ASSESSING THE EFFECTS OF STRUCTURAL DIFFERENCES ON ACTION, REACTION AND CONFORMATION IN CONSTRUCTION PROJECTS

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ABSTRACT

Research studies indicate the existence of three generic ways for dealing with uncertainties: control, flexibility and buffers. These are the ways of assuring organizational robustness to support the proactive and reactive management of events that occur during the project. Traditionally, project management practices have strongly relied on the combined use of control and buffers. However, the increasing notion of project complexity has changed paradigms and pushed structural changes towards the development of flexibility capabilities. One such change is the adoption of a more flat organizational structure characterized by autonomy and decentralization, being its most visible aspect the multi-functional teams working as mobile production cells.

This paper focuses on structural changes required for this type of flexibility and its effects on managers' interventions and use of buffers. Interviews were conducted with project managers from five high rise building firms who adopt different organizational structures and a parallel between their distinct practices was established. The analysis of strategic contents shows the successful implementation of this type of flexibility as the result of strategic choices accompanied by bundles of best practices at the operational level and by proper decisions regarding the use of buffers at the tactical level.

KEY WORDS

Flexibility, production cells, best practices, strategic choices.

INTRODUCTION

Following the trajectory taken by manufacturing industries, the Brazilian building sector is undergoing a change of paradigms and opening to new approaches for project management. Behind the changes lies the realization that project managers are incapable of planning and controlling all variables in such a complex phenomenon as construction. Therefore, the focus has been deviated from management as planning to management as organizing. Far from only meaning the provision of proper work conditions, it is being understood as the creation of a coherent organizational structure and culture, with delegation of responsibility, commitment, cooperation and learning as guiding principles.

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In terms of organizational structuring, there has been a significant effort to break away from the conventional hierarchical manner of dividing contracts by functions, sub optimizing for individual benefits and communicating through narrow channels. As mentioned by Monostori et al. (1998), the high complexity environment has led the companies to decentralize functions and to exploit the creativity, experience and competence of all employees. The main driver for the change has been the acknowledgement of construction workers as a special kind of structural resource capable of assuming more than the role of sources of physical manpower.

The shift into a flat structure where workers are given responsibilities and empowered to control their tasks has also been a process of developing new roles for managers. By holding key positions as the links between top management and workers, project managers are critical to making a successful outcome. This suggests that the success or failure of competitive strategies can be explained in many cases by the alignment of strategic choices, management style and best practices. According to Zuo and Zillante (2005), this is quite important because both leadership and organizational structure impact on the culture developed within a project, which in turn has to be as strong and unified as possible for the attainment of project goals.

Decisions regarding strategic choices in construction and best practices are fundamental to shaping the organizational structure and need to be tailored to an ever changing external context through an iterative process. Thus, an exploratory five-company case study was used to investigate changes related to the application of the mobile production cell concept within construction firms. The main objectives are:

1) to highlight the combination of strategic choices considered to bring the best results when combined with bundles of best practices supporting pull production;
2) to identify changes in management style and the relative importance of different types of control and buffers after implementing this flexibility capability; and
3) to provide a further understanding on the inter-relationship between control, flexibility and buffers and propose a conceptual model for project robustness.

ROBUSTNESS IN PROJECT BASED ORGANIZATIONS

PROACTIVE AND REACTIVE MANAGEMENT

According to Monostori et al. (1998), proactive management is a behaviour aimed at fostering anticipation, learning and coherence. It is generally a process of preventing anticipated disturbances as early as they are foreseeable from monitored and sampled performance trends. On the other hand, the authors describe reactive management as a behaviour aimed at achieving an adaptive coordinated response to changes. It is an event-driven incremental repair process to current internal and external circumstances. Both proactive and reactive management decisions should be based on real time monitoring and a continual data-acquisition in the shop floor.

Despite the fact that good management is primordially proactive instead of reactive, both proactivity and reactivity must be combined for the effective fulfilment of performance goals (e.g., Monostori et al. 1998). As Schmenner and Tatikonda (2005) put it, “the study of the Japanese flexible factory has not only led researchers to question whether tradeoffs (e.g. cost vs quality) actually exist, but has also shown the importance

of its complementarity with proactive management." This statement indicates that a firm is flexible in adapting to uncertainty part because it is proactive in controlling it. Among other aspects, it reaffirms the importance of adequately matching types of control and flexibility. It also reminds of the importance of making the proper decisions regarding organizational structuring, since all resources contribute to flexibility. Slack (1987) agrees by saying that flexible technology cannot be totally effective without flexible labour and vice versa. Neither can be effective without a set of procedures, systems and controls which are themselves capable of coping with the flexibility of the physical processes.

ACTION, REACTION AND CONFORMATION

Robustness is commonly mistaken for redundancies in task-resource allocation. However, from a strategic perspective, control, flexibility and buffers are complementary ways of dealing with the same problem: uncertainty. Together they comprise the set of strategies, capabilities and capacities that build organizational robustness and, therefore, must be rationally used to support proactive and reactive management during the project life cycle. Despite the major developments in industrial management, most research studies have only examined superficially the mechanisms behind their inter-relationships, especially when used in different organizational structures. Nevertheless, a comparative analysis indicates the importance of carefully applying them according to the conditions because each handles uncertainty in a different manner:

- Control (action): abilities and strategies that identify and influence the occurrence of events with the objective of preventively reducing their effects on the system;
- Flexibility (reaction): capabilities that quickly adapt the system in response to the effects of non-planned changes, without inflicting damage to production goals;
- Buffers (conformation): redundancies that allow the system's structural arrangement to accommodate disturbances and variability.

In manufacturing, Corrêa (1992) found evidence of a hierarchic application in which control mechanisms are used as "filters" that restrict the amount of changes to be dealt by the system. Some changes and their effects that pass through the "filters" will be managed by flexibility capabilities within the system. However, Slack (1987) mentions the control as being incapable of dealing with all variables and flexibility as preferably avoided by companies due to its high development costs. This suggests the use of buffers as the third way of handling the rest of the uncertainties due to their broader applicability.

Although it is clear that the development of tools and techniques for production planning and control is the most studied topic in construction management (e.g., Ballard and Howell 1997, Alarcón et al. 2005), there has been a growing effort to implement different types of flexibility within the Construction Industry (e.g., Santos et al. 2002, Miranda Filho et al. 2005). There are also recent studies (e.g., Sakamoto et. al., 2002; e.g., Nielsen and Thomassen, 2004) showing the proper sizing and location of buffers to positively impact on project performance. This leads to the observation that an adequate representation and analysis of organizational robustness in civil construction must encompass the three ways of handling uncertainties, as they are crucial elements to both proactive and reactive management. Hence, a conceptual model is proposed with flexibility as the central element of organizational robustness (Figure 1).

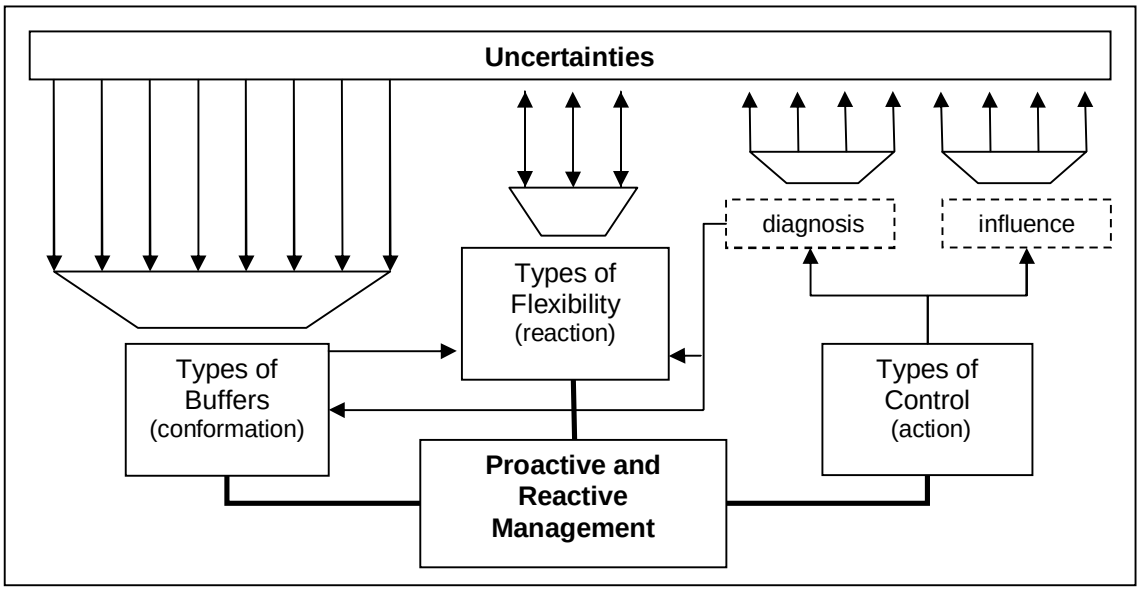

Figure 1: Uncertainty Management as a Balance between Action, Reaction and Conformation

ORGANIZATIONAL STRUCTURING AND STRATEGIC CHOICES

There are multiple, equally effective ways in which an organization can achieve environmental fit to compete within a particular industry. These in turn are accompanied by different strategic choices concerning production technology and production management. Although there is no generally accepted definition of manufacturing strategy, authors agree that it involves key decision areas such as vertical integration, workforce, capacity, technology, facilities and organization (specialization, centralization and formalization) (e.g., Acur et al. 2003). Coherent decisions in manufacturing strategy must be taken for the organization to be capable of supporting the business strategy.

In addition, Harris (1997) reports the existence of interactions between strategic, tactical and operational factors and argues that consistent decisions at all three levels will give returns over and above the benefits obtained from particular levels of any one factor. Even though the alignment of fundaments and subsequent decisions is crucial for success, too little effort is put into analysing the relationship between strategic choices and best practices implemented on the level of operation. Both are clearly subordinated to business strategies. However, Voss (1995) mentions the link between strategic choices in manufacturing strategy and best-practice programmes as being less clear.

As discussed by Voss (1995), a best practice will not by itself guarantee improved performance because it cannot solve all problems nor may it be appropriate for all companies. Best practices usually come in small isolated pieces such as JIT and TQM. They are also easily imitable and are unlikely to give sustainable competitive advantage. But even worse, some are only applicable in specific contexts or may only bring the best results under certain circumstances. So it all points back to the problem of matching decisions, since major strategic choices have a strong impact on manufacturing processes, infrastructure processes and best practice implementation. This explains why some best practices fail to provide the alleged positive results. A good example is ISO9000, which has not been successfully implemented outside offices and auxiliary processes partly due to high labour turnovers and outsourcing decisions in construction projects.

This indicates caution when implementing the practices comprised in the lean toolbox. Bundles of best practices supporting pull production may also be considered fads and fashions like those that have come before unless they are matched with the proper strategic choices. Mohan and Iyer (2005) have already presented results showing a small amount of lean principles and practices effectively used in construction companies and an even smaller amount of major benefits realized. These results are a warning to the lean construction community and a reminder for a better understanding on the impacts of underlying strategies.

RESEARCH METHODOLOGY

The research protocol consisted primarily of visits to 8 construction sites and in-depth interviews with 15 project managers and CEOs from five building firms. Initially a literature review was required to prepare a semi-structured questionnaire for the interviews. This method of gathering information was chosen for being the most appropriate when the logic of a situation is not clear. The suitability for an exploratory study was later confirmed as trends and relevant aspects appeared during the interviews.

Among other questions, the interviewees were asked to comment and rate different types of control, flexibility and buffers with respect to their relevance in the projects: 1 (low); 2-3 (below average); 4 (average); 5-6 (above average); and 7 (high). This was done to identify trends or maybe even causal connections between variables. The considered types and their nomenclature were extracted from the literature review (e.g., Slack 1987, Corrêa 1992, Sakamoto et al. 2002, Nielsen and Thomassen 2004):

- Control: coordination, monitoring, forecasting, subcontracting and partnering;
- Flexibility: flexible labour;
- Buffers: inventory, capacity, work-in-process and time.

RESULTS

CASE DESCRIPTIONS

The five firms are both developers and builders, being mainly involved in multi-storey residential building projects in the city of Fortaleza (Brazil). For these firms quality and delivery performance are qualifying criteria. The order winning performance criterion is product flexibility. Thus, the firms can be considered to belong in the same strategic group, since they follow a similar strategic orientation and share the same geographic area. This was important to leave out many uncontrollable variables and highlight as much as possible structural differences and its effects on control, flexibility and buffers. Such differences were most evident in strategic choices concerning team skills (specialized or multi-skilled) and levels of subcontracting (make or buy) and partnering (strategic collaboration or flexibility).

Strategic choices and practices in firms A and B were considerably different than those in firms D and E (Table1). The intermediate case was represented by firm C, which possessed a fair amount of implemented practices but maintained a structure based on specialist teams. It was clear to most respondents in firms C, D and E that bundles of best practices underpinning pull production reinforced each other and had to be implemented in order to achieve a significant positive effect on performance. The practices were

perceived to enable tasks and those who perform them to be closely connected in terms of space, time and information. This shows accordance with Hyer and Brown's (1999) description of time, space and information as the linking elements necessary for effective cell operation, with information having the most dynamic influence on the system.

Table 1: Comparison between Strategic Choices and Practices in the Five Building Firms

Firms	Respondents	Practices	Skills	Subcontracting	Partnering
A	1 CEO and 2 site managers	JIT, Last Planner	Specialist	Low	High
B	1 CEO and 1 site manager	JIT, Last Planner, LOB	Specialist	Medium	High
C	1 CEO and 2 site managers	5S, JIT, Andon, Last Planner, Kanban, LOB	Specialist	Medium	Medium
D	1 CEO and 2 site managers	5S, JIT, Andon, Last Planner, Kanban, LOB	Multi-skilled	Low	High
E	1 CEO and 3 site managers	JIT, Andon, Last Planner, Kanban, LOB	Multi-skilled	Low	High

SUMMARY OF RESULTS

The impact of strategic choices and practices was assessed by the relative importance managers give to different types of control, flexibility and buffers in their projects:

- *Inventory*: Just-in-Time material delivery is used for low cost and locally supplied construction materials. However, the distance to some suppliers and the low reliability of plans makes necessary a certain level of inventory for some materials. Hence, inventory was given a **below average** relevance in most answers from all five firms. Besides JIT, some interviewees mentioned the smaller inventory as decurrent from the caution in not leaving enough room for buffers of workable assignments;
- *Capacity*: in general, managers considered avoiding added capacity as a way of lowering costs. However, the three firms with specialized teams gave it a **below average** relevance because additional capacity is sometimes necessary for minimizing delays. On the other hand, the answers in both firms using multi-skilled teams gave **low** relevance to this type of buffer. Firms D and E are much reluctant in accepting workers that are not familiar with organizational procedures and culture. These firms prefer to increase work hours or move multi-skilled workers between functions to absorb demand fluctuations;
- *Work-in-Process*: the interviewees described it as being mainly a consequence of the batch size (the number of apartments handed-over from the previous trade to the next trade). This internal inventory along the production line has a **below average** relevance for firms A, B and C because of higher hand-overs between specialist teams. There is a concern that the reduction of batch-size will allow disruptions to disturb subsequent trades. Firms D and E are less concerned about interdependency problems and consider this type of inventory to have **low** relevance inside work

packages performed by multi-skilled teams. Small transfer batches are possible due to lower rework and setup times in these activities;

- *Time*: a reduction in batch-size means that rooms will spend less time standing idle waiting to be worked on. This allows the total building time to be reduced using different planning techniques. Firms D and E use a Pull technique to develop a schedule with minimum buffers inside work packages performed by multi-skilled teams. Any time left after working from a target completion date backwards is used to build the project buffer. Most answers in both firms considered this buffer as being of **average** relevance. With no reference to decide what assigned tasks should have unpadded durations, firms A, B and C unfairly distribute time buffers along tasks and tend to consider them as being of **above average** relevance for project performance.

- *Flexible Labour*: Many respondents mentioned that reductions in batch size and building time may turn the project manager into an informational bottleneck unless they are met with the proper conditions. Firms D and E coped with the problem by investing on structural and infrastructural resources to create mobile production cells in charge of performing work packages. The package's payment is previously negotiated because each presents a different set of activities and a distinct level of difficulty. In both firms there was a tendency to rate this type of flexibility as being of **high** relevance. Managers in firms A, B and C classified the use of this flexibility capability as of **low** and **below average** relevance in their projects, despite the fact that most recognized its development to be desirable;

- *Coordination*: managers in all five firms agreed on the importance of coordination. But there were striking differences in opinions regarding the management of work between internal clients. In firms D and E, the answers suggested that employing mobile cells reduced both the intensity and frequency of managerial interventions. It was mentioned that multi-skilled workers generated fewer hand-overs while material flow control practices like Kanban supported autonomy and decentralization in problem solving. Most managers rated this type of control with an **average** relevance, since they felt a reduction in worker job control. As expected, the answers in firm C tended to give coordination an **above average** relevance while those from firms A and B tended to consider coordination as of **high** relevance;

- *Monitoring*: at the construction site, monitoring is mainly done through inter personal contacts, performance measurement and visual controls. The amount of monitored variables is perceived to vary during the construction phase. Surprisingly, its relevance was evaluated as of **above average** by most managers in all five firms. However, the interviews revealed that this happens for different reasons. Management in firms D and E is concerned with better supporting the work of mobile cells. Therefore, the creation of a data base from self performed and subcontracted activities is seen as a way of avoiding unnecessary buffers and improving plans in current and future projects. Except for firm C, firms with specialist teams considered it to be part of an effort to micro manage quality and interdependency problems. The objective is to support managerial interventions;

- *Forecasting*: it requires the development of procedures and the investment on infrastructural resources to monitor, organize and store data. It is seen as a strategic decision to support other strategies. According to the answers, it has **high** relevance

for firms D, E and C and **average** relevance for firms A and B. Interviewees in firms A and B recognized forecasting as useful, but mentioned the lack of organizational culture and infrastructure to make the best of it. Differently, firms D and E need a more accurate forecast on the amount of resources and production rhythm because of small transfer batches and time buffers in their plans. Since prototyping is sometimes not possible due to project stress, forecasting is done by adjusting productivity data from learning curves of previous projects to the dimensions and characteristics of the next similar project. However, forecasting shows deficiencies when applied to non-repetitive activities or activities that suffer changes in the original scope of work;

- *Subcontracting*: a firm's control of all the value string can be reduced by externalizing non-strategical activities to more competent specialists. By distributing technical and financial risks to subcontractors, the contractor may concentrate on core competencies and tactical level issues. However, the interviews showed subcontracting primarily used with the purpose of cost reduction and, therefore, not generating the expected benefits. Unlike what is theoretically intended, managers complained about having to monitor and intervene on subcontracted activities. The subcontractors' lack of commitment with project goals and attempts to optimize their workload were cited among the main causes of problems. Thus, subcontracting had a **low** relevance in both firms with multi skilled teams and in one firm with specialized teams. These firms focused on training, committing and motivating their own staff;

- *Partnering*: managers argue that long-term alliances with subcontractors and suppliers are improbable due to characteristics of the building sector. Therefore, a certain level of substitution is likely to occur from project to project. Nevertheless, the firms seek as much as possible to establish strategic partnering with project participants in order to obtain collaboration during and after project execution. Continuous improvement is also fostered as lessons learned in one project are more likely to be implemented in future projects. But just as important is the perception that long term relationships allow operational procedures and performance standards to be known ahead, making forecasting of outcomes in plans more accurate. Except for firm C, all other firms gave partnering a **high** relevance for project performance.

Although the presentation of quantitative data for further discussion is not possible due to space limitation, the comparative analysis above shows the two firms with multi-skilled teams as the ones having the best alignment between strategic, tactical and operational choices. This is noticed by their capability in maintaining small buffers without making the construction process highly volatile. The firms understand that their competitive capability is significantly linked to the capabilities of the outsourced operations. So both firms seem to share the common goal of reducing complexity and interdependencies within their projects. They are doing this by limiting the amount and variety of project participants in the construction sites. Thus, strategic choices involved a combination of low level of subcontracting and high levels of partnering and labour flexibility.

One interesting observation is that the degree of leanness seems to be related to implementation "width" and "depth". In this study, width can be understood as the amount of practices from the lean toolbox that have been effectively implemented. On the other hand, depth refers to strategic changes undertaken in order to make the best use of the practices. Although there is a strong complementarity between practices some may only bring the best results under certain circumstances. This study has confirmed that this

is partially due to major strategic choices. This seems to be the case of firm C if compared to firms D and E. It just could not benefit from the same results by only relying on practices. This allows a speculative observation that there may not be such thing as a "best" practice, unless there is a clear understanding of the underlying strategies that make it so highly effective in some firms. True best practice seems to arise from the alignment of strategic choices and practices.

Another aspect that stands out is the importance of changes in management style. Without these, the combination of strategic choices and practices that generate cells would not be fully effective. In other words, proactive decisions concerning the use of buffers and supported by different types of control enhance the basic flexibility capability at the operational level (Figure 2). Moreover, such decisions increase the total efficiency by appropriately sizing buffers and thereby compensate the cost of becoming flexible.

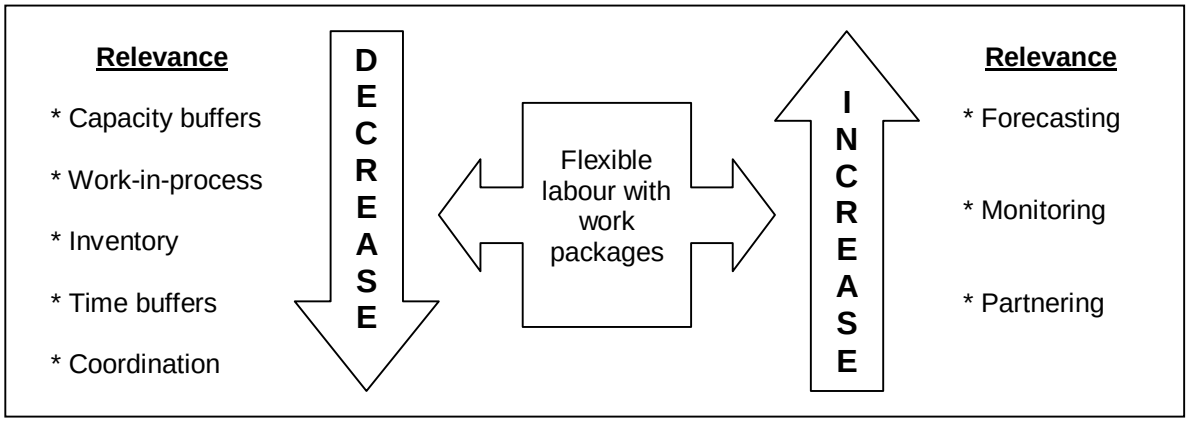

Figure 2: Trends in the Relevance of Different Types of Buffers and Controls after Implementing Cells

CONCLUSIONS

There are plenty of studies showing the positive impacts and minor tradeoffs caused by lean practices in civil construction. However, as lean construction broadens its scope and develops into being more than just a pull programme, the general context and underlying strategies of best performers need to be exploited. In order to assess the effects of strategic choices and lean practices, a conceptual model has been proposed with control, flexibility and buffers forming the three pillars of organizational robustness.

Owing to the fact that practices are easily developed and imitable, this study provides evidence that true best practices arise from the interaction between strategic choices, individual practices and management style. The findings suggest that lean practices closely connect site personnel in terms of time, space and information. In addition, strategic choices that favour multi-skilling, decentralization and partnerships are needed to fully benefit from such gains. Thus, the common rationale seems to be the creation of a stable organization characterized by a smaller amount of participants closely connected and responsible for carrying out a larger number of activities in the construction process.

Labour flexibility also results from such interactions, as they reduce structural constraints that impede the workers' control over the tasks. Plus, flexibility appears to be the central element around which control and buffers are developed. Although buffers should be sized and positioned according to the situation, there is little guidance on how to do it. Nevertheless, this study shows that mobile cells supported by vertical

information systems and lateral relations possess timely information for control purposes and therefore do not need self-contained tasks and slack resources within their work packages. Thus, flexibility capabilities within the process must guide buffer management.

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