VIRTUAL MANUFACTURING

Critical Capabilities and Actual Practice

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Preface

Welcome to the world of virtual manufacturing! This book[1] explores the critical capabilities of virtual manufacturing and their implications for organisational performance in today's rapidly changing business landscape.

Virtual manufacturing has emerged as a transformative approach, going beyond traditional practices of outsourcing and subcontracting. It leverages operations strategies, supply chain management techniques, and business dynamics to achieve a competitive edge. Understanding the critical capabilities that drive virtual manufacturing is essential for sustaining business success.

This book fills a gap in research by identifying and examining the relationship between critical capabilities and organisational performance in virtual manufacturing. Through surveys and data analysis, four critical capabilities are identified, namely relationship capability, technological capability, dynamic capability, and marketing capability. These capabilities significantly influence organisational performance measures such as personnel performance, corporate social performance, relationship performance, and marketing performance.

A case study of King's Flair International (Holdings) Limited validates the statistical findings, while benchmarking with Li & Fung Limited provides additional insights. This book empowers virtual manufacturing firms to prioritise and allocate resources effectively, enhancing their critical capabilities and achieving superior organisational performance.

1 This book is a modified version of the following doctoral thesis: Wong, S.W. (2019). "An Exploratory Study of the Critical Capabilities of Virtual Manufacturing and Their Organizational Performance Implications". *DBA Thesis*, Faculty of Business, The Hong Kong Polytechnic University, Hong Kong.

Join us on this journey into the realm of virtual manufacturing, where innovation and strategic capabilities drive success in a dynamic global economy.

Prof. Alex Wong Siu-wah
Prof. Petrus Choy Wai-cho
Ir Prof. Edwin Cheng Tai-chiu

Acknowledgements

It was a long but amazing six-year journey to complete The Hong Kong Polytechnic University (PolyU) DBA programme. Finally, I have been fortunate enough to reach the destination of my dream – as a "scholar-leader".

Despite having been conferred honorary doctoral degrees by various tertiary education institutions in recognition of my active support and participation in their social and charitable activities, my strong inclination and desire to obtain a doctoral degree by my own efforts were always in my mind. Thus, I was so pleased to gain admission to the PolyU DBA programme in 2013. Unfortunately, the initial stage of my academic journey was not as smooth as I had been expecting. Immediately after commencing my DBA studies, I became completely occupied with the listing requirements and corporate restructuring exercises of my company, which was to be listed on the Hong Kong Stock Exchange. In the first three years of my studies, I only managed to complete two out of the eight required taught subjects, which meant that I had to complete the remaining six taught subjects and, most daunting of all, the doctoral thesis in the remaining three years. It was tough, but a really worthwhile learning experience in terms of both the academic knowledge and professional application that I garnered from the University's knowledgeable and committed professors and mentors.

In the last four decades, I have been working in the manufacturing industry accumulating considerable experience and expertise. After founding my own company, King's Flair, in 1979, I have devoted all my time and efforts to developing the business itself on the one hand, and fine-tuning the business and management approaches on the other. With the efforts and commitment of my colleagues, I am fortunate enough to have achieved my goal, which was recognised by the market and my customers. However, I was somehow at a loss at the beginning of my DBA study as I felt that I was not quite able to

match the academic knowledge I was gaining from the programme with my practical experience, which I had developed over the years based on my own management philosophy, approaches, and disciplines in the past years. However, with my professors' dedicated teaching and inspirational sharing, and my close interaction with my classmates from different disciplines and professions, I was able to gradually pick up my learning momentum and elevate myself to become a "scholar-leader", which has enabled me to continue to widen my exposure and apply what I have learned in breadth and depth in my daily work.

I would like to take this opportunity to express my sincere gratitude and appreciation to all the DBA programme respected professors, who kindly shared their insightful knowledge, suggestions, comments, and advice with me over the six years of my studies. Special gratitude and appreciation shall go to my two doctoral thesis supervisors, Ir Prof. Edwin Cheng and Prof. Petrus Choy, who meticulously, patiently, and positively supported, guided, and walked with me throughout the hectic journey to the successful completion of my doctoral thesis. Both of them provided tremendous encouragement to me in the last two years every time when I was not able to understand some technical issues or when I failed to move forward my doctoral thesis. I must say that my doctoral thesis would not have been completed without their great support and generous patience. Needless to say, I am more able to apply the findings of my doctoral thesis practically in enhancing and fine-tuning my business and management philosophy, approaches, and disciplines.

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I strongly believe that the completion of my DBA programme was not the end-point, but rather a starting point from which I can utilise the huge reservoir of knowledge gained for my life-long usage. I assure everyone who has contributed to my DBA journey that I will continuously devote my best efforts to widening and deepening my knowledge with help from all of you.

My heartfelt thanks and appreciation to all of you once again – let us walk and work together to build a better world and community for the best well-being of all.

Prof. Alex Wong Siu-wah

Abstract

Virtual manufacturing is an emerging manufacturing approach that is increasingly popular among manufacturers. Unlike conventional approaches of outsourcing and/or subcontracting different aspects of operational functions for the purposes of cost reduction, the success of virtual manufacturing requires an in-depth understanding and innovative application of operations strategies, supply chain management techniques, and business dynamics that are key to operations management. On the other hand, the ongoing downturn in the global economy, together with such trends as rapidly changing customer behaviour and increasing societal demand, has rendered the manufacturing industry highly competitive. Therefore, it is necessary for virtual manufacturing firms to find ways to sustain their businesses and organisational performance. Identification of the critical capabilities of virtual manufacturing is the first step in this direction because it enables virtual manufacturing firms to understand the sources of their competitive advantage on the one hand, and to leverage their assets to achieve superior organisational performance on the other.

The aim of this study is then to identify the critical capabilities of firms that adopt virtual manufacturing and understand the implications of their organisational performance. To-date, studies on virtual manufacturing are limited. Specifically, few studies have been conducted to identify the critical capabilities of virtual manufacturing and examine how these are related to the firms' organisational performance. To fill this gap, the study compiled two lists of initial constructs of capabilities and organisational performance measures, both from an academic perspective (based on generic and industry-specific manufacturing perspectives) and from a practical perspective (employing a Grounded Theory approach based on focus groups). From the two lists, nine initial constructs comprising 100 measurement indicators of capabilities and six initial constructs with 70 measurement indicators of organisational performance

measures relevant to virtual manufacturing were identified. Based on these constructs and their corresponding measurement indicators of capabilities and organisational performance measures, a structured survey questionnaire was designed for data collection and applied to conduct an organisational-level field study. The survey questionnaire was sent to 193 selected suppliers of King's Flair International (Holdings) Limited (KFI) (SEHK: 6822.HK). The survey returned 150 valid responses, which were analysed by exploratory factor analysis to identify the potential critical capabilities and organisational performance measures relevant to virtual manufacturing, and by multiple regression analysis to examine their relationships to determine the critical capabilities of virtual manufacturing and their organisational performance implications.

Four critical capabilities, namely *Relationship Capability, Technological Capability, Dynamic Capability,* and *Marketing Capability*, and four organisational performance measures, namely *Personnel Performance, Corporate Social Performance, Relationship Performance*, and *Marketing Performance* were identified. The four critical capabilities are statistically associated with the four organisational performance measures at different levels of significance. *Relationship Capability* is the most prominent among the four critical capabilities as, in the case of virtual manufacturing, it is significantly associated with all the four organisational performance measures.

A case study of KFI was conducted to validate the study's statistical findings, whereby the measures and practices undertaken to achieve superior organisational performance were critically reviewed and discussed. Another listed virtual manufacturing company in Hong Kong, Li & Fung Limited (SEHK: 494.HK), was also studied for benchmarking purposes.

This study contributes to research on virtual manufacturing from an academic perspective by identifying the critical capabilities of virtual manufacturing, and on the practice of virtual manufacturing from

an application perspective by establishing the relationships among the critical capabilities and different organisational performance measures. This study also contributes to real-world operations management by providing guidance to virtual manufacturing firms on prioritising and allocating resources for developing, maintaining, and enhancing their critical capabilities to attain superior organisational performance.

Keywords: Critical Capability, Organisational Performance, Virtual Manufacturing

CHAPTER 1

Introduction

1.1 Background

1.1.1 What is Virtual Manufacturing?

Virtual manufacturing is an emerging manufacturing approach that is increasingly popular among manufacturers in response to the ever-shortening product life cycle and the ever-changing business environment. Demand for high-end products and high-quality services has become the fundamental feature of the manufacturing and business sectors in recent years (Reed, Lemak & Mero, 2000; Lee, Wang & Liu, 2011). At the same time, markets and customers are becoming highly diversified, prompting businesses to turn to specialisation and globalisation. As a result, faster responsiveness to unexpected and dynamic changes in the markets and customers is becoming the key factor for business success, growth, and survival. It is unsurprising that demand is growing rapidly for highly effective and efficient businesses that are capable of enabling agile manufacturing and marketing, and dynamic operations (Zhang & Sharifi, 2007). Outsourcing and subcontracting have long been among the legacy of business approaches in the manufacturing sector. However, "virtual manufacturing" has evolved and is gaining increasing attention from both practitioners and academics in the field of operations management.

Previous studies have discussed virtual manufacturing from different perspectives (see, for example, Jain, Choong, Aye & Luo, 2001; Offodile & Abdel-Malek, 2002; Sha & Che, 2005; Wang, Tai & Wei, 2006; Sarkis, Talluri & Gunasekaran, 2007; Shamsuzzoha & Helo, 2018). Bharath & Patil (2015) conducted a literature review focusing on various aspects of virtual manufacturing in terms of

its definition, history, types, visions, benefits, systems, methods, applications, future research, and drawbacks. In their study, and also in the study by Bohidar & Sen (2015), virtual manufacturing is considered as the application of "virtual reality" and "augmented reality" technologies to simulate and improve production processes. Therefore, in this sense, virtual manufacturing is not concerned only with production of physical goods, but also production in the computer and network system related to virtual software and systems. Jain et al. (2001) proposed that in order to cope with the rapid product and process realisation and to enable enterprise integration, a virtual factory could be developed on the basis of extensive simulation technology to facilitate the design and validation of all major parts of a manufacturing system. They argued that the use of a virtual factory should be extended to other stages of manufacturing due to the prevalent modelling and simulation essential to the next generation of manufacturing. Similarly, Wang et al. (2006) argued that virtual integration between a firm and its suppliers was similar to vertical quasi-integration in lean supply, which offered benefits based on the assumption that vertical integration should provide these benefits, and that flexibility is the main focus of this virtual integration. Sarkis et al. (2007) and Swierczek & Kisperska-Moron (2016) considered an agile virtual enterprise or virtual supply chain as a strategic alliance of independent business processes or enterprises with each contributing "core competencies" in such areas as design, manufacturing, and distribution to the customer networks. They also suggested that such types of new organisational structure as agile virtual enterprises, dynamic network companies, and value-added partnerships could be solutions to effectively dealing with the pressures of constantly changing customer needs and mass customisation requirements (Johnston & Lawrence, 1991; Byrne, Brandt & Port, 1993; Christopher & Towill, 2000; Gou, Huang, Liu & Li, 2003; Ekbia & Kling, 2005; Swafford, Ghosh & Murthy, 2006a; Swafford, Ghosh & Murthy, 2006b). Agile manufacturing is defined as the capability that allows firm to survive and grow in a competitive business environment due to their significant and dynamic marketing changes, based on the fact that this capability

equips firm with quick and effective reaction to proactively respond to the external environment, which is often driven by customer needs and consumer behaviour (Zhang & Sharifi, 2007; Singh Patel, Samuel & Sharma, 2017).

Therefore, in this study, virtual manufacturing is defined, in a broad sense, as a vertical end-to-end approach, which enables agile manufacturing, in which the virtual manufacturing firm proactively responds to the needs of downstream customers in terms of marketing of products and, at the same time, dynamically leads, monitors, and controls the operations of a great number of upstream suppliers with production factories and facilities without directly or indirectly owning any significant manufacturing-related equipment. This definition emphasises three key aspects of virtual manufacturing:

- the ultimate goal of virtual manufacturing is to facilitate an agile supply chain,
- a virtual manufacturing firm does not merely deliver physical products and/or value-added services to customers, but also virtual or digital products and/or services, and
- like an agile virtual enterprises network, without directly or indirectly owning any production factory and/or facility, a virtual manufacturing firm dynamically leads, monitors, and controls operations of upstream suppliers with production factories and facilities.

For the purpose of elaborating, discussing, and analysing the features and operations of virtual manufacturing, King's Flair International (Holdings) Limited (KFI) (HKSE: 6822.HK) was adopted for this study. KFI has been listed on the Hong Kong Stock Exchange since 2015. By employing and adopting virtual manufacturing as defined above, KFI has successfully transformed from a traditional manufacturing factory to one of the world's leading suppliers of houseware products. This study discusses virtual manufacturing

in the context of the businesses and operations of KFI. In the sections below, the characteristics of virtual manufacturing and its implementation in KFI are first described, followed by detailed descriptions and discussion of the differences between traditional manufacturing and virtual manufacturing.

1.1.2 Characteristics of Virtual Manufacturing

This section describes the features of virtual manufacturing and also gives a brief introduction to the virtual manufacturing workflow based on the business operations of KFI. From an academic viewpoint of operations management, virtual manufacturing employs a unique set of operational strategies, supply chain management techniques, and business capabilities that are profoundly different from the conventional approaches of outsourcing and/or subcontracting,

In general, unlike conventional outsourcing, virtual manufacturing firms are more closely bonded with outsourcing factories and production facilities in terms of product development, material sourcing, production control, warehousing, and logistics. Virtual manufacturing firms are also able to maintain or even improve their production capacity and efficiency as compared to subcontracting firms. In addition, unlike traditional manufacturing firms, virtual manufacturing firms take part in all manufacturing activities without directly and indirectly owning any physical factories and/or production facilities. Instead, virtual manufacturing firms work very closely with their upstream suppliers and logistics providers on the one hand and downstream customers on the other in regard to aspects such as product design, engineering, and quality control rather than simply production operations. Shamsuzzoha & Helo (2018) argued that the idea of a collaborative product development process could be defined in detail through an example network, in which the participating firms form a temporary virtual organisation and make contributions to the whole product development

processes. Offodile & Abdel-Malek (2002), on the other hand, emphasised the characteristics of virtual manufacturing specifically from the perspective of technology development. They described virtual manufacturing as the use of information technology and computer simulation to model and simulate real world manufacturing processes for the purpose of analysing and understanding the process.

As a firm implementing a vertical end-to-end virtual manufacturing approach, KFI is mainly involved in the design, development, and supply of houseware products and services to international customers, with the products being sold on by the company's customer-owned distribution channels to local retailers. KFI also outsources its entire manufacturing operations to its associated upstream suppliers who own production factories and facilities in China. By doing so, KFI itself acts as a virtual manufacturer providing a vertical end-to-end manufacturing and servicing platform by connecting its upstream facility-owning suppliers with downstream customers possessing distribution channels. Figure 1 shows the essential details and activities of KFI's virtual manufacturing activities.

Virtual manufacturing has emerged as a transformative approach, going beyond traditional practices of outsourcing and subcontracting. It leverages operations strategies, supply chain management techniques, and business dynamics to achieve a competitive edge. Understanding the critical capabilities that drive virtual manufacturing is essential for sustaining business success.

This book explores the critical capabilities of virtual manufacturing and their implications for organisational performance in today's rapidly changing business landscape. It fills a gap in research by identifying and examining the relationship between critical capabilities and organisational performance in virtual manufacturing.

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