Tracking the Evolution of Research Issues on Agility

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Abstract
This study traces the evolution of past researches in agility. Personal interpretations from authors as participant-observers are combined with a data-based analysis of the evolution of agility research. Bibliographic analysis spanning the last 17 years (1991-2008) provides the basis for the study. A chronological surveying traces its evolution within these years. Discussion of literature identifies how research issues and research methods have evolved. It could be observed what have been found and what remain to be answered in agility. Finally, this study, by presenting the evolution of researches in agility, provides further insights for future studies with respect to where this topic should or would develop.

Keywords: Agility, agile manufacturing, agile supply chain

1. Introduction

Over the last 17 years, fundamental changes have occurred in business environments with these changes having dramatically transformed business strategies. Consumers demand more variety, finer quality and better services in terms of their reliability and response times. At the same time, product life cycles have been shortened while products are proliferating. To satisfy these requirements, a new production paradigm, agility, emerges to respond to these rigorous challenges. Agility is defined as a business-wide practice that comprises organizational structures, information systems, logistical processes, and employee mindsets (Christopher, 2000). Now, this concept is showing in many companies, such as Zara (Christopher, 2000), Griffin (Christopher and Towill, 2002; Stratton and Warburton, 2003), Nokia (Collin and Lorenzin, 2006), and Dell (Christopher and Towill, 2002).

Although related studies on ability have developed for nearly 17 years, some research challenges remain. First, researchers often talk about agility to aim at specific issues and we don’t have an overall map to position research achievements. Therefore, to look back on the growing concern and application of agility as a rediscovery of the concept to find out what is new and what has been changed might shed some light. We need to ask ourselves what we already know and what we still need to learn about agility in a new business environment and organizational context. Second, most authors have developed their own concepts and enablers of agility, but existing works are few to be foundations of further researches and hence, have weak impacts on the development of theory. Yet a thorough review that organizes and

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summarizes the research literature over the last decade to reflect the changing environment is lacking. It is unclear what exactly has been learned from researches and what questions remain unresolved. In our opinion, it is very important to lay a foundation for future researches on introspecting existing achievements. Finally, although some literature-review-based studies have been published (e.g. Gunasekaran, 1999a; Leitao et al., 2001; Mohammed et al., 2008; Onuh et al., 2007; Sanchez and Nagi, 2001; Sheresiya et al., 2007; Vernadat, 1999; Yusuf et al., 1999), these studies mainly focused on summarizing the key concepts, drivers and attributes of agile manufactures that employ agility theory and then constructed a framework to facilitate agility process in manufacturing industries. A literature review that outlines the evolution of the research issues on agility is necessary for future research directions. In particular, the issue development of agility after post-2000 substantially differs from pre-2000 in the sense that agility is discussed under the context of supply chains. Moreover, agility has been combined with an opposite concept, i.e. leanness, to develop a new concept: leagility. These features differentiate this literature review from previous studies.

Since it is worthwhile to review what has happened about the idea based on existing studies, this paper tries to review the literature on agility that has been available to date. The aim is to compare and classify existing researches so both contents and research methods that be used are taken as criteria in a systematic overview of the available literature. Some key elements (such as the field/ subject of research, the definition agility and it’s construct/ attribute, and the methodology to achieve agility) of the agility research will be identified to characterize and classify these works. We hope to present the development evolution of researches and some important research findings in this area. Finally, future research challenges or limits will be discussed and some aspects for future studies will be suggested.

The rest of this paper is organized as follows. Section 2 introduces the research method used in this research. Then in Section 3, the literature review presents a summary of key papers. Research methods employed in the literature are discussed after a survey of the contents in Section 4. Based on findings from this review, some future directions of the agility study are proposed in Section 5.

2. Research method

Critical Incident Technique (CIT) is employed for data classification in this study. The CIT, as a method of classification, “determines categories based on analysis of a specific set of data and is particularly useful when there is little documentation of the properties that are likely to be important for classifying” (Bitner et al., 1990) or when the concepts or phenomena are not entirely clear or understood (Walker and Truly, 1992). Therefore, CIT is deemed appropriate for this study.

Applying CIT methodology involves: (a) identifying the critical incidents that are the target of investigation, (b) collecting data, and (c) using content analysis to interpret the data (Flanagan, 1954). Therefore, using trained people to collect data is necessary to assure data quality. To collect suitable literature, two trained Ph.D. candidates (A and B) in a Department of Business Management volunteered to administer the survey. The bibliographic data employed here are from academic journals, books and conference proceedings. Notably, this review did not include textbooks. Such books explain the basics of agility theory, but do not present new research issues and contributions. Furthermore, the academic papers investigated in this research were not limited to any particular discipline, since the goal is to identify various perspectives of agility. The term agility or agile were input as a search key in the ABI/INFORM, the EBSCO, the Emerald Fulltext, the Science Direct, and the Taylor & Francis systems. References in papers were checked for more related papers. Hence, the
literature examined was primarily English-language studies. Moreover, numerous publications listed here were judged to be of significant interest and value to this area. Papers that did not match with research purposes were omitted. Finally, about 137 publications are obtained. There should be other studies about agility, but their focuses are not pertinent to this study and are not detailed here.

The two judges, A and B, then independently read through the abstracts of these publications to do classification. The publications were firstly sorted by their published year and further adjusting them by their themes. Different opinions were resolved through discussion. After completing the first round of sorting, the two judges and one of the principal researchers compared the content of categories to achieve as much conformity as possible in the final categorization schema. The categorization of literature results in the emergence of four different stages. The first stage represents the concept building and its meanings in manufacturing, the second stage discusses the processing of achieving agile manufacturing, the third stage repositions agility in the context of supply chains and compares agility with other paradigms, and the fourth stage provides concrete methods for achieving/measuring agility. This division is somewhat arbitrary but reasonable. Although some overlap existed in the years among four stages, this had no effect on research. A summary tally of agility literature across the four evolutionary stages is presented in Table 1.

3. Reviewing the evolution of the concept of agility

In the following subsections, the concept evolution in agility is analyzed to identify what has been already known and what still requires development. It should be noticed that although 137 publications were obtained, only those papers that make major contributions to the development of the theory or that are often cited in many studies are discussed.

3.1 Stage 1: Building the concept and meanings in agile manufacturing

The global marketplace has been undergoing dramatic changes and becoming more sophisticated for the last twenty years. This new context requires better-quality goods and services. Furthermore, U.S.A. enterprises have faced increased threats from competitors such as Japanese-based manufacturers. The terms “agility” or “agile manufacturing” were originally developed in manufacturing industries in U.S.A. in 1991 as a paradigm capable of enhancing efficiency and competitiveness edge. The agility philosophy later blossomed into a new production paradigm that was seen as a synthesis of existing technologies and methods of organizing production systems (Goldman and Nagel, 1993). In the following, the delineation of this stage is observed followed by a discussion of the contributions and features of some important publications.

In the early stages of agility research, most publications focused mainly on clarifying what agility was. Numerous definitions and constructs for agile manufacturing were proposed to describe the observed changes in the marketplace. Agility has been defined either in term of outcomes, such as “dynamic, context specific, aggressively change embracing and growth oriented…succeeding…winning profits, market share and customers,” (Goldman et al., 1995) or the ability of a business to grow in a competitive market with continuous and unanticipated change (Kidd, 1996). Alternatively, it has been defined as operationalization (Kidd, 1994) that enabled cooperative enterprises to adapt and to respond quickly to consumers’ constantly changing needs (Yusuf et al., 1999). The perspectives developed during this period were significantly varied. Each definition or construct was based on a scholar’s understanding of agility (see Table 2).
### Table 1. The collected publications (until July 2008)

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<td>Journal articles</td>
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<td>Journal articles</td>
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<tr>
<th>Stage 3 (1999-2007)</th>
<th>N= 40</th>
<th>N= 2</th>
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<tr>
<td>Journal articles</td>
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<tr>
<td>Books/Book chapter</td>
<td>Christopher and Towill (2000a) and Harrison et al. (1999).</td>
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<td>Conference proceedings/working papers</td>
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<th>Stage 4 (2006-present)</th>
<th>N= 17</th>
<th>N= 1</th>
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<td>Books/Book chapter</td>
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Table 2. Main publications and their contributions in the first stage

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<tr>
<th>Author/ year</th>
<th>Definition of agility</th>
<th>Major contribution</th>
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<tbody>
<tr>
<td>Youssef (1992)</td>
<td>No explicit definition. It indicated that agile manufacturing, quick response and time-to-market were related.</td>
<td>Positioning agility in a new paradigm.</td>
</tr>
<tr>
<td>Goldman and Nagel (1993)</td>
<td>Agility assimilates the full range of flexible production technologies, along with the lessons learned form TQM, JIT, and lean production.</td>
<td>Discussing the background where agility appears.</td>
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<tr>
<td>Kidd (1994)</td>
<td>Agile manufacturing seeks to cope with demand volatility by allowing changes to be made in an economically able and timely manner.</td>
<td>Defining and clarifying the concept of agile manufacturing.</td>
</tr>
<tr>
<td>Nagel and Bhargava (1994)</td>
<td>Agility is the ability to move quickly and resourcefully, and in an adaptive manner.</td>
<td>Indicating the principles of agile manufacturing and encouraging absorbing this concept into the criteria of Malcolm Baldrige National Quality Award.</td>
</tr>
<tr>
<td>Goldman et al. (1995)</td>
<td>Agility is a comprehensive, strategic response to fundamental and irreversible structural changes.</td>
<td>Discussing the emergence, characteristics and social implication of agility.</td>
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There are three noteworthy characteristics in this stage. First, agility was discussed in single enterprises that were required to adjust to fast-changing external changes. During the 1980s and early 1990s, most manufacturing companies were experiencing dramatic changes in the competitive environment, a result of numerous factors, including increasing globalization, market fluctuations, development of IT, etc. All these changes forced companies to develop new skills and capabilities to deal with the new marketplace. However, adjustments were usually internal and consequently, the scope of the new “agile manufacturing paradigm” was limited to individual enterprises. There was little concern about cooperating with other companies to achieve agility.

Second, these studies laid the foundation for later development. Definitions or concepts created in this stage were widely used or cited in later studies. For example, the works of Goldman and Nagel (1993) and Kidd (1994) were cited by Sharifi and Zhang (1999) with the goal of crystallizing the definitions in these works and developing a methodology to achieve it. More details about the research of Sharifi and Zhang will be introduced in the following. The constructs of agility proposed by Goldman et al. (1995) were extended by Katayama and Bennett (1999) as indices for measuring agility-related performances.

Finally, since this saw the development of the concept agile manufacturing, this stage was still primitive in terms of the development of research methodology. Most of the research in this stage was theoretical. Definition-based assertions about the characteristics of agility were often the principal focus of these papers. Perhaps the major result of this stage was that agility was circumscribed. Few papers incorporated empirical investigations. The novelty of this field meant avenues for publication were somewhat limited.

In summary, as the new paradigm, a fundamental debate regarding the position and legitimacy of agility emerged from this stage and continued for a long time. Initially, agility was considered to be a new way of describing the lean/flexible approach to running a manufacturing business (Sheridan, 1993; Richards, 1996). While there are similarities between agility and established paradigms, there are fundamental differences as well. The first step defining agility or determining how agile a company already is may be to distinguish
between the characteristics of agility and other established paradigms such as mass, lean, or flexible manufacturing. In this stage, some researchers argued that agility may be a new paradigm to replace previous paradigms (Burgess, 1994; Noaker, 1994; Goldman et al., 1995; Richards, 1996), and similar arguments have been debated for a long time. On the other hand, although a number of reports have appeared in the business press and business journals (e.g. Youssef, 1992; Sheridan, 1993; Vasilash, 1993), theories of and implementation methods for agile manufacturing need to be advanced well. These unresolved issues have guided research directions of the second stage of evolution.

3.2 Stage 2: Achieving agile manufacturing on strategic aspects

Stage 2 was a time of significant interest in agility, especially in manufacturing sectors. Although the leanness versus agility debate began to wane, it was still a lingering dispute. Developing methods to achieve agile manufacturing became the foundation of this stage. Moreover, during this stage, more scholars began to explore issues unique to agility theory and hence, the number of paper published increased significantly, particularly in the International Journal of Agile Management Systems and International Journal of Production Economics.

3.2.1 General observations

Although the definitions for and the constructs of agility had been developed for some time, how to move an enterprise toward agile manufacturing still required an answer (Sharifi and Zhang, 1999). Typically, research into methods for achieving agility was ignored. Researches began to address this issue in this stage. Emphases switched from developing a “suitable” definition to how to achieve agile manufacturing successfully. This switch resulted in the development of numerous enablers, methodologies and comprehensive models. Furthermore, earlier in this stage, approaches tended to be tactic-oriented and were viewed from a single perspective. Immediately thereafter, increasing numbers of integrated systems or models to achieve agile manufacturing were proposed. These models highlighted systematic schemes to implementing agility throughout an entire organization.

Moreover, the growth of works dealing with agility issues during the Stage 2 is well documented (see Table 1). Notably, most papers about agility published during Stage 2 were not limited in journals of production management area, such as in the International Journal of Logistics Management, International Journal of Production Economics, Logistics and Transport Focus, and Supply Chain Management: An International Journal. In addition, the first journal dedicated mainly to the study of agility, the International Journal of Agile Management Systems, was established in 1999. The increasing number of published research in these journals meant that a pattern of innovation in the field of agility research had begun. Increasing numbers of scholars began research in this field. However, few papers about agility were published in SSCI or SCI journals. Even agility literature was not positioned in the academia. This fact seems to imply that there was a problem developing in the field.

3.2.2 Relevant publications

As identified by Goldman et al. (1995), implementing agility is extremely context dependent. Fliedner and Vokurka (1997) noted that firms were implementing a variety of specific strategic practices to achieve agility. These practices included initiatives implemented both internally (within an organization) and externally (to other organizations) to enhance competitiveness. Backhouse and Burns (1999) also considered internal agility as well as external agility. However, they argued that being agile both externally and internally might not be the most optimal way for an individual enterprise to enhance competitive edge. The best strategy was to utilize characteristics of external agility combined with internal agility, called internal flexibility. This combination of models could be achieved by controlling the
value chain. Comparing with the two studies, there are similarities, i.e., both internal and external agility are discussed both papers are the first to explore how to best achieve agility strategically. However, agility remained to be considered as the abilities of an enterprise. Although the concept of external agility had been proposed, little has been said about supply chains nor did agility have a place in supply chain systems. Despite similarities in both studies, Fliedner and Vokurka (1997) only listed initiatives corresponding to external and internal agility implemented in practices. They neither differentiated the two agilities nor identified suitable situations for each. In contrast, Backhouse and Burns (1999) more precisely differentiated between internal and external agility and explored methods to achieve them through value chains.

Although the concept of agility has been developed for a while and had taken its place in the research area, a statistical survey by Katayama and Bennett (1999) showed that realizing agility was not an easy task. They investigated the role of agility in Japanese manufacturing companies and found that even if the companies were aware of the importance of agility and had implemented action programs, their policies were developed on an item-by-item basis. Investments within enterprises focused on separate improvements no yet linked to concrete actions of agility. This is the only empirical study to date that provides a report from the industrial sector and plays a pivotal role in elucidating experimentation with agility in industries as well as in providing directions for future development of agility theory. Their survey suggested that until the late '90s, there was no business reported to possess all the defined specifications of agility. Hence, it is necessary to consider an adjustment in the developing direction for agility, which leads to the following works.

Sharifi and Zhange (1999) also believed that the proposals for moving toward an agile state and the characteristics defined for an agile manufacturer were more or less Utopian expression. The problem was seen to be rooted in the lack of systematic methods and support tools; the former could assist organizations in deciding how to implement agility while the latter were helpful when making strategic decisions in the pursuit of agile manufacturing. Based on these perspectives, Sharifi and Zhange developed a series of long-term projects (Sharifi and Zhang, 1999, 2001; Zhange and Sharifi, 2000) to create a conceptual model for implementing agility and accordingly developed a methodology to guide manufacturers in formulating matching strategic policies. Then, tools on questionnaire were developed to assist enterprises in applying the methodology for achieving agile manufacturing. The concepts employed by the methodology were supported both by a large-scale industrial investigation and by in-depth case studies. Results of these studies played a crucial role in realizing agility in the sense that they extended the research scope beyond its theoretical stage and made agile manufacturing more feasible, concrete and complete. More importantly, the models and questionnaires could be generalized to other industries or other countries.

Similar to Sharifi and Chang’s series studies, Gunasekaran et al. also developed series studies of their own for producing agile manufacturing systems with different methods (Gunasekaran, 1998; 1999a; 1999b; Yusuf et al., 1999). In contrast to the studies by Sharifi and Zhange where a conceptual model was developed and refined through literature surveys, questionnaire surveys and case studies, Gunasekaran et al. proposed an integrated agile manufacturing system solely from reviewing and classifying previous research on agile manufacturing. This integrated framework took into account the customization and system integration that could identify key strategies and procedures of agile manufacturing. Based on this system, a case study of an aerospace company was performed (Gunasekaran et al., 2002). Although, according to Gunasekaran et al., this model could be tested with suitable empirical studies and multiple case studies, there was only one case study presented in the series studies. The lack of empirical studies may lie in the difficulty posed by business unfamiliar with the notion of agility. Other researchers, including Sharifi and Zhange, faced this same obstacle.
Despite many large and comprehensive schemes for achieving strategically agile manufacturing, little research has focused on tactics. In 1996, Cho et al. proposed enabling technologies such as standard for the exchange of product (STEP), concurrent engineering (CE), component-based distributed shop floor control system (SFCS) and virtual manufacturing. In Stage 2, this study was the only one that discussed agile manufacturing from a technical and instrumentation perspective even though the proposed IT skills may not be very unusual. Another important feature of their research was that they studied various activities related to agile manufacturing in Korea, rather than in the West.

Overall, studies in Stage 2 attempted to validate agility concepts in terms of business practices. Case studies and empirical data started to appear; however, they took a minor role in supporting the authors’ viewpoints as common business practices did not match the proposed construct of agility. Additionally, attention was focused on integrating all sections within a company in carrying out agile manufacturing (Fliedner and Vokurka, 1997; Backhouse and Burns, 1999) and led to more studies exploring agility across organizations in Stage 3. However, the primary focus in Stage 2 was on a single enterprise. Moreover, the prescriptions for agility in Stage 2 were only confined to the context or structure of manufacturing organizations (see Table 3).

Table 3. Main publications and their contributions in the second stage

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<tr>
<th>Author/ year</th>
<th>Definitions of agility</th>
<th>Major contribution</th>
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<tr>
<td>Cho et al. (1996)</td>
<td>The capability of surviving and prospering…by reacting quickly and effectively to changing markets, driven by customer-designed products and services.</td>
<td>Presenting various enablers related to agile manufacturing under development in Korea.</td>
</tr>
<tr>
<td>Fliedner and Vokurka</td>
<td>The ability to successfully market low-cost, high-quality products with short lead times and in varying volumes that provide enhanced value to customers through customization.</td>
<td>To address internal and external initiatives to promote agility and enrich customers.</td>
</tr>
<tr>
<td>Gunasekaran (1999a)</td>
<td>Same as Cho et al. (1996).</td>
<td>Integrating strategies and technologies into a system to form an agile manufacturing system.</td>
</tr>
<tr>
<td>Backhouse and Burns</td>
<td>The ability of an enterprise to adapt unpredicted changes in the external environment.</td>
<td>Building a new performance measurement for agile manufacturing.</td>
</tr>
<tr>
<td>Sharp et al. (1999)</td>
<td>Adopting the ones of Kidd (1994) and Goldman et al. (1995).</td>
<td>Proposing a conceptual model based on joint researches and assessing the current states where UK’s companies are becoming agile firms.</td>
</tr>
<tr>
<td>Katayama and Bennett</td>
<td>Same as Kidd (1994).</td>
<td>Comparing with three production paradigms and examining where the agile concepts are explored in Japan.</td>
</tr>
<tr>
<td>Sharifi and Zhang</td>
<td>Same as Kidd (1994).</td>
<td>Forming a complete framework that is assisted by statistical surveys to find a way to achieve agility.</td>
</tr>
<tr>
<td>Sharifi and Zhang</td>
<td>N/A</td>
<td>Applying the result from Zhang and Sharifi (2000) into two UK manufacturing companies</td>
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3.3 Stage 3: Move from agile manufacturing to agile supply chain

This stage could be characterized as a key period in the agility literature. There has been negligible discussion of whether agility replaced leanness, but rather research focused on how to combine the two paradigms. This focus problem resulted in a field that is becoming increasingly cross-organizational as many of the issues under researched have multiple roots and multiple solutions that span traditional organizational boundaries.

3.3.1 General observations

The year 1999 was an obvious turning point with the development of the new paradigm leagility. Its emergence marks the start of Stage 3. Three characteristics in this stage differentiate it from the two earlier stages. First, perspectives on agility have changed from agile manufacturing to agile supply chains after 1999. This phenomenon reflected new contexts in which competition was no longer among companies, but among supply chains. Operating as a single enterprise was insufficient for satisfying the needs of end consumers or understanding the marketplace. Second, based on supply chain frameworks, a new discussion emphasized combining two production paradigms, agility and leanness, which in turn redefined and enriched the meaning of agility. The new concept, namely, leagility, was developed and feasible methods to combine both paradigms soon appeared. The question of whether leanness could be, or should be, replaced or supplemented by agility was no longer disputed. Third, a comparison of Stage 3 to the two earlier stages demonstrated that this phase was more practice-oriented and few articles relied on pure theory. Theories and practices were now almost inseparable. More solid and detailed case studies were developed, which served as more than a mere foil to theories.

In this stage, agility articles published in journals became more empirically based and theory driven, as opposed to focusing on conceptual discussions or debates. Moreover, since the discrimination between agility and leanness was ignored, researchers began to focus on substantive business issues and the problems stemming from practical phenomena. However, not until Stage 3 could a cohesive core of research be identified. And yet most research papers were published in academic journals in the manufacturing or production areas. This fact means that more effort is needed to enrich agility research.

3.3.2 Primary papers

The forerunner in this stage is the article published by Naylor et al. (1999). They claimed that two current popular paradigms—leanness and agility—could be and have been combined within successful well-designed supply chains. Their proposition extended the extent of agility research and result in the new paradigm leagility. After the article was published, there were two principal changes in the evolution of agility. Agile supply chains, not agile manufacturing, became the focal point of research. Moreover, the definitions and constructs of different paradigms were no longer the prime concern. The work of Naylor et al. (1999) formed the basis upon which most future studies were based. The concept of combining leanness and agility became generally accepted. The research focus was now on developing techniques that integrate the two models; this perspective was later adopted as the primary focus for most research.

Based on the argument presented by Naylor et al. (1999), Mason-Jones et al. (2000a, 2000b) further explored the leagility paradigm. They differentiated between the characteristics of leanness and agility by the total value metric in Johansson et al. (1993), market qualifiers—market winners in Hill (1993) and product classification from Fisher (1997). Leanness and agility could then be combined with a decoupling point and the notion of postponement in a supply chain. The position of a decoupling point was identified according to the characteristics of product and market and hence, affected the supply chain’s structure. This
fact meant that the position of a decoupling point could be used to decide when and where to adopt leaness or agility. Clearly, the concepts presented by Mason-Jones et al. were more feasible than Naylor et al. (1999). One of their case studies was to describe a leagile supply chain for electronics products (Mason-Jones et al., 2000b), which verified that leagility existed in practices.

Later, Christopher and Towill went a step further and expanded the discussion in Naylor et al. (1999) and Mason-Jones et al. (2000a, 2000b). Christopher and Towill supported the concept of hybrid supply-chain strategies and identified three practical ways of combing the lean and agile paradigms: the decoupling point; the Pareto curve approach; and, by separating demands into base and surge (Christopher, 2000; Christopher and Towill, 2000b; 2001). These three strategies were complementary rather than mutually exclusive, and yet it was likely that each would work better than others in certain contexts. Christopher and Towill (2001) proposed that identifying methods to combine leaness and agility appropriately should be the real focus of enabling a leagile supply chain. Therefore, an integrated model for enabling the agile supply chain was proposed. This model was illustrated with a lighting-manufacturer case study (Aitken et al., 2002) and to demonstrate that a pure strategy was insufficient.

McCullen and Towill (2001) also showed that a connection between the lean and agile approaches existed by employing a case study under the supply-chain framework. Differing from previous research, they argued that the methods for achieving leaness and agility separately may be markedly similar and the only difference was in the outcome and strategic intention used to drive through the necessary changes. Thus, by viewing manufacturing in the context of the supply chain as a whole, it was possible to see how agile manufacturing could subsume the paradigm of lean production.

Although most agility studies provided conceptual overviews (Gunasekaran, 1999a; Sharifi and Zhang, 1999; Yusuf et al., 1999) and offered preliminary empirical assessments for agility (Sharp et al., 1999), van Hoek et al. (2001) argued that existing literature primarily presented agility as a general-management or as a concept with a strongly manufacturing bias. Explicit linkages that fused agility and supply chain management were needed. From this viewpoint, van Hoek et al. were to build such an explicit fusion. They used existing researches on various sections in the supply chain as building blocks and then introduced a preliminary strategy for creating an agile supply chain, in which there were four cornerstones: customer sensitivity, process, network and virtual integration. Based on this framework, an audit process was developed with the goal of understanding the status and challenges in agile capabilities. This agility audit was then employed in an empirical investigation in Europe to investigate the level at which the concept of the agile supply chain was accepted and applied in practices. Findings showed that, among the four cornerstones, customer sensitivity was the primary concern in today’s turbulent marketplace.

In addition to decoupling point identification, there are other approaches to achieve a leagile supply chain. One such method is transshipment. Most research of the leagile supply chain was heavily dependent on identifying the decoupling point, which, in turn, is enabled by postponement. Postponement strategies, however, present a cross-functional challenge for implementation and new organizational relationships must be introduced and costly investments made. On account of these obstacles, Herer et al. (2002) proposed a tactically feasible approach that monitored the movement of stock between locations at the same echelon level in a supply chain. These stock movements, referred to as transshipments, naturally led to coordinated replenishment policies across locations.

Another approach was proposed by Stratton and Warburton (2003). They argued that leaness and agility were in practice caught in a trade-off conflict. However, if it were possible to define explicitly the trade-offs, then a solution to resolve this contradiction was
possible. In this way, they interpreted the conflict nature in terms of dependency, fluctuation, inventory and capacity, and then systematically linked such trade-offs to develop another hybrid approach. This approach was combined with other approaches: the theory of inventive problem solving (TRIZ for short) and the theory of constraints (TOC for short). TRIZ consisting of a number of principle-based solution systems was applied to solve the physical contradictions between leanness and agility while TOC was resolving trade-offs for highly complementing to TRIZ. The Griffin Manufacturing case study was utilized to illustrate how to use these approaches to integrate strategically agile and lean supply chains (Warburton and Stratton, 2002).

In summary, how to effectively merge leanness and agility paradigms was the primary concern in Stage 3. There are numerous feasible methods for integration and many case studies or practice-oriented discussions that verify these methods (see Table 4). Moreover, the connection between the two paradigms was achieved under supply chain frameworks, not in single enterprises. However, although there may exist various ways to combine them, it is significantly important that lean production is a necessary but not a sufficient condition for achieving agility (Kidd, 1994; Robertson and Jones, 1999; Mason-Jones et al., 2000b; Christopher and Towill, 2001). Furthermore, agility cannot be achieved without experiencing relevant stages of leanness. Mason-Jones et al. (2000a) presented two reasons for this fact. First, lean and agile supply chains share many common features that help speed up the achievement of leagility. Hence, agility may be initiated by building on the relevant features of leanness. Second, agility requires control of all processes in the supply chain. It is difficult, if not impossible, to see how agility can be acquired without having first gone through the process enhancement stage of lean production.

3.4 Stage 4: Concrete methods for achieving agility

Based on the development of the previous stages, it is obvious that there is no “one fits all” strategy to achieve agility. The most effective strategy to implement the agile paradigm will be markedly contingent upon contexts, depending various conditions, for example, product type, demand characteristics, and information richness, etc. Under this consideration, how to implement agility contingently is the key question. More and more studies provide solutions for achieving agility, especially within recent three years. Compared with the second stage, the methods for achieving agility proposed in the fourth stage are more concrete and these studies make agility become a management practice, rather than an abstract concept. The related studies are listed in Table 5.

4. Observations for research methods

Despite the productive development in theory, there is lack of discussions regarding research methodologies for agility. Here, various research methods in our collected publications (not including books) were roughly divided into four types: theoretical/conceptual, simulation/modeling, case study, and statistical survey (see Table 7). Notably, more than two methods may be used in one paper.

In addition, although many studies have developed measurements to evaluate how agility an enterprise is (e.g. Arteta and Giachetti, 2004; Giachetti et al., 2003; Kassim and Zain, 2004; Sarkis, 2001; Sieger et al., 2000; Sharp et al., 1999; Tsourveloudis, 2005; Tsourveloudis and Valavanis, 2002; Tsourveloudis et al., 1999; Weber, 2002), researches that tried to measure performances from agility are relatively few in previous stages. In the fourth stage, another main research issue is to measure performance from applying agility with different research methods. A suitable performance measurements and techniques are helpful to justify investment and implementing change. The measurement of implementing agility is the second focus in the fourth stage and related studies are listed in Table 6.
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Definitions of agility</th>
<th>The approach to combine paradigms</th>
<th>Major contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naylor et al. (1999)</td>
<td>Using market knowledge and a virtual corporation to exploit profitable opportunities in a volatile market place.</td>
<td>The decoupling point and the notion of postponement.</td>
<td>Combining lean and agile thinking via decoupling point and market knowledge.</td>
</tr>
<tr>
<td>Mason-Jones et al. (2000 a)</td>
<td>Same as Naylor et al. (1999).</td>
<td>Same as Naylor et al. (1999).</td>
<td>Expanding the concept of Naylor et al. (1999) focusing on how to achieve leagility through reengineering the supply chain.</td>
</tr>
<tr>
<td>Mason-Jones et al. (2000 b)</td>
<td>Same as Naylor et al. (1999).</td>
<td>Same as Naylor et al. (1999).</td>
<td>To expand the concept of Naylor et al. (1999) by adding the concept of product types to decide the supply chain strategy.</td>
</tr>
<tr>
<td>Christopher and Towill (2001)</td>
<td>Same as Naylor et al. (1999).</td>
<td>An integrated model for enabling the agile supply chain.</td>
<td>An integrated approach to supply chain design is proposed based on Mason-Jones et al. (2000a, 2000b) and Christopher and Towill (2000a, 2000b).</td>
</tr>
<tr>
<td>McCullen and Towill (2001)</td>
<td>Same as Kidd (1994).</td>
<td>N/A</td>
<td>The difference between lean and agile approaches may be just in terms of outcomes and strategic intents.</td>
</tr>
<tr>
<td>Van Hoek et al. (2001)</td>
<td>N/A</td>
<td>A preliminary framework for creating an agile supply chain.</td>
<td>Building a preliminary framework for creating an agile supply chain and then develop an audit to investigate firms’ agile capabilities.</td>
</tr>
<tr>
<td>Herer et al. (2002)</td>
<td>Same as Naylor et al. (1999).</td>
<td>The notion of transshipment.</td>
<td>Proposing a tactical approach, transshipments, which can be implemented quickly with limited monetary investments.</td>
</tr>
</tbody>
</table>
Table 5. The approaches for achieving agility

<table>
<thead>
<tr>
<th>Author/ year</th>
<th>The approach for achieving agility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baramichai et al. (2007)</td>
<td>A tool, named the Agile Supply Chain Transformation Matrix (ASCTM), is proposed to help companies identify the most appropriate way to improve their supply chain agility.</td>
</tr>
<tr>
<td>Collin and Lorenzin (2006)</td>
<td>Through the case study with Nokia, they suggested that suppliers should pay more attention on effectively utilizing customer's project plans for aligning their supply chain.</td>
</tr>
<tr>
<td>Ismail and Sharifi (2006); Sharifi et al. (2006)</td>
<td>A model which integrates aspects relating to product development and supply chain development is proposed and these aspects are defined as “design of supply chain” (SCD) and “design for the supply chain” (DfSc).</td>
</tr>
<tr>
<td>Jiang and Chen (2007)</td>
<td>A production planning and scheduling framework, which integrates lean and agile production concepts, is proposed.</td>
</tr>
<tr>
<td>Masson et al. (2007)</td>
<td>Identify key elements of contemporary supply chain management practice, namely the growing use of global supply for innovative products and the essential and valuable role played by intermediaries in such supply chains.</td>
</tr>
<tr>
<td>Onuh et al. (2007)</td>
<td>Argue that Rapid Prototyping (RP) and Rapid Manufacturing (RM) has been used successfully for implementing agility in a number of research fields.</td>
</tr>
<tr>
<td>Ramesh and Devadasan (2007a)</td>
<td>Through reviewing literature, this article proposes a comprehensive model that identifies the criteria for attaining agility and suggest a procedure to successfully implement it in manufacturing sectors.</td>
</tr>
<tr>
<td>Tanimizu et al. (2006)</td>
<td>Propose a new reactive scheduling method based on the Genetic Algorithm (GA) to achieve agile manufacturing system.</td>
</tr>
<tr>
<td>Verma (2006)</td>
<td>Use a base stock model and computer based simulations to calculated the fill rate, probability that the order has arrived before demand, and the reorder point.</td>
</tr>
<tr>
<td>Vinodh et al. (2008)</td>
<td>A technique named as “agile Innovative Total Quality Function Deployment” (agile ITQFD) is proposed and tested with case study to verify the feasibility of successfully implementing agile ITQFD.</td>
</tr>
</tbody>
</table>

Table 6. The method of measuring the performance of agility

<table>
<thead>
<tr>
<th>Author/ year</th>
<th>The method of measuring the performance of agility</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faisal et al. (2007)</td>
<td>Quantify supply chain agility on the bases of agility attributes and sub-attributes.</td>
<td>Using the graph theoretic approach, interdependencies at system and sub-system levels were visualized along with their contribution to the overall supply chain agility.</td>
</tr>
<tr>
<td>Goldsby et al. (2006)</td>
<td>Build simulation analyses in the Heating, Ventilating, and Air-Conditioning industry.</td>
<td>The lean system excels in customer service performance while the leagile system results in lower enterprise-wide inventory levels under modeled circumstances.</td>
</tr>
<tr>
<td>Liu and Zheng (2006)</td>
<td>Using analytic hierarchy process (AHP) and Bayesian belief networks (BBN) to arrive at a reasonable final decision.</td>
<td>(1) AHP-BBN is effective for aggregating a group of expert's opinions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) AHP-BBN is easy for presentation and documentation.</td>
</tr>
<tr>
<td>Ramesh and Devadasan (2007b)</td>
<td>Being carrying out the tools for qualifying and quantifying agility in manufacturing companies.</td>
<td>Implementing agile manufacturing practices leads to better operational, market and financial performance.</td>
</tr>
<tr>
<td>Vázquez-Bustelo et al. (2007)</td>
<td>A conceptual mode is developed based the literature, and then this model is tested on manufacturers using a survey methodology.</td>
<td></td>
</tr>
</tbody>
</table>

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Table 7. The statistic of research methods

<table>
<thead>
<tr>
<th>Stage</th>
<th>Theoretical/conceptual</th>
<th>Case study</th>
<th>Simulation/modeling</th>
<th>Statistical survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>13</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Stage 2</td>
<td>23</td>
<td>16</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>Stage 3</td>
<td>22</td>
<td>14</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Stage 4</td>
<td>2</td>
<td>8</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>40</td>
<td>29</td>
<td>14</td>
</tr>
</tbody>
</table>

As to the characteristics of research methods in each stage, the first stage was a period of concept development. Most articles were focused on defining agility’s concepts and hence, most work was theoretical with few small-scale case studies. It was in the level of philosophy. When the agility evolved to the second stage, the discussion switched to a focus on the feasibility of agility and diversified research methods (especially case study and simulation/modeling) were used. However, pure theoretical discussions on feasibility still dominated in this stage, practical facts only played a supportive role in explaining theories. Consequently, what they specified was briefly sketched and only descriptive. The important exceptions were the study conducted by Katayama and Bennett (1999) and a series of long-term projects developed by Sharifi and Zhang (Sharifi and Zhang, 1999; 2001; Zhang and Sharifi, 2000), in which a large-scale industrial survey were performed. In Stage 3 and Stage 4, the research issues are more and more concrete and lead to case studies playing a significant role in investigation. Various theoretical models were proposed with the verification by case studies. Based on these observations, we could conclude discussions and proposed three suggestions as follows.

First, most researches are mainly concerned with theory building further verified by case studies. These theories lack the support of practical examples that truly implemented agility from scratch, and the empirical analyses require to confirm the theoretical arguments. Most of existing empirical researches in agility are based on case studies. However, many of these cases are exploited to demonstrate authors’ position, while the case studies of companies are not necessarily constructed from the principle of agility. Therefore, we suggest that research methods should be diversified to get evidences with both validity and credibility.

Second, since each expert has his own viewpoint of agility, agility still remains a very contested concept. The diversified characteristics of agility lead to difficulties generalizing each case to other companies or other industries. Existing statistical surveys are not broad in scope and as such, multi-company comparisons are rare. Furthermore, the studies have few significant results demonstrated agility’s effectiveness (e.g. Hoyt et al., 1997; van Hoek et al., 2001; Vázquez-Bustelo et al., 2007). One of the reasons for the scarcity might be that suitable samples were relatively rare. Another problem might be that it was not easy to compare companies or industries when each has different degrees of agility. To understand that whether agility is commonly accepted and whether it differs across different industries, questionnaire survey is necessary to be conducted.

Finally, the observed enterprises in empirical studies were primarily concentrated in manufacturing, and especially in industries producing electronics products and apparel. This may be misleading while the concept of agility is not only suitable in manufacturing industries. However, empirical results obtained by Menor et al. (2001) in the retail banking sector demonstrated that service industries showed agility characteristics just like their manufacturing counterparts. Therefore, the scope of the related studies in the future should not be limited to the manufacturing sector.
5. Envisioning the future studies

This article documents the findings, emergence, and contributions of a new production paradigm presented in literature. According to observations, although the concept of agility has evolved over 17 years, it still does not been viewed as a main research area. It is obvious that the related studies on agility are few to be seen in SSCI/SCI journals. Hence, reviewing agility literature might be viewed as a summary of previous research achievements and help people to get familiar with the concept. The article tries to capture the origins and development of the concept and theory of agility to some time period and some limited extent. By presenting the developmental evolution of agility research, directions for future studies are proposed.

First, methods to implement agility need to be reexamined. The main obstacle to agility research is that suitable agile samples are relatively rare and difficult to find. Perhaps the scope of agility is so extensive that many researchers attempt to suggest a general framework for building agile systems. Nevertheless, because of its comprehensive characteristics, it is difficult to identify an agility benchmark and judge which actions would achieve agility and which will not. Therefore, there is significant lack of guidelines for any enterprise that wants to implement agility philosophy. The barrier may be moderated if the concept of agility could be materialized, just like JIT or six-sigma. Fostering applied guidelines of agility is an important and difficult task. These guidelines are required in the near future.

Second, until now, interfaces between agile organizations and agile supply chains are lacking. Although numerous studies explored the issues associated with agile organizations, including innovative alliances, agile-enabled technologies, flat organizations, team-based productions, empowerment strategies etc., there is very little analysis of how to deal with cross-functional or cross-organizational issues. Since the core concept of agility is business-wide ability, considerations of inter- and intra-system linkages are inevitable. These systems require a high level of connectivity between a firm and its strategic partners. This connectivity would cover not only the exchange of demand-based information and inventory levels, but also the multiple and collaborative working relationships across organizations at all levels. It is increasingly common for companies to create cross-functional teams to interface with customers and suppliers. This is an issue worthy of further investigation.

Finally, we suggest that extension of agility’s scope is needed. Although there are considerable numbers of papers discussing agility research, most of these studies still stay in a manufacturing environment (Ramesh and Devadasan, 2007b). There may be four directions to extend. (a) Investigate the current situation of applying agility. According to the literature review, agility is recognized as an important production paradigm. However, why there are so few empirical studies? Does agility been utilized as important as it was expected? These questions are interesting to explore. (b) Extend to other fields. Most recent studies focus on agile manufacturing and agile supply chains. Research in other fields is lacking, which may eventually affect the working definition for agility. Marketing, for example, could be considered to be within the scope of research and increase the effectiveness of agility. Human resources are another field that could be utilized. It is almost impossible to achieve agility without knowledgeable, skilled, and innovative work forces. Consequently, approaches to cultivating human resources that fit with agility is an issue to be considered while working on the structure of the agility. (c) Extend to other industries. Most studies are focusing on manufacturing industries, but other industries may be suitable in applying agility as well. For example, Menor et al. (2001) demonstrated that services, specifically retail banks, displayed agility characteristics similar to manufacturing industries. Poolton et al. (2006) extended the principles of “agile manufacturing” to marketing strategy, planning and management, in the context of small and medium-sized enterprises (SMEs). Therefore the scope of related studies...
in the future should not be limited to the manufacturing sector. (d) Extend to other contexts. Most empirical investigations about agility applications have been conducted in the Western regions (especially in the U.S.A. and the U.K.), but agility may also be widely practiced in other regions such as the Asia Pacific. In countries that have very limited resources and rely heavily on export, agility plays a key role in economic survival; Hong Kong, Taiwan and Singapore are three successful examples. Studies based on these countries may shed light on the agility theory and, hence, help countries that share similar situations.

References


