PARADOXES OF INNOVATION AND ARCHITECTURAL DESIGN: A MODEL OF DESIGN KNOWLEDGE GENERATION IN ARCHITECTURAL PRACTICES

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Abstract

What are the organisational paradoxes that beset the design process in architectural firms? As innovative knowledge workers and system integrators architects are often called upon to produce innovative and custom designed buildings. Architects can be characterized as knowledge intensive professionals who help to lead innovation. However, most of the research conducted in design innovation and organisational paradoxes has had a product portfolio focus. For example, it has been claimed that product innovation relies on two seemingly contradictory and paradoxical processes in product development organisations: the exploitative and the exploratory. How might these concepts be related to architectural firms and design teams? Using the above concepts an initial model was developed and then tested in order to understand the paradoxical processes that architects employ when designing. How might design processes in service firms differ from either linear or dichotomous models of innovation with their origins in product development? An initial model is proposed which is then tested and refined. These questions are tested in a broader survey of 73 Australian architectural practices. The survey aimed to identify the links between exploitative and exploratory design processes in the firms and the organisational paradoxes which surround these. A survey framework was developed which defined and highlighted to what degree architects instigate Radical or Incremental design changes in projects. The survey identified the extent to which Australian architects generate new design solutions after a particular design has been mandated. It concludes that these architects deliberately sought to foster highly paradoxical processes within their firms in the early stages of a project in order to create new design knowledge. Highly paradoxical processes, which oppose exploitative and exploratory design activities, tend to diminish as the project proceeds. Further research is needed to clarify if design processes with a high degree of paradox are where project innovation occurs. The paper concludes by outlining a model of exploitative and exploratory innovation and organisational paradox in knowledge intensive design firms.

Keywords: Architecture, Design, Organizational Paradoxes, Innovation.

INTRODUCTION

Design architects are often accused of changing their minds once decisions have been made during the project development and delivery process. Design changes are often seen as being unwelcome and at odds with sequential project development milestones. Some have argued that this contributes to rework during the construction process and adds to project risks. On the other hand creative and generative design is seen to foster innovation. This paper explores the paradoxes evident within the architectural design process. For the purposes of this paper a paradox is defined as "the simultaneous presence of contradictory even mutually exclusive elements" (Cameron and Quinn 1988:2 in Clegg, Cunha and Cunha et al 2010). In

construction management very little is known about how organizational paradoxes might play themselves out within design teams. This may be because design is an activity which 'poses difficult managerial problems' which requires interdependent decision-making. (Tzortzopolous and Cooper 2007, 17). The need to understand the interdependencies and paradoxes between an initial design concept and its implementation and delivery as a constructed project is important. One way to understand these interdependencies is to investigate the paradoxical modes of design that architects appear to employ.

The paper proposes and then tests a theoretical model of how design oriented organisational paradoxes are created and resolved within architectural practices. Tushman and Benner's concepts of exploitative and exploratory innovation are adapted to the architectural design context (Benner and Tushman 2003). It will be seen to what extent these different modes exist simultaneously when creating design knowledge and that this process should not be characterised as being either strictly binary or linear. The model developed in this paper suggests that Architects might blur sequential distinctions between exploitative and exploratory design by pursuing both at the same time. Specifically, the model suggests that both types of design take place simultaneously and that the pathway to an innovative project outcome is not linear. The model suggests that during the design process exploitative innovations are purposefully destroyed in order to create exploratory outcomes; and conversely, exploratory outcomes are destroyed in order to create exploitative innovations. Moreover, it will be suggested that design paradoxes are resolved through processes of improvisation.

Design Knowledge Creation and Organisational Paradox

Linear and binary descriptions of the design process abound in design literature. However, these concepts have not often been developed as paradoxical concepts. For example, Winch theorises that designing can either be characterized as a conjectural model or a linear model (Winch, 2008). He claims that the linear model is a problem solving approach which involves analysis, synthesis and evaluation. He argues that the conjectural model, a model which is arguably linked to design, is 'much closer to scientific method' and more discontinuous or disruptive. This model is not unlike Tushman's concept of exploratory innovation. Winch argues that in a conjectural design approach, an initial hunch or conjecture is formulated and following this the process then proceeds through a number of iterations. It is through these paradoxical iterations that design knowledge is created; in each iteration conjectures are proposed and then abandoned. Lawson argues that architectural design processes are complex and need to be distinguished from engineering definitions of optimised design. He argues that many of the maps or descriptions of the design process tend to be overly theoretical or prescriptive and that these tend to place a value on those linear descriptions of the design process sometimes ignoring the iterative design process that takes place within a particular design exercise. (Lawson, 1980, 29).

Architects have also been seen as Systems Integrators who are able to create innovations. However, System Integration has not been developed further or conceptualized in terms of organizational paradoxes. Obviously, the systems integration concept could easily be seen as the means by which paradoxes, for example, related to different innovation pathways or requirements, might be reconciled. In a study of 10 architectural firms Renier, Volker and Wamelink test Winch's idea that architects are System Integrators (Renier et al 2010). They conclude that architects are indeed System Integrators who will strive to attain a particular level of innovation in order to maintain the firm's competitive advantage. Referring to

Winch's two-moment model of innovation they assert architects have two primary modes of idea generation: The first is based on problem solving dynamics centered on the project, often as the result of the need to develop new solutions. The second dynamic is the generation of new ideas as a result of changes in broader market conditions. In this model Winch contextualizes innovation with reference to the way in which a firm and a project are linked to its broader environments: "new ideas can either be adopted by firms and implemented on projects, or result from problem-solving on projects or be learned by firms" (Renier et al. 2010). This model is based on a binary top down and bottom up model. But it does not explore or suggest how these two different modes of innovation might generate paradoxes either in the organization or within the project.

Another more complex model that has been advanced is the idea that architectural designers can be characterised as Knowledge Intensive Professionals Firms who 'have a pivotal role of the knowledge worker in leading the co-production of innovation with clients' (Lu and Sexton, 2006). Despite the fact that architects and clients are often in conflict this model does not see co-production as having a paradoxical potential. Shu-Ling and Sexton have adapted and developed Nonaka and Takeuchi's spiral model of Knowledge Capital creation in order to explain how knowledge is created in, what they call, KIPFCS. Interestingly, this is a model which does not describe the role of paradoxical processes in the creation of design knowledge. It is an interaction model which posits that knowledge - for example, design knowledge - is created via individuals in project organizations. This knowledge then becomes more explicit, rather than tacit, through collaborative interaction between individuals, teams and organizations. The model presumes that knowledge is created in a continuous or linear fashion in which knowledge capital is increased as these interactions increase. The model is linear, despite its spiraling nature, because it does not allow for the paradoxical processes that might take place in the interactions between individuals, teams and organisations.

In attempting to adapt ideas of organizational paradox to construction Price and Newson argue that strategic management in organizations has been portrayed as a linear process, that is, a process which privileges notions of rationality and logic over those of creativity and the imagination. Price and Newson adopt a top down strategic management approach to describe paradoxes in relation to strategy formulation in construction organizations. They argue that construction organisations should pursue an optimal balance between organizational paradoxes when planning long term strategies. They conceive of, from a construction viewpoint, a taxonomy of paradoxes, which they categorise in binary terms as: Logical (rational) versus creative (generative) strategies; Intended (deliberate) versus realized (emergent) strategies; Revolutionary versus Transformational strategies; Strategic fit versus strategic stretch; and Strategy versus organizational effectiveness (Price and Newsom 2003).

Of the paradoxes identified by Price and Newsom the terms Logical and Creative are characterized as signifying a paradox between "structured decision-making" that leads to incremental change and a "more creative approach" that may lead to greater innovation and "Radical step changes." This distinction echoes the work of Tushman and Benner who have made the distinction between exploitative and exploratory innovation. Exploitative actions utilize existing organizational resources in order to generate short term competitive advantage. Exploratory innovation employs new organizational resources in order to generate "sustainable long term competitive advantage. Clegg, Cunha and Cunha suggest that some of the above binary dichotomies and distinction can be reconciled using a bilateral relational model of organizational paradoxes. In this model they employ the concept of improvisation and claim that this is the process by which organizations resolve paradoxes. They highlight

the paradoxes that exist between exploration and exploitation in organizations. They state that "exploration and exploitation enter a mutually supportive relationship when existing resources are used to look for and take advantage of new opportunities." (Clegg, Cunha and Cunha et al 2010).

Each of the above models or concepts is conceived to explain a different aspect of organisations' approach to innovation. All of the above models are built on a range of expressions that signify binary oppositions: external and internal, top down and bottom up, logical versus creative, rational versus generative, linear versus iterative and exploitative and exploratory. Remarkably, these terms seem to exist in isolation. Very little discussion is noted about the process by which these paradoxes are held apart, consciously encouraged or resolved. If these concepts are regarded as paradoxes then it is possible that more dynamic models may emerge that better relate design processes to construction innovation. Improvisation by way of generative problem solving or designing is not conceptualised in the above models. Seeing architects as systems integrators suggest that they can easily reconcile conflicting and contradictory elements within different project contexts. But this says little about how this is done.

Methodology

The above concepts were examined in a way that attempted to illuminate the paradoxes between rational and exploitative design process and generative design. Underlying the approach in this context is the idea that organizational paradoxes should be examined at the level of project and team business processes and not exclusively from a top down strategic management approach. As suggested above, this survey presumes that generative or exploratory actions are a key driver of innovation. This research aims to understand if simultaneous occurrence of design paradoxes in a project organization may be related to
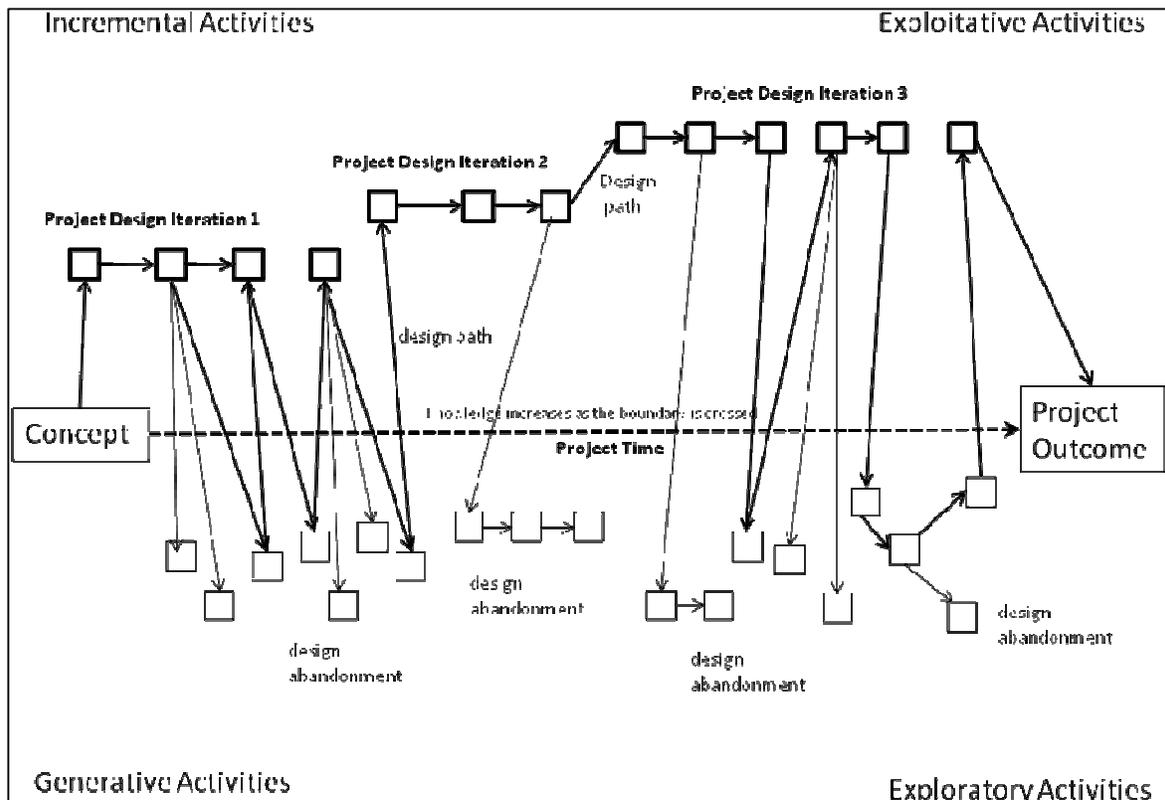
Fig 1: Design Paradox Systems Integration Model

innovative outcomes. This research is a first step in approaching this aim. An initial model of how Incremental and Exploitative activities might take place during the design process is set out in Figure. 1. A paradox occurs when generative or exploratory activities occur at the same time as Incremental or Exploitative activities. The survey was designed to ascertain to what degree architects paradoxically pursue both Radical or Incremental design solutions in a given project context. The term Incremental is a signifier for exploitative, logical, and rational design versus Radical which signifies exploratory, generative and creative design. In the survey in order to begin to define these terms, Radical and Incremental were also equated with the kinds of design changes that might take place in a project context. The survey respondents were also asked to define how they themselves defined these terms in a project context.

Using the above definitions the hypothesis employed was the proposition that architects deliberately seek to foster highly paradoxical processes within their firms in order to create new design knowledge. To achieve this the research questions of this paper are aimed to discover to what degree architects are *continuing to simultaneously generate both radical and incremental design solutions throughout the design process.* In order to test this hypothesis a survey was developed that would begin to investigate how architects approached concepts of incremental and radical design during the sketch design, design development and construction stages of the project process. In other words as the design proceeds, to what degree do architects continually question and reconsider design knowledge that has already been created? To what degree will architects consider making radical design changes after a particular design stage has been decided upon? It is important to also understand if architects pursue both Radical and Incremental design solutions at the same time.

In the survey the underlying structure is that exploratory actions are designated as Radical design solutions. These are generative and conjectural in nature. Likewise, incremental design solutions are translated from the concept of exploitative actions. These are linear and incremental in nature. The survey was sent to 1145 architects around Australia all of whom were members of the Australian Institute of Architects. There were 63 responses.

Survey Questions

Given that most architectural practices are SMEs and work on a range of projects in size and financial value it was decided to develop the survey by identifying each practice's largest project, the number of staff in the practice and the type of work they did. The survey also identifies the predominant project type in the firm as well as the monetary value of this project in order to ascertain the complexity of the project. Alongside this project context the number of staff in the practice was identified together with the role, experience and involvement of survey respondent.

Having asked questions about the architectural firm the survey then included questions about how the firm might define Radical and Incremental design changes. Respondents were then asked why such changes take place during the project delivery process. Following this a number of questions were asked about the extent to which Design teams or designers within the practice have the freedom to continue to generate Radical design solutions even if a design or design stage has been agreed on. Finally, the respondents were asked to respond to

a number of statements which gauged to what degree they felt Radical or Incremental design solutions coexisted within a particular project context or design process.

Results

There were 73 responses to the survey out of 1145 invitations. 95% of respondents were architectural directors and 70% of these had over twenty years experience. Most practices were small with 43% having between 2 and 5 staff and 18% having up to 10 staff. 8% of respondents came from practices that were larger than 50 staff. 48% of respondents stated that the largest project in their office was between $AUD1M and $AUD5M. Notably, 78% of respondents stated that they spent at least 25% of their time managing design and design teams.

The respondents strongly agreed that Radical design changes were most related to: the functionality of the project as a result of briefing changes 69%, the overall floor area or building heights 59%, the projects siting or orientation 54%. Radical design changes were seen to encompass a wide range of activites such as: "the inclusion or removal of significant functions", "significant change in the floor area", "changes in leadership within the briefing team", "planning or design changes required due to significant program or delivery timing parameters/budget amount/funding source/ legislative changes." Many respondents were less specific in their definitions and stated that Radical design changes were design changes that: "lead to fundamental rethinking of elements of the project", "affect the form or conceptual origin", "change the design concept" or "A change that affects the fundamental design - so great that the concept must be re-assessed or thrown out."

In response to the question of why Architect initiated Radical design changes are instigated, the respondents agreed that such changes were neccesary in order to: respond to a cost cutting or value management exercise 82%, better co-ordinate services and systems within the project 55%, improve the quality of the projects aesthetic or spatial qualities 50%. Finally, 58% of respondents agreed or strongly agreed that such changes were often made to deliberately explore innovative aesthetic and spatial solutions.

Once a Conceptual or Sketch Design has been signed off, to what extent will the designer and project team be allowed to:					
Number %	Greatly Discouraged	Discouraged	Neither Discouraged or Encouraged	Encouraged	greatly Encouraged
Continue to test the Conceptual Design or Sketch Design solutions by creating alternatives to it.	5	17	24	25	2
	7%	23%	33%	34%	3%
Pursue new design solutions at the risk of creating a new Conceptual or Sketch Design.	8	30	23	11	0
	11%	42%	32%	15%	0%

Play with the design in order to see what new concepts or solutions may emerge.	6	25	25	15	2
	8%	34%	34%	21%	3%
Use the Conceptual Design or Sketch Design as a basis for generating new subsidiary design solutions in order to advance the design to the next stage.	2	10	11	41	9
	3%	14%	15%	56%	12%
Advance the design to the next stage using the practice's processes and resources.	1	5	8	45	14
	1%	7%	11%	62%	19%

Table 1: *% of firms that continue to generate creative design solutions after sketch and concept design stage.*

The responses seemed to indicate that most exploratory or generative design activities take place in the early stages of the project design process. At this stage, as can be seen in table 1, even though a sketch design or concept design had been mandated, 38% of firms either encouraged or greatly encouraged a generative design process in order to create alternative solutions to the mandated design. Most firms or directors encouraged their teams to use the Conceptual Design or Sketch Design as a basis for generating new subsidiary design solutions in order to advance the design to the next stage. However, a significant percentage actively pursued and encouraged new design solutions or explored the design in order to seek new concepts and solutions. However, it can be seen in tables two and three that once the sketch design stage has passed, architects are reluctant to pursue alternative design solutions.

Once a project has been signed off at Design Development stage to what degree will the designer and project team be allowed to:					
Number %	Greatly Discouraged	Discouraged	Neither Discouraged or Encouraged	Encouraged	Greatly Encouraged
Continue to test the Design Development solution by creating alternatives to it.	13	27	23	7	2
	18%	38%	32%	10%	3%
Pursue new design solutions at the risk of creating a new Design Development solution.	19	27	19	5	1
	27%	38%	27%	7%	1%

Play with the design in order to see what new concepts or solutions may emerge.	21	24	18	9	0
	29%	33%	25%	12%	0%
Use the Design Development stage as a basis for generating new subsidiary design solutions in order to advance the design to the next stage.	13	12	23	23	1
	18%	17%	32%	32%	1%
Advance the design to the next stage using the practice's processes and resources.	7	6	11	39	9
	10%	8%	15%	54%	12%

Table 2: *% of firms that continue to generate creative design solutions after design development stage.*

It can be seen in Table 2 above and Table 3 below that once the sketch design stage has passed that architects are reluctant to pursue alternative design solutions for their own sake. They will, however, pursue any design solution that will advance the design to the next stage. Obviously in some circumstances, if there is a change of brief of example, this would mean employing Radical design soultions to do this. However, the results suggest that architects are more likely to pursue incremental or exploitative changes at these stages through the generation of subsidiary design solutions and the exploitation of the firm's normative processes and resources.

Once a project has been signed off after Tender stage and is in Construction to what degree will the designer and project team simultaneously:					
Number %	Greatly Discouraged	Discouraged	Neither Discouraged or Encouraged	Encouraged	Greatly Encouraged
Continue to test the Sketch, Design Development and Documentation solutions by creating alternatives.	49	16	7	1	0
	67%	22%	10%	1%	0%
Pursue new design solutions at the risk of creating a new conceptual or Sketch Design.	51	16	5	0	0
	71%	22%	7%	0%	0%

Play with the Design in order to see what new concepts or solutions may emerge.	48	16	5	3	0
	67%	22%	7%	4%	0%
Use the Construction stage as a basis for generating new subsidiary design solutions in order to improve the design.	30	16	13	11	3
	41%	22%	18%	15%	4%

Table 3: % of firms that continue to generate creative design solutions after design development stage.

Table 3 above indicates that architects are very reluctant to pursue alternative design solutions once a project is under construction. No firms indicated a willingness to pursue new design solutions at the risk of creating a new sketch or conceptual design. A very few respondents did appear to encourage playing with the design in order to see what new concepts would emerge. However, 19% of respondents did see the construction phase as an opportunity for generating new subsidiary design solutions in order to improve the design as it neared completion.

To what extent do you agree or disagree with the following statment	
Pursing Radical design changes is a part of the practice's normal design process.	28%
In our practice any project the principal designer, designer teams and design architects have the time to pursue new design solutions throughout the project.	29%
Design teams or designers within the practice have the freedom to continue to generate Radical design solutions even if a design has been agreed on.	17%
Continuing to generate both Incremental and Radical design solutions throughout the process helps to identify and highlight new design issues and problems as the design progresses.	42%
Continuing to generate both Radical and Incremental design solutions throughout the process outweighs impacts on project delivery time or cost.	21%
Implementing Radical design solutions throughout the process outweighs impacts on project delivery time or cost.	21%
Sometimes it is necessary to discard a design solution or sketch design and start the design process again in order to achieve a better project outcome.	72%
It is difficult to manage designers and design teams who pursue both radical and incremental design changes in a project simultaneously.	57%
Creating and then culling both Radical and Incremental successive design solutions in a given project helps to achieve high quality and innovative design.	65%

Table 4: % of firms that agree or strongly agree with the question.

Discussion

The survey appears to indicate that a significant proportion of architects foster paradoxical design processes in their firms. The initial model proposed here posited that architectural designers and design teams will undertake exploratory and exploitative activities simultaneously. The hypothesis tested was the proposition: that many architects deliberately seek to foster highly paradoxical processes within their firms in order to create new design knowledge. It would appear that this is the case even though an initial sketch design has been mandated. In the early design stages of a project 37% of architects will continue to pursue alternative design solutions and 15% of architect respondents will continue to test a design solution at the risk of creating a new design solution. Architects will continue to play with the design solution in order to see what new concepts emerge through sketch design, 24%; design development 12% and even into the construction phase 4%.

The results indicate that architects continue to, *simultaneously generate radical and incremental solutions throughout the design process;* this only holds true for the early stages of the project prior to design development. It would appear that the sketch design stage is the stage that appears to be the most paradoxical. This is because it is the primary stage where both exploratory and exploitative activities take place during the project. This is described in Figure 2 which is a revision of the initial model as set out in figure 1. This model, which would be tested by further future research, indicates that in the early stages of a project architects freely generate design solutions which create design paradoxes with other project elements and systems. Some of these solutions are abandoned, or destroyed, and others are then integrated into the project and developed in an exploitative fashion. As the project advances fewer paradoxes are created. This is because fewer generative design solutions are created and the focus in the project is on developing subsidiary solutions and systems integration as the project approaches construction delivery. Those paradoxes that are created

One limitation of this research has been the initial necessity to establish the definitions of what architects regard as radical and incremental design changes. In the survey Radical and Incremental were also equated with the kinds of design changes as well as the solutions that might take place in a project context. These changes are regarded as Radical if they require a substantial change to the brief or a significant change to the original design concept or strategy. Future research would better align definitions of what architects regard as Radical design changes with what they regard as Radical design solutions. Future research could also look at the design processes within a small range of architectural practices, or projects, over time in longitudinal detail. This might require a close observation of architectural design processes particularly in the early design stages. A key aim of future research would be to establish to what degree construction or design innovation is achieved in the early design stages of a project. Creating both exploratory and exploitative design solutions simultaneously may not necessarily lead to innovation.

It would appear that once a design concept is produced Architects deliberately pursue generative solutions which tend to create paradoxes with other more rational project constraints. But this appears to take place primarily in the early stages of a project where architects have more freedom to explore and are not as constrained by time and cost

Deadlines. Through a process of systems integration these solutions are developed and advanced though exploitative means. In the later stages of a project, as can be seen from the results generative, a lesser number of generative, or exploratory, solutions are pursued at the

same time that earlier generative solutions are being integrated, by exploitative means into the project process. On the basis of thesis results it could be argued that for architects the creation of design paradoxes, using generative and exploratory means, diminish as the project proceeds. Nevertheless, the model suggests how architects act as systems integrators and that both types of design take place simultaneously and that the pathway to an innovative project outcome is not linear.

Theories of organisational paradox should allow for the fact that paradoxes are often nested. One paradox may appear one reside within another Paradox. Examining one paradox may often reveal another paradox at a different level or scale. For example For example, 57% of respondents cited the difficulty of managing design teams that pursue both incremental and radical design changes simultaneously. However, they still agreed that creating and destroying both Radical and Incremental design solutions was at least one way to achieve design innovation. If any overarching paradox exists within construction project processes it is that many project systems favour sequential linearity, in other words exploitative processes, alongside actual project processes which are never linear and often complex and chaotic.
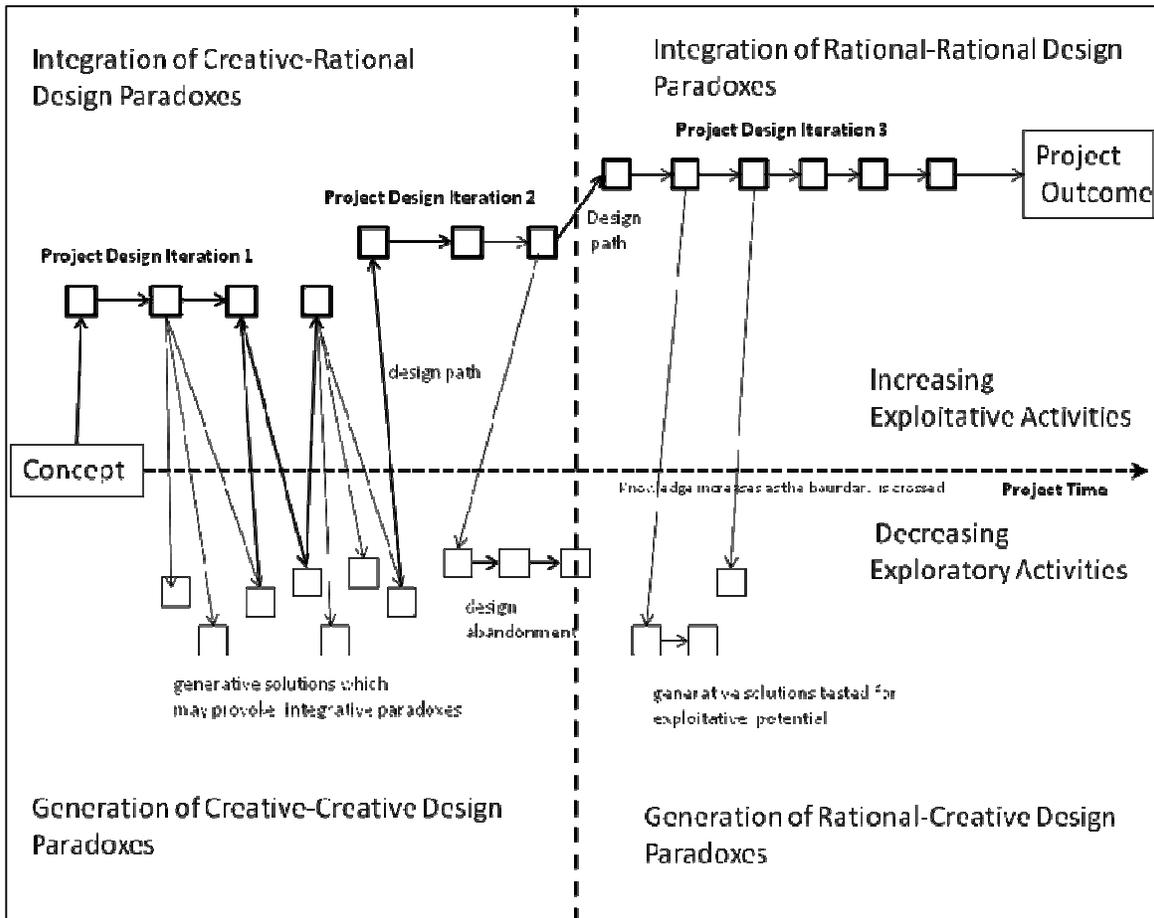
Figure 2: Revised Paradox Systems Integration Model
Conclusion

Future research would also examine in detail those firms that continued to engender design paradoxes by pursuing exploratory design solutions throughout the entire process. Whilst only a very small minority of firms were willing to do this after the tender or bid stage it would be interesting to know more about the characteristics of these firms. Are they firms with a good reputation for design? More importantly do paradoxical processes create high quality design knowledge that drives innovation? Much of the literature suggests that in theory so called creative, non linear and conjectural processes create innovation. However, these assertions need to be tested in project organisations and teams. Organisational paradoxes should not be seen as existing only in the domain of high level strategic management. Paradoxically, this research itself raises a number of paradoxes that should be the focus of future research.

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