METHODOLOGICAL CHALLENGES OF KNOWLEDGE PRODUCTION IN CONSTRUCTION MANAGEMENT RESEARCH: THE CASE OF A POSTGRADUATE RESEARCH INTO SUPPLY CHAIN INTEGRATION

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Construction management research implies quite a few challenges with regards to methodology and scientific rigour. In essence, this is true for management research in general. Much of the management research can be typified as theory-driven empirical research, often using qualitative and interpretative research techniques. This is also true for construction management research. A central issue of management research is that the research findings are closely related to their empirical context. In that context, management research tries to understand as well as solve problems, and aims to test as well as build theory. This phenomenon often turns out to be a great methodological challenge for management researchers. An essential aspect of this challenge is that the research process is aimed at the production of so-called solution-oriented knowledge, or Mode 2 knowledge (Gibbons et al 1994). In itself, Mode 2 knowledge production has a potential to improve the relevance of construction management research. However, application of a Mode 2 research approach often implies that researchers base their research strategies on their own paradigmatic convictions and methodological pluralism, rather than following a traditional interpretation of existing research standards and techniques. This paper discusses the challenges of applying Mode 2 knowledge production in construction management research. This is illustrated by means of the research design process of a postgraduate research into supply chain integration in construction.

Keywords: construction, management research, mode 2 knowledge production, research methodology, supply chain integration.

INTRODUCTION

Construction management research has been deemed to be rather narrow, and researchers should show 'courage and adventure to challenge the paradigmatic intransigence' existing within the built environment research community (Dainty 2007b). Apparently construction management research has been plagued by a lack of novel approaches including the application of mixed methods (Dainty 2007a). Although mixing methods and 'multi-methodology' research approaches could provide deeper insights and better understanding of construction management practice than single methodology can provide (Dainty 2007b). These approaches connect better with the multi-faceted structure and complex social network of the construction industry. Therefore construction management researchers need to think about how they can best understand construction practice, and adopt a robust research

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methodology if they are to effectively solve the problems of the industry (Love *et al.* 2002a). One way to do so is that construction management research makes its connections and interactions with both theory and practice more explicit, and explores the balance between rigour and relevance. In research operational terms, the practical context of the industry should be used to find as well as answer research questions through empirical field work, and by doing so add to new knowledge (Harty & Leiringer 2007).

These views on construction management research have given rise to the concept of knowledge production, in particular the development of problem-solving knowledge which is applicable to practice, such as Mode 2 knowledge production (Gibbons *et al.* 1994). In contrast to Mode 1 knowledge, which is abstract and universally valid, Mode 2 knowledge is applied and contextually embedded, and 'more socially accountable and reflexive' (Gibbons *et al.* 1994). Perhaps a shift from Mode 1 to Mode 2 knowledge production could contribute to a research paradigmatic change in construction management research contributing both to relevant new insights for practice and rigorous theory building in academia.

THEORY BUILDING

The process of theory building has been explained in terms of building blocks (Whetten 1989), processes (Weick 1989). and procedures (Handfield & Melnyk 1998; Wacker 1998). Completeness is an essential criterion for robustness of theories (Whetten 1989). In order to be complete, a theory must consist of four essential elements: 1) What (variables, constructs and concepts as part of the explanation of the phenomena of interest), 2) How (causal relationships between the factors explaining the phenomena), 3) Why (rationale that justifies the selection of factors, causal relationships and conceptual assumptions), and 4) Who/where/when (contextual assumptions and boundaries of the theory to which extent it can be generalised). Weick (1989) views theory building as a process of imagination disciplined by evolutionary processes analogous to artificial selection; a process of "thinking and trial". Handfield and Melnyk (1998) propose a procedures of six stages: 1) discovery (uncover areas for theory development), 2) description (explore territory), 3) mapping (identify key variables and draw a map of the territory=theory), 4) relationship building (identify linkages between variables and the reasons why), 5) theory validation (test the construct of variables and linkages and predict outcomes), 6) theory extension/refinement (expand the theory map and improve its structure). Wacker (1998) presents a similar procedures of four stages: 1) definitions of variables (who and what), 2) limiting the domain (when and where), 3) relationship/model building (why and how), 4) predictions and empirical support (could/should/would the phenomena occur). These procedures are not always as sequential as this may seem. It starts with discovery and cumulates to theory along a sequence of repeated extension, validation and refinement. And there are many methods – analytical and empirical – to get there. In essence this matters only partly, as long as it is 'well-defined, well-argued and well-executed' (Snijders & Vos 2007).

RESEARCH PHILOSOPHY

A robust methodological approach needs to take account of both epistemological and ontological positions, and needs to be firmly rooted in those positions (Love *et al.* 2002a). Epistemology refers to the understanding of knowledge, and in particular the accepted knowledge in a field. In terms of research it expresses the relationship between the researcher and reality, and the way in which a researcher attributes

meaning to the subject of research. Ontology is the "science of what is" studying conceptions of reality and the nature of being. In social science it aims to describe categories, entities and relationships between them (Crotty 1998). Generally there are two main epistemological positions - positivism versus interpretivism - and two main ontological positions - realism versus idealism. Within these positions three main types of research can be observed (Figure 1): 1) objectivism (things exist as autonomous and meaningful entities independent of the viewpoint taken), 2) constructivism (the meaning of things and phenomena, and thus truth are constructed in the mind, in relation to the things or phenomena observed), and 3) subjectivism (meaning and truth are imposed upon things and phenomena irrespective of the object) (Crotty 1998).

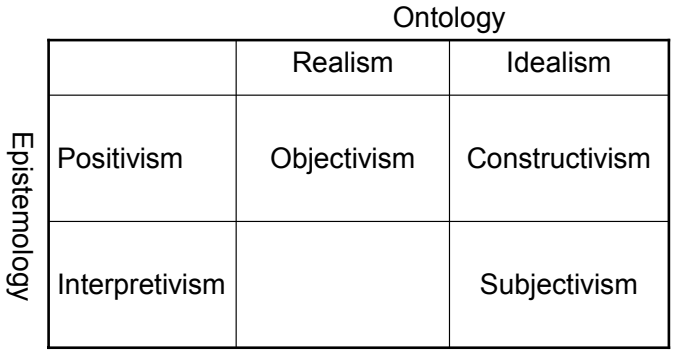

Figure 1: Epistemological versus ontological positions of three research types

Although management research can be either quantitative or qualitative, in many cases it is interpretative, rather than positivist. The former is often associated with qualitative research referred to as: soft, flexible, subjective, political, case study, speculative, grounded. The latter often refers to the claimed features of quantitative research: hard, fixed, objective, value-free, survey, hypothesis testing, abstract (Silverman 2000). When viewing management research as an act of theory building in the domain of social science, a plausible paradigm for management research would then be qualitative interpretivism, leading to new theory via the route of induction, often by means of case study research (Eisenhardt 1989).

MANAGEMENT RESEARCH AS MODE 2 KNOWLEDGE PRODUCTION USING CASE STUDIES

Taking into account the aspiration of most management research – understanding as well as solving problems of practice – Mode 2 knowledge production can be a valuable type of knowledge production (Harty & Leiringer 2007). Because of the focus on application and context, the attributes of Mode 2 knowledge are useful for management research: 1) knowledge production in the context of application (problem solving organised around a particular application), 2) transdisciplinarity (consensus and integration of different skills in a framework to guide problem solving), 3) heterogeneity and organisational diversity (composition of the problem solving framework over time), 4) social accountability and reflexivity (contextual awareness and consideration), 5) quality control (peer reviews and judgements from individual in the context) (Gibbons *et al.* 1994). Viewing management research as product-aimed design science, Mode 2 knowledge production aims at designing 'solution-oriented research products' rather than deducing 'analysis-based explanations' (Van Aken 2005).

Theory building can be based on analytical methods (deductive) as well as empirical methods (inductive) (Wacker 1998). However most theory building, and knowledge production, is empirically based. The most common research type for theory building is case study research, i.e. inductive case study research (Eisenhardt 1989). Normally this involves selection of new cases and 'live coverage' of those cases. However, the use of existing case studies is possible too, applying a process of iterative triangulation to build theory (Lewis 1998). This process employs systematic iterations between literature, case evidence and theory creativity. Generally the rigour of case study research has often been a concern. Particularly case study research in supply chains needs to be comprehensive, and the data collection methods need to be flexible enabling access at various stages of the supply chain with a range of data gathering techniques (Seuring 2008).

A CASE OF CONSTRUCTION MANAGEMENT RESEARCH: POSTGRADUATE RESEARCH INTO SUPPLY CHAIN INTEGRATION IN CONSTRUCTION

The research reported in this paper endeavours to build a multi-aspect supply chain integration model and corresponding guidelines to enable the integration of multiple firms in the construction supply chain. This paper gives an overview of the status of the research, which is currently underway. In particular, the paper tries to give an insight in the 'building blocks' found in theory and practice, to be used in the process of shaping the envisaged model further on in the research.

The phenomenon that construction is predominantly a demand-driven process, and design is often disconnected from production, lead to various problems of production. In addition production involves many crafts and many relatively small firms. The mechanisms of causality and interdependence within the supply chain cause problems originating upstream the supply chain to persist and often become worse downstream. This notion leads to the main idea of the work presented aimed at the development of a model for integrated construction supply chains. This touches on the basic peculiarities of construction as a disintegrated industry, and the negative effects of this on the performance of the construction supply chain. The premise here is that the construction supply chain would function better when approached and (re)built as a single entity, an extended enterprise. In a way, the broader issue is whether construction could or should develop towards the standards of a "normal", more integrated, supply-driven industry.

Research approach

The research presented follows the ideas of theory building from case studies as introduced by Eisenhardt (1989). The approach is semi-inductive starting from theory and case studies (building blocks), shaping hypotheses, and from there building a theory (model). This corresponds with the ideas of 'constructive research', which combines the analysis of existing phenomena and building new concepts at the same time. The research approach could be summarised as an engineering approach, i.e. engineering a supply chain integration model as it were a system that should be functional and useful. This engineering process starts by building the generic supply chain integration model using the theoretical 'building blocks' found in the four theoretical perspectives presented below: social, economic, organisational and production. The generic model built from the theoretical building blocks will next be validated by confronting it with empirical evidence from case studies of supply chain integration, outside and inside construction.

Theoretical phase of the research: theoretical building blocks

Systems theory views the world in terms of collections of resources and processes that exist to meet subordinate goals. Two aspects of systems theory are of particular importance for supply chains: synergy and entropy. Synergy means the parts of a system working together can achieve more than the sum of achievements that each one would achieve separately. Entropy refers to the necessity of feedback across the chain to prevent debilitation of the system (New & Westbrook 2004). Hassan (2006) suggested the application of system engineering to the design and formation of supply chains. The structurist character of systems thinking can be helpful building the structure and operations of the supply chain in a systematic manner, assuring its effective functioning.

In terms of systems typology, supply chains are human activity systems and social systems, consisting of actions performed by individuals and groups of individuals, i.e. firms (Checkland 1981). Supply chains can be characterised as networks between economic actors (e.g. firms), engaged in a voluntary relationship to produce and deliver a product or service. Rouse (2005) considers the nature of firms as systems, and supply chains as 'systems of systems'. This is essential to fully understand and thus be able to find integrated solutions to improve firms and systems of firms, i.e. supply chains. However, systems approaches are not fully capable as yet of capturing 'soft factors' such as power, trust and human factors.

Supply chain viewed as a social system

In construction the relations between firms are typically maintained for the duration of the project. Supply chains are not merely directed towards minimizing transaction costs, but also towards enhancing the transfer of expertise and systematic feedback between parties, and ultimately towards joint value maximization. Increased co-operation and integration between supply chain parties enables delivery of a total product with quality guarantees to the market. Bounded rationality and differences in know-how between firms would be resolved by joint product development. Opportunistic behaviour is then replaced by mutual trust, which obviously is necessarily for an open dialogue, and an optimal knowledge sharing.

On an industry scale, Dubois and Gadde (2002) distinguish tight couplings in individual couplings in projects and loose couplings in the permanent network within the industry as a "loosely coupled system". The pattern of couplings influence productivity and innovation, and the behaviour of firms. In terms of organizational behaviour, cultural and human issues such as trust and learning have been indicated as major implications on construction supply chains (Love *et al.* 2002b). The social systems approach therefore lays the socio-organizational basis for improved inter-firm relationships within the supply chain.

Supply chain viewed as an economic system

In economic terms a supply chain is a series of economic actors, i.e. firms buying from and selling to each other. From an economic perspective the choice of a co-ordination or governance structure is made by economizing on the total sum of production and transaction costs (Williamson 1979). Transaction cost economics (TCE) provides an explanation for the existence and the nature of co-ordination within a supply chain (Hobbs 1996). When transaction costs are low, contracting is used (i.e. market structure), while internalization will prevail for high transaction costs (i.e. hierarchy). Intermediate modes are often referred to as hybrid modes Williamson 1991).

TCE recognises that transactions do not occur without friction. Transaction costs arise from the interaction between firms. These include costs for supplying information, negotiating, and monitoring or enforcement Hobbs 1996). Transaction costs would be zero if humans were honest and possessed unbounded rationality. Transactions costs for a particular transaction depend on the three critical dimensions: asset specificity, uncertainty and frequency (Williamson 1985). Besides, Milgrom and Roberts (1992) add two more items: difficulty of performance measurement, and connectedness to other transactions. Both are relevant from a supply chain viewpoint, and influence the possibilities to reduce transaction costs. Obviously improved collaboration and communication in the supply chain will reduce transaction costs.

Supply chain viewed as a production system
The supply chain is aimed at the delivery of a product or service to an end market or a single customer. This implies a production process which is purposive. The management of the production process needs to ensure the purpose of the process is achieved effectively and efficiently by addressing the transformation (conversion), flow and value aspects of production in an integrated manner (Koskela 2000). Following the analogy of the firm, all primary and support activities must be aligned and aimed at the delivery of customer value, and as a result profit of the supply chain (Porter 1985).

Supply chain viewed as an organisational system
Firms as well as supply chains are organisational systems built from various vital elements that make them function as they do. By viewing organisations as systems of flows, Mintzberg (1979) identifies four system representations of organisations together making up the structure and infrastructure of organisations; the organisation as a system of formal authority, regulated flows (material, information), informal communication, work constellations, and ad-hoc decision processes.

Typically, the supply chain is a ‘system of systems’, or a ‘superstructure’ of organisations’. Firms along the supply chain perform distributed production activities and business functions. This raises the issue of core competences of firms (Prahalad & Hamel 1990), together making up an ‘extended enterprise’. In construction this relates to the idea of the ‘quasi-firm’ coined by Eccles (1981).

Empirical phase of the research: empirical building blocks

Based on the theoretical building blocks, first a generic supply chain integration model will be built. The generic model will next be specified and validated by adding empirical ‘building blocks’ from few case studies of supply chain integration outside and inside construction. These case studies include multiple cases including the four cases below, i.e. two companies outside construction (truck manufacture and shipbuilding), and two construction firms (housing and commercial building). For reasons of limited space in this paper, below the four cases are described very briefly.

Supply chain integration outside construction: truck manufacture and shipbuilding
In the early 90s the Dutch truck industry went to a crisis. After drastic reforms most companies recovered, and are currently doing quite well. One of the measures was to reform and integrate the supply chain. Suppliers have been integrated in product development, planning and logistics. Towards the clients, in Europe, an integrated dealer network has been established, which assures direct follow-up of defects to trucks, and 24h on-road maintenance.

In the Dutch shipbuilding industry, few producers have improved their businesses drastically. They are globally leading companies in few product categories. For those products they have introduced strict standardisation and modularisation, and imposed this on their suppliers. This has improved the profitability and quality dramatically. Some suppliers have become 'external business' units, guaranteeing the close links.

Supply chain integration in construction: housing and commercial building
In the Dutch housing sector, few builders have transformed their business and became suppliers of completely pre-engineered house. They deliver houses from their catalogues to be built in 1 week. The different types of houses can be customised completely according to clients' wishes. The fully integrated in-house production and pre-installation of the houses assure a smooth process, and prevent delays and quality problems. In addition to the delivery of the house itself, they arrange for the permissions from local governments, mortgage, and other additional issues.

In the Netherlands, many project developers have moved their business towards the 'front end' of the supply chain. They have acquired land and existing building to be developed and redeveloped. Additionally they deliver all services desired by their clients including finances, maintenance, facility management and operations such as security and restaurants of offices. Some project developers have integrated the supply chain to such an extent that they actually became their own clients, in order to find users of their projects after completion.

Comparing supply chain integration outside and inside construction
When comparing the examples of supply chain integration inside and outside construction, one sees differences as well as similarities. Differences can be found in the possibilities to pre-engineer products, and integrate the supply chain. Outside construction the levels of pre-engineering and integration are higher, because levels of repetition are generally higher. Similarities can be found in the mechanisms to integrate design, follow-up clients, and offer additional services to clients. Apparently these issues are generally valid and play a role in most industrial sectors.

Squaring the theoretical and empirical building blocks to build the model for supply chain integration

The theoretical and empirical building blocks are arranged in a research cycle in order to build the model for supply chain integration (Figure 2). The research cycle is a closed loop starting from theory via hypotheses to empirical observations (deduction), and next from empirical observations via generalisations leading to theory (induction). This first step of the research cycle represents the theoretical framework which implies the development of an "initial model" based on existing theories. The last step is aimed at the building of the envisaged model for supply chain integration in construction, i.e. contribution to theory.

First the theoretical aspects of supply chain integration found in literature are squared with the empirical findings in the industries outside construction, identifying the supply chain integration strategies and techniques applied in those industries, and how they apply to the aspects found in literature ("analytical" cases). Next the supply chain integration strategies and techniques found in the industries outside construction are squared with examples of application of integrated strategies in construction, trying to find "translation routes" of more comprehensive supply chain integration strategies from the other industries to construction ("constructive" cases). Again the strategies in construction are observed as how they apply to the four aspects found in literature,

and how they relate to and affect the positions of parties along the integrated construction supply chain (Figure 3).

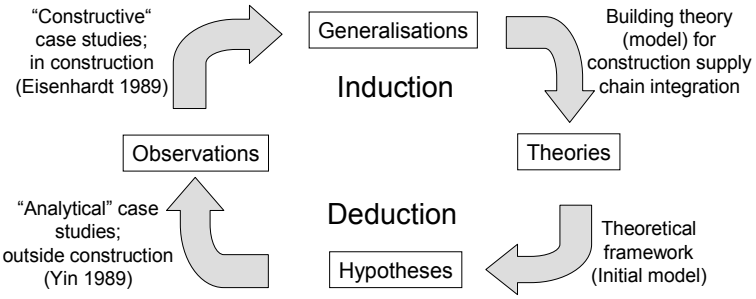

Figure 2: Research cycle squaring up theoretical and empirical building blocks (Adapted from Love et al. 2002a)

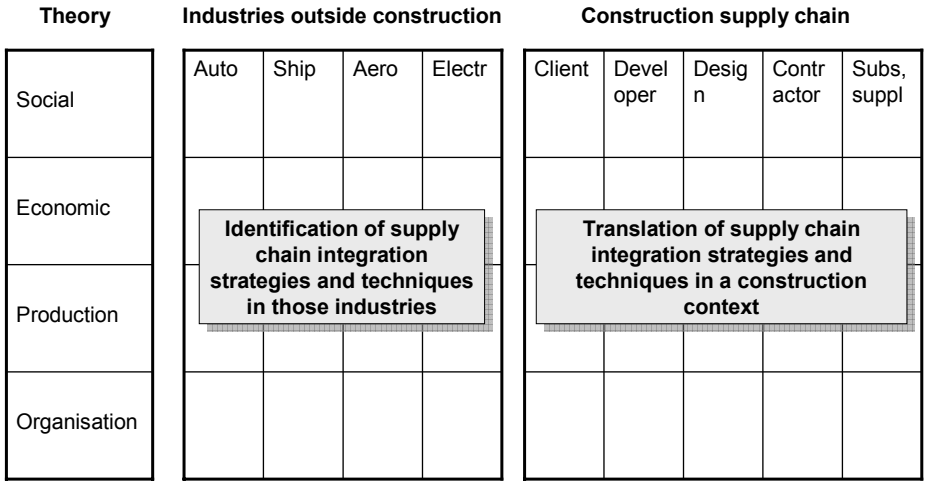

Figure 3: Squaring theoretical and empirical building blocks

The final step is to aggregate and generalise the last findings into the envisaged model for supply chain integration. This model represents a contribution to theory, but also implies a model that is applicable to practice. Therefore the model will be accompanied with a "change model" and guidelines for construction parties along the construction supply chain whishing to start applying construction supply chain integration to their supply chains.

CONCLUSIONS

Mode 2 knowledge production has the potential to improve the relevance of construction management research. It relates to the theory-driven empirical research approaches, and qualitative and interpretative research techniques often used in construction management research. It contributes to the aspiration of management research to understand as well as solve problems, and to test as well as build theory. However, a Mode 2 knowledge production often implies that researchers must redevelop their research strategies based on new methodological paradigms and methodological pluralism, rather than applying single methodology and following existing research traditions. This often leads to concerns about the rigour of these approaches. In the case of the postgraduate research presented in this paper Mode 2 knowledge production can help investigating and building a model (theory) for supply chain integration in construction squaring theoretical insights and empirical material,

within the empirical context of construction. This means the model must by adapted and built in correspondence with the characteristics of construction. A systems approach as proposed in this research is helpful to build the integration model, and improve construction supply chains as well. This approach implies a 'building exercise' using theoretical building blocks (concepts) and empirical buildings blocks (cases) leading to a theory and practical insights for 'organisational rebuilding' and integration of the construction supply chain.

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