

**STRATEGIC DEVELOPMENT OF THE BUILT ENVIRONMENT  
THROUGH INTERNATIONAL CONSTRUCTION, QUALITY AND  
PRODUCTIVITY MANAGEMENT**

By

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A thesis submitted to the University of Birmingham for the degree of  
DOCTOR OF SCIENCE

School of Civil Engineering  
College of Engineering and Physical Sciences  
The University of Birmingham

June 2012

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## **Abstract**

This thesis presents a coherent, sustained and substantial contribution to the advancement of knowledge or application of knowledge or both in the field of construction management and economics. More specifically, this thesis outlines the strategic development of the built environment through lessons from international construction, quality and productivity management. The strategic role of construction in economic development is emphasized. It describes the contributions transnational construction firms made towards modern-day construction project management practices globally. It establishes the relationship between construction quality and economic development and fosters a better understanding of total quality management and quality management systems in enhancing construction industry performance. Additionally, it prescribes lessons from the manufacturing industry for construction productivity and identifies the amount of carbon emissions reduced through lean construction management practices to alleviate the generally adverse effects of the built environment on global climate change. It highlights the need for integrated management systems to enhance quality and productivity for sustainable development in the built environment. The thesis is an account of how the built environment has evolved, leveraging on lessons from international construction, quality and productivity management for improvements over the past two decades.

## **Dedication**

This thesis is dedicated to my wonderful wife, Alice, and my two awesome children, Jasmine and Isaac. Thank you for the joy, the fun, and the laughter we have together as a family.

## **Acknowledgements**

This thesis would not have been possible without the kind help, encouragement and financial contributions generously given by so many people over the past 22 years. It all started in 1986 when the University of Birmingham gave me a scholarship to study construction management in the School of Civil Engineering, where I also have the good fortune of meeting Dr David Seymour. I am indebted to Dr David Seymour for providing me with a very solid grounding in construction management research for me to be able to write and publish my first journal paper. Between 1987 and 1990, Professor John Andrews was my doctoral supervisor at University College London (UCL) who not only further honed my research skills but also fired up my passion and interests in construction economics. I am what I am today because of what Dr David Seymour and Professor John Andrews have done for me in my formative years as a young researcher.

I am also grateful to the National University of Singapore, my employer, for providing an environment conducive for me to continue from where I left off in Birmingham and UCL. The past 22 years have been most fruitful, productive and enjoyable where my academic career is concerned. For this, I have many people to thank for making this possible: my colleagues, undergraduate and graduate students, collaborators, governments and funding agencies. None of this work would have been possible without their generosity and contributions to bring this thesis to fruition.

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## **1. Introduction**

This thesis presents a coherent, sustained and substantial contribution to the advancement of knowledge or application of knowledge or both in the field of construction management and economics. More specifically, this thesis outlines the strategic development of the built environment through lessons drawn from international construction, quality and productivity management over the past two decades. The thesis presents my publications in the three knowledge areas of:

- International Construction Management
- Construction Quality Management, and
- Construction Productivity Management

(Note: numbers in parentheses below refer to paper numbers in the chronological list of publications submitted.)

## **2. International Construction Management**

In the body of knowledge relating to international construction, I have contributed to a better understanding of the global construction market at the regional (8) and country (9) level, including the construction market in ASEAN (5), APEC (6) and EU using Geographical Information System (GIS) (215, 231) and computer-based cartograms in the case of EU (234) and ASEAN (235), as well as the effects of Free Trade Agreements (FTAs) on construction firms (220). From a macro-economic standpoint, I have shown the presence of a North-South divide in the global construction industry (4, 7). I have also contributed to a better understanding of the relationship between construction, marketing and economic development. From revisiting Turin's paradigm, the relationship between construction and economic development at the global level was first examined (15) and key concepts reviewed over the past 40 years (259); followed by establishing the relationship between global cement consumption and economic development (21). My analysis went on to synthesize the relationship between construction and marketing in global economic development (24). More significantly, and for the first time, the tripartite relationship between construction, marketing and economic development was established in Singapore (27, 32) and in a comparative study of Great Britain, the United States and Japan (28); as well as in ten African and Asian countries (36). These tripartite studies established the need for governments to synthesize construction and marketing when formulating policies relating to economic growth (33). A framework for planning construction and marketing in economic development policies was subsequently established (47) for this purpose.



I have shown how Singapore developed her forays in construction export marketing (10) and how construction firms in Singapore developed their strategic outlook and responses (14, 94) over two recessions and the importance of physical presence in the overseas construction market (253). From a structural standpoint, I have uncovered how international construction firms organized their marketing function when sourcing for projects overseas (2); the effectiveness of government intervention in export marketing by construction firms in Singapore (83); and the international project delivery systems that might be used by such firms by extending Dunning's Eclectic Paradigm to include the Specialty (S) advantage among the conventional Ownership, Location and Internalization (OLI) advantages (168<sup>1</sup>, 190<sup>2</sup>). The Eclectic Paradigm was further extended to better understand the operations of Singapore's transnational construction companies (142, 148, 173, 218). Moving beyond Singapore, the internationalization processes of top Chinese construction enterprises were examined (149, 153, 266) using rough sets analysis (205), and their international performance measured (157) with respect to top international (159, 164) and British construction firms (162). I have provided a better understanding of how Chinese construction enterprises practised external risk management in the international market (228, 246) and the role of organizational learning for such practices (240).

I have contributed to a better understanding of cultural issues when businesses internationalized their operations, particularly within the general context of East Asia and more specifically, in China (109, 120, 132, 135) as well as problems faced by Chinese construction

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<sup>1</sup> Keynote paper presented at the invitation of Kyoto University and the Architectural Institute of Japan.

<sup>2</sup> This paper was presented at the invitation of the Chartered Institute of Building (Malaysia Centre) and the Master Builders' Association, Malaysia (MBAM).

workers overseas (230). Beginning with a need for international corporations to understand Chinese philosophies in order to do business in China (48<sup>3</sup>, 140), the influence of Chinese philosophies on arbitration was examined (50). Subsequently, specific Chinese treatises were singled out for further studies. These included how Sun Tzu's *Art of War* could be applied positively for developing leadership qualities, client-project manager relationship (31), and retail marketing (77). Lao Tzu's *Tao Te Ching* (from which Taoism evolved) was another important Chinese treatise that could be applied for developing positive project leadership (46). Detailed studies relating to ancient philosophies and management principles were completed, specifically those whose origins were in China, and how these might be applied for effective and/or strategic construction project management. These included Thai battlefield strategies (65); biblical wisdom (78, 91); Sun Tzu's *Art of War* (41, 171, 177); Zhuge Liang's *Art of Management* (67<sup>4</sup>, 68, 88); the Thirty-six Chinese Classical Strategies (44, 97); the Thick Face, Black Heart philosophy (69); and Tao Zhugong's Business Principles (101<sup>5</sup>, 105, 125, 169). Construction technology used in old conservation projects (60, 63) and in ancient China was examined (131, 165) to determine the management principles used to manage such projects. The major findings seemed to suggest that such principles were not any different from the strategic project management concepts applied in the modern-day context (195, 210), with an extension to the application of the Blue Ocean strategy in construction (248).

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<sup>3</sup> This paper won a Certificate of Merit award in the world-wide Millennium 2000 Essay Competition organized by The CPD Foundation, London in conjunction with 17 construction-related professional institutions in the United Kingdom that included the CIOB, ICE, RIBA, RICS, etc.

<sup>4</sup> This paper won the MCB University Press Citation of Excellence Award.

<sup>5</sup> This paper won the Best Paper Award (2000) from the Royal Institution of Surveyors, Malaysia; the first time in the history of the Institution that the same author won the award in two consecutive years. See Footnote 6.

Construction procurement was another area in which I have made a sustained contribution to the advancement of knowledge. This included my joint research project with the Singapore Institute of Surveyors and Valuers (SISV) into the use of different procurement methods in Singapore (12); management contracting (84); Design and Build (D&B) (87<sup>6</sup>, 112); selection of design consultants in D&B projects (113, 143); selection of sub-contractors for refurbishment projects (166, 174); partnering, relationship marketing (90, 138, 227); strategic marketing mix for quantity surveying firms (59); work-life balance of consultant quantity surveyors (256) and work-family conflicts experienced by project managers in China (268); the impact of a newly introduced Goods and Services Tax (GST) in the construction industry (38); the attributes developers looked for when selecting real estate marketing agencies (29, 37, 39); homeowners' expectations (160); en bloc property transactions (89); developers' crisis management (96) and management of natural disasters from a construction industry development viewpoint (204) and the associated issues of crisis communication (243); effectiveness of managing agents (26); factors influencing design development time (75, 79) and effective communications (181); ethical issues (45) that caused insolvency of sub-contractors (156); creditworthiness (194) and risks management using a prediction model for workmen's compensation insurance premiums via a fuzzy knowledge-based decision support system (192, 199, 202, 213, 217, 219, 226); and arising there-from, issues relating to Business Continuity Management (BCM) (224, 232, 250) within the context of an Institutional Framework in China, Hong Kong and Singapore (258).

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<sup>6</sup> This paper won the Best Paper Award (1999) from the Royal Institution of Surveyors, Malaysia.

A joint research project in collaboration with the Project Development and Management Branch of the Ministry of Education identified the causes (179) and effects (188) of variations (163) in school building projects; the measures and modeling of a knowledge-based decision support system (184, 189<sup>7</sup>, 191, 193, 196, 200, 203, 214) that might be implemented to reduce their negative impact over a project's time-line (209); how developers (182), designers (180) and contractors (198) perceived such occurrences of variations; and the associated contractual implications (212) as well as the causes of construction delays in selected ASEAN countries (238) and in China (247).

In summary, the major contributions which I have made in this segment of the construction industry include the following:

- a. I have extended Turin's paradigm of construction and economic development to further include marketing at the global, regional and country level.
- b. I have established a better understanding of how transnational construction companies evolved and performed globally; including extending Dunning's Eclectic Paradigm (OLI advantages) to further include the Specialty (S) advantage.
- c. I have applied time immemorial strategic management/business principles (particularly those from China) to modern-day construction project management practices.
- d. I have contributed to a better understanding of various issues that might impact upon procurement in the construction industry and the closely allied real estate sector.

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<sup>7</sup> This paper was presented at the invitation of the Project Management Institute (Singapore Chapter) after the research team led by me won the Donald S. Barrie Award for Best Paper from the PMI, United States.

### 3. Construction Quality Management

I have also contributed to a significant body of knowledge in the area of construction quality and more specifically, in the field of ISO 9000. I have conducted studies into what construction quality entailed (1, 3), how it was rationalized contractually (25), and appropriately implemented using IT (11). A significant contribution to professional practice relates to my extensive studies on how quality assurance and ISO 9000 were implemented by architects (17, 49, 56), developers (23), engineers (13), quantity surveyors (43), small contracting firms (57) and in civil engineering projects (35). The relationship between construction quality and economic development was established for the first time (22, 245); including the influence of workload instability on construction quality (52); and public policies implemented by the Singapore government to manage construction quality (53).

I have examined how ISO 9000 was implemented in Singapore (19, 20, 42, 85, 167) and elsewhere (114) at various time periods (136, 257); the problems encountered (30, 34, 70); and in collaboration with the then Construction Industry Development Board, determined the effectiveness of ISO 9000 in raising quality standards (93) and how quality costs might be quantified (76) in a joint research project. The problems relating to segmentalism and maintenance of (58, 72) as well as authority/power (64, 261) in ISO 9000 quality management systems (QMS) were identified, including that of middle management (241). A systemic view to managing total service quality was eventually established as a necessity (73<sup>8</sup>) for contractors to accomplish good quality standards (155<sup>9</sup>), including cross-cultural influence on QMS (108) and

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<sup>8</sup> This paper won the MCB University Press Literati Club's Outstanding Paper Award.

<sup>9</sup> This paper won the Best Paper Award at the Joint International Symposium of CIB W55, W65 and W107 on Knowledge Construction.

legal implications of the Price-Quality Method (208, 211). Other quality concepts such as Quality Function Deployment (QFD) (100, 123, 128, 141, 150, 151); QS 9000 (104); Six Sigma (161); Value Engineering/Value Management (236) and their applications in the construction industry were examined.

A framework for implementing Total Quality Management (TQM) in construction firms was proposed (55, 252); and applied in construction firms (158, 260); and in public housing (124, 137), drawing lessons on how Japan managed to raise its post-war quality standards through the samurai's zero-defect mindset as presented in the *Book of Five Rings* (62<sup>10</sup>) and *Hoshin Kanri* (242). The relationship between organizational culture and TQM in construction firms was established (223).

I have contributed significantly to a better understanding of the legal/contractual implications relating to various quality and productivity concepts, including those of ISO 9000 (71); Construction Quality Assessment System (CONQUAS) (80); QFD (92<sup>11</sup>); buildability principles (102) and the Buildable Design Appraisal System (BDAS) (126); JIT philosophy (106<sup>12</sup>); and QS 9000 (110). A first in built environment research, I have also examined how Total Building Performance or the TBP concept and its associated performance mandates could affect buildability (221, 222, 229) and extension into China for possible application (216).

A significant contribution relates to my studies on integrated management systems (178) using ISO 9000 as the global platform for integrating other quality and/or productivity concepts

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<sup>10</sup> This paper won the MCB University Press Topman Global Forum Award.

<sup>11</sup> The legal/contractual implications of this paper were developed from an earlier paper by the first author who won a Best Paper Award from the Singapore Institute of Engineering Technologists.

<sup>12</sup> This paper attained an Excellent Rating from His Honour Judge Humphrey Lloyd, QC of the High Court of Justice in England and Wales.

(115<sup>13</sup>, 118) such as the Just-In-Time philosophy (86, 99, 111); buildability principles (103, 116, 122) and linkages with sustainability (255) as these affect building envelope design (265); construction safety principles (107, 139) and OHSAS 18001 (145); ISO 14001 (186); QS 9000 (117); Japanese 5-S principles (129, 144); TQM (147); in reducing building defects (121, 134) and in a joint research project partly funded by the Building and Construction Authority, identified the measures for preventing latent building defects (154, 187, 201).

In summary, the major contributions which I have made in this segment of the construction industry include the following:

- a. I am the first person to establish the relationship between construction quality and economic development.
- b. I have contributed to a better understanding of ISO 9000 quality management systems and TQM in the construction industry.
- c. I have contributed to a better understanding of the legal/contractual implications of various quality and productivity concepts when applied in the construction industry.
- d. I have identified the need for, and successfully applied integrated management systems to enhance quality and productivity in the construction industry.

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<sup>13</sup> This paper won the Best Paper Award at the 5<sup>th</sup> International Conference on ISO 9000 and TQM.

#### **4. Construction Productivity Management**

I am arguably one of the very few researchers in the construction management fraternity who contributed to a coherent, sustained and significant body of knowledge relating to the application of JIT principles in construction and providing a bridge to western management theories (264). This body of knowledge included studies that examined how productivity might be raised in the construction industry in Singapore (18, 74); the need for integration of architectural and engineering designs (40); and success factors for managing large-scale upgrading programs in public housing (54).

Having its origin in manufacturing (237), the JIT philosophy in the construction industry was reviewed for its applicability (16, 81) and readiness for application by precasters (127) and main contractors (130). This was followed by extensive studies of how JIT might be applied in the following scenarios to raise productivity: facilities design and layout in industrial (225) and airport terminal buildings (262); process layout for the production and management of precast concrete components (51, 98, 119, 133, 146) to avoid site congestion; measuring JIT wastages in public housing (61), D&B school (66) and private condominium (82) projects; and site layout (95). Being a perishable product, it was established that the production and delivery of ready mixed concrete could benefit tremendously from the application of JIT principles (152) both in China (170) and Singapore (185); although the implementation of JIT purchasing could be dependent on fixed costs (197) and the Economic Order Quantities (EOQ) with/without a price discount (172<sup>14</sup>, 175, 176, 183, 206, 207).

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<sup>14</sup> This paper was rated the top-ranked accessed paper for the Journal of Construction Research in 2007.



In sustainable construction, JIT and by extension, lean management, was found useful for mitigating carbon emissions (233). The Institutional Framework was applied to better understand the sustainable agenda (244), with the journey towards green buildings (249)<sup>15</sup> and the development of various building/sustainability controls (263)<sup>16</sup> as well as green rating systems (251) over time tracked. Carbon labeling practices in construction were found to benefit from lean management principles (267)<sup>17</sup>, with lean production leading to enhanced sustainability in a precast concrete factory (269) and reduced embodied carbon in precast concrete columns (270). Policies relating to cross-border movements of foreign workers and their implications for carbon emissions were established (239). Innovation-wise, it was found that outer-space technology has immense potential contributions for sustainability (254).

In summary, the major contributions which I have made in this segment of the construction industry include the following:

- a. I have established the applicability of JIT principles to raise productivity in the construction industry.
- b. I have applied JIT principles specifically in site management, precast concrete and ready mixed concrete production and deliveries.
- c. I have extended JIT and Lean management principles in facilities design and layout of buildings.

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<sup>15</sup> Keynote paper presented at the invitation of the National University of Malaysia, University of Malaya and the Construction Industry Development Board, Malaysia.

<sup>16</sup> Keynote paper presented at the invitation of University Technology Mara, Royal Institution of Surveyors (Malaysia) and the Royal Institution of Chartered Surveyors.

<sup>17</sup> This paper won the Best Paper Award at the Second International Conference on Project and Facilities Management.

- d. I have quantified the amount of carbon emissions that may be reduced through lean management in construction.

## **5. Conclusion**

The construction industry plays a significant role in economic development. It is important to ensure that processes and practices in the construction industry are carried out to acceptable quality standards, productively. Where an indigenous industry is limited by resource and/or technical constraints, international construction firms play a strategic role in plugging the gaps. This thesis draws on the author's contributions over the past two decades in drawing out lessons from international construction management, construction quality management and construction productivity management to achieve strategic development of the built environment. These lessons collectively provide best practice guidelines for policy-makers in the global construction industry. Future research directions will increasingly point towards sustainable development and growth in the construction industry, a built environment that is friendly to an ageing population, and practices that promote inclusivity in divergent societies.

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