Enterprise Networks and Logistics for Agile Manufacturing
Enterprise Networks and Logistics for Agile Manufacturing
Preface

Manufacturing has been one of the key areas that support and influence a nation’s economy since the eighteenth century. As the primary driving force behind economic growth, manufacturing serves as the foundation of and contributes to other industries, with products ranging from heavy-duty machinery to hi-tech home electronics. In past centuries, manufacturing has contributed significantly to modern civilisation and created the momentum that drives today’s economy. Despite various revolutionary changes and innovations in the twentieth century that contributed to manufacturing advancement, we are constantly facing new challenges in the global marketplace.

Today, agile manufacturing has gained prominence due to recent business decentralisation and outsourcing. Manufacturing companies are competing in a dynamic marketplace that demands a short response time to changing markets and agility in production. In the twenty-first century, manufacturing is gradually shifting to a distributed environment with increasing dynamism. In order to win orders, locally or globally, customer satisfaction is treated as priority. This has led to mass customisation and ever more agile manufacturing processes, from the shop floor to every level of the manufacturing supply chain. At the same time, outsourcing has forged a multi-tier supplier structure with numerous small-to-medium-sized enterprises (SMEs) involved, where enterprise networks are formed and broken dynamically in order to deal with issues of logistics and supply chain management, effectively and efficiently. Moreover, environmental concerns have forced companies to address the recycling and re-manufacturing of end-of-life products, and this has created problems for both the reverse supply chain and reverse logistics. These issues constantly challenge manufacturing companies, and create a lot of uncertainty in agile manufacturing. Engineers across organisations often find themselves in situations that demand advanced planning and management capability when dealing with daily operations related to enterprise networks and logistics.

Targeting the uncertainty issues in agile manufacturing, over the past decade, research efforts have focused on improving the flexibility, adaptability, productivity, agility and leagility of manufacturing, particularly in supply chain management and logistics of decentralised enterprise networks. Various Web-based and artificial intelligence (AI) based tools have been developed to deal with these issues, and many research projects have been devoted to improving the throughput and efficiency of agile manufacturing. Thanks to recent advancements in information technology, research in supply chain management and logistics has progressed to a new level in adaptive decision making and trouble shooting, in order to address the problems encountered in today’s enterprise network environment with increasing globalisation and outsourcing. While research and development efforts have resulted
in a large volume of publications and impacted both present and future practices in agile manufacturing, there still exists a gap in the literature for a focused collection of works dedicated to enterprise networks and logistics. To bridge this gap and present the state-of-the-art to a broad readership, from academic researchers to practicing engineers, is the primary motivation behind this book.

As a general overview, Chapter 1 begins with a clear definition of enterprise network, logistics, supply chain, supply network and value chains, and explains the contexts within which they differ. Based on a comparative analysis of the existing literature, this chapter provides a discussion on decentralised decision making and presents both the current status and potential future trends in enterprise networks and logistics within the context of agile manufacturing. The discussion of decentralised decision making is extended in Chapter 2. Particularly, it reviews the research and practices of the industrial networks of the future. This chapter also identifies the fundamental challenges of preparing for the industrial networks of 2020 and beyond. Chapter 3 then introduces a unique perspective showing where agile manufacturing can position itself in complex supply networks. Through a Co-OPERATE project, it aims to develop a Web-based system for improved coordination of manufacturing planning and control activities across a supply network.

Recognising the importance of structure versus operation of an organisation, Chapter 4 focuses its attention around enterprise architecture in order to determine how an organisation can most effectively achieve its current and future objectives. Assuming that a portion of the value of an enterprise architecture initiative is in the form of embedded options (or real options), this chapter proposes the use of real options that allow flexibility for architects to change plans, so that uncertainties can be resolved over time. In light of the current popularity of information and communication technologies (ICT), Chapter 5 reports on ICT standardisation, aiming at ensuring interoperability between the various systems of an enterprise network.

Chapter 6 highlights ways of collaborative demand planning, particularly when information is shared in the downstream supply chain between manufacturer and retailer. It regards information sharing concerning demand signals within supply chains as one of the keys to responding to retail demands with greater agility.

In the area of supply selection, Chapter 7 depicts an empirical analysis of value creation and supplier selection. This chapter also examines the criteria used in the suppliers’ selection process and thereby in the supply chain. Continuing this theme, Chapter 8 utilises a fuzzy AHP (analytic hierarchy process) approach to address the supplier selection problem. When faced with incomplete information from experts, the fuzzy set theory is found to be useful to handle uncertainties.

These discussions are extended in Chapter 9 to include a sustainable green supply chain platform in a globally integrated supply chain network. Based on preliminary analyses, this chapter offers some suggestions to help manufacturers and logistics service providers to restructure their supply chain strategies.

The primary goal of a supply chain is to meet the varying demand of customers where coordination among the customers is paramount. Realising this, Chapter 10 proposes a multi-agent self-healing approach that can assist in selecting outsourcing partners, and developing effective coordination among themselves and between manufacturing units. The agent-based approach is extended in Chapter 11 to cover
simulation-based optimisation for supply chain management, and considers the entities (e.g. supplier, manufacturer, distributor and retailer) in a supply chain as intelligent agents in a simulation. This chapter also gives an outline on how these agents pursue their local objectives as well as how they react and interact with each other to achieve a more holistic outcome.

In addition to forward supply chains, reverse supply chains are becoming equally important, owing to increasing environmental concerns. Chapter 12 identifies the major barriers of a battery recycling system as an example, and shows how the interaction among those barriers hinders the recycling activities along its reverse supply chain. The issue of the reverse supply chain is further discussed in Chapter 13, looking at the optimal design of reverse logistics and closed-loop supply chain networks.

In a decentralised environment, global logistics services have increased dramatically and become extremely complex and dynamic. The logistics industry is changing in a variety of ways, including mergers to form integrated transportation service providers, outsourcing, and the increased use of information technology. Chapter 14 provides an overview of this evolution and looks at important trends in the logistics services industry. In this sector, routing and scheduling of delivery vehicles often involves complex decision making. Chapter 15 addresses the problem of multiple-vehicle pick-up and delivery, with time windows and heterogeneous capacitated vehicles, using simulated annealing as well as a simple and fast meta-heuristic.

Chapter 16 proposes the use of conventional simulation tools to model and visualise the coordinating behaviours of a networked distributed system. This can be a great assistance in accelerating system development, especially when it is large in size and complex in nature.

Finally, Chapter 17 discusses the implication of robustness and capability indices in the optimisation process of an airline’s fleet. It introduces a technique capable of effectively addressing contradicting outcomes and minimising potential losses.

All together, the seventeen chapters provide an overview of some recent R&D achievements in supply chain design, supplier selection, vehicle routing, and system visualisation. With the rapid advancement of ICT, particularly Internet- and Web-based, we believe that this will continue to be a very active research field for years.

The editors would like to take this opportunity express their deep appreciation to all the authors for their significant contributions to this book. Their commitment, enthusiasm, and technical expertise are what made this book possible. We are also grateful to the publisher for supporting this project, and would especially like to thank Anthony Doyle, Senior Editor for Engineering, and Claire Protherough, Senior Editorial Assistant, for their constructive assistance and earnest cooperation, both with the publishing venture in general and the editorial details. We hope that readers find this book informative and useful.
Contents

List of Contributors............................................................................................................. xvii

1 Overview of Enterprise Networks and Logistics for Agile Manufacturing........................................................................................ 1
   S.C. Lenny Koh, Lihui Wang
   1.1 Introduction .............................................................................................. 1
   1.2 Logistics ................................................................................................... 2
   1.3 Supply Chain Management ...................................................................... 2
   1.4 Agile Manufacturing – Towards Leagile Manufacturing and Supply Chain? .................................................................................... 3
       1.4.1 Lean Strategy ................................................................................ 5
       1.4.2 Agile Strategy ............................................................................... 5
       1.4.3 Leagile Strategy .......................................................................... 5
   1.5 Cases from Logistics Sectors .................................................................... 6
       1.5.1 Foreign 3PL: Company A Logistics and Maersk Logistics .......... 6
       1.5.2 Domestic 3PL: Longfei Logistics and Company B Logistics ....... 7
   1.6 Supply Chain Transformation .................................................................. 8
   1.7 Conclusions .............................................................................................. 9
   References .......................................................................................................... 9

2 A Review of Research and Practice for the Industrial Networks of the Future .................................................................................. 11
   Rob Dekkers, David Bennett
   2.1 Introduction ............................................................................................ 11
       2.1.1 Brief History of Industrial Networks .................................................. 12
       2.1.2 The Impact of Globalisation ............................................................. 14
       2.1.3 Scope of Chapter ........................................................................... 15
   2.2 Traditional Views about Networks ............................................................. 16
       2.2.1 Core Competencies and Outsourcing .................................................. 17
       2.2.2 Keiretsu and Chaibol Networks .......................................................... 18
       2.2.3 Agile Manufacturing Networks ......................................................... 19
       2.2.4 Supply Chain Management ............................................................... 20
       2.2.5 Traditional Views on the Wane .......................................................... 21
   2.3 Future Networks ....................................................................................... 22
       2.3.1 Network Configuration ..................................................................... 23
       2.3.2 Manufacturing as a Commodity .......................................................... 25
2.3.3 Added Value of Industrial Networks .......................................... 26
2.3.4 Sustainability of Supply Chains .................................................. 27
2.4 Research Agenda for Industrial Networks .............................................. 28
2.5 Implications for Practice ......................................................................... 30
2.6 Conclusions ............................................................................................ 31
References........................................................................................................ 31

3 Agile Manufacturing in Complex Supply Networks ................................... 39

Henry Xu

3.1 Introduction ............................................................................................ 39
3.2 An Overview of Commercial Solutions for SNC ................................... 40
3.3 Challenges and Requirements of SNC ................................................... 41
3.4 A Research Framework for SNC ............................................................ 42
  3.4.1 Seven Coordination Processes .................................................... 42
  3.4.2 Functional Relationship Between the Focused Processes ........... 44
3.5 The Overall Co-OPE RATE System ....................................................... 45
  3.5.1 System Design Approach ........................................................... 45
  3.5.2 Network Coordination Architecture ........................................... 46
  3.5.3 Operational Ordering and Planning ............................................ 51
  3.5.4 Visibility of Order Progress ........................................................ 53
  3.5.5 Exception Handling .................................................................... 56
  3.5.6 Request and Feasibility Studies .................................................. 58
  3.5.7 Comparison of Co-OPE RATE with Other Solutions .................. 60
3.6 Implementation and Evaluation .............................................................. 60
  3.6.1 Process Design and Implementation ........................................... 60
  3.6.2 Pilot System Evaluation .............................................................. 61
3.7 Conclusions and Future Work ................................................................ 62
References........................................................................................................ 63

4 Enterprise Network and Supply Chain Structure: the Role of Fit ............ 67

Federica Cucchiella, Massimo Gastaldi

4.1 Introduction ............................................................................................ 67
4.2 Relevance of Enterprise Architecture .................................................. 69
4.3 The IFIP–IFAC Task Force................................................................. 70
4.4 The First IFIP–IFAC Mandate .............................................................. 71
  4.4.1 The Historical ‘Type 2’ Architecture .......................................... 72
4.5 The Second IFIP–IFAC Mandate ........................................................... 76
4.6 The GERAM Model ............................................................................... 78
  4.6.1 Life-cycle Concept ...................................................................... 78
  4.6.2 Enterprise Entity Types Concept ................................................ 80
  4.6.3 Enterprise Modelling Concept ..................................................... 82
  4.6.4 Modelling Language Concept .................................................... 83
  4.6.5 Generic Enterprise Engineering Methodologies ......................... 83
  4.6.6 Generic Enterprises Modelling Languages .................................. 83
  4.6.7 Generic Enterprise Modelling Tools .......................................... 84
  4.6.8 Enterprise Models ....................................................................... 84
9.5 Important Things to Consider while Designing a Network................. 199
  9.5.1 Controlling Emissions Across the Supply Chain...................... 199
  9.5.2 Restructuring the Network.................................................. 199
  9.5.3 Performing Life-cycle Assessments .................................... 201
9.6 Implementation Challenges of a Sustainable Supply Chain .......... 202
  9.6.1 Green Logistics Initiatives in the UAE................................. 203
  9.6.2 Implementation Challenges Perceived in the UAE................. 203
9.7 Managerial Implications and Concluding Remarks.................... 204
References..................................................................................... 205

10 A Multi-agent Framework for Agile Outsourced Supply Chains ....... 207
    N. Mishra, V. Kumar, F.T.S. Chan
    10.1 Introduction ........................................................................ 207
    10.2 Agile Manufacturing ........................................................ 209
    10.3 Problem Scenario ............................................................. 210
    10.4 Agent Framework ............................................................. 211
      10.4.1 Agent Architecture.................................................... 211
      10.4.2 Communication Channel ........................................... 221
    10.5 Conclusions ....................................................................... 222
References..................................................................................... 223

11 Agent-based Simulation and Simulation-based Optimisation for Supply Chain Management .............................................. 227
    Tehseen Aslam, Amos Ng
    11.1 Introduction ........................................................................ 227
    11.2 Literature Review: Agent-based Simulation.......................... 229
    11.3 An ABS Framework for Multi-objective and Multi-level Optimisation ......................................................... 233
    11.4 A Simple Case Study ......................................................... 238
    11.5 Conclusions ....................................................................... 242
References..................................................................................... 243

12 Analysing Interactions among Battery Recycling Barriers in the Reverse Supply Chain ............................................. 249
    P. Sasikumar, A. Noorul Haq
    12.1 Introduction ........................................................................ 249
    12.2 Survey of Previous Work .................................................... 252
    12.3 Description of Recycling Barriers ....................................... 254
    12.4 Interpretive Structural Modelling ........................................ 255
    12.5 Case Study ......................................................................... 257
      12.5.1 Structural Self-interaction Matrix .................................. 257
      12.5.2 Reachability Matrix ..................................................... 259
      12.5.3 Level Partitions ............................................................ 260
12.6 Formation of the ISM-based Model ..................................................... 262
12.7 MICMAC Analysis .............................................................................. 262
12.8 Conclusions .......................................................................................... 264
References ...................................................................................................... 265

13 Design of Reverse Supply Chains in Support of Agile Closed-loop Logistics Networks ................................................................. 271
Anastasios Xanthopoulos, Eleftherios Iakovou

13.1 Introduction: Motivation and Concepts ................................................ 271
13.2 Design of Reverse Logistics Networks: a Literature Review ............... 273
  13.2.1 Independent Reverse Logistics Networks........................................ 273
  13.2.2 Configuration of Reverse Logistics Networks by Considering the Synergies with the Forward Channel........... 274
  13.2.3 CLSC Networks........................................................................... 274
  13.2.4 Literature Review Insights........................................................ 275
13.3 System Description .............................................................................. 275
  13.3.1 Problem Definition .................................................................... 275
  13.3.2 Major Modelling Assumptions ................................................. 280
13.4 Model Formulation ............................................................................... 280
  13.4.1 Nomenclature............................................................................. 280
  13.4.2 Optimisation Model .................................................................. 284
  13.4.3 Solution Performance ............................................................... 289
  13.4.4 Sensitivity Analysis and Managerial Insights............................... 290
13.5 Extensions and Future Research Directions ......................................... 291
  13.5.1 Model Extensions ..................................................................... 291
  13.5.2 Future Research ........................................................................ 293
13.6 Conclusions .......................................................................................... 294
References ...................................................................................................... 294

14 The Evolution of Logistics Service Providers and the Role of Internet-based Applications in Facilitating Global Operations ................. 297
Aristides Matopoulos, Eleni-Maria Papadopoulou

14.1 Introduction .......................................................................................... 297
14.2 Logistics Service Providers: Evolution and Major Trends ................. 298
  14.2.1 LSPs: Context and Types............................................................ 298
  14.2.2 Evolution and Characteristics of the LSP Market......................... 299
  14.2.3 Major Trends ............................................................................ 300
14.3 Evolution and Current State of Electronic Marketplaces in Logistics ........................................................................... 302
  14.3.1 Electronic Marketplaces and Logistics: Concept, Context and Evolution........................................... 302
  14.3.2 Electronic Logistics Marketplaces: an Overview........................ 303
14.4 Conclusions and Future Trends ............................................................ 306
References...................................................................................................... 307
15  A Heuristic for Heterogeneous Capacitated Pick-up and Delivery Logistics Problems with Time Windows in Agile Manufacturing and the Distribution Supply Chain ................................................................. 311

P. Sivakumar, K. Ganesh, S.P. Nachiappan, S. Arunachalam

15.1 Introduction ........................................................................ 311
15.2 Research Problem ................................................................ 313
15.3 Literature Review ................................................................ 315
15.4 Problem Description ......................................................... 316
  15.4.1 Notations ..................................................................... 316
  15.4.2 Problem Representation ................................................ 317
  15.4.3 Problem Constraints ...................................................... 319
  15.4.4 Problem Objective ......................................................... 319
15.5 Proposed Simulated Annealing for Solving m-PDPTWH ........ 321
  15.5.1 Neighbourhood Structure ............................................. 322
  15.5.2 Evaluation Function, Ranking and Temperature Assignment .. 323
15.6 Computational Study ......................................................... 327
15.7 Conclusions ........................................................................ 327
References .................................................................................. 329

16  Visualisation and Verification of Communication Protocols for
    Networked Distributed Systems ............................................ 333

Z.M. Bi, Lihui Wang

16.1 Introduction ........................................................................ 333
  16.1.1 Basic Strategy to Deal with System Complexity .......... 334
  16.1.2 Development of a Decentralised System ...................... 334
  16.1.3 Development of Decentralised Control Systems .......... 335
  16.1.4 Life Cycle of Control Systems Development ............... 336
  16.1.5 Overview of the Presented Work ................................ 337
16.2 Distributed Sensor-based Information System .................... 338
  16.2.1 Application Scenarios .................................................... 338
  16.2.2 Classes of Components in a DSBIS ............................. 340
  16.2.3 An Example of the Algorithms – Ring Extrema
    Determination .................................................................... 342
16.3 Modelling Methodologies .................................................. 347
16.4 DSBIS Modelling in QUEST ............................................. 348
16.5 Case Study ........................................................................ 349
  16.5.1 Basic Components and Communications ................... 350
  16.5.2 Coordinating Algorithm .............................................. 352
16.6 Conclusions ........................................................................ 354
References .................................................................................. 354

17  Robustness and Capability Indices in the Optimisation of
    an Airline’s Fleet – Bridging Contradicting Outcomes ............... 359

Leo D. Kounis

17.1 Introduction ........................................................................ 359
### 17.2 Literature Review

### 17.3 Contribution of Quality Standards in the Airline Industry

17.3.1 Design of Experiments: Industrial Application of SNRs
17.3.2 Implications of Capability Indices

### 17.4 Research Methodology

17.4.1 Areas of Further Improvement between $C_{pk}$ and SNRs
17.4.2 Summary of Most Commonly Used Approaches

### 17.5 Analysis of Noteworthy Approaches

### 17.6 Discussions on Current Techniques

17.6.1 Development of New Hubs:
   - Strategic Uses and Applied Policies
17.6.2 Proposed Model by Martin and Roman
17.6.3 Proposed Model by Rietveld and Brons
17.6.4 Evaluation of Hub-influential Parameters

### 17.7 Preliminary Model

17.7.1 Input Parameters for Development of a Factorial Experiment
17.7.2 Factorial Experiment for Smaller-the-Better

### 17.8 Conclusions and Future Work

References

---

**Index**

399
List of Contributors

Blandine Ageron
Department of Supply Chain and Information Systems
University of Grenoble
26901 Valence Cedex 9
France

S. Arunachalam
School of Computing and Technology
University of East London
Essex
UK

Tehseen Aslam
Virtual Systems Research Centre
University of Skövde
PO Box 408, 541 28 Skövde
Sweden

David Bennett
Operations & Information Management Group
Aston University
Birmingham B4 7ET
UK

Z.M. Bi
Department of Engineering
Indiana Purdue University Fort Wayne
Fort Wayne, IN 46805-1499
USA

Elias G. Carayannis
School of Business
George Washington University
Washington, DC 20052
USA

F.T.S. Chan
Department of Industrial and Systems Engineering
The Hong Kong Polytechnic University
Hung Hom, Hong Kong
China

Federica Cucchiella
Department of Electrical and Information Engineering
University of L’Aquila
Monteluco di Roio, 67040 L’Aquila
Italy

Rob Dekkers
University of the West of Scotland
Paisley PA1 2BE
United Kingdom

K. Ganesh
Global Business Services – Global Delivery
IBM India Private Ltd.
Bandra Kula Complex, Mumbai, 400051
India

Massimo Gastaldi
Department of Electrical and Information Engineering
Faculty of Engineering
University of L’Aquila
Monteluco di Roio, 67040 L’Aquila
Italy

Mark Goh
NUS Business School
National University of Singapore
Singapore 117574
A. Noorul Haq
Department of Production Engineering  
National Institute of Technology  
Tiruchirappalli, 620 015
India

Eleftherios Iakovou
Industrial Management Division  
Department of Mechanical Engineering  
Aristotle University of Thessaloniki  
54124 Thessaloniki
Greece

Cengiz Kahraman
Department of Industrial Engineering  
Istanbul Technical University  
34367 Macka, Istanbul
Turkey

İhsan Kaya
Department of Industrial Engineering  
Istanbul Technical University  
34367 Macka, Istanbul
Turkey

S.C. Lenny Koh
Management School  
The University of Sheffield  
9 Mappin Street, Sheffield S1 4DT
UK

Leo D. Kounis
Department of Aviation Technology  
Halkis Polytechnic  
34 400 Psachna Evias  
KEA, Research Department  
State Aircraft Factory  
Hellinikon, Athens
Greece

V. Kumar
Department of Management  
Exeter Business School  
University of Exeter  
Exeter, EX4 4PU
United Kingdom

Sushmera Manikandan
The Logistics Institute – Asia Pacific  
National University of Singapore  
Singapore 117574

Aristides Matopoulos
Department of Business Administration and Economics  
International Faculty of the University of Sheffield  
54626 Thessaloniki
Greece

N. Mishra
School of Computer Science and Information Technology  
University of Nottingham  
Nottingham, NG8 1BB
UK

S.P. Nachiappan
Department of Mechanical Engineering  
Thiagarajar College of Engineering  
Madurai
India

Amos Ng
Virtual Systems Research Centre  
University of Skövde  
PO Box 408, 541 28 Skövde
Sweden

Yiannis Nikolaidis
Department of Technology Management  
University of Macedonia  
59200 Naousa
Greece

David van Over
Faculty of Business and Management  
University of Wollongong in Dubai  
Knowledge Village, Dubai, 20183
UAE

Eleni-Maria Papadopoulou
Department of Applied Informatics  
University of Macedonia  
156 Egnatia Street, 540 06, Thessaloniki
Greece

Karine Evrard Samuel
Centre of Studies and Research in Management  
University of Grenoble  
38040 Grenoble Cedex 9
France
P. Sasikumar  
Department of Production Engineering  
National Institute of Technology  
Tiruchirappalli, 620 015  
India

P. Sivakumar  
Vickram College of Engineering  
Madurai-Anna University  
Tiruchirappalli  
India

Robert de Souza  
The Logistics Institute – Asia Pacific  
National University of Singapore  
Singapore 117574

Alain Spalanzani  
University of Grenoble  
51, rue B. de Laffemas – BP 29  
26901 Valence Cedex 9  
France

Balan Sundarakani  
Faculty of Business and Management  
University of Wollongong in Dubai  
Knowledge Village, Dubai, 20183  
UAE

Lihui Wang  
Virtual Systems Research Centre  
University of Skövde  
Sweden

Anastasios Xanthopoulos  
Department of Mechanical Engineering  
Aristotle University of Thessaloniki  
54124 Thessaloniki  
Greece

Henry Xu  
UQ Business School  
The University of Queensland  
St Lucia, Queensland, 4072  
Australia
Overview of Enterprise Networks and Logistics for Agile Manufacturing

S.C. Lenny Koh¹ and Lihui Wang²

¹ Logistics and Supply Chain Management (LSCM) Research Centre
Management School, The University of Sheffield
9 Mappin Street, Sheffield S1 4DT, UK
Email: s.c.l.koh@sheffield.ac.uk

² Virtual Systems Research Centre
University of Skövde
PO Box 408, 541 28 Skövde, Sweden
Email: lihui.wang@his.se

Abstract

The demand for research and development of enterprise networks and logistics has been on an upward trajectory over the last decades. With a need for more innovative and responsive enterprise network structure, technology and supply chain to deal with an ever-changing and highly competitive market, the agility of processes, organisations and their supply chain, particularly in a manufacturing environment, need to be re-examined. This chapter provides an overview of the current status and potential future trends in this area. More specifically, this will be analysed within the context of agile manufacturing.

1.1 Introduction

The terms of enterprise network, logistics, supply chain, supply network and value chain are often used interchangeably and interpreted synonymously in the literature. The terms carry different meanings, depending on how these terms are interpreted and in what context they are being used.

Taking a normalised perspective from the literature, this chapter begins with a clear definition of their variations and explains the contexts within which they differ. We will then overview and critically analyse enterprise networks and logistics in the context of agile manufacturing. Previous literature in these related fields will be drawn on to provide a baseline for comparative analytics driving the discussions between current and future projections of enterprise network and logistics for agile manufacturing.
1.2 Logistics

Authors often use the term supply chain management synonymously with the term logistics. Logistics is actually a sub-set of supply chain management. Logistics refers to the distribution and movement of materials, components, parts, products and services from one node to another, up and down the supply chain. Logistics involves deciding upon various transportation modes, for example, air, rail, road and sea, to manage the movement and distribution of the above. From an organisational perspective, logistics could also be categorised into inbound and outbound logistics. Inbound logistics deals with managing the inward flow of materials, components, parts, products and services from suppliers or third party logistics to the organisation. Outbound logistics deals with managing the outward flow of materials, components, parts, products and services from the organisation to customers or third party logistics. Many organisations, in diverse industries, do not want to manage their own logistics operation, and use third party services in this area. Fourth party logistics has also emerged providing another layer of services to third party logistics. When the demand on third party logistics is very high and triggers insufficient capacity (e.g. fleet and so on) to manage the delivery, fourth party logistics will be used to meet the demand. Both inbound and outbound logistics requires good relationship management with suppliers and customers. The relationship with tier suppliers is paramount and the same applies to tier 1 customers. A tier 1 customer could be a distributor or retailer and this provides a large market size for the product or service. Hence, management of the supply chain is very important in ensuring that the right quality and the right quantity are delivered and received at the right time.

Reverse logistics is equally important given the nature for rework and re-distribution of products in order to satisfy various environmental requirements. When designing a logistics operation, one must consider the element of reverse logistics and how this could be designed into or designed out of the process. Designing reverse logistics into the operation includes considerations such as the methods by which the product could be returned directly to manufacturers. Designing reverse logistics out of the operation includes consideration such as the methods by which good product design eliminates the needs for return (e.g. decomposable materials).

1.3 Supply Chain Management

Supply chain management, taking logistics as a sub-set, integrates with all other important elements such as suppliers, manufacturers, distributors, retailers and customers in a holistic whole to ensure that the entire supply chain is integrated upstream and downstream. Supply chain management activities include sourcing, procurement, manufacturing and logistics. In a supply chain, in addition to managing the flow of materials, components, parts, products and services, managing information/knowledge, cash and intellectual capital flow are equally important. Building a long-term partnership with suppliers rather than an arms-length relationship is paramount in a supply chain.
Supply chains compete, not organisations. It is fundamental that organisations should re-examine their supply network and, if necessary, restructure the supply chain in order to compete with other supply chains. An enterprise network is the basis of a supply network. An enterprise network is a group of organisations working together for a common goal. The notion of an enterprise network interlinks with the work in cluster, enterprise system and extended enterprise. An enterprise network could be formed formally or informally. A formally structured enterprise network, such as a consortium, provides buying power for the group of organisations in the enterprise network. An informally structured enterprise network exists in a more virtual manner, which comes together and dissolves depending on specific opportunistic alliances and joint ventures. Unlike a cluster, the formation of an enterprise network could be independent of sector. A cluster, whether formal or informal, is normally structured around a sector, for example, the cheese and wine cluster in south east Europe. In contrast, an enterprise network is formed around the supply chain of the organisation; for example, there is an enterprise network around the ODM/OEM (original design/equipment manufacturer) suppliers to ACER and Phillips. When an enterprise network matures over time, it provides an opportunity to enable the supplier to work more closely with the manufacturer. This scenario will lead to potentially three outcomes: (1) a supply network, (2) a value chain, and (3) an integrated supply chain. Supply network formation creates a mutually beneficial environment with a common supply base to enable organisations to flexibly source the required products or services from the supply network. When value is added to the process in this supply network, for example, outsourcing of some processes to suppliers, a value chain is created. This enables an even closer collaboration between the suppliers and manufacturers and creates an environment for innovation. When the relationship between the supplier and the manufacturer has reached a further maturity point, it creates an opportunity to enable the supplier to have a physical presence at the manufacturer’s plant, providing the highly responsive and agile processes required to fulfil demand. This leads to an integrated supply chain, where the supplier’s supply chain is integrated with the manufacturer’s supply chain. In this scenario, the supplier is still owned by the supplier and not the manufacturer, which makes it different to vertical integration. The automotive industry is pioneering the notion of integrated supply chains and the shipping industry is also looking at how the integrated supply chain model could be adapted to suit demand in the shipping industry given the need to re-examine their infrastructure. The notion of integrated supply chain was derived from Dell’s supply chain model, but with an extension to consider ways in which it could be adapted to different industries’ supply chains and ways in which relevant information systems are required to enable seamless exchange and sharing of information and resources.

1.4 Agile Manufacturing – Towards Leagile Manufacturing and Supply Chain?

Agile manufacturing environment requires responsive-to-demand facility and lean production. An agile manufacturing environment creates processes, tools, and knowledge base to enable the organisation to respond quickly to customer needs and
market changes whilst still controlling costs and quality. Agile manufacturing cannot be achieved without facilitation by appropriate manufacturing and information technologies, and, more importantly, the appropriate integration of these technologies along the supply chain, including responsive manufacturing system, flexible manufacturing system, virtual manufacturing system, ultra rapid prototyping, process modelling, Computer Aided Manufacturing (CAM), Enterprise Resource Planning (ERP), mobile manufacturing services, on-line stock control system, satellite controlled networked maintenance, repair and overhaul database, Customer Relationship Management (CRM), Supplier Relationship Management (SRM), RFID, e-commerce, e-business and so on. These are crucial technologies required to enable seamless exchange and sharing of information, and provide a responsive manufacturing capacity required.

One of the biggest challenges facing organisations today is dealing with volatility in demand. Due to high demand volatility, there is no one strategy that can be adopted and this has led to the need for organisations to adopt a multiple chain strategy. This helps them to quickly respond to the both in terms of changed variety and volume.

One way to identify the type of supply chain strategies that will best suit the organisation is to position the products in an organisations portfolio according to their supply and demand characteristics. ‘Supply characteristics’ means the amount of time that it takes to replenish the stock. ‘Demand characteristics’, on the other hand, deals with how well the organisation can predict the demand for goods and services. To achieve both of these objectives satisfactorily, an organisation must re-examine how responsive and how agile their systems are.

Figure 1.1 suggests four generic strategies that can be adopted to meet demand and these are dependent on the combination of supply and demand characteristics for each product.

![Figure 1.1. Generic supply chain strategies [1.1]](image-url)
1.4.1 Lean Strategy

Womack and Jones [1.2] developed the *lean enterprise* concept and later expanded it into the wider concept of *lean thinking*. Leanness is about doing more with less. It owes its origins to the Toyota Production System (TPS) [1.3], where the concern was the reduction of waste (or *muda* in Japanese) within the factory environment. The focus of lean thinking is to eliminate all type of waste such as reduction of inventories, lot-size, supplier base and elimination of paperwork so that a level schedule can be established. However, the problem with lean thinking is that it originated in the Japanese automobile industry of the 1970s, whereas now we are in a different era of manufacturing, with lower demand, higher variety and higher uncertainty in the supply chain. Christopher [1.1] states that ‘lean’ works best in high volume, low variety and predictable environments. This led to the development of the agile concept.

1.4.2 Agile Strategy

Hiebelar *et al.* [1.4] introduced the agile strategy with the aim to satisfy demand by taking minimal lead times. ‘Agility’ is primarily concerned with responsiveness and the ability to match supply and demand in unpredictable markets where the demand for variety is very high. The distinguishing feature of agile supply chain is that it is ‘market sensitive’. The idea of manufacturing flexibility was later extended by Nagel and Dove [1.5] into a wider framework and the concept of agility as a supply chain paradigm was born. However, Harrison *et al.* [1.6] realised that for agility to work, information flow within the supply chain partners is necessary, and stated that it could only happen with the use of information technology. This will then minimise the lost sales and also reduce the cost of stocking inventory.

1.4.3 Leagile Strategy

The top-right quadrant in Figure 1.1 represents a situation where the lead times are long and demand is unpredictable. In such situation, the first priority is to decrease the lead times since the variability of demand is totally uncertain and beyond the control of the organisation. However, if lead time cannot be reduced, then the next option is to seek to create a hybrid lean/agile solution. Various researchers suggest that the lean and agile approaches can be integrated to form a ‘leagile’ strategy. Christopher and Towill [1.7] formed the following three distinct lean–agile hybrids:

- **Pareto rule**
  This recognises that 80% of an organisation’s revenue is generated from 20% of its products. Goldsby and Garcia-Dastugue [1.8] suggest that if 20% of the production is managed in a lean manner given that demand is stable, the remaining 80% can be managed in an agile manner.

- **Base and surplus demand**
  This is founded on the principle of base and surplus demand, which assumes that most organisations experience a base level of demand that can be
managed by a lean strategy, and the remaining demand that is periodical or seasonal can be managed by an agile strategy.

- **Postponement**

Postponement strategy is founded on the principle of postponement, which requires the supply chain to be ‘de-coupled’ through holding strategic inventory in some generic or unfurnished form, with final configuration being completed rapidly once the real demand is known. Bucklin [1.9] states that the risk and uncertainty costs mainly occur due to the differentiation in products in the supply chain and that the postponement strategy will help to reduce or fully eliminate this cost by postponing certain activities until the actual demand arises.

Leagile supply chain systems have several advantages:

- they increase the organisation’s ability to adjust products to specific customer wishes;
- inventory can be held at a generic level, resulting in lower stock-keeping and hence reducing the holding, transportation and obsolescence costs;
- keeping the inventory in a generic form gives greater flexibility, as the same inventory can be used to produce variety of end products;
- forecasting is easier at the generic level than at the level of the finished item;
- finally, the ability to customise products locally means that a higher level of variety may be offered at a lower total cost, enabling strategies of ‘mass-customisation’ to be pursued.

Taking the analysis of the leagile strategy and agile manufacturing together, the literature above suggests the extension of agile manufacturing towards a leagile manufacturing and leagile supply chain direction.

### 1.5 Cases from Logistics Sectors

This section summarises the cases published in Koh and Tan [1.10] and extends the narratives by considering the leagility of their supply chains as a result of changes made to their logistics operations and enterprise network. Due to confidentiality requests, both Company A Logistics and Company B Logistics prefer to remain anonymous in any publications.

#### 1.5.1 Foreign 3PL: Company A Logistics and Maersk Logistics

Technological use, including the application of e-commerce in Company A Logistics and Maersk Logistics, is advanced or even in leading position in the industry. For example, Company A Logistics spent around US$200 million in IT development and is maintaining the technological leader position of the 3PL logistic industry in the world. The general manager of Company A Logistics pointed out that the current concerns of e-commerce in Company A Logistics are not to develop new e-commerce technologies, but to apply all existing functions to the China market.
This finding suggests the importance of the diffusion of technology across the supply chain. Once it is proven to provide significant improvement in one site of the chain, the organisation is keen to extend that across the chain.

Maersk Logistics’ parent companies have invested heavily in developing new technologies (e.g. some e-commerce functions such as M*Power Web Report Builder, M*Power Web Search, M*Power Web Shipper, Startrack, e-SOP, etc.). This supports the finding from Langley et al. [1.11] that competition at the technological level is one of most important future trends, hence that providing more reliable and comprehensive services to customers in 3PL industry through the use of e-commerce could be regarded as providing the critical competitive advantage. The use and application of e-commerce must be supported by reliable technologies. Therefore, the development of new technologies makes it possible to supply better and more reliable services than competitors. This finding suggests the thirst of the organisation to search for new and innovative technologies to enable information exchange and sharing across the supply chain. Given that Maersk Logistics is a key player in the logistic sector, it is not surprising to note this demand. With the introduction of leagile manufacturing and supply chain, the projection of the future trends in the application of the leagile supply chain in this sector is promising.

1.5.2 Domestic 3PL: Longfei Logistics and Company B Logistics

The use of technologies and e-commerce in Longfei Logistics and Company B Logistics tends to be behind their foreign competitors due to the lack of sufficient funds and capabilities to develop leading technologies. The sources of e-commerce applications in these two domestic 3PL providers are mainly through two channels, namely, purchase from external vendors or cooperation with their partners. Longfei Logistics purchased all its logistics software as off-the-shelf packages and Company B Logistics purchased significant parts of their software using the same method. They do not own or use any advanced technologies such as track and trace systems, EDI with customers or JIT services. However, on some occasions they could provide those services to their customers by cooperating with partners who have the relevant technologies. For example, Company B Logistics share the warehousing systems of Maersk Logistics, and Longfei Logistics provide part of their goods tracking by using their partners’ capabilities.

These technological strategies have many disadvantages. For example, they may never catch up with the new technology development and may never become a technology leader in the industry. Sometimes, they may be somewhat controlled by the partners. Besides, using partners’ capabilities and/or purchasing from external vendors may cause an increase in cost, and thus diminish their competitiveness.

Despite these disadvantages, the two domestic 3PL providers are found to be willing to pursue their current strategies for practical reasons; it is almost impossible for them to catch up with the technology level of Company A Logistics and Maersk Logistics, whose parent companies invest heavily in R&D to keep their leading positions in new technology development. Longfei Logistics and Company B Logistics benefit from the cheaper solutions since they could acquire new technologies quickly and only purchase those technologies that they need or cooperate with those partners who could provide them with such technological
advantages. Their technological strategies are more geared towards customer needs rather than developing new or advanced technologies which need huge amount of investment and may not be used in the near future.

The cases from the domestic 3PL sector discussed above illustrate different angle in terms of their degree of diffusion and adoption of enterprise network and logistics for leagility, as compared to the previously reported cases from the foreign 3PL sector. However, these cases suggest an interesting point, which is that they all rely on information technology to provide the competitiveness and responsiveness required. Due to the nature of this sector (i.e. not manufacturing), we cannot extract the manufacturing conditions from the above four cases. However, extrapolation of the findings suggests that pressure from demand (in manufacturing organisations) for such a movement indicates that the responsiveness of an organisation does relate to demand. This implies that higher leagility in the supply chain facilitated by innovative manufacturing and information technologies are essential to compete with other supply chains.

1.6 Supply Chain Transformation

Understanding a supply chain requires understanding the ways in which the organisations in the supply chain operate. Abundant research has examined organisational-level intervention, for example, lean production, agile manufacturing and so on. Research on the supply chain domain has been illumined considerably over the last decade spawning from the globalisation debate. The research on the supply chain itself has also evolved, and this section connects its evolution with enterprise network, logistics and agile manufacturing.

For a manufacturing organisation to sustain its competitiveness, it is important that the organisation re-examines its supply chain structure (including evaluation of the enterprise network and logistics operations). A supply chain structure can be represented in the following ways and this represents the transformation (periodically) now and into the future. The supply chain transformation starts from the classical linear supply chain, which represents the baseline of a normal buyer and supplier scenario. Integrating this from the traditional economic model and the purchasing techniques in the supply chain literature, it represents an arms-length relationship where there is minimal partnership, sharing of information and joint development between supplier and customer. The classical linear supply chain is the most basic form.

This type of supply chain then evolves to a more dynamic and responsive form of supply chain, which captures the importance of lean production, agile manufacturing and leagile strategy. In the dynamic and responsive supply chain, it encapsulates all the discussions above in this chapter, depending on the diffusion and use of manufacturing and information technologies to respond with maximum leagility. The relationship-based characteristic starts to emerge in this form, but further consolidated and solidified via the collaborative and relationship-based supply chain. It is over an acceptable period of time and numerous projects and collaborations between the suppliers, manufacturers and customers that then further extend those relationships to a solid collaborative nature. This involves consistent
joint venture and joint development, sharing of information as well as resources. The integrated supply chain falls into this formation.

Simply competing between supply chains with the normal economic indicators, such as price, market share and so on, is no longer adequate. The market with increased awareness of green consumerisms, the legislation with tightened taxation and financial penalty, the industry with intense competition for a lower-carbon product and service, the manufacturer with demand on green purchasing and standards in place, such as ISO14000, WEEE, RoHS and so on, have all driven the transformation of supply chain to a new level. This new level of supply chain is termed the green and low-carbon supply chain, and encapsulates the notion of the triple bottom-line objectives, i.e. economic, environmental, and social. This implies that the KPI (key performance indicator) and priorities in organisations and supply chains need to be reshuffled in order to reflect this direction. There are massive challenges in creating a green and low-carbon organisation, let alone a green and low-carbon supply chain. Hence, an increased effort has been invested in finding innovative ways to lower CO\(_2\) from a supply chain perspective, which also provides a positive response to social and economic objectives. This challenge is currently facing many industries and supply chains. Given also the importance of ensuring sustainability in how we respond to the changes, a balanced and next-generation supply chain form will emerge. The rapid transformation of supply chain formations does not start or stop periodically (discrete), it overlaps with classical and future forms (continuous) and it hybridises many characteristics from various forms.

1.7 Conclusions

This chapter provides an overview of the upward trajectory trend over the last few decades in enterprise networks and logistics, and how this shapes and influences the development of manufacturing and supply chain management. A detailed discussion supported by four industrial cases rationalising the need for more innovative and responsive enterprise network structure, technology and supply chain to deal with the ever-changing and highly-competitive market characteristics are presented. Agility of processes, organisations and its supply chain, particularly in the manufacturing environment, need to be re-examined. The analysis suggests that agile manufacturing is inadequate and we must look at leagile manufacturing and leagile supply chain in order to compete effectively with other supply chains. An overview of the current status and potential future trends in this area is provided, suggesting also supply chain transformation and how these are shaping future research in this area.

References


A Review of Research and Practice for the Industrial Networks of the Future

Rob Dekkers¹ and David Bennett²

¹University of the West of Scotland, Paisley PA1 2BE, UK
Email: rob.dekkers@uws.ac.uk

²Aston University, Birmingham B4 7ET, UK
Email: d.j.bennett@aston.ac.uk

Abstract
Academic researchers have followed closely the interest of companies in establishing industrial networks by studying aspects such as social interaction and contractual relationships. But what patterns underlie the emergence of industrial networks and what support should research provide for practitioners? First, it appears that manufacturing is becoming a commodity rather than a unique capability, which accounts especially for low-technology approaches in downstream parts of the network, for example, in assembly operations. Second, the increased tendency towards specialisation has forced other, upstream, parts of industrial networks to introduce advanced manufacturing technologies for niche markets. Third, the capital market for investments in capacity, and the trade in manufacturing as a commodity, dominates resource allocation to a larger extent than was previously the case. Fourth, there is becoming a continuous move towards more loosely connected entities that comprise manufacturing networks. Finally, in these networks, concepts for supply chain management should address collaboration and information technology that supports decentralised decision-making, in particular to address sustainable and green supply chains. More traditional concepts, such as the keiretsu and chaibol networks of some Asian economies, do not sufficiently support the demands now being placed on networks. Research should address these five fundamental challenges to prepare for the industrial networks of 2020 and beyond.

2.1 Introduction
In recent years, practitioners and researchers have started to look increasingly at companies as part of networks within which they operate. The emergence of manufacturing networks is often associated with the possibilities offered by information technology and data-communication for collaboration and coordination, the globalisation of markets and the increasing tendency of companies to specialise, e.g. [2.1]. These possibilities provide firms with easier access to the capabilities and resources of others, moving them further away from the traditional logic behind the
make-or-buy decision; even though this particular manufacturing decision still attracts attention from researchers to develop appropriate models, e.g. [2.2–2.4]. Additionally, the world of management has seen an abundance of theories that might have been adequate to deal with the contemporary challenges for some enterprises, but not for many others [2.5, 2.6]. The notion of core competencies and the concept of lean production serve as examples of such theories that address questions relating to supply chain management in the context of industrial networks; but it could be questioned whether they really deal with the characteristics of networked organisations. Capello [2.7] (p. 496) supports this statement by noting that not enough is known about the failure of networks. In this chapter, we argue that industrial networks require the adaptation of existing theories to fit their particular characteristics as well as the development of grounded theories based on the unique characteristics of industrial collaboration.

2.1.1 Brief History of Industrial Networks

Although the study of industrial networks has attracted recent attention among researchers, there was already an awareness of the implications associated with the particular characteristics of networked organisations [2.8, 2.9]. In particular, academic interest has centred on two periods in the past. The first of these is in the 1970s and 1980s, when attention was focused on Japanese manufacturing concepts and techniques, including just-in-time (JIT), co-production and ‘keiretsu’ networks. The second period starts in the 1990s, after the bursting of Japan’s ‘bubble’ economy, as a consequence of the drive for even lower cost, greater efficiency, and responsiveness to customer demands. This resulted in a more formal recognition of the networked organisation as a follow-up to the paradigm of core competencies and the consequent escalation in outsourcing. Mayntz [2.10] acknowledges networks as capable of solving complex tasks and exceeding the capability of individual firms. The earlier overview by Miles and Snow [2.11] illustrated the move from the simpler paradigms to more complicated forms of network-based organisations that subsequently have been witnessed in recent years (see Table 2.1) and consequently have attracted academic deliberation.

The establishment and emergence of industrial networks is closely related to the subject of manufacturing strategy. Since Skinner’s seminal work in 1969 [2.12], manufacturing has been recognised as a fundamental cornerstone for achieving corporate competitive advantage. Although it recognises the traditional and limited perspective of considering low cost and high efficiency as dominant objectives within manufacturing strategy, this earlier work of Skinner is still rooted in the tradition that economies of scale provide competitive opportunities (see pp. 260–265 in [2.13]). That tradition gave rise to the monolithic company driven by forward and backward integration [2.14], which implied an emphasis on the coordination of operations. Only later, in 1986, does Skinner consider the role of smaller-scale units that may now be regarded as elements of an industrial network [2.15], while subsequently questioning the traditional effort towards productivity improvement through making large capital investments in manufacturing [2.16]. According to Sturgeon [2.17] (pp. 8–10), American firms – compared with most Asian and many European companies – have generally placed manufacturing in a low position on the
Table 2.1. Evolution of organisation forms [2.11]. This indicates the evolution of organisation forms that are both internally and externally consistent. Miles and Snow [2.11] state in their paper that a minimal fit is necessary for survival, and that tight fit associates with corporate excellence, and early fit provides a competitive advantage. Therefore, dynamic networks (industrial networks) require both internal fits and external fits, giving early adopters a competitive advantage.

<table>
<thead>
<tr>
<th>Period</th>
<th>Product-market strategy</th>
<th>Organisation structure</th>
<th>Inventor or early user</th>
<th>Core activating and control mechanisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1800–</td>
<td>Single product or service. Local/regional markets</td>
<td>Agency</td>
<td>Numerous small owner-managed firms</td>
<td>Personal direction and control</td>
</tr>
<tr>
<td>1850–</td>
<td>Limited, standardised product or service line. Regional/national markets</td>
<td>Functional</td>
<td>Carnegie Steel</td>
<td>Central plan and budgets</td>
</tr>
<tr>
<td>1900–</td>
<td>Diversified, changing product or service line. National/ international markets</td>
<td>Divisional</td>
<td>General Motors, Sears, Roebuck, Hewlett Packard</td>
<td>Corporate policies and division profit centres</td>
</tr>
<tr>
<td>1950–</td>
<td>Standard and innovative products or services. Stable and changing markets</td>
<td>Matrix</td>
<td>Several aerospace and electronic firms</td>
<td>Temporary teams and lateral resource allocation devices such as internal markets, joint planning systems, etc.</td>
</tr>
<tr>
<td>2000–</td>
<td>Product or service design. Global, changing markets</td>
<td>Dynamic network</td>
<td>International/ construction firms. Global consumer goods companies. Selected electronic and computer firms (e.g. IBM)</td>
<td>Broker-assembled temporary structures with shared information systems as basis for trust and co-ordination</td>
</tr>
</tbody>
</table>

hierarchy of corporate esteem. However, in contrast to Sturgeon’s belief, it is argued here that this is also the case for European firms. For example, most companies still regard efficiency as the main objective of their production departments in a survey amongst Spanish companies [2.18]. Consequently, during the 1960s and 1970s the make-or-buy decision was at the heart of operations management research. Then, in the 1980s, the interest in Japanese manufacturing techniques, including partnerships with suppliers, sparked the next step towards models for collaboration and supply chain management using JIT principles, while in the early 1990s the concept of core competencies led to renewed interest in outsourcing models. Later the over-the-wall tactics of outsourcing made companies examine the networks they had created while