficult labour situation has become a major problem. The fundamental cause is that young people are reluctant to enter the building industry and so the workforce is getting older. The average age of the workforce has risen to a point where the inevitable slowing down of older people is having an adverse effect on productivity. To try to attract good young people into the industry, wages have been raised. This on balance is thought to have made the problem worse. The higher wages mean that the industry's existing workforce does not need to work the long hours of overtime which used to be normal in order to get an acceptable income. So productivity per day has been further reduced.

Current actions aimed at solving the problem appear to be concentrated on improving the industry's image. The three Ks (Kitanai, Kiken and Kitsui) which literally translates into dirty, dangerous and heavy work but which are often expressed in English as the three Ds – that is, dirty, dangerous and dull. In either form, this characterization of construction provides an unattractive picture for bright young people making career decisions. Therefore the *big five* are putting considerable effort into providing very attractive site offices, keeping sites clean and tidy, building luxurious residential accommodation with good sports, study and recreatio-

nal facilities for new recruits, and making high profile, but relatively superficial, use of high technology. None of this is likely to solve the biggest problem currently facing Japan's building industry.

Labour shortages are getting worse and will continue to get worse. A few people within the Japanese building industry think that the solution may be to allow foreign workers into the country. However, it seems difficult for Japanese people to contemplate the 5% of foreigners in the country which would be needed to make any real difference to the labour situation. At present the figure is less than 1%. Also in Japan there are powerful political objections to immigration.

In the past, subcontractors have usually had enough labour to undertake site work. Consequently general contractors have placed particular emphasis on maintaining their relationships with their traditional subcontractors. Nevertheless, over the past 5 years there has been a reduction in the work undertaken by traditional subcontractors of the order of 10% of the total work involved in a typical building project. There has also been a compensating increase in the proportion of the work undertaken by industrialized subcontractors.

These changes are likely to continue as building becomes more industrialized. They potentially represent a major change in the structure of the Japanese building industry. Whilst traditional subcontractors are willing to play a subordinate role in the industry, many of the industrial subcontractors are major international companies as big, if not bigger, than the *big five* companies. They are likely in time to want to dictate the pace and nature of change in the industry. As their products become more sophisticated and need larger capital investments, so they will seek to secure reliable markets. This potential pressure will in the future act as a spur to the *big five* general contractors to increase the pace of change. At least this has been the experience in the UK where the industralization of buildings has already gone further than in Japan and has produced a move away from general contracting towards approaches which provide independent construction management.

Thinking in Japan about the changing nature of the industry's subcontractors appears to be restricted and muddled. In part this is because the industry's work is divided by the perceived spheres of influence of two separate government departments. These are the Ministry of Construction, which governs the general contractors and the traditional subcontractors, and the Ministry of International Trade and Industry, which governs the industrial subcontractors. The allegiance of the industrial subcontractors to MITI causes many in the traditional industry to disregard these major companies in their thinking because they are perceived as being outside of the industry. It will prove increasingly difficult to sustain this attitude because the industrial subcontractors will inevitably play a major part in shaping Japan's building industry as it moves towards the 21st century.

However, at present long-term relationships with subcontractors appear to inhibit change. There is a reluctance to use technology which will take work away from an established subcontractor. In other words long-term harmony is seen as more important than short-term efficiency.

Viewed from the outside, the obvious answer to the Japanese building industry's labour shortage is to use prefabrication and robots. No other country is better equipped to create such a high-technology building industry. Japan has a high and relatively stable level of demand, excellent manufacturing ability and unrivalled knowledge of the use of robots. Yet the change is being resisted because it would disturb long-term relationships with subcontractors. Furthermore, it is seen as involving an increase in risk through the adoption of more capital-intensive methods. In any case, the labour problem is seen by many people as temporary and is fairly widely expected to disappear with the next downturn in demand.

This situation tends to confirm a hypothesis suggested by Lawrence (1981) about managers' perception of their environments. It suggests that managers tend to see their environments as more similar than in fact they are. Managers faced with simple, stable environments tend to develop over-complex models of the world with which they have to deal and to see their environments as moderately complex and uncertain. Managers faced with rapidly changing, unpredictable and very diverse environments tend to simplify and so they also see their environments as moderately complex and uncertain.

Certainly there are large cultural differences in these behaviours but in general it seems that managers in the Japanese building industry see problems in circumstances where Western managers would see a wonderfully stable and predictable situation ideal for rapid and confident innovation. This may be because the Japanese managers are comparing their own situation with that of the major Japanese manufacturing companies. Therefore they perceive problems where in fact opportunities exist. It may be important to its own long-term health for the Japanese building industry to recognize that it has an unrivalled opportunity to shape the building industry of the 21st century and that is it moving very slowly to realize the potential of its unique strengths.

Certainly there are some wonderful ideas for the use of prefabrication and automation in the industry's publicity material on the automated building construction systems. However these ideas still have a long way to go before they are fully developed, practical technologies. Japan's building industry has a world lead in terms of quality and reliability but given its distinct advantages, development could be and, arguably, should be faster. Indeed time may now be short for the industry to

undertake these developments since its overall performance is already deteriorating.

Performance of the Japanese building industry

The most dramatic fact that had to be taken into account during the RCAST study is that building costs in Japan are rising rapidly. Part of the increase in costs is due to the production of more sophisticated buildings. Modern buildings are intelligent, they provide more control for users and better comfort conditions and as noted above they are increasingly expected to provide flair and excitement. It is believed by senior managers in the *big five* that a 20–25% increase in costs has resulted from improved standards. However these developments do not explain the whole of the increases in costs. The other major factor is the industry's labour problem described earlier in this paper. It is believed that there has been a 15–20% increase due to higher wages and reducing productivity. Although the last few years has been a period of boom conditions for building, productivity per man-day in the traditional site-based crafts is falling. This in turn is leading to work being moved from site into factories. As an example, steelwork rather than reinforced concrete frames is used because more work is carried out in factories. Thus the demand for site labour is reduced. This is a general trend which has been under way for about 5 years and is reflected in the increasing proportion of work subcontracted on a labour and materials basis (from 55% to 65% of the direct cost of construction) and also in the decreasing cost of materials bought for direct use on site (from 15% to 10%). Both of these sets of figures describing changes in the build up of construction costs were provided to the author by senior managers from the *big five* companies. If the productivity of site labour had kept pace with increases in wages, as happens in efficient industries, then its cost would have fallen in line with the reduction in the cost of materials used on site. In fact the proportion of total costs attributable to labour has hardly changed.

Given that over this period, according to the *Building Construction Cost Index* published monthly by the Ministry of Construction, building costs have increased about 4% per annum faster than the general rate of inflation in Japan, the changed pattern of building costs suggests a serious escalation in the costs of site based labour relative to factory based labour. On the basis of simple arithmetric, the deterioration in the relative efficiency of traditional site labour appears to be of the order of 30% over about 5 years. This should serve to accelerate the introduction of automated site construction. That would however represent a very significant altering innovation for the *big five*'s construction sites. At present, as described earlier in this paper, there appears to be great reluctance to introduce this fundamental change to the industry's technology. The main reason for avoiding the steps that appear to be necessary to overcome the serious labour shortage seems to be a concern within the *big five* to preserve the long-established relationships with their subcontractors.

Theoretical analysis

To this point we have relied on Clark and Staunton's (1989) categories of entrenching and altering innovations to draw a distinction between steady incremental improvements, which take place throughout the *big five*'s organizations, and major changes, that are needed to respond to environmental pressures. The major changes have been accepted with regard to the organization of head-office relationships with customers but resisted where they would fundamentally alter the *big five*'s site-based operating core.

The author's attempts to understand these events was helped by the extensive literature about stability and change in organizations. It is much concerned with interactions between organizations and their environments and with the patterns of differentiation and integration which emerge within organizations in response to environmental changes. There is wide acceptance of the significance of environments in shaping organizations. However, two distinct approaches exist. One, largely grounded in sociology, views environments in terms of the information perceived by members of organizations. The other, largely based on economics, sees environments in terms of the resources they provide.

March and Simon (1958) provided an early attempt to bridge this division with their exploration of bounded rationality. Thompson (1967) went further in developing the concept of 'norms of rationality'. Lawrence and Lorsch (1967) provided, in the concepts of differentiation and integration, a clear framework for understanding the impact of environments on organizations. Lawrence and Dyer (1983) provide a tight conceptual framework which embodies this set of concepts. Their framework sees environments as producing various levels of information complexity and resource scarcity. By taking three levels – high, intermediate and low – for both of these variables, Lawrence and Dyer form a matrix which provides nine distinct environmental states each of which tends to support distinct types of organization. Figure 1 illustrates their scheme.

In developing their theory, Lawrence and Dyer studied the house building industry in the USA and found that traditionally it occupies the difficult area 3 in Fig. 1. In this area, construction faces high uncertainty

due to information complexity and scarcity of resources. This is an environmental state close to perfect competition which tends to produce small firms earning low profits. Resource scarcity is caused by the dispersed, site-based nature of construction, cyclical fluctuations in demand and intense competition amongst large numbers of small firms. The scarcity of resources in turn prevents firms from investing in the research and development needed to understand their complex environments. They are therefore driven to arbitrary strategic decision-making. Adoption comes from natural selection, not from any internal learning processes.

The result is that the construction industry tends to consist of many separate, simple organizations typically run in a centralized way by a manager who is often a partial owner. These simple organizations are usually functionally based with the manager co-ordinating the work of one layer of subordinate managers. There are few specialists and few integrating mechanisms. Such firms can respond quickly to environmental change but only within a very limited repertoire of potential responses. If the environmental change requires a response outside the range of actions known to the manager, it is likely that the organization will fail.

Lawrence and Dyer describe the way that successful house building firms have overcome their difficult environmental conditions by using subcontracting to create quasi-firms. This enables small firms to behave as if they are big by concentrating the central intelligence activities of marketing, planning and development within a general contracting firm and subcontracting all the direct work. The quasi-firm provides a scale of activities which allows specialized units and appropriate integration to be employed. Such firms can also afford to employ some buffer resources and give them time to learn new approaches which can be applied as the state of the environment dictates. In these ways, the creation of quasi-firms has enabled construction firms to manage the impact of their environments sufficiently to move towards area 5 of Fig. 1. Organizations in such environments face moderate levels of information complexity and resource scarcity.

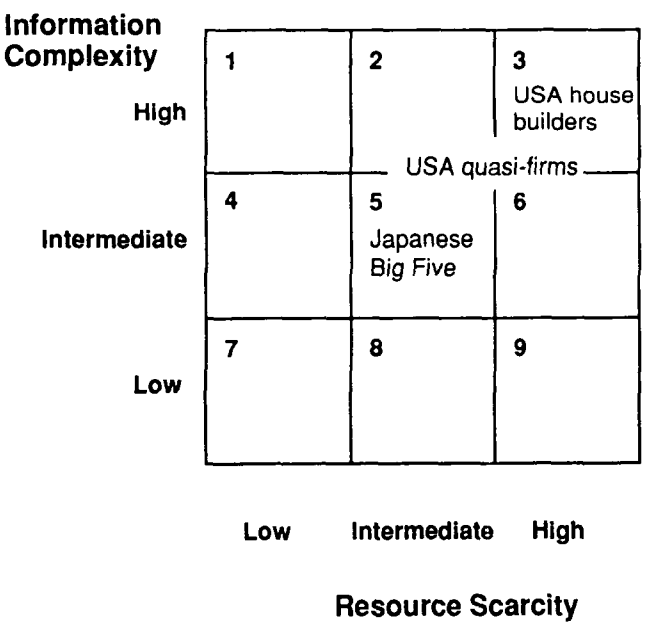

Figure 1 General relationship between information complexity, resource scarcity and construction organizations

Lawrence and Dyer's research into the performance of a number of American industries caused them to conclude that area 5 is most likely to encourage the emergence of organizations which achieve a balance between efficiency, innovation and the involvement of their members. This balance breeds organizations that enjoy long-term success. Such organizations are sufficiently differentiated to deal with their environmental complexity and they use sufficient integrating devices, including clan, market and bureaucratic methods, to enable their differentiated units to work together. They also distribute power sufficiently to ensure the commitment of all their members.

Given these views, Lawrence and Dyer see the emergence of the quasi-firm in construction as important in providing appropriate differentiation without losing integration. This form of organization has a better chance to innovate and be efficient than do stand-alone firms, given the nature of construction's technology. This is confirmed by Lawrence and Dyer's finding, contrary to much conventional wisdom, that the American house-building industry has a good record in terms of efficiency. This efficiency is masked because quality, in terms of functional performance, has improved year after year while construction costs in real terms, have remained steady. Also the industry has a good record in terms of innovation with an increase in its use of industrialized components. Furthermore procedures have become standardized, much construction now takes place off-site and many parts of the actual construction process have been mechanized.

The concept of the quasi-firm appears to be especially relevant in attempting to understand the activities of Japan's *big five*. They have many of the characteristics of the general contractors that Lawrence and Dyer identified as the central hub of successful quasi-firms. As a hybrid between the pure market form and the pure hierarchical form of organization, the quasi-firm serves to counter the complexities and uncertainties of the construction environments. Predictability and mutual support grow out of the long-term relationships between general contractors and their regular subcontractors. They are bonded together by a rich mix of

integrating devices. In a formal sense, their relationships are market-based contracts but the ongoing relationship has clan characteristics of obligation and friendship that go beyond merely legal requirements. There are also bureaucratic features in the relationships arising from the need to keep track of time, materials, equipment and labour. Lawrence and Dyer found that efficient general contractors tend to negotiate contracts for new projects with subcontractors they have worked with previously. Competitive bids are used occasionally only to test current market prices.

Quasi-firms encourage innovation. When a project requires a new technique, the general contractor merely seeks out a subcontractor with the necessary knowledge and skills. However, innovation in construction tends to be much more concerned with finance and marketing than with technology – that is, innovations in general contractors' relationships with their customers are used to insulate their operating cores from altering innovation. These observations based on practice in the American house building industry are closely mirrored in Japan as described earlier in this paper. It seems likely therefore, as Fig. 1 suggests, that the *big five* have established themselves firmly in a moderately demanding environment.

The similarities between the *big five* and the ideal quasi-firm goes further since Lawrence and Dyer found that the distinctive characteristics of quasi-firms are deepened as firms get bigger. Large firms tend to subcontract all the direct construction work, as do the *big five*, while small- and medium-sized ones subcontract about 50% and 70% respectively. Large firms are more conservative about technology, innovating only where there are clear and large reductions in cost of substantial improvements in quality. Many of the large firms' regular subcontractors work for only one general contractor. In effect, large firms provide a franchised system of production, supplying management and marketing services. This is characteristic of all the site-bound technology industries studied by Lawrence and Dyer.

We can theorize therefore that construction environments provide the resources and information that contractors need in order to survive and grow. Resource scarcity forces organizations to concentrate on achieving efficiency by means of entrenching innovations whilst increased information complexity tends to require altering innovations. However, extreme resource scarcity combined with uncertainty about customers, competitors, technological developments and other relevant areas of information are the market conditions faced by general contractors engaging in pure competition. In these circumstances, contractors struggle to survive.

To develop and grow in the medium-term, contractors must be efficient and must innovate. These two objectives tend to obstruct each other. Efficiency tends to be short-term and requires effective control, while innovation needs long-term investment and depends on creativity. Lawrence and Dyer found that success is most likely when resource scarcity and information complexity are both intermediate between high and low. This allows and encourages managers to strive for efficiency and innovation. For these strivings to be effective, the environmental influences must be disseminated to all parts of the organization. Thus, an organization's entire membership should be cognizant of its broad purpose, ethical standards and operating principles. Beyond this, efficiency and innovation are both encouraged when power is spread evenly.

These environmental conditions and cooperative characteristics have been observed in all the earlier studies of the *big five*'s methods and style of working. It is therefore significant that Lawrence and Dyer conclude that the way an organization positions itself in relation to its environment and the way it chooses to respond to the resulting environmental forces are determined inside the organization. In other words, efficiency and innovation begin with the internal organization and its perception of the relevant environments. Obviously success depends on there being a close fit between actual and envisaged environments. Nevertheless the choice of mental models used in thinking about the *big five* is important in understanding how these remarkable companies will develop in the future.

A new model

In each of the *big five* general contractors, the system within which new ideas form and are developed includes the whole company. Indeed it ranges beyond the legal boundaries of the companies and includes customers, consultants, manufacturers, subcontractors and university professors. In the terms used earlier in this paper, the *big five* are quasi-firms based on networks of long-term relationships between separate companies. However, the form of that system is becoming significantly different in each of the *big five* general contractors. Nevertheless there are some common features in the management processes now being adopted by the *big five* general contractors. The consistent picture which has emerged is of a deliberate strengthening of separate and distinct cultures within each of the companies. The specific emphases vary from company to company: some have focused on design, some on sales and marketing, some on technical development and some give a distinct emphasis to research. A second consistent element is a reliance on almost free-ranging links being formed between people throughout each company.

The *big five* are making good use of information technology to support these links. An interesting example of a good use of information technology is a system used on a company-wide network of personal computers. At present the network has about 1000 terminals attached to it. Anyone in the company whose budget can provide the necessary personal computer can apply for a password and join the network. The system allows staff who have access to the network to ask for information about, for example, some aspect of the work of a particular subcontractor or the use of a new product or material. The request for help may be responded to by anyone linked to the network who has the required information. This in effect allows any individual to search rapidly through the whole of the company's memory and to form a link with anyone who has relevant information or experience. Links which are found to serve important tasks facing the company are reinforced by repeated use and over time they become strong. The creation of these personal networks, built up over many years, is very reminiscent of the way the human brain itself functions.

The cortex, the highest level of the brain, can usefully be thought of as consisting of millions of neurons which are elaborately interconnected. Neurons, like individual humans, can store and process information. The brain appears to work by looking for patterns in this information. As information enters the brain, it is searched for patterns. Patterns which recur form reinforced connections between the neurons that identify them. Thus the pattern is remembered. If a pattern keeps recurring, it becomes deeply embedded in our memory. If a pattern fails to recur, if will fade away and be forgotten by the conscious memory. Thus the rich set of patterns and potential patterns in any one brain are shaped by the experiences of the individual who owns the brain.

There are obvious links with the way the Japanese *big five* general contractors are organized. This suggests that we might well use the human nervous system as a model for understanding how the Japanese building industry behaves. The background to this idea is described in Beer (1972) and Bennett (1991).

As a start, it seems accurate to regard the big general contractors as the brain of their parts of the industry. First, they provide the overall sense of direction for the industry. They establish long-term goals and set the tone for the industry's work, in, for example, choosing to concentrate on quality, reliability, productivity or speed. Second, the general contractors appear to be structured rather like the human brain. The various departments and divisions have different functions which are becoming more highly differentiated. In a closely similar way, there are distinct parts to the human brain which have different functions. Thus there are parts to deal with sense inputs, parts to deal with speech, yet other parts to handle numbers, pattern recognition, manual skills and so on.

Another important similarity is provided by the very long on-the-job training of engineers within the *big five* general contractors before they are given project responsibilities. This is analogous to the long childhood of humans during which the brain is trained to adopt an adult view of the world. The *big five*'s willingness to invest in researchers' work over many years is analogous to the formal education provided for individuals. In both cases, it is hoped that the knowledge gained will eventually be useful but, irrespective of that, the disciplines learned are of importance. Also, of course, the *Kaizen* activities continue the learning process throughout the whole industry; just as the whole of the human nervous system is continually learning from its day-by-day experiences. So there are more than superficial similarities between the brain and general contractors and the parts of the industry which they lead.

One obvious question which arises if we are to regard the general contractors as the brain of the industry, is who plays the part of muscles and those parts of the nervous system which activate them. The equally obvious answer, is that these roles are played by the subcontractors. They work within an overall framework provided by the brain but like the various remote parts of our bodies, they make independent decisions. In the human body, these are called reflex actions and learned habits. They do not require conscious thought by the brain. They automatically undertake the work of maintaining the body in a fit and healthy state. In the work of subcontractors, the role of reflex actions and learned habits is provided by the agreed standards and established methods used throughout the industry. They ensure that work meets good standards of quality and is finished on time. Indeed, in parts of the industry, there now is considerable investment in education and training to help subcontractors to not only undertake direct work more effectively but also to extend their role to include first level management. This is directly analogous to the role of the distributed nerves and muscles in the human body.

It is helpful at this point to remember how other metaphors have in earlier days helped managers to think effectively about their own organizations. Early management theories viewed organizations as machines, each designed for a specific purpose. Taylor (1903 and 1911) is famous, or perhaps more accurately infamous, for treating the design of human organizations as a problem of engineering. Deming's ideas also embody a production engineering view of organizational design. However his approach is more mature than Taylor's in that it recognizes the key contribution of the workers themselves in improving production systems. Nevertheless, Deming's influence means that machine-based

ideas can be recognized in the work of the mainstream production system of the Japanese building industry. It is important to remember that the metaphor of machines is helpful for managers working in organizations with fixed tasks and stable environments.

A later group of theories recognize that the machine metaphor provides only a limited basis for explaining the behaviour of organizations. These include human relations theories and contingency theories of management. They recognize that organizations have many of the characteristics of living organisms. Thus they see organizations as open systems. Such theories concentrate on the interactions between organizations and their environments in explaining both stability and change. The organism metaphor helps organizations with fixed tasks to understand and deal with complex and uncertain environments. What then are likely to be the strengths of the brain as a metaphor for organizations?

The human brain is especially designed for reflecting on the actions of the rest of the body, judging their appropriateness and, if necessary, selecting new tasks. Thus, the brain is supreme at initiating intelligent, creative action. The brain processes information but in a very free-ranging manner. The brain learns from its sense inputs, which importantly include feedback about the effects on the environment of its body's actions. It organizes itself on the basis of what it learns in order to reinforce successful behaviour and inhibit actions which are found to create problems.

Organizations which use the metaphor of the brain to guide their thinking about themselves are therefore likely to be creative, to be able to innovate and to evolve. The brain metaphor will help organizations become learning systems that are open to inquiry and self-criticism. Their interactions with their environments will be based on reflection as well as on wide-ranging inputs and feedback. Such organizations need to self-organize as they learn what works and what does not.

To gain the full benefits from thinking about the *big five* companies as brains, it will be necessary to allow parts of the organization responsible for separate kinds of knowledge and skills to develop their own ways of working. However, at the same time, it will be necessary to ensure that the parts are fully linked into an overall co-ordination network which enables the organization to behave as a whole. In the past, much of this coordination has been provided automatically for the companies by means of the consistent culture of the Japanese engineers who made up their staff. As more distinct cultures are brought into the companies and encouraged to grow and develop within them, more explicit attention will need to be given to coordination. It is in designing their overall coordination systems that the human nervous system is likely to provide the most useful guide for the *big five*.

Another aspect of the brain which may be of interest in using it to guide the development of management systems is that in its autonomous functioning it appears to be more concerned with avoiding pain than with seeking pleasure. This suggests that organizations which follow conventional management wisdom and concentrate on setting specific goals may be limiting their learning potential. By specifically identifying things to be avoided, and by implication allowing everything else, organizations open themselves to wider and more robust learning processes and to a greater range of actions. To achieve this effect, senior managers will need to define limits and constraints but leave individuals free to choose their own goals. Using the brain as a metaphor for the role of the *big five* also serves to emphasize the importance of senior managers looking ahead, anticipating potential problems and devising plans to avoid them.

At present, change in the Japanese building industry can with some justice be characterized as modest, incremental development. It has more structure and consistency of direction than does change in Western building industries and therefore in the long-run is likely to be more significant. However, change in the Japanese building industry is still undertaken slowly. This caution has allowed a serious labour problem to grow and there does not yet appear to be a coherent strategy for fundamentally changing the industry's technology which seems to be necessary to solve the problem. As argued earlier in this paper, there is no apparent reason for the industry not to be much bolder in envisaging change.

In other words, the brains of Japan's building industry are inhibited from making necessary changes by their own view of their world. They still perceive the building industry in its traditional form and so decisions are made slowly and carefully. It is certainly the case that when a change is agreed upon, it is implemented by the distributed nervous system of the industry with great competence. Learning and information are widely distributed and so the industy as a whole currently forms a very robust system. However the industry is being subjected to major changes in demand: fashion now determines many aspects of the industry's products. The industrialization of technology will dicate fundamental changes to the way buildings are produced. As a consequence, the culture of the *big five* will have to change or else building in Japan may well become dominated by big manufacturing companies.

Changing a culture is always difficult and, in the short-term, painful. In undertaking this difficult task, there may well be much merit in the *big five* general contractors ranging even wider than at present in the kinds of knowledge and skills which they bring into their own organizations. For example, although some con-

struction think-tanks and futures research institutes already exist, at present they appear to be concentrating on short-term issues and immediate problems. They need to be encouraged to range widely in the ideas and the sources of ideas with which they work. Hasegawa *et al.* (1988) provide an excellent example of the exciting and well thought-out ideas likely to emerge from good think-tanks. Also the *big five*'s research institutes could be allowed to develop their ideas with less concern about short-term development. They are at present over concerned with developments which fit within the framework of established subcontractor relationships.

So, on balance, although the industry is doing very well, it currently faces major changes which require it to quicken the speed of its responses. Much good and directly relevant work is already under way and these initiatives need to be pushed ahead rapidly. In doing so it is suggested that it will be helpful for the industry to use the human nervous system as a guide in designing its own structure and organization.

Future research

The RCAST study consisted of theory formation and so, at this stage, the idea of using the human nervous system to help in understanding the behaviour of the Japanese building industry and as a model in designing organization structures and processes is an untested theory. However if experienced people within the industry find the idea interesting, then further research is needed to test the new model. it seems likely that this will require a multi-cultural research team drawn from both inside and outside the Japanese building industry.

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