Articles

# Managerial research on the pharmaceutical supply chain – A critical review and some insights for future directions

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## ARTICLE INFO

## ABSTRACT

This paper presents a systematic review of research on management in the pharmaceutical supply chain (PSC). Recent PSC literature, published in peer-reviewed academic journals, was collated for content analysis. Research efforts depict a traditional focus on efficiency-improvement, with an emerging interest in process-analysis and technology implementation in the PSC. PSC research is also highly context-specific and focuses on developed economies. Accompanied with a transition towards network-centric approaches, studies depict distinct focus on three levels of industrial interaction, which influence the final value delivered. Research focus is rapidly moving from value addition within the pharmaceutical manufacturing and distribution environment to the interface with healthcare services, facilitated by the healthcare procurement and supply function. The review broadly outlines the scope for integrating research efforts from R&D to final healthcare delivery and for more studies in emerging economies.

## 1. Introduction

The global health economy is growing at a faster pace when compared to the overall economy (World Health Organization, 2008). Nevertheless, issues of inequity in healthcare provision and complexities in the healthcare systems persist across the globe, highlighting the need for efficient management of healthcare supply chains. Literature depicts an increasing but fragmented interest in supply chains in health services (de Vries and Huijsman, 2011). The complexity of the interactions between players such as government bodies, healthcare purchasing groups, healthcare providers and manufacturing companies has also resulted in attention towards the value-chain concept in healthcare (Burns and Wharton School Colleagues, 2002; Pitta and Laric, 2004).

Apart from health services, supply chains of healthcare products are important contributors to the healthcare system. Different healthcare products are distributed and traded differently and vary in their cost, criticality to delivery of patient care and potential impact on service improvement (Zheng et al., 2006). Among healthcare products, medicines account for 20–30% of global health spending (World Health Organization, 2010). The United Nations Millennium Development Goals also identify the pharmaceutical industry as one of the major drivers of the healthcare sector. Hence, the effective management of the pharmaceutical supply chain (PSC) is crucial for the healthcare system.

While consumer/physician level behaviors and health expenditures are areas of immense research interest in the pharmaceutical industry, supply chain management (SCM) and research and development (R&D) have also emerged as significant avenues for research (Narayana et al., 2012). However, Shah (2004) observes a low focus of healthcare research on the PSC, that historically addresses sales/marketing or drug discovery, which form the two extreme ends of the chain. Recent reviews are also restricted to specific issues in the PSC such as optimization (Shah, 2004), implementation of just-in-time (Jarrett, 2006) or issues in specific countries such as healthcare reforms (Yu et al., 2010), sourcing decisions (Pazirandeh, 2011), etc. Among other areas of research, there is a need to review research efforts on SCM in the pharmaceutical industry (Narayana et al., 2012). Thus, the overall aim of this study is to provide a holistic review of current trends in management research on the PSC. Specifically, the paper aims to:

1. Analyze the progress of research interest in recent literature on the PSC across themes of study and across the structure of the PSC.
2. Analyze the research interest in pharmaceutical supply chains across geography and through methodological approaches applied in literature.
3. Explore the contribution of research to final value delivered to the end-consumer in the pharmaceutical supply chain.

This study is one of the few review papers that holistically reviews research progress for a product-specific supply chain, specifically, the pharmaceutical supply chain. Key findings in this review emphasize recent calls for integrated research efforts on value delivery and more studies in emerging economies. In addition to depicting traditional research interest in the manufacturing and distribution environment, this study also highlights the crucial boundary-spanning roles played by healthcare procurement and R&D in managing the PSC. These business processes are also of interest to industries where innovation and time-based competition are strong forces (e.g. telecommunications industry) and where bulk procurement and public–private partnerships are involved in the purchasing processes (e.g. construction industries and agri-supply chains). By exploring the contribution of the research to final value delivery, this paper also attempts at providing a much-needed linkage between research and the needs of practice. Hence, this review is of interest to supply chain professionals, researchers and government bodies in healthcare as well as in other industries.

## 2. Review methodology

In line with the aim of this study, the pertinent research questions can be delineated as follows:

RQ1: what is the progress of recent management research on the PSC across themes of study?
RQ2: what is the progress of this research across the structure of the PSC?
RQ3: what is the progress of the recent research on the PSC across the world?
RQ4: what are the methodological approaches that have been utilized in recent research on the PSC?
RQ5: how has recent management research addressed the final value delivered by the PSC?

A systematic review of relevant research literature is carried out as it provides transparent protocols by which researchers search for and assess the field of studies relevant to a specific research question (Macpherson and Holt, 2007). The review of PSC literature is based on the systematic review methodology outlined by Tranfield et al. (2003), Pittaway et al. (2004) and Macpherson and Holt (2007).

There are two basic stages of the systematic review process. "First, defining review protocols and mapping the field by accessing, retrieving and judging the quality and relevance of research (in relation to the research topic). Second, reporting the findings to identify gaps and inform propositional conclusions as to where future research might be usefully directed" (Macpherson and Holt, 2007). This section describes the first stage, which includes the search and selection method, analysis framework and data extraction.

### 2.1. Search and selection method

Four stages of search and selection were performed in this review (Appendix A). The inclusion and exclusion criteria were jointly decided by the three authors.

The pharmaceutical industry refers to the complex of processes, operations and organizations involved in the discovery, development and manufacture of drugs and medications (Shah, 2004). Sinha and Kohnke (2010) explain that drugs and pharmaceuticals form a part of the healthcare bundle along with diet and exercise, medical devices, new biologics, invasive procedures of treatment, medical travel and lodging and payment and reimbursement for

healthcare. Based on these descriptions, the authors used search strings that combine primary and secondary keywords. The primary keywords depict (i) pharmaceutical preparations and products or (ii) the interaction between the pharmaceutical industry and the healthcare bundle. Secondary keywords are related to supply chain literature.

In stage 1, the keyword search retrieved articles published between the years 2000–2011, from peer-reviewed academic/scholarly journals in online databases. These databases were selected as they have some of the largest repositories of business research. The resulting 3000 records of citations and abstracts were exported and compiled using EndNote, a referencing database. Further filtration was performed in stages 2 and 3, by reading through abstracts and article content, respectively.

Finally, articles were selected based on their individual research contributions. Initially, it was decided to select only those articles published in journals indexed in the 2010 Journal Citation Reports® (Thomson Reuters, 2011). However, this resulted in the exclusion of studies on certain relevant topics (e.g. counterfeit medicines). Therefore, each author selected some articles from the excluded studies, based on their perception of the article's research contribution in terms of rigor, relevance and readability. This subjective judgment was applied only in the last stage. Similar to the findings of Macpherson and Holt (2007), the final set of 99 studies contains articles from both, high impact factor and lesser known journals. Table 1 reveals that most articles are from journals in the field of engineering or operations management rather than healthcare research, suggesting a focus on efficiency improvement studies.

### 2.2. Analysis framework

The analysis framework described here is used to analyze the collated literature in relation to the research questions. In this review, research questions RQ1–RQ4 are addressed by (i) mapping research progress across relevant categories over time and (ii) performing cross-categorical analysis which helped in addressing multiple research questions using two or more categories. The categories considered for analysis are major theme, terminology used to address the PSC, structural dimensions, geography and primary research methodology.

Terminologies used in literature to address the PSC help to understand the level of research interest in managing PSCs, the various interpretations of the PSC and the context addressed in terms of the stakeholders and industries being studied. The major themes of study depict current research trends and the depth of research interest in the PSC through the business processes and issues that have been addressed in literature.

The structure of the PSC in this review refers to two structural dimensions of the supply chain, namely the level of analysis and the element of exchange. Croom et al. (2000) recommend the use of these dimensions in a framework for the analysis of studies in supply chain management. The analysis of the collated literature across these dimensions can provide deep insights into the progress of research across the structure of the PSC. Themes and terminologies are also analyzed within the 2-dimensional framework by developing supply chain content matrices. This cross-categorical analysis adds to the understanding about the structure of the PSC and the research focus across it.

Finally, geographical locations of the studies and the primary methodologies have been analyzed individually, together and across themes. The analysis of these categories aims to assess research development with respect to the development of healthcare systems across the world and the utilization of methodological approaches in PSC research.

**Table 1**
Literature collated on the pharmaceutical supply chain from different journals.

| Journal name | Number of studies per journal | Number of studies |
| --- | --- | --- |
| **Journals related to pharmaceuticals/healthcare** | | |
| Health Care Management Science, Journal of Health Economics | 1 | 2 |
| International Journal of Pharmaceutical and Healthcare Marketing | 3 | 3 |
| International Journal of Health Care Quality Assurance, Leadership in Health Services | 2 | 4 |
| Health Policy Planning | 4 | 4 |
| Health Policy | 5 | 5 |
| **Total number of studies** | | **18** |
| **Journals not directly related to pharmaceuticals/healthcare** | | |
| Managerial Decision Economics, Productivity Planning and Control | 3 | 6 |
| International Journal of Operations and Production Management, Interfaces | 5 | 10 |
| Computers and Chemical Engineering, Supply Chain Management: An International Journal, International Journal of Physical Distribution and Logistics Management | 4 | 12 |
| European Journal of Operational Research, Industrial Engineering and Chemical Research, Industrial Innovation, International Journal of Production Economics, International Journal of Quality and Reliability Management, Journal of Manufacturing Technology Management, Management Research Review, Omega | 2 | 16 |
| Benchmarking: An International Journal, Business Process Management Journal, Central European Journal of Operations Research, Competitiveness Review, Computers and Industrial Engineering, Computers and Operations Research, Decision Support Systems, European Management Journal, Group and Organization Management, Human Resource Management, Industrial and Corporate Change, Industrial Management+Data Systems, Industrial Marketing Management, INFOR: Information Systems and Operational Research, International Journal of Accounting, International Journal of Computer Integrated Manufacturing, International Journal of Information Management, International Journal of Logistics Management, International Journal of Logistics Research and Applications, International Journal of Productivity and Performance Management, International Journal of Systems Science, International Marketing Review, International Small Business Journal, Journal of African Business, Journal of Business Venturing, Journal of Development Effectiveness, Journal of Management, Journal of Management Development, Journal of the Operational Research Society, Journal of Small Business Management, Journal of Supply Chain Management, OR Spectrum, Production and Operations Management, Strategic Change, Strategic Management Journal, The Journal of Industrial Economics, Total Quality Management and Business Excellence | 1 | 37 |
| **Total number of studies** | | **81** |
| **Total number of studies collected across all journals** | | **99** |

Effectively, according to research questions, the categories analyzed are major theme (from RQ1 to RQ4), terminology (RQ2) and structural dimensions (RQ1 and RQ2), geography and primary methodologies (RQ1, RQ3 and RQ4). This type of content analysis aims to combine the thematic and descriptive analyses that have been recommended by Tranfield et al. (2003) for a systematic review of literature.

The findings of RQ1–RO4 are used to address RQ5. In the study of value in healthcare, Pitta and Laric (2004) suggest that at each stage in the supply chain (or value delivery network), value should be created for the ultimate consumer. Sinha and Kohnke (2010) also propose that healthcare supply chains should be designed keeping in view the affordability of, access to and awareness of healthcare to the end-consumer. In this review, the following *human* healthcare needs of the consumer are considered to form the important dimensions of the final value delivered by the PSC:

(i) availability of medicines;
(ii) access to medicines (including physical access to medicines and access to medical care);
(iii) affordability of medicines and
(iv) safety of medicines (including safety in administration, consumption and environmental safety).

These dimensions may not be exhaustive of all aspects of the final value delivered. However, the findings of the review are used to explore how PSC research has addressed the final value delivered in terms of these dimensions.

### 2.3. Data extraction

Tranfield et al. (2003) recommend the use of data extraction forms in systematic reviews as a direct means to assess the studies in relation to the research question, to provide a historical record of decisions made during the process and to provide the data-repository from which the analysis emerges. Data extraction includes coding and classification of collated studies by identifying specific characteristics in the study. Each study was coded according to a major theme studied, business processes and sub-issues addressed by it, the terminology used to address the PSC, the level of analysis, the elements of exchange, the primary research methodology applied and the geographical region where the research was conducted (Appendix B). Coding and classification were based on the iterative process of content analysis of logistics literature (Seuring and Müller, 2008; Gravier and Farris, 2008).

Croom et al. (2000) suggest that supply chain research caters to six bodies of literature – strategic management, organizational behavior, relationships/partnerships, marketing, best practices and logistics. Initially, each author coded and classified each article into one of these major themes, guided by business processes and sub-issues. Coding differences were resolved through discussion, resulting in the identification of new major themes, sub-issues and business processes. Accordingly, reclassification was done and the process was repeated for 5–6 iterations, until no new themes emerged. Discussion and reclassification was performed across all other categories as well, but with less iteration.

For classification into the 2-dimensional framework, each study was searched for direct or indirect specifications of the level of analysis and the elements of exchange (i.e., the structural dimensions) which have been adopted from Croom et al. (2000) as follows:

- *Level of analysis*: the levels include (i) dyadic level (two party relationships), (ii) chain level (a set of dyadic relationships), and (iii) network level (a network of operations). In this study, networks have been analyzed upstream and downstream of the manufacturer as well as the whole network of business operations from the supplier to the end consumer.

- *Element of exchange*: four elements of exchange have been utilized in the analysis, namely, assets, information, knowledge and relationships in business-to-business interactions.

Similarly, studies were coded according to their usage of primary and secondary keywords and then grouped into classes of terminologies used.

Studies were also coded according to the research methodologies used, namely, conceptual study, opinion survey/interview-based study, case-based study, mathematical modeling/secondary data analysis and literature review. The methodological evolution of studies is analyzed based on the assumption that research in any area follows a cyclic process, beginning with exploratory studies (using opinion surveys/interviews and case research) that aid mathematical modeling and conceptual studies, which are then critically examined for future research scope through literature reviews. Case-based studies include those employing case research in data collection, followed by formulation and mathematical analysis of the problem. Similarly, studies in mathematical modeling also include model formulation based on available literature and/or secondary data. Finally, articles were coded according to the continent of research (or) authors' location (if the study is not region-specific). North and South America, together, were considered as the American region.

Reliability of the review was addressed to a certain extent by involving the three authors in search and selection of articles, while formulating the analysis framework and during data extraction. Category reliability and interjudge reliability were achieved according to acceptable standards (Kassarjian, 1977) for the two types of analyses through the iterative process of content analysis, wherein differences were analyzed and resolved through discussion and mutual agreement. To improve validity of the categories and classification, the review was presented, in different stages, at conferences and seminars to receive expert feedback.

The second stage of the systematic review uses this framework to address the research questions in the following sections. Themes and terminologies used in the collated literature are identified in Section 3, while Section 4 further analyzes these categories within the supply chain content matrices. Section 5 analyzes the studies across geography, research methodologies and themes, while Section 6 explores the contribution of research to value delivered. The concluding Section 7 summarizes the analysis to identify research gaps and a broad scope for future research.

## 3. Terminologies utilized and themes studied in PSC literature

This section presents and analyzes terminologies used to address the PSC, major themes, business processes and sub-issues in PSC literature. Through the analysis of these categories, this section addresses some part of RQ1 (themes) and RQ2 (terminologies)

### 3.1. Evolution of studies across terminologies

While there is no clear definition available in literature for the term "pharmaceutical supply chain", data extraction revealed the usage of three classes of terminologies (Fig. 1):

(i) Generic supply chain terminologies [G] (e.g. supply network, distribution network, logistics, etc.): the continued presence of studies using these terminologies strengthens supply chain literature, while providing an understanding of issues in the pharmaceutical and healthcare industries.

(ii) Terminologies specific to the pharmaceutical industry [P] (e.g. pharmaceutical supply chain, drug distribution, medicine logistics, etc.): generally, studies using these terminologies refer to material flow in the manufacturing and distribution environment of the pharmaceutical industry (e.g. Shah (2004)). Over the last 2–3 years, a larger number of studies have used these terminologies. This reflects increasing appreciation for the supply chain as an entity with characteristics that represent the issues and complexities in the pharmaceutical industry.

(iii) Terminologies specific to the healthcare industry [H] (e.g. healthcare supply chain, hospital logistics, etc.): most studies using these terminologies focus on supply chains for hospitals, while some (e.g. Pedroso and Nakano (2009)) follow the description of the healthcare supply chain as provided by Burns and Wharton School Colleagues (2002). In this latter description, the healthcare supply chain includes healthcare producers, healthcare product intermediaries, healthcare providers, healthcare fiscal intermediaries and purchasers. Although fewer in number, the emergence of these studies in the last 5–6 years suggests greater research interest in the interdependence between the pharmaceutical and healthcare industries.
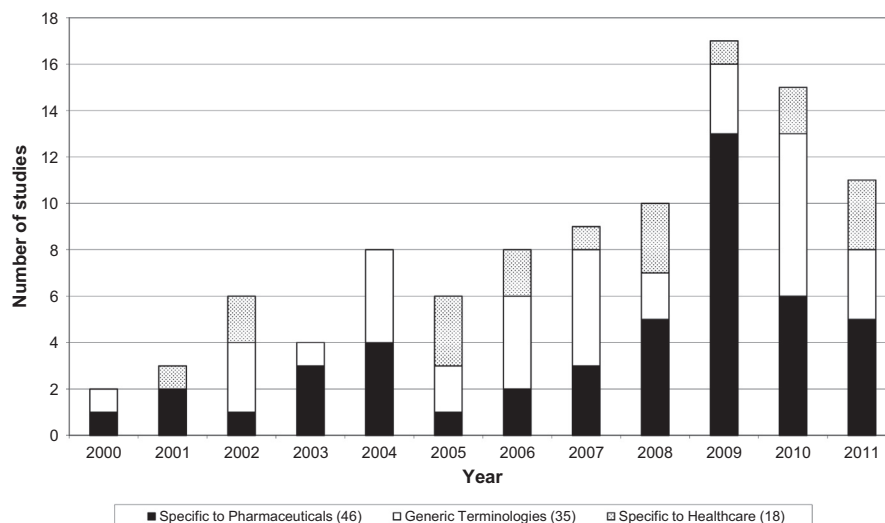


**Fig. 1.** Evolution of terminologies used in PSC literature (2000–2011).

**Table 2**
(a) Business processes and sub-issues studied across major themes related to the management of the PSC.

| Major theme/business process | Publications | Major theme/sub-issue | Publications |
|---|---|---|---|
| **Logistics management (LM)** | | | |
| R&D and new product development | Papageorgiou et al. (2001), Levis and Papageorgiou (2004), Shah (2004), Sundaramoorthy and Karimi (2004), and Fleischhacker and Zhao (2011) | • Optimization strategies for scheduling and capacity planning, network planning and design, portfolio planning | Papageorgiou et al. (2001), Grunow et al. (2003), Levis and Papageorgiou (2004), Shah (2004), Talluri et al. (2004), Sundaramoorthy and Karimi (2004), de Magalhães and de Sousa (2006), Zhuan et al. (2008), Chahed et al. (2009), Shang et al. (2009), Fleischhacker and Zhao (2011), and Shen et al. (2011) |
| Production | Papageorgiou et al. (2001), Grunow et al. (2003), Levis and Papageorgiou (2004), Shah (2004), Talluri et al. (2004), Sundaramoorthy and Karimi (2004), Chahed et al. (2009), Boulaksil and Fransoo (2010), Fleischhacker and Zhao (2011), and Shen et al. (2011) | • Dynamic vehicle routing<br>• Disaster/emergency response management<br>• Business process re-engineering (BPR) | de Magalhães and de Sousa (2006), Shen et al. (2011), Archer et al. (2008), and Shang et al. (2009) |
| Distribution and transportation | Shah (2004), Talluri et al. (2004), de Magalhães and de Sousa (2006), Zhuan et al. (2008), Chahed et al. (2009), Shang et al. (2009), Schwarz and Zhao (2011) | • Best practices (JIT, VMI, hybrid stockless, activity based costing, information sharing, ICT implementation) | Rivard-Royer et al. (2002), Danese (2006), Jarrett (2006), Kumar et al. (2008), Mustaffa and Potter (2009), Aptel and Pourjalali (2001), Schwarz and Zhao (2011), and Shen et al. (2011) |
| Purchasing and supply management, sustainable purchasing, packaging | Rivard-Royer et al. (2002), Strijbosch et al. (2002), Pan and Pokharel (2007), Kumar et al. (2008), Aptel and Pourjalali (2001), Sundaramoorthy and Karimi (2004), Boulaksil and Fransoo (2010), Shen et al. (2011), and Danese (2006) | • Strategic alliances, outsourcing logistics functions, contract manufacturing, investment buying, stockpile creation | Rivard-Royer et al. (2002), Grunow et al. (2003), Aptel and Pourjalali (2001), Strijbosch et al. (2002), Danese (2006), Kumar et al. (2008), Schwarz and Zhao (2011), Shen et al. (2011), Pan and Pokharel (2007), and Boulaksil and Fransoo (2010) |
| Hospital/healthcare logistics | Rivard-Royer et al. (2002), Chahed et al. (2009), Archer et al. (2008), Kumar et al. (2008), Aptel and Pourjalali (2001), Mustaffa and Potter (2009), Jarrett (2006), Pan and Pokharel (2007), and Shen et al. (2011) | | |
| **Pricing and financing (P&F)** | | | |
| • R&D<br>• Production<br>• Distribution and retail | Bardey et al. (2010), Lybecker (2008), Yu et al. (2010), Robbins and Jackson (2011), Garattini et al. (2008), Lybecker (2008), Kanavos and Vandoros (2010), Maïga and Williams-Jones (2010), Russo and McPake (2010), Yu et al. (2010), and Bardey et al. (2010) | • Price regulation and healthcare reforms | All studies in pricing and financing |
| Procurement and SUPPLY management | Chaudhury et al. (2005), Seoane-Vázquez and Rodríguez-Monguió (2007), Rodríguez-Monguió et al. (2007), Merkur and Mossialos (2007), Ellison and Snyder (2010), Bardey et al. (2010), Robbins and Jackson (2011), and Hu and Schwarz (2011) | • Pricing methods and strategies, distribution margins, price competitions, parallel trade, collusion, countervailing powers of wholesalers | Seoane-Vázquez and Rodríguez-Monguió (2007), Garattini et al. (2008), Maïga and Williams-Jones (2010), Russo and McPake (2010), Merkur and Mossialos (2007), Kanavos and Vandoros (2010), Lybecker (2008), Ellison and Snyder (2010), Bardey et al. (2010), Hu and Schwarz (2011), and Lybecker (2008) |
| Pharmaceutical lending and funding, healthcare funding | Rodríguez-Monguió et al. (2007), Yu et al. (2010), and Bardey et al. (2010) | • Anti-counterfeiting | |
| (b) | | | |
| **Decision making (DM)** | | | |
| • Production, distribution and transportation | Dekker and Van Goor (2000), Gupta et al. (2002), Danese et al. (2006), Choudhury et al. (2004), Arora et al. (2010), and Rossetti et al. (2011) | • Drug/budget/workload/bids allocation and selection, scheduling and planning | Gupta et al. (2002), Talluri (2002), Swaminathan et al. (2004), Swaminathan (2003), Danes et al. (2006) Lapierre and Ruiz (2007), Arora et al. (2010), and Pazirandeh (2011) |
| • Procurement and supply management, inventory management | Talluri et al. (2006), Kirytopoulos et al. (2008), Talluri (2002), Lapierre and Ruiz (2007), Danas et al. (2006), Danese et al. (2006), Arora et al. (2010), Rossetti et al. (2011), Pazirandeh (2011), Ertay et al. (2011), Swaminathan et al. (2004), and Swaminathan (2003) | • Supplier selection/evaluation<br>• Disaster/emergency management<br>• Business process redesign, change management | Talluri et al. (2006), Kirytopoulos et al. (2008), Ertay et al. (2011) Arora et al. (2010)<br>Gebauer (2008), Dekker and Van Goor (2000), Danese et al. (2006), and Rossetti et al. (2011) |
| Healthcare logistics and delivery | Swaminathan et al. (2004), Swaminathan (2003), Gebauer (2008), Lapierre and Ruiz (2007), Danas et al. (2006), Pazirandeh (2011), and Arora et al. (2010) | • Application of multi-attribute classification/selection (MASTA, AHP, ANP, Fuzzy AHP, game models, Chance constrained DEA), tabu search | Talluri (2002), Talluri et al. (2006), Kirytopoulos et al. (2008), Choudhury et al. (2004), Danes et al. (2006), Ertay et al. (2011), and Lapierre and Ruiz (2007) |
| | | • Optimizing redistribution<br>• Decision making processes and frameworks<br>• Decision support systems (DSS) | Arora et al. (2010)<br>Danese et al. (2006), Gebauer (2008), Rossetti et al. (2011), Pazirandeh (2011)<br>Swaminathan et al. (2004), Swaminathan (2003), Gupta et al. (2002) |

- Best practices (ABC, VMI) — Dekker and Van Goor (2000), Danese et al. (2006)

**Organizational behavior and human resource management (OB&HRM)**

R&D — Hess and Rothaermel (2011)

- Decentralization vs. centralization — Bossert et al. (2007) and Meijboom and Obel (2007)

Production — Koulikoff-Souviron and Harrison (2010), Harwood and Chapman (2009), Meijboom and Obel (2007), and Mangan and Christopher (2005)

- Strategic alliances, partnerships, mergers and acquisition, intra-firm integration — Beekman and Robinson (2004), Harwood and Chapman (2009), Koulikoff-Souviron and Harrison (2010), and Hess and Rothaermel (2011)

Procurement and supply management, packaging — Nollet and Beaulieu (2005), Mangan and Christopher (2005), Koulikoff-Souviron and Harrison (2010), Beekman and Robinson (2004), Meijboom and Obel (2007), Bossert et al. (2007)

- Competency development, recruitment of scientists, HR practices — Mangan and Christopher (2005), Koulikoff-Souviron and Harrison (2010), Hess and Rothaermel (2011)

Distribution — Şengün and Wasti (2007), Şengün and Wasti (2009), Jambulingam et al. (2009), Mangan and Christopher (2005), Harwood and Chapman (2009), and Meijboom and Obel (2007)

- Trust, fairness, loyalty, risk matters — Harwood and Chapman (2009), Şengün and Wasti (2007), Şengün and Wasti (2009), and Jambulingam et al. (2009)

Healthcare logistics and delivery — Bossert et al. (2007) and Nollet and Beaulieu (2005)

- Group dynamics — Nollet and Beaulieu (2005)
- Change management — Harwood and Chapman (2009)

(c)
**Quality management** and **performance management (QM&PM)**

Production — Srivastava (2008), Enyinda and Tolliver (2009), Patel et al. (2009), and Asamoah et al. (2011)

- Service quality — Ahmad et al. (2009) and Schofield and Breen (2006)
- Best practices (TQM, BSC) — Kumar et al. (2005) and Awan et al. (2009)

Procurement and supply management — Kumar et al. (2005), Patel et al. (2009), and Asamoah et al. (2011)

- Healthcare reforms — Oduor et al. (2009), Patel et al. (2009), McKone-Sweet et al. (2005), and Asamoah et al. (2011)

Distribution — Ahmad et al. (2009), Schofield and Breen (2006), Awan et al. (2009), Oduor et al. (2009), Patel et al. (2009), and Enyinda and Tolliver (2009)

- Implementation barriers, critical success factors — McKone-Sweet et al. (2005), Awan et al. (2009), and Asamoah et al. (2011)
- Performance measurement, cost of quality — Kumar et al. (2005), Srivastava (2008), and Ahmad et al. (2009)

Healthcare logistics and delivery — Oduor et al. (2009), Patel et al. (2009), McKone-Sweet et al. (2005), and Asamoah et al. (2011)

- Outsourcing (micro-franchising, contract manufacturing) — Oduor et al. (2009), Srivastava (2008)
- Supply chain security, quality assurance — Enyinda and Tolliver (2009), and Patel et al. (2009)

**Reverse logistics (RL)**

Production and distribution — Amaro and Barbosa-Povoa (2008), Amaro and Barbosa-Povoa (2009), and Kumar et al. (2009)

- Scheduling and planning, distribution network design — Amaro and Barbosa-Povoa (2008) and Amaro and Barbosa-Povoa (2009)

- Product recalls, product safety — Kumar et al. (2009) and Ritchie et al. (2000)
- Health care prediction — Antai and Mutshinda (2010)

Recycling and disposal — Ritchie et al. (2000), Amaro and Barbosa-Povoa (2008), Amaro and Barbosa-Povoa (2009)

- Process control (FMEA) — Kumar et al. (2009)
- Business process redesign — Ritchie et al. (2000)

Healthcare logistics — Ritchie et al. (2000) and Antai and Mutshinda (2010)

- Partnerships, co-sourcing, third party logistics — Amaro and Barbosa-Povoa (2009), Ritchie et al. (2000), and Kumar et al. (2009)

(d)
**E-commerce (ECOM)**

Procurement and supply management, e-procurement — More and McGrath (2002), Caridi et al. (2004), Breen and Crawford (2005), Cullen and Taylor (2009), Kulp et al. (2006), Ketikidis et al. (2010), Bhakoo and Chan (2011)

- Process improvement, healthcare reforms — More and McGrath (2002), Breen and Crawford (2005), Cullen and Taylor (2009), Ketikidis et al. (2010), Bhakoo and Chan (2011), and Kulp et al. (2006)

Internet retail — Spain et al. (2001)

- Business process redesign — More and McGrath (2002), Caridi et al. (2004), Kulp et al. (2006), Ketikidis et al. (2010), and Bhakoo and Chan (2011)

- Compliance management — Kulp et al. (2006)
- Regulation — Spain et al. (2001)

**Table 2** (continued)

| Major theme/business process | Publications | Major theme/sub-issue | Publications |
|---|---|---|---|
| **Knowledge and innovation management (K&IM)** | | | |
| R&D | Alshawi et al. (2003), Pedroso and Nakano (2009), Lane and Probert (2007), Ruckman (2008), Van de Vrande et al. (2009), Gupta et al. (2009), Ceccagnoli et al. (2010), Odagiri (2003), Sabatier et al. (2010) | • Knowledge sourcing, knowledge acquisition, research alliances<br>• Data warehousing | Lane and Probert (2007), Ruckman (2008), Van de Vrande et al. (2009), Gupta et al. (2009), Ceccagnoli et al. (2010), Odagiri (2003)<br>Alshawi et al. (2003) |
| Production, distribution, marketing, healthcare delivery | Pedroso and Nakano (2009) | • Network coordination<br>• Managing knowledge and information flow, demand generation | Sabatier et al. (2010)<br>Pedroso and Nakano (2009) and Sabatier et al. (2010) |
| **IT applications (ITAPP)** | | | |
| Hospital procurement and supply management | Bendavide et al. (2010) | • Radio-frequency identification (RFID) | Wyld (2008), Bendavide et al. (2010), Kwok et al. (2010) |
| Manufacturing, distribution and inventory management | Wyld (2008) and Kwok et al. (2010) | • Anti-counterfeiting<br>• Best practice (e-Kanban) | Wyld (2008) and Kwok et al. (2010)<br>Bendavide et al. (2010) |

### 3.2. Themes studied in the PSC

The major themes that were identified in the collated literature are:

(i) Logistics management (LM) in the forward supply chain.
(ii) Decision making (DM).
(iii) Organizational behavior and human resource management (OB&HRM).
(iv) Pricing and financing (P&F).
(v) Quality management and performance management (QM&PM).
(vi) Knowledge and innovation management (K&IM).
(vii) E-commerce (ECOM).
(viii) Reverse logistics (RL).
(ix) Information technology applications (ITAPP).

These themes do not exhaustively address all PSC issues, but provide a glimpse into related research efforts (Fig. 2). Table 2a–d depicts the business processes and sub-issues corresponding to these themes. A major theme provides the broad perspective of the research problem or strategy (sub-issue) addressed with respect to the business process. In terms of number of studies, the business processes of most interest in PSC research are procurement and supply management (44), distribution (36), production (32), healthcare logistics and delivery (24) and to some extent, R&D (16). Sub-issues of interest include business process-redesign (BPR), inter-organizational relationships, best practices, optimization strategies, etc. A study can address multiple business processes and sub-issues within a single major theme (e.g. Papageorgiou et al. (2001) provide optimization strategies for simultaneous portfolio planning in R&D and capacity planning in production). Similarly, major themes address common business processes and/or sub-issues.

Studies on logistics management (the most researched theme) have typically analyzed issues of design and optimization strategies across most processes. The studies that analyze R&D and production processes depict features and complexities typical of the pharmaceutical process industry such as the long and risk-intensive research, discovery and development phases, primary and secondary stages in manufacturing, long production lead times, etc. The study of best practices and BPR depicts acceptable practices and the continuous pursuit for improving purchasing and supply management, distribution and hospital logistics. The study of just-in-time (JIT) and hybrid-stockless policies in procurement reflects evolving debates on the effectiveness of stockless inventory policies in the PSC. The focus on home healthcare services reflects the increasing customization of medical care. The shift in focus from logistics management to other emerging themes further suggests the relative maturity of research in this theme.

Research in decision making has appeared in the earlier years and is mostly related to logistics management. However, these studies focus on the development and implementation of decision making tools (e.g. decision support systems and multi-attribute classification) and the complexities associated with decision making processes (e.g. BPR) in the PSC. Decision problems include planning, supplier selection and resource allocation in production, purchasing and supply and healthcare logistics.

Studies on organizational behavior and human resource management have emerged in the last 5–6 years. These studies focus on managing industrial relationships in production, distribution, procurement and supply. The few studies on human resource management depict the importance of both scientific and managerial expertise in the PSC.

Studies on pricing and financing are rapidly emerging, given the critical value of pharmaceuticals and healthcare. The studies analyze different pricing strategies, pricing regulations and competitive behavior among the players. Different contractual

**Table 3**
Terminology matrix for PSC literature.

| Level of analysis | Terminology | Element of exchange | | | | Total number of papers |
|---|---|---|---|---|---|---|
| | | Asset | Information | Knowledge | Relationship | |
| Dyad | P | 15 | 15 | 11 | 13 | 16 |
| | G | 15 | 13 | 8 | 13 | 15 |
| | H | 5 | 5 | 3 | 4 | 5 |
| | Total | 35 | 33 | 22 | 30 | 36 |
| Chain | G | 8 | 8 | 7 | 8 | 8 |
| | H | 4 | 4 | 3 | 4 | 4 |
| | P | 3 | 3 | 3 | 3 | 3 |
| | Total | 15 | 15 | 13 | 15 | 15 |
| Network (upstream) | P | 4 | 4 | 2 | 3 | 4 |
| | G | 3 | 3 | 2 | 3 | 3 |
| | Total | 7 | 7 | 4 | 6 | 7 |
| Network (downstream) | P | 16 | 16 | 8 | 13 | 16 |
| | H | 9 | 8 | 5 | 8 | 9 |
| | G | 5 | 4 | 1 | 3 | 5 |
| | Total | 30 | 28 | 14 | 24 | 30 |
| Network (whole) | P | 7 | 7 | 4 | 7 | 7 |
| | G | 3 | 3 | 4 | 4 | 4 |
| | Total | 10 | 10 | 8 | 11 | 11 |
| All levels | P | 45 | 45 | 28 | 39 | 46 |
| | G | 34 | 31 | 22 | 31 | 35 |
| | H | 18 | 17 | 11 | 16 | 18 |
| | Grand total | 97 | 93 | 61 | 86 | 99 |

mechanisms and healthcare reforms have also been analyzed in the procurement and funding of pharmaceuticals. These studies depict challenges in balancing the competitive objectives of the industry with governance for equitable healthcare.

While research interest in the management of quality and performance in the PSC is not new, it appears to have increased in the last 2–3 years. There is a strong interest in process quality, which is highlighted through the analysis of costs of quality in manufacturing, service quality in distribution and the implementation of best practices in both distribution and procurement. Supply chain security in the PSC has emerged as an area of interest, with respect to safeguarding product quality and consumer health. Through the analysis of performance barriers and the evaluation of performance, studies on performance management depict scope for improving PSC operations.

There is an emerging interest in pharmaceutical reverse logistics. Concerns of product recalls and safety are reflected in the study of process control. Innovation in healthcare prediction is depicted through the analysis of product returns. Recycling, disposal, scheduling and planning have been studied in the context of designing effective distribution networks and healthcare logistics. These research efforts depict the prevalence and scope for sustainable practices in the PSC.

In the last five years, the emergence of more studies on knowledge and innovation management in the PSC reflects the increasingly competitive environment that pressurizes pharmaceutical companies to discover and develop innovative medicines. Studies in e-commerce have been prevalent for some time and mostly analyze the adoption of e-procurement as a part of healthcare reforms and process improvement. Typically, studies on BPR and change management present the complexities in e-adoption. Though limited, the focus on internet retail reflects the challenges in employing the internet to distribute and sell sensitive products such as medicines. The emergence of innovative IT applications (e.g. RFID) has resulted in the emergence of studies dedicated to designing efficient business processes, product tracking strategies, anti-counterfeiting strategies, and best practices in the PSC around such sophisticated tools.

Overall, PSC research has progressed along three primary classes of interdependent themes. Firstly, the research interest has traditionally focused on *efficiency/profitability improvement*, reflected through several studies related to operations management literature and an upcoming interest in pricing studies. Secondly, there is an emerging interest in *process analysis* over the last few years, focusing on people and processes. These process-oriented themes include organizational behavior and human resource management, decision making processes, quality management and performance management, e-commerce and some aspects of logistics management, pricing and financing. Finally, there is an increasing interest in building *technological competence* in the PSC through R&D (knowledge and innovation management) and the implementation of information systems such as e-commerce and other IT applications. The overlap between these themes reflects the inter-disciplinary nature of supply chain literature as well (Croom, et al., 2000).

## 4. Supply chain content matrices

In this section, the progress of PSC research across structural dimensions (level of analysis and element of exchange) is presented. The supply chain content matrices for terminologies used (Table 3) and major themes in PSC research (Table 4) depict the progress of research across these categories across the PSC structure. Hence, through cross-categorical analysis, this section focuses on further addressing RQ1 and RQ2 together.

### 4.1. Analysis across levels of analyses

Fig. 3 highlights the evolution of the studies on PSC across the levels of analyses, one of the structural dimensions of the PSC. While most of the research focuses on the dyad, there is a growing dominance of network-centric (upstream, downstream and whole network) studies. Research efforts across themes further explain the progress of research across the levels of analyses, through the business processes that have been studied. Similarly, the usage of

**Table 4**
Supply chain content matrix for PSC literature.

| Level of analysis | Major theme | Element of exchange | | | | Total number of papers |
|---|---|---|---|---|---|---|
| | | Asset | Information | Knowledge | Relationship | |
| Dyad | LM | 9 | 8 | 2 | 5 | 9 |
| | DM | 7 | 7 | 4 | 6 | 7 |
| | OB&HRM | 6 | 5 | 5 | 6 | 6 |
| | P&F | 4 | 4 | 2 | 4 | 4 |
| | QM&PM | 4 | 3 | 3 | 4 | 4 |
| | K&IM | 3 | 4 | 4 | 4 | 4 |
| | ECOM | 1 | 1 | 1 | 1 | 1 |
| | ITAPP | 1 | 1 | 1 | – | 1 |
| | Total | 35 | 33 | 22 | 30 | 36 |
| Chain | P&F | 6 | 6 | 6 | 6 | 6 |
| | LM | 5 | 5 | 3 | 5 | 5 |
| | DM | 1 | 1 | 1 | 1 | 1 |
| | K&IM | 1 | 1 | 1 | 1 | 1 |
| | QM&PM | 1 | 1 | 1 | 1 | 1 |
| | ECOM | 1 | 1 | 1 | 1 | 1 |
| | Total | 15 | 15 | 13 | 15 | 15 |
| Network (upstream) | K&IM | 3 | 3 | 3 | 3 | 3 |
| | ECOM | 2 | 2 | 1 | 2 | 2 |
| | LM | 2 | 2 | – | 1 | 2 |
| | Total | 7 | 7 | 4 | 6 | 7 |
| Network (downstream) | DM | 7 | 6 | 2 | 5 | 7 |
| | RL | 5 | 5 | 1 | 4 | 5 |
| | ECOM | 4 | 4 | 4 | 4 | 4 |
| | LM | 3 | 3 | – | 1 | 3 |
| | QM&PM | 3 | 3 | 2 | 3 | 3 |
| | P&F | 3 | 2 | 2 | 3 | 3 |
| | OB&HRM | 3 | 3 | 2 | 3 | 3 |
| | ITAPP | 2 | 2 | 1 | 1 | 2 |
| | Total | 30 | 28 | 14 | 24 | 30 |
| Network (whole) | LM | 4 | 4 | 2 | 4 | 4 |
| | QM&PM | 2 | 2 | 1 | 2 | 2 |
| | OB&HRM | 1 | 1 | 2 | 2 | 2 |
| | K&IM | 1 | 1 | 1 | 1 | 1 |
| | P&F | 1 | 1 | 1 | 1 | 1 |
| | DM | 1 | 1 | 1 | 1 | 1 |
| | Total | 10 | 10 | 8 | 11 | 11 |
| All levels | LM | 23 | 22 | 7 | 16 | 23 |
| | DM | 16 | 15 | 8 | 13 | 16 |
| | P&F | 14 | 13 | 11 | 14 | 14 |
| | OB&HRM | 10 | 9 | 9 | 11 | 11 |
| | QM&PM | 10 | 9 | 7 | 10 | 10 |
| | K&IM | 8 | 9 | 9 | 9 | 9 |
| | ECOM | 8 | 8 | 7 | 8 | 8 |
| | RL | 5 | 5 | 1 | 4 | 5 |
| | ITAPP | 3 | 3 | 2 | 1 | 3 |
| | Total | 97 | 93 | 61 | 86 | 99 |

different terminologies depicts the extent of research interest in interactions between industries across these levels.

The increased focus on dyadic studies in the last five years is due to the increasing presence of process-oriented studies (organizational behavior, decision making, and quality and performance management) (Table 4). These studies depict continuing efforts to explore and analyze two-party exchanges within business processes, upstream (R&D, procurement and supply) and downstream (distribution, healthcare procurement and healthcare logistics). Studies in dyads have mostly used pharmaceutical-specific and generic terminologies and reflect a high focus on the pharmaceutical manufacturing and distribution industry (Table 3).

Studies specific to upstream networks have appeared in the last 2–3 years due to a continued interest in e-commerce and an emerging interest in knowledge and innovation management. By focusing on R&D, production, procurement and supply management, these studies depict interactions between the R&D-specific

biotechnology industry and the pharmaceutical manufacturing industry. The low focus on upstream networks can be attributed to (i) a higher focus on upstream dyads, instead, and (ii) the greater importance given to downstream material flows, where, as much as 80% of demand is observed through wholesalers (Shah, 2004). The absence of studies using healthcare-specific terminologies suggests that upstream issues are considered separately from downstream healthcare concerns.

Most of the research on the downstream network relates to operations management (particularly, decision making), e-commerce and pricing. These studies span business from production and distribution to healthcare procurement, healthcare funding, and healthcare logistics. Studies using pharmaceutical-specific terminologies and an increasing number of studies that use healthcare-specific terminologies focus on downstream networks. These findings further highlight an increasing appreciation for the interdependencies between the two industries.
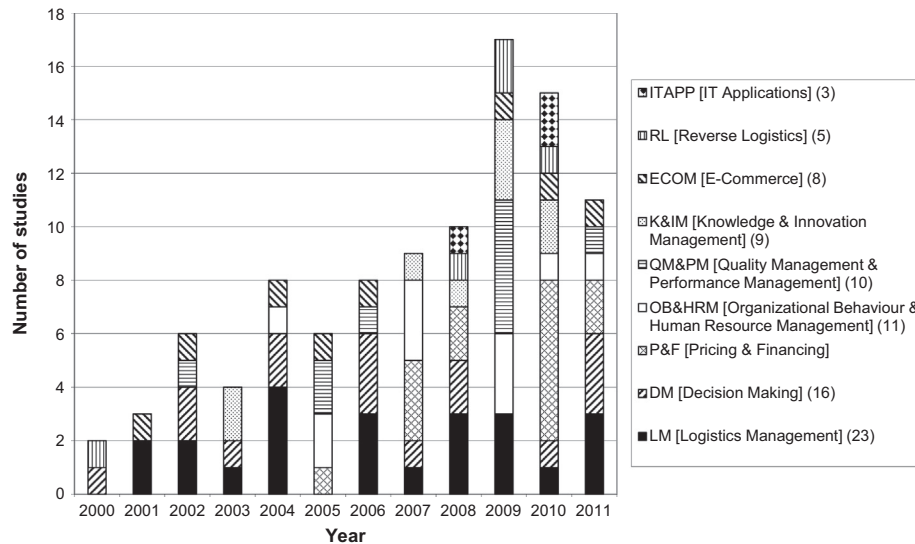
**Fig. 2.** Progress of studies on issues related to management of the PSC (2000–2011).
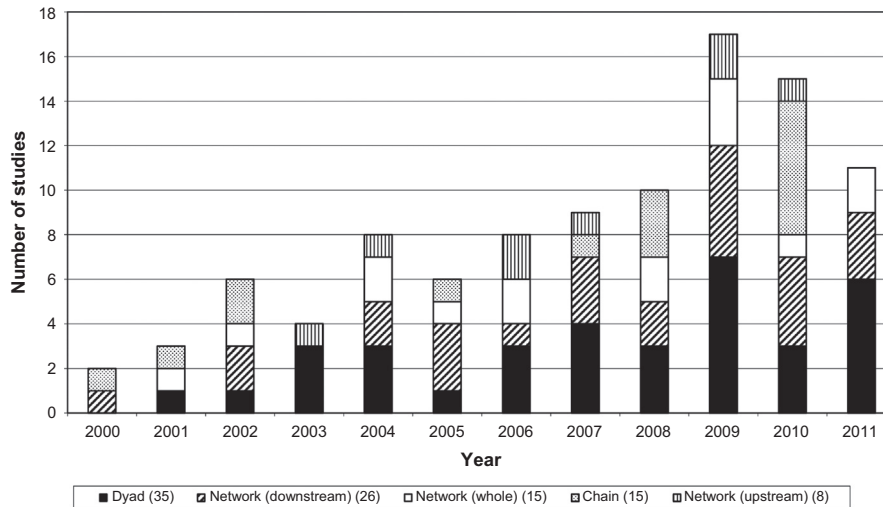


**Fig. 3.** Variation of studies on the PSC across levels of analyses (2000–2011).

Research efforts are low and fragmented in their focus on issues related to the complete network. Most of them are related to the management of logistics and quality, from upstream supplier networks to downstream distribution networks. Through an upcoming interest in knowledge and innovation management, business processes from R&D to healthcare delivery are also being considered. Studies using pharmaceutical-specific terminologies dominantly focus on the whole network. Thus, research interest in the functioning of PSC, as a whole, appears to depict an efficiency perspective of the pharmaceutical manufacturing and distribution industry.

Increased interest in medicine pricing in distribution and continued focus on logistics management contribute to research at the chain level, using generic and healthcare-specific terminologies. This low focus can be attributed to a higher research interest in dyads and network-centric studies, instead.

### 4.2. Analysis across elements of exchange

Fig. 4 depicts the progress in focus on the elements of exchange, over time. Each article addresses multiple elements of exchange simultaneously, indicated by variation in focus across

them. Traditionally, most studies analyze asset, information and relationship exchanges, with a relatively lower focus on knowledge exchange. Within each element of exchange, there have been different aspects of interest across the themes (Table 5).

Similar to traditional SCM research, studies in PSC literature focus on asset exchange. Themes related to operations management, IT applications and e-commerce study all types of assets (material, financial and technological), indicating interdependencies between asset exchanges. In downstream networks, the study of pricing and financing of pharmaceuticals focuses on financial asset exchange that accompanies material exchange, while studies in knowledge and innovation management depict the management of technological and financial resources in upstream networks (Tables 4 and 5). In addition to the static dimensions of exchange (quantity, quality, pricing and location of assets), dynamic dimensions are addressed through the analysis of scheduling, distribution and transportation, in logistics and decision making. Process-oriented themes study the interdependence between physical exchange of assets and the implementation of best practices and BPR (e.g. changing medicine packaging to suit the implementation of e-commerce).
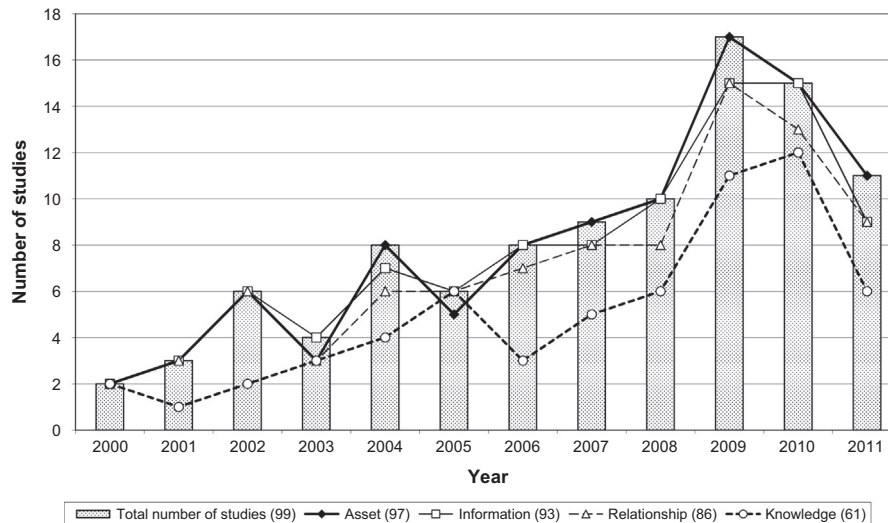
**Fig. 4.** Variation of studies on the PSC across elements of exchange (2000–2011).

Almost all studies also focus on information exchange in the PSC (Fig. 4). Efficient functioning of the PSC is highly dependent on effective management of business process information, as indicated by the focus of most themes on orders, sales data, contractual information, etc. (Table 5). The varied potential of technical information, comprising of consumer-specific data, has been depicted across different applications such as demand generation in knowledge management, drug-budget allocation, healthcare logistics management, etc. Product-specific data have been studied to a minor extent in the design of logistics networks, knowledge management and developing medicine pricing strategies for various types of pharmaceuticals. The study of technological advances in information exchange depicts how the implementation of technology enables informed decision making and the design of streamlined and secure PSC networks. Given the use of different forms of data, the implementation of new processes and competition in the pharmaceutical industry, most themes stress on resolving issues of collaboration and coordination between players.

The presence of several studies on relationship exchange reflects a strong understanding of the foundations for a successful and efficient PSC. Efficiency-related themes such as logistics management, decision making and IT applications depict higher focus on asset and information exchange. Consequently, focus on relationship exchange is relatively low in dyads and downstream networks which are dominated by these themes and also in studies using pharmaceutical-specific terminologies (Tables 3 and 4). Research efforts also depict and study different macro-level relationships that form in the PSC (Table 5). Purchasing and supply partnerships are an integral part of studies on logistics design and material handling practices. The study of pooled procurement in downstream networks reflects the importance of group purchasing in healthcare (Nollet and Beaulieu, 2003). Outsourcing has emerged as a business strategy in the context of manufacturing and material handling functions for both forward and reverse logistics and in the context of knowledge intensive activities in upstream networks. Similarly, several studies on hierarchical relationships depict growing dependence on knowledge acquisitions in upstream networks and dyads. However, vertical integration, mergers and acquisitions and delegation of authority in the PSC have been studied in a fragmented fashion for their impact on price, organizational change, logistics design, etc. The mechanisms through which these relationships have been sustained in the PSC are depicted at the micro-level, especially in process-oriented themes and in studies

related to pricing and financing. These themes illustrate the importance of formal relationship instruments (contracts and tenders) in supporting the exchange of business process information and assets in the PSC. In downstream distribution, the study of the informal aspects of buyer–supplier relationships (trust, risk, etc.), collusion and counterfeiting reveals a growing interest in a variety of real-world behaviors and their role in healthcare policies and PSC strategies.

At around 60% of the total number of studies, research efforts on knowledge exchange in the PSC, are fewer and sporadic, but have been increasing of late (Fig. 3). Most studies in logistics management, reverse logistics and decision-making focus on other elements of exchange. Consequently, fewer studies address knowledge exchange in downstream networks, the holistic PSC network and in studies using healthcare-specific terminologies (Tables 3 and 4). The study of process knowledge is integral to process-oriented themes. These themes depict the challenges in building mutual understanding and compatible know-how that supports BPR, change management and technology-implementation in the PSC. The utility of product knowledge is depicted in upstream product development and, to some extent, in providing business value and supply chain security in the PSC through intellectual property protection.

## 5. Research progress across geography and methodological approaches utilized in PSC studies

This section analyzes the literature at an aggregate level and across major themes with respect to geography and methodological approaches used.

### 5.1. Inter-continental comparison of studies across research methodologies

Through the analysis of studies across geography and across research methodologies utilized, this sub-section aims at addressing RQ3 and RQ4 together.

The European and American regions have consistently displayed the largest quantum of studies on PSC management (70% of the collated literature) and have utilized most of the research methodologies, especially empirical methods and mathematical modeling (Figs. 5 and 6). The presence of a significant number of

**Table 5**
Various elements of exchange, as studied in PSC literature.

| Element of exchange | | Major themes |
|---|---|---|
| *Asset* | | |
| Material | – Raw materials, pharmaceuticals and packaging | LM, DM, QM&PM, ECOM, OB&HRM, PFA, ITAPP |
| Financial | – Sales, budgets, profits, royalties, costs, distribution margins, healthcare finance, etc. | LM, DM, QM&PM, P&F, ECOM, K&IM, ITAPP, OB&HRM |
| Technology | – Utilization of R&D resources | K&IM, LM |
| | – Technology implementation | LM, DM, ECOM, ITAPP, QM&PM |
| *Information* | | |
| Business process information exchange | – Orders, demand forecasts, plant plans, lead time, product returns data, sales data, billing and invoice information | LM, DM, RL, QM&PM, ECOM, ITAPP, P&F |
| | – Contractual and regulatory information | P&F, LM, DM, RL, OB&HRM, QM&PM, ECOM |
| Technical information exchange | – Consumer/patient-specific data (healthcare statistics, clinical trials data, prescription data) | K&IM, DM, LM, RL, QM&PM |
| | – Product-specific data (composition of pharmaceuticals, shelf life, therapeutic uses) | LM, DM, K&IM, P&F |
| Technological advances in information/data exchange | – Product tracking technology (RFID, bar-coding) | ITAPP, ECOM, LM, RL, PFA, QM&PM |
| | – Electronic data interchange, use of internet | ITAPP, ECOM, LM, RL, DM |
| | – Information systems (DSS, accounting systems, ERP, etc.) | DM, ECOM, LM, ITAPP |
| Information coordination/ collaboration | – Standardized product coding, application of standard operating procedures, improved communication between stakeholders, etc. | LM, DM, RL, QM&PM, ECOM, P&F, K&IM, ITAPP, OB&HRM |
| *Relationship* | | |
| Macro-level: | – Purchasing and supply partnerships | |
| – Partnership/strategic alliances | – Pooled procurement | LM, DM, RL, OB&HRM, QM&PM |
| | – Integration of information systems | DM, OB&HRM, ECOM, P&F |
| | – Integration of R&D activities | ECOM |
| | | K&IM |
| – Outsourcing | – Contract manufacturing, outsourcing material handling functions | LM, QM&PM |
| | – Contract research | K&IM |
| | – Micro-franchising of distribution | QM&PM |
| | – Co-sourcing and third party logistics | RL |
| – Hierarchical relationship | – Knowledge acquisition | K&IM |
| | – Vertical integration | P&F |
| | – Mergers and acquisition | OB&HRM |
| | – Authority delegation (VMI implementation, decentralization vs. centralization) | LM, OB&HRM, ECOM |
| – Collusion | – Pricing tactics | P&F |
| Micro-level: | – Contracts and tenders | P&F, QM&PM, ECOM, OB&HRM, DM, LM |
| | – Trust, risk, compliance, control, service quality, power dynamics, countervailing | OB&HRM, QM&PM, ECOM, P&F |
| | – Counterfeiting | P&F, QM&PM |
| *Knowledge* | | |
| Process-knowledge | – Individual competency (training and skill development) | OB&HRM, ECOM, LM, DM, RL, ITAPP |
| | – Legacy systems and knowledge sharing | OB&HRM, ECOM, QM&PM, DM, LM, ITAPP |
| | – Values, beliefs and mental models | OB&HRM, ECOM, QM&PM, DM |
| Product knowledge | – Technical knowledge (product design) | K&IM |
| | – Intellectual property | P&F, QM&PM, LM |

literature reviews also indicates prior research, conceptual clarity and the enthusiasm to explore new research avenues. Thus, it appears that PSC research in these two regions accompanies the developments of their economies, health systems and pharmaceutical markets, given that the regions account for at least 70% of the global market value (Datamonitor, 2011).

The Asian and African regions comprise economies that are struggling with developing strong health systems and have low public investments in healthcare (World Health Organization, 2010, 2008). Therefore, the low quantum of research efforts across these regions (Fig. 5) is an area of concern. The Asia-Pacific market is more developed, contributing to 25% of the global market value, while Middle-East and Africa are relatively unexplored (Datamonitor, 2011). Similarly, research efforts are also rapidly increasing in Asia, while gradually developing over the last 3–4 years in Africa (Fig. 6). Additionally, the presence of case-research and survey-based studies suggests that researchers are currently exploring the development of good healthcare systems in these regions. The low quantum of trans-continental research indicates an emerging interest in global pharmaceutical supply chains. As Australia accounts for a small part of the world pharmaceutical market (Bhakoo and Chan, 2011), the research focus on the PSC in this region is also low.

Finally, Figs. 5 and 7 help in connecting research methodologies used with research efforts across regions. The prevailing differences in the healthcare systems and infrastructure, across regions, are reflected in the large number of case studies. The near absence of conceptual studies further suggests that PSC research is highly context-specific. The increasing use of mathematical modeling/secondary data analysis can be attributed to its increasing use in the American region. Similarly, emerging research interest in developing economies has contributed to the increasing use of field research.

### 5.2. Inter-continental comparison of studies across major themes

Fig. 8 depicts the geographical spread of the studies with respect to the major themes identified in Section 3.2, and helps in addressing RQ1 and RQ3 together.

All major themes have been addressed in the American region. The high focus on logistics management is spread across network design, BPR and healthcare procurement. Research in this region leans towards devising competitive strategies for the pharmaceutical industry, by using high-end technology and informed
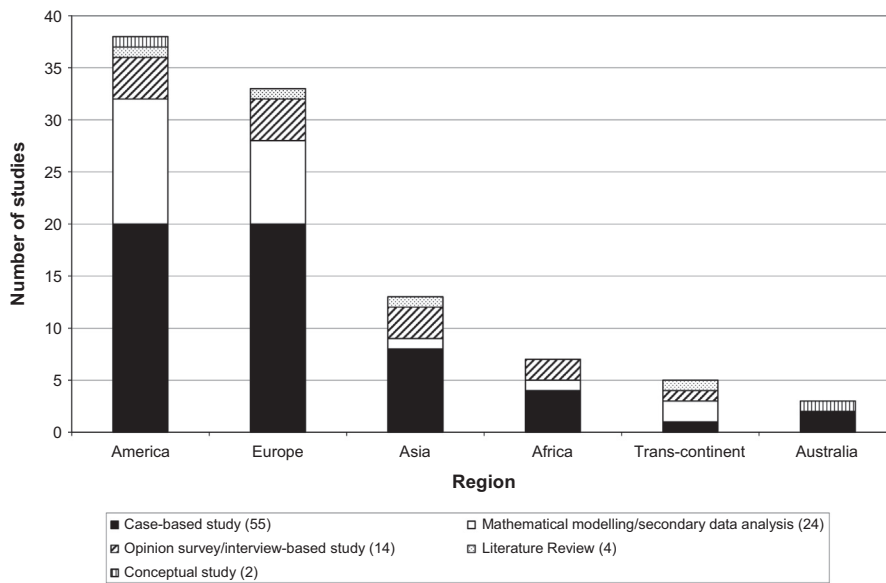


Fig. 5. Classification of studies based on geography and research methodologies.
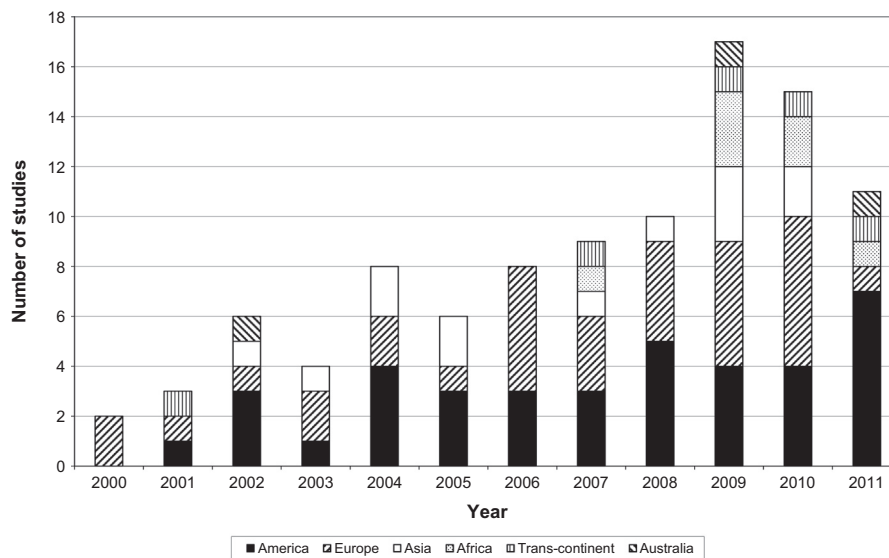


Fig. 6. Geographical distribution of studies on the PSC (2000–2011).

decision making techniques and by managing knowledge and innovation. This thematic progress reflects the increasing interest of practitioner press in this region towards technological and operations infrastructure (Rossetti et al., 2011). Also, similar to Section 4.1, these findings reflect the presence of a competitive and mature industry and well-developed healthcare reforms. Studies in Australia have also focused on technological capabilities in the PSC (e-procurement and knowledge outsourcing). Hence, the presence of only a few publications in the refereed journals does not completely reflect their developed healthcare systems.

Studies in Europe span most of the themes, differing slightly from the research efforts in America. The high focus on forward and reverse logistics reflects an interest in efficient and sustainable PSC operations. The presence of several studies on pricing highlights the presence of competitive pricing strategies and stringent regulations in healthcare financing. Studies on e-procurement describe the technological advances in the public health systems The high focus on organizational behavior, e-commerce and decision making processes depicts

efforts to understand change management, micro-level issues and hierarchical linkages in the PSC. Thus, research in Europe exhibits an interest in value-addition, through an appreciation for managing people, processes, the environment and relationships.

Compared to the research contexts of Europe and America, Asia and Africa are at a nascent stage in thematic research. Health Action International and World Health Organization (2009) attributes the major causes of poor health systems in these regions to inadequate funding, lack of incentives for maintaining stocks, inability to forecast accurately, inefficient distribution systems, leakage of medicines for private resale etc. The themes addressed in these regions reflect these persistent concerns. Studies on quality and performance management in Africa depict issues in the distribution and procurement of medicines (quality assurance, counterfeiting, etc.) that are directly related to public health. Research in Asia is more advanced and focuses on developments in distribution and healthcare procurement, such as quality and performance measurement and best practices (TQM and BPR). The high focus on logistics management in the Asian regions is
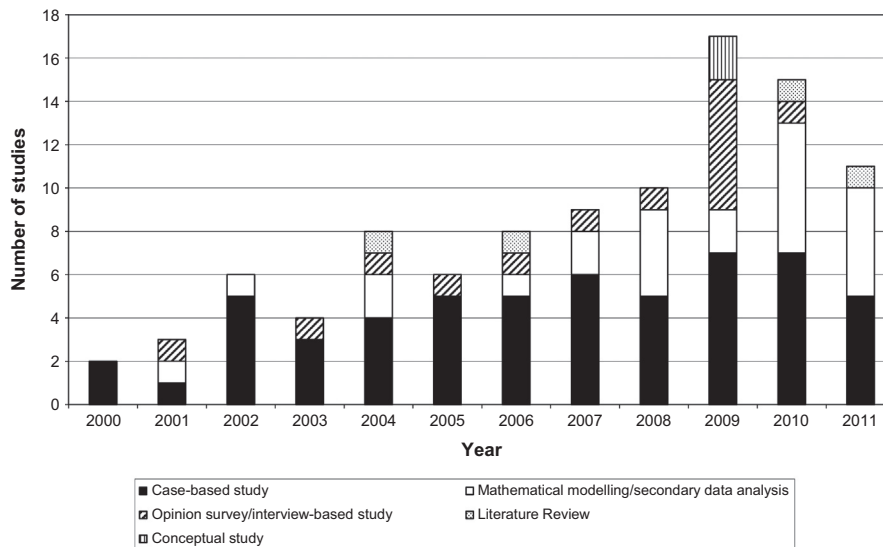


**Fig. 7.** Application of research methodologies in studying the PSC (2000–2011).
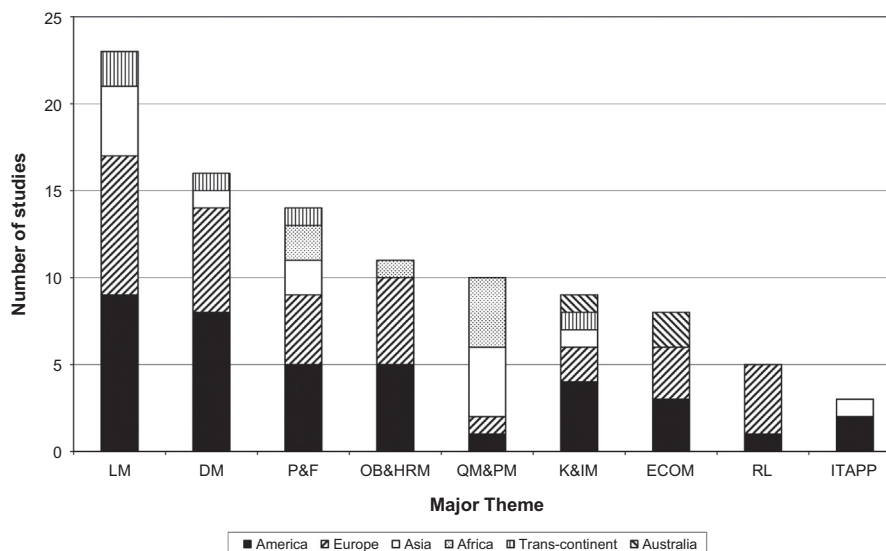


**Fig. 8.** Studies on major themes in the pharmaceutical supply chain across the world.

directed towards materials management and strategic alliances in distribution and hospital logistics. The considerable focus on pricing and healthcare financing depicts the implementation of pooled procurement practices and a growing interest in healthcare reforms in the two regions. Finally, there are a few trans-continental studies that either compare logistics practices across regions or study sourcing/procurement at a global level.

### 5.3. Research methodologies used in studying major themes

Fig. 9 depicts the research methodologies used to study different major themes and is used to address RQ1 and RQ4 together.

Case-based research is the leading methodology across process-oriented themes (organizational behavior, e-commerce and decision making), logistics management and themes of upcoming interest (reverse logistics and IT applications). Studies in logistics and decision making apply and test quantitative models in scenarios spanning network design, vehicle routing, supplier selections, purchasing and supply management, etc. Studies in IT applications wholly explore implementing new product tracking technologies in scenarios such as anti-counterfeiting and inventory management. Further, studies in e-commerce and organizational behaviors have applied qualitative research techniques like stakeholder analysis (More and McGrath, 2002) and grounded theory (Harwood and Chapman, 2009).

Opinion surveys/interviews have been extensively used in studying quality management, organizational behavior and logistics in the PSC. Process-oriented themes have utilized this methodology to analyze micro-level issues in dyadic relationships. Additionally, current and best practices in quality management, logistics management, pricing and financing, e-commerce and knowledge management have been explored using this methodology.

Mathematical modeling/secondary data analysis is utilized in studies that have direct implications for efficiency/profitability improvement. Evaluation of healthcare and pricing policies and the modeling of competitive behaviors in the PSC are based on the analysis of pricing and funding data. Using theoretical approaches such as transaction-cost economics and resource-based views, such analysis is also extended to knowledge and innovation management in upstream networks. In logistics and decision making, secondary data is used to develop optimization models

and multi-attribute selection tools in production, planning and purchasing activities.

Literature reviews have been restricted to either well-studied themes of logistics management and decision making (inventory management and optimization strategies) or emerging areas of critical interest such as pricing and healthcare reforms. Conceptual studies depict exploratory efforts in understanding newer themes like reverse logistics and knowledge outsourcing in the PSC.

## 6. PSC research and final value delivered

This section utilizes the insights from Sections 3–5 to explore the contribution of PSC research in studying dimensions of the final value delivered to the consumer (availability, access, affordability and safety). Burns and Wharton School Colleagues (2002) indicate that the interactions within the healthcare value chain lead to value-addition. Adapting their description of the U.S. healthcare value chain, Fig. 10 depicts that research efforts on managing the PSC exhibit distinct interest in three different levels of industrial interaction, which influence final value delivery:

(i) *Biotechnology industry – pharmaceuticals manufacturing and distribution industry*: there is a rapidly emerging research interest in managing R&D within the PSC through interactions in this interface. These studies analyze a variety of macro-linkages that facilitate the exchange of technology, information, technical product knowledge and financial remunerations in upstream networks and dyads. Hence, they depict the challenges in managing the resource-intensive R&D process, which influences the availability and affordability of innovative drugs. Further, they highlight the role of regulatory agencies in ensuring the development and production of safe drugs for the market.

(ii) *Intra-industry interactions in the pharmaceuticals manufacturing and distribution environment*: around 40% of the studies focus on PSC operations within the manufacturing and distribution environment of the pharmaceutical industry. Utilizing generic and pharmaceutical-specific terminologies, these intra-industry interactions have been analyzed through all the structural dimensions. Apart from some efforts on incorporating R&D into logistics design, most of these studies have explored and
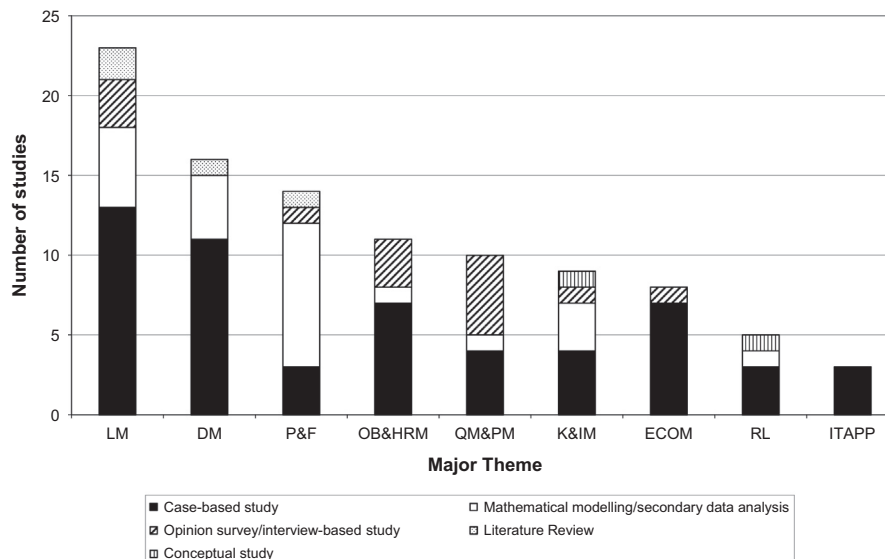


**Fig. 9.** Research methodologies used in studying major themes in the PSC.

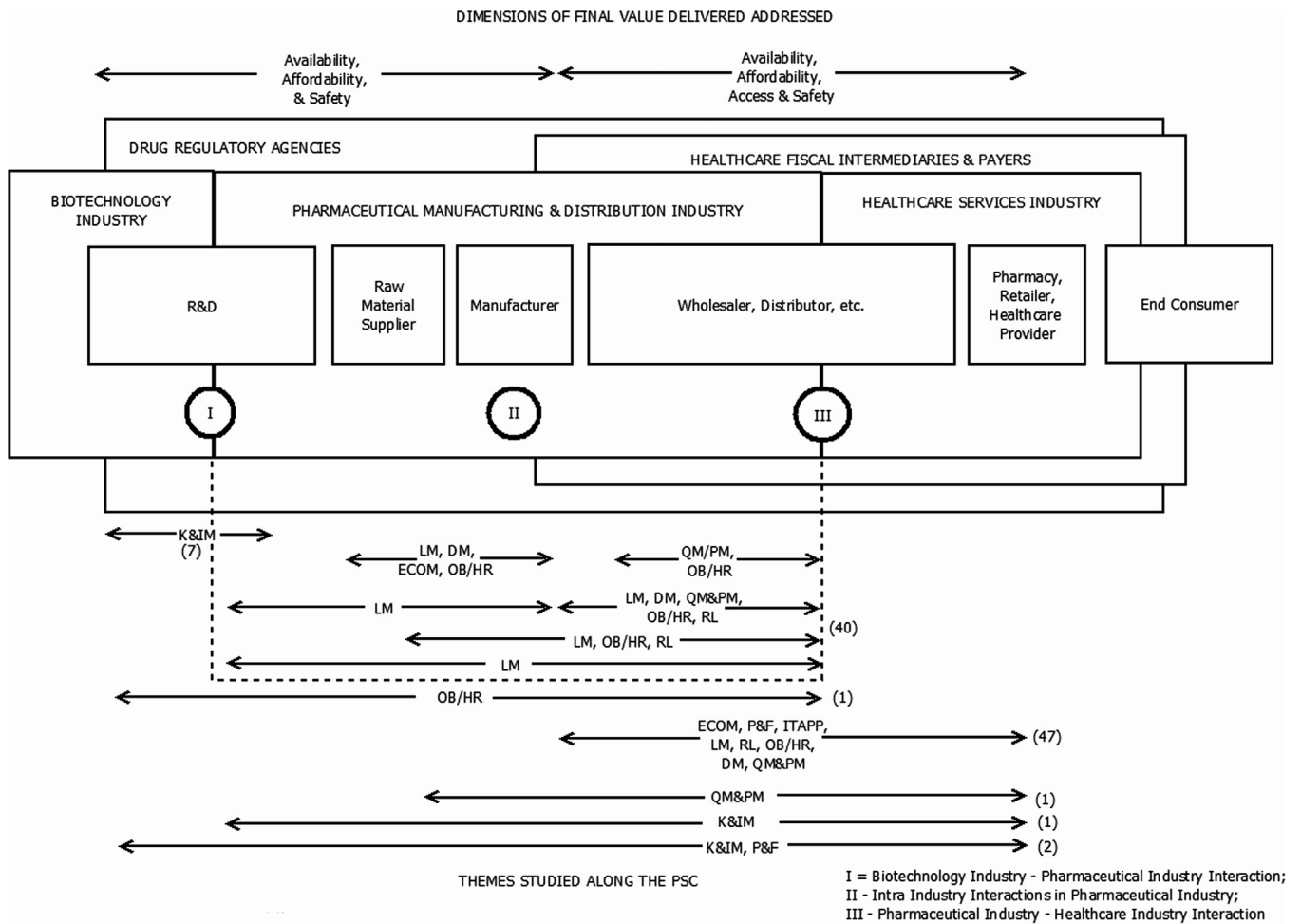DIMENSIONS OF FINAL VALUE DELIVERED ADDRESSED



**Fig. 10.** PSC research progress and final value delivered to the end-consumer.

modeled efficiency-related, process-oriented and technological issues, from purchasing and supply of raw materials to production and distribution of finished products. Studies on upstream networks and dyads address the physical availability of medicines in the market, while downstream studies further explore the physical accessibility of these products to industrial purchasers/product intermediaries. These themes depict a relatively low focus on the role of drug regulatory agencies and healthcare fiscal intermediaries. Nevertheless, they highlight the strategies and challenges in creating safe and affordable processes for the industry. By primarily addressing value delivery to industrial customers, these research efforts are indirectly linked to the final value delivered to the consumer.

(iii) *Pharmaceutical manufacturing and distribution industry – healthcare service industry*: as noted in Section 3.1, several studies at the dyadic and chain levels and much of the growing interest in network-centric studies focus on the interface between the pharmaceutical and healthcare industries (around 50% of all studies). These research efforts primarily depict the crucial role played by procurement and supply function in enabling healthcare delivery. Efficiency-related themes depict cost-effective and safe exchange of medicines across this interface, enabled by effective management of technical and business process information. Process-oriented and technology-related themes depict efforts to streamline the interaction via e-procurement, pooled procurement and quality management. These studies are critical

to understand how the healthcare providers and hence, end-consumers obtain safe physical access to medicines that are already available in the market. Mathematical analyses of financial asset exchange address price regulation and healthcare financing that facilitate the procurement process. Overall, studies in this interface highlight the role played by drug regulatory authorities, fiscal intermediaries and payers (government, group purchase organizations, third-party payers, etc.) in this facilitation. Therefore, this research is also important to address the affordability of medicines while managing profitability/cost reductions in both, the manufacturing and healthcare service industries.

## 7. Conclusion

This concluding section briefly addresses the research questions and identifies gaps and avenues for future research.

In terms of research progress across themes (RQ1) the content analysis (Sections 3–5) reveals the presence of individual themes that cater to three types of inter-dependent perspectives (efficiency/profitability improvement, process analysis and building technological competence).

Studies focusing on efficiency/profitability improvement reflect the traditional interest of SCM research in material and information flows, through the development of optimal and sustainable models and redesign strategies for the pharmaceutical supply

chain. A rapidly increasing interest in process-oriented themes complements these research efforts by providing exploratory and qualitative understanding of pharmaceutical supply chain issues. Through a moderately high focus on information, relationship and knowledge exchanges, that spans dyadic and network levels of analyses, these themes depict the following:

- Continuous evolution of the pharmaceutical supply chain through different types of process redesign and change (implementation of best practices and technology, healthcare reforms, formation of macro-level linkages in the interacting industries, etc.).
- Role of micro-level interactions (formal and informal) in sustaining supply chain operations.
- Management of value-addition through information collaboration and the effective management of business process knowledge.

While themes related to operational research demonstrate the use of technology in developing and simulating optimal strategies, there is an increasingly specific focus on technology-oriented themes. Using a network-centric approach, these themes display the means to develop technological competence in the pharmaceutical supply chain as following:

- Managing R&D in the pharmaceutical industry through strategic relationships.
- Streamlining business processes through product labeling and e-procurement.
- Improving product security through product tracking technology.
- Managing e-adoption using a process-oriented approach, especially in the procurement processes.

Research efforts are also continuously evolving across the structure of the pharmaceutical supply chain (RQ2). The analysis of the supply chain content matrices depicts the transition of research approaches from dyadic to network-centric analyses, with the focus being on the exchange of assets, information and relationships. The themes have also studied a variety of aspects of each element of exchange, indicating the richness of the exchange within the pharmaceutical supply chain. Finally, the analysis of the business processes studied and the terminologies used reveals that the research interest is rapidly moving from a traditional view of the PSC functioning within the manufacturing and distribution environment to a more inclusive approach that includes the biotechnology and healthcare industries, regulatory bodies and fiscal players.

Geographically, research efforts are divided into two streams of literature (RQ3). In Europe and America, the large variety of themes researched and the high quantum of studies reflect their well developed healthcare systems and pharmaceutical markets. In Africa and Asia, there is an emerging interest in understanding demand-side concerns and downstream supply-side inefficiencies. Overall, it appears that the development of healthcare systems and pharmaceutical markets is closely linked to the quantum and nature of research efforts (thematically and methodologically) in the regions. In terms of methodological approaches used (RQ4), the research is highly context-specific, as many studies use cases and surveys to analyze SCM issues for specific organizations and regions, within the context of the pharmaceutical/healthcare industries. Several studies depict application-oriented cases and use mathematical modeling/secondary analysis (especially in efficiency and pricing-related themes), thus forming a useful repository of tools and techniques for supply chain managers in the pharmaceutical supply chain.

The contribution of research to addressing value delivery (availability, affordability, access and safety) is understood in terms of one of the three levels of interaction that have been distinctly studied (RQ5). While addressing all the dimensions of value, many studies focus on value addition within the manufacturing and distribution environment of the pharmaceutical industry. Value delivery that is closely related to the end-consumer is addressed through a rapidly increasing level of interest in the interface between the pharmaceutical and healthcare industries, where interaction is facilitated by the healthcare procurement and supply function. There is also a low but distinct research focus on value-creation at the product development stages and an emerging interest in integrating the two ends of the value chain (R&D and healthcare delivery).

### 7.1. Research gaps and future research scope

The analysis of the collated literature indicates that research efforts are fragmented across the value delivery network. Danese et al. (2006) suggest that as supply networks of pharmaceutical companies can be complicated, researchers tend to focus on parts of the supply chain. Nevertheless, there is very low focus on upstream networks and business processes. The integration of new product development (NPD) and supply chain design has the potential to promote product availability and profitability (van Hoek and Chapman, 2006). Shah (2004) discusses feasible methodologies for pipeline development, risk management and capacity planning for pharmaceutical supply chains, using studies from different domains. However, despite developments such as knowledge outsourcing, stringent government regulations, increasing market risk, etc., there has been limited research interest in integrating NPD with supply chain design.

Furthermore, in some themes (e.g. organizational behavior and reverse logistics), the studies focus more on the manufacturing and distribution environment, while in others (i.e. pricing financing and e-commerce), most of the research efforts are directed towards the downstream interface with the services industry. Although waste management and pollution prevention are crucial to pharmaceutical production (Linninger and Chakraborty, 2001), studies in reverse logistics and quality are yet to address the impact of the pharmaceutical supply chain on the environment as a whole. Also, at the complete network level, few studies (e.g. Bardey et al. (2010)) attempt to understand the links between healthcare financing and supply chain financing (including upstream investments in R&D, production, distribution, etc.). The analysis of the same is important at the level of healthcare providers where decisions are made with respect to how much innovation can be affordably utilized for a patient's treatment (Burns and Wharton School Colleagues, 2002).

Given that supply chain management is itself evolving in terms of its definition (Croom et al., 2000; Stock and Boyer, 2009), our aim was not to define the pharmaceutical supply chain or its configuration. However, the analysis of the terminologies and structural dimensions of the pharmaceutical supply chain revealed a limited research interest in the actions and decisions of individuals (doctors, scientists, sales personnel, etc.) and other organizations (third party logistics providers, waste management companies, NGOs, etc.), who may actually play an active role in the pharmaceutical supply chain. Such a low focus on behaviors of individuals has the potential to limit the robustness, predictive accuracy and overall usefulness of logistics models (Tokar, 2010). Additionally, although several studies focus on the *business* aspects of the elements of exchange, only some studies, in themes related to efficiency/profitability improvement, utilize technical information (e.g. time-to-market, shelf-life, mortality data, etc.) and product knowledge that are specific to the interacting industries. Although available in abundance, patient- and physician-level data are not fully leveraged in strategic planning in the pharmaceutical

industry (Paich et al., 2011). Similarly, as product types (generics, cold chain products, etc.) have the potential to fragment the pharmaceutical supply chain (Rossetti et al., 2011), the increasing importance of these product-related forces cannot be ignored.

Due to a fragmented focus of research on different themes, structural dimensions and levels of interaction, current research is yet to address the dimensions of value in an integrated fashion. This can detrimentally affect the final value delivered. For example, despite an ample and convenient supply of medicines, affordability of medical services can be low for the poor (Yu et al., 2010).

The development of integrated models from drug discovery to final consumption has been suggested to improve strategic decision making in the pharmaceutical supply chain (Shah, 2004). Additionally, Pedroso and Nakano (2009) suggest that success in the pharmaceutical business requires alignment and integration between the flows of technical information, order information, materials and finances. We suggest the use of an integrated approach towards research on the pharmaceutical supply chain, which employs the structural dimensions of the supply chain. Final value delivered needs to be analyzed with respect to the transformation of and interdependencies between and within the elements of exchange, through the various levels of analyses (i.e. from dyadic to network-centric analyses). These transformations and interdependencies include, but are not restricted to:

- Material transformation from R&D (e.g. clinical trials) and raw material procurement to production, distribution, healthcare procurement, healthcare delivery and reverse flows.
- Financial transformation from healthcare financing and medicine pricing in the manufacturing and distribution industry to supply chain financing and investments in technology and R&D.
- Transformation of technical information to business process information and vice versa.
- Transformation of knowledge (product and process-specific), from scientific in upstream networks and managerial across business processes to medical in healthcare delivery and vice versa.
- Interdependencies between micro-level linkages ranging from R&D-manufacturer to sales personnel–doctor and patient–doctor interactions.
- Interdependencies between the elements of exchange (e.g. product knowledge and commercial value, business process information and process knowledge, patient–doctor interactions and product knowledge, etc.), etc.

While theoretical perspectives have been used to understand knowledge management strategies, there is scope to extend the same to developments in downstream networks (e.g. pooled procurement, formation of trade associations, online retail and pricing/financing mechanisms) and the whole network (e.g. merging supply chains). These studies would also help in understanding the changing configuration of the pharmaceutical supply chain (role and participation of stakeholders, decoupling points, power dynamics, etc.), in light of these developments. There is also scope to utilize case-based and survey research at the whole network level, to analyze challenges in NPD–supply chain design integration, implementation of environmentally sustainable initiatives (reverse logistics, green supply chain design), impact of micro and macro-level linkages on supply chain performance, etc. Finally, behavioral research needs to be utilized along with secondary data (technical and business process information) in order to simulate transformations in the supply chain structural dimensions and the development of integrated design strategies. Challenges to be explored within this context include increasing cost-competition, competition across therapeutic segments, increasing healthcare customization, changing healthcare policies and industry dynamics, counterfeiting, introduction of alternative treatments, etc.

These research avenues call for the use of multidisciplinary approaches that draw insights not only from other domains (e.g. consumer behavior, chemical engineering, health economics, etc.) but also from supply chains in other industries, although drawing parallels with them is debatable (Rossetti et al., 2011). The pharmaceuticals industry follows the telecommunications industry in developing its NPD processes (Gupta et al., 2007). Compared to high product complexity in industries that comprise of assembled products (e.g. automobiles, electronics, etc.), the pharmaceuticals industry is characterized by high process complexities that impose special demands on factory management (Khurana, 1999). Regulatory, shelf-life and quality issues are commonly observed in both pharmaceuticals and food products. Further downstream, public procurement and third party payment mechanisms are also present in agri-supply chains and construction supply chains, while inventory management can be similar for hospital pharmacies and spare part inventories in industrial plants (Danas et al., 2006). Supply chain content matrices would be useful in analyzing and comparing the respective supply chains, to understand what they can learn from each other.

Through further exploratory field research and process-analysis, studies in the regions of Africa and Asia should assist in strengthening their pharmaceutical supply chain capabilities, by analyzing the following:

- development of technological competence, that includes R&D and implementation of information systems in the network;
- development of holistic network design and optimization strategies;
- mechanisms used in medicine pricing and healthcare financing;
- dynamics of stakeholders in the network at the macro and micro-levels of analyses;
- adoption of environmentally sustainable practices and
- prevalence and growth of expertise in upstream capabilities (e.g. low-cost manufacturing and contract research operations in Asia).

More studies are also required to assess and understand the development of the pharmaceutical supply chain in Australia. Given the high competition in the pharmaceutical industry and the challenges faced in improving healthcare systems across the world, there is a need to explore the adoption of supply chain strategies across regional boundaries. Also there is a need to assess the impact of globalization and uncertainties in political stability on the final value delivered. These requirements underline the need for trans-continental studies to compare healthcare systems, regulatory policies and behavior of organizations with respect to supply chain structures and practices across regions Suggested research avenues include humanitarian logistics, global purchasing policies, healthcare tourism, etc.

## 7.2. Limitations

The limitations of this study are primarily based on the inclusion and exclusion criteria used in the collation of literature. The analysis of value delivered is exploratory and is currently limited to human healthcare needs and four dimensions of value. Also, as the review focuses only on industrial interactions, there is scope to analyze consumer–pharmaceutical supply chain interfaces and further explore the dimensions of value.

The management of the pharmaceutical supply chain has emerged as a specific area of research interest over the last decade and signifies the importance of interactions between the research, manufacturing, services and regulatory environments in fulfilling the healthcare needs of the population. Further, the studies identified are also of relevance to researchers and practitioners

in boundary-spanning business processes such as R&D and health-care procurement. The systematic review identifies a variety of developments, strategies and challenges in managing these inter-actions through different structural dimensions of the pharmaceutical supply chain. The development and analysis of supply chain content matrices adds to recent attempts at applying the 2-dimensional framework provided by Croom et al. (2000) (Giunipero et al., 2008; de Vries and Huijsman, 2011). This content analysis helps in making the "evidence-informed" analysis, as suggested for systematic reviews (Tranfield et al., 2003).

The research progress in studying the pharmaceutical supply chain reflects the present status of supply chain/logistics research, which is also dominated by operations management/logistics/purchasing disciplines (Burgess et al., 2006), and more IT-related articles in recent times (Giunipero et al., 2008). Particularly, the strong research focus on downstream procurement and supply processes resonates with the increasing interest of purchasing and supply literature in health providers and public procurement (Wynstra, 2010; Zheng et al., 2007). The suggested future research directions in this review are relevant for advancement of research on topics of growing academic and corporate interest such as NPD–supply chain integration (van Hoek and Chapman, 2006; Hilletofth and Eriksson, 2011), sustainable and green supply chain management (Seuring and Müller, 2008; Sarkis et al., 2011), value addition in SCM (Stock and Boyer, 2009), etc.

While enhancing the understanding of SCM, it is hoped that the suggested integrated approach for research enables the pharmaceutical supply chain to deliver strongly as an integral part of the healthcare value chains across the world.

## Appendix A

Table A.1 provides details of the search for and selection of literature on the PSC.

## Appendix B

Table B.1 provides the details of the literature on the PSC. The key is as follows:.

- Region: Am=America, As=Asia, Af=Africa, Aus=Australia, Eu=Europe, and TC=Trans-Continent.
- Research methodology: CB=case-based study, M=mathematical modeling/secondary data analysis, S=survey-based study, L=literature review, and C=conceptual study.
- Level of analysis: D=dyad, Ch=chain, UNW=upstream network, DNW=downstream network, and WNW=whole network.

**Table A1**
Stages in literature collection.

| Stage | Details | Number of records |
|---|---|---|
| Stage 1: keyword search | • Search string: primary keyword AND secondary keyword<br>  *Primary keywords:* pharma\*, medic\*, drug, hospital, health\* (e.g.: "medic\*" searches for all articles in the search space that contain the words beginning with "medic", such as "medicine", "medical", "medication", etc.)<br>  *Secondary keywords:* supplie\*, supply AND chain, value AND chain, logistics, distribut\*, retail\*, purchas\*, procur\*, sourc\*, integrat\*, wholesal\*<br><br>• Search Databases: EBSCOhost, ABI/INFORM®, and Sciencedirect<br>• Search space: Title OR Abstract OR Keywords<br>• Journal type: Academic/scholarly and peer-reviewed<br>• Time filter: Published in the years 2000–2011 (both years included) | 3000 |
| Stage 2: select and sort (based on analysis of title/abstract) | • Inclusion criteria: Studies related to management issues in pharmaceutical supply chain<br>• Exclusion criteria:<br>  – Duplicate records, Conference papers/proceedings, Working papers, Market reports, Company/Industry reports, Editorials and News reports<br>  – Articles not written in English<br>  – Studies on technical/scientific aspects related to chemical formulation and composition of medicines and chemical analyses of their effects | 220 |
| Stage 3: refined select and sort (based on analysis of article content, title and abstract) | • Inclusion criteria: Articles should study exchange activities between two or more entities related to the management of pharmaceuticals<br>• Exclusion criteria:<br>  – Studies that analyze pharmaceutical/healthcare industries along with other unrelated industries<br>  – Studies that focus on healthcare products other than drugs or medicines (e.g. medical equipment, hospital stationery, etc.)<br>  – Studies on healthcare services only (e.g. nursing, healthcare management, etc.)<br>  – Studies of issues at the organizational level only | 123 |
| Stage 4: final selection | • Inclusion criteria: Article should be published in journals indexed in 2010 Journal Citation Reports®<br>• For other articles: Articles should meet standards of perceived quality of rigor, relevance and readability | 99 |

**Table B1**
Details of literature on the pharmaceutical supply chain.

| Major theme and publications | Region | Research methodology | Terminology | Is the element of exchange studied (yes/no = Y/N)? | | | | Level of analysis |
|---|---|---|---|---|---|---|---|---|
| | | | | Asset | Information | Knowledge | Relationship | |
| **Logistics management** | | | | | | | | |
| Aptel and Pourjalali (2001) | TC | S | H | Y | Y | N | Y | D |
| Papageorgiou et al. (2001) | Eu | M | P | Y | Y | N | Y | WNW |
| Rivard-Royer et al. (2002) | Am | CB | H | Y | Y | N | Y | Ch |
| Strijbosch et al. (2002) | Eu | CB | G | Y | Y | N | Y | Ch |
| Grunow et al. (2003) | Eu | CB | P | Y | Y | N | N | UNW |
| Levis and Papageorgiou (2004) | Eu | M | P | Y | Y | N | Y | WNW |
| Shah (2004) | Eu | L | P | Y | Y | Y | Y | WNW |
| Sundaramoorthy and Karimi (2004) | As | M | P | Y | Y | N | Y | UNW |
| Talluri et al. (2004) | Am | CB | G | Y | Y | N | N | D |
| Danese (2006) | Eu | CB | G | Y | Y | Y | Y | WNW |
| de Magalhães and de Sousa (2006) | Eu | CB | P | Y | Y | N | N | D |
| Jarrett (2006) | Am | L | H | Y | Y | N | Y | DNW |
| Pan and Pokharel (2007) | As | S | G | Y | Y | Y | Y | D |
| Archer et al. (2008) | Am | CB | H | Y | Y | Y | Y | Ch |
| Kumar et al. (2008) | Am | S | H | Y | Y | Y | Y | Ch |
| Zhuan et al. (2008) | As | CB | P | Y | Y | N | N | DNW |
| Chahed et al. (2009) | Eu | CB | P | Y | N | N | N | D |
| Mustaffa and Potter (2009) | As | CB | H | Y | Y | N | Y | D |
| Shang et al. (2009) | Am | CB | G | Y | Y | N | N | DNW |
| Boulaksil and Fransoo (2010) | TC | CB | G | Y | Y | Y | Y | Ch |
| Fleischhacker and Zhao (2011) | Am | M | P | Y | Y | Y | N | D |
| Schwarz and Zhao (2011) | Am | CB | P | Y | Y | N | Y | D |
| Shen et al. (2011) | Am | M | G | Y | Y | N | Y | D |
| **Decision making** | | | | | | | | |
| Dekker and Van Goor (2000) | Eu | CB | G | Y | Y | Y | Y | Ch |
| Gupta, Peters et al. (2002) | Am | CB | G | Y | Y | Y | Y | DNW |
| Talluri (2002) | Am | M | G | Y | Y | N | Y | D |
| Swaminathan (2003) | Am | CB | P | Y | Y | Y | Y | D |
| Choudhury et al. (2004) | As | CB | G | Y | Y | N | N | DNW |
| Swaminathan et al. (2004) | Am | CB | P | Y | Y | Y | Y | D |
| Danas et al. (2006) | Eu | CB | H | Y | Y | N | Y | DNW |
| Danese et al. (2006) | Eu | CB | G | Y | Y | Y | Y | WNW |
| Talluri et al. (2006) | Am | M | G | Y | Y | N | Y | D |
| Lapierre and Ruiz (2007) | Am | CB | H | Y | Y | N | N | DNW |
| Gebauer (2008) | Eu | CB | H | Y | Y | Y | Y | D |
| Kirytopoulos et al. (2008) | Eu | M | P | Y | Y | N | Y | D |
| Arora et al. (2010) | Am | M | G | Y | Y | N | Y | DNW |
| Ertay et al. (2011) | Eu | CB | G | Y | Y | Y | N | D |
| Pazirandeh (2011) | TC | L | H | Y | N | Y | Y | DNW |
| **Pricing and financing** | | | | | | | | |
| Hess and Rothaermel (2011) | Am | M | G | Y | N | Y | Y | WNW |
| Chaudhury et al. (2005) | As | CB | P | Y | Y | Y | Y | DNW |
| Merkur and Mossialos (2007) | Eu | M | G | Y | Y | Y | Y | Ch |
| Rodríguez-Monguió et al. (2007) | TC | M | G | Y | N | N | Y | DNW |
| Seoane-Vázquez and Rodríguez-Monguió (2007) | Am | CB | P | Y | Y | Y | Y | D |
| Garattini et al. (2008) | Eu | M | G | Y | Y | Y | Y | Ch |
| Lybecker (2008) | Am | M | P | Y | Y | Y | Y | WNW |
| Bardey et al. (2010) | Eu | M | G | Y | Y | Y | Y | Ch |
| Ellison and Snyder (2010) | Am | M | P | Y | Y | Y | Y | Ch |
| Kanavos and Vandoros (2010) | Eu | M | G | Y | Y | Y | Y | Ch |
| Maïga and Williams-Jones (2010) | Af | S | G | Y | Y | N | Y | D |
| Russo and McPake (2010) | Af | CB | P | Y | Y | Y | Y | Ch |
| Yu et al. (2010) | As | L | P | Y | Y | Y | Y | DNW |
| Hu and Schwarz (2011) | Am | M | H | Y | Y | Y | Y | D |
| **Organizational behavior and human resource management** | | | | | | | | |
| Beekman and Robinson (2004) | Am | S | G | Y | N | Y | Y | D |
| Mangan and Christopher (2005) | Am | CB | G | N | Y | Y | Y | WNW |
| Nollet and Beaulieu (2005) | Am | CB | H | Y | Y | Y | Y | DNW |
| Bossert et al. (2007) | Af | CB | P | Y | Y | N | Y | DNW |
| Meijboom and Obel (2007) | Eu | CB | G | Y | Y | N | Y | D |
| Şengün and Wasti (2007) | Eu | CB | P | Y | Y | Y | Y | D |
| Harwood and Chapman (2009) | Eu | CB | P | Y | Y | Y | Y | DNW |
| Jambulingam et al. (2009) | Am | S | P | Y | Y | Y | Y | D |
| Şengün and Wasti (2009) | Eu | S | P | Y | Y | Y | Y | D |
| Koulikoff-Souviron and Harrison (2010) | Eu | CB | G | Y | Y | Y | Y | D |
| Beekman and Robinson (2004) | Am | S | G | Y | N | Y | Y | D |
| **Quality management and performance management** | | | | | | | | |
| Srivastava (2008) | As | CB | H | Y | Y | N | Y | DNW |

**Table B1** (continued)

| Major theme and publications | Region | Research methodology | Terminology | Is the element of exchange studied (yes/no = Y/N)? | | | | Level of analysis |
|---|---|---|---|---|---|---|---|---|
| | | | | Asset | Information | Knowledge | Relationship | |
| Kumar et al. (2005) | As | CB | H | Y | Y | Y | Y | Ch |
| McKone-Sweet, Hamilton and Willis (2005) | Am | S | H | Y | Y | Y | Y | DNW |
| Schofield and Breen (2006) | Eu | S | P | Y | Y | Y | Y | D |
| Ahmad et al. (2009) | As | S | P | Y | Y | Y | Y | D |
| Awan et al. (2009) | As | S | P | Y | Y | Y | Y | D |
| Enyinda and Tolliver (2009) | Af | CB | P | Y | Y | Y | Y | WNW |
| Oduor et al. (2009) | Af | M | G | Y | N | N | Y | D |
| Patel et al. (2009) | Af | S | P | Y | Y | Y | Y | DNW |
| Asamoah et al. (2011) | Af | CB | P | Y | Y | N | Y | WNW |
| **Knowledge and innovation management** | | | | | | | | |
| Alshawi et al. (2003) | Eu | S | P | N | Y | Y | Y | D |
| Odagiri (2003) | As | CB | G | Y | Y | Y | Y | D |
| Lane and Probert (2007) | Am | CB | G | Y | Y | Y | Y | UNW |
| Ruckman (2008) | Am | M | G | Y | Y | Y | Y | D |
| Gupta et al. (2009) | Aus | Co | P | Y | Y | Y | Y | UNW |
| Pedroso and Nakano (2009) | Am | CB | P | Y | Y | Y | Y | WNW |
| van de Vrande et al. (2009) | TC | M | G | Y | Y | Y | Y | D |
| Ceccagnoli et al. (2010) | Am | M | G | Y | Y | Y | Y | Ch |
| Sabatier et al. (2010) | Eu | CB | P | Y | Y | Y | Y | UNW |
| **E-commerce** | | | | | | | | |
| Spain et al. (2001) | Am | CB | P | Y | Y | Y | Y | Ch |
| More and McGrath (2002) | Aus | CB | P | Y | Y | Y | Y | DNW |
| Caridi et al. (2004) | Am | CB | G | Y | Y | Y | Y | UNW |
| Breen and Crawford (2005) | Eu | CB | G | Y | Y | Y | Y | D |
| Kulp et al. (2006) | Am | CB | G | Y | Y | N | Y | UNW |
| Cullen and Taylor (2009) | Eu | S | P | Y | Y | Y | Y | DNW |
| Ketikidis et al. (2010) | Eu | CB | H | Y | Y | Y | Y | DNW |
| **Reverse logistics** | | | | | | | | |
| Ritchie et al. (2000) | Eu | CB | P | Y | Y | Y | Y | DNW |
| Amaro and Barbosa-Povoa (2008) | Eu | CB | P | Y | Y | N | Y | DNW |
| Amaro and Barbosa-Povoa (2009) | Eu | CB | P | Y | Y | N | Y | DNW |
| Kumar et al. (2009) | Am | Co | P | Y | Y | N | Y | DNW |
| Antai and Mutshinda (2010) | Eu | M | P | Y | Y | N | N | DNW |
| **Information technology application** | | | | | | | | |
| Wyld (2008) | Am | CB | P | Y | Y | N | N | DNW |
| Bendavide et al. (2010) | Am | CB | H | Y | Y | Y | N | D |
| Kwok et al. (2010) | As | CB | P | Y | Y | Y | Y | DNW |

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