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3PL, 4PL and reverse logistics: part 1

Guest Editor: B.S. Sahay

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Introduction

About the Guest Editor *Dr B.S. Sahay is currently Director at Institute of Management and Technology, Ghazibad, India. Prior to joining IMT, he was Dean (Research), Professor of Operations Management, and Founder Chairman of Centre for Supply Chain Management at the Management Development Institute, Gurgaon, India. His teaching, research and consulting interest include supply chain management, operations management, productivity management and business modelling. He has published seven books and 130 papers in international/national journals and conferences. IN token of excellence of his research work he has received six awards including three best paper awards. He is on the Editorial Board of seven international and many national journals.*

A growing number of organizations are outsourcing select or entire logistics activities to third party logistics (3PL) or fourth party logistics (4PL) service providers not merely as a means to achieve cost efficiency, but also with a long-term strategic objective for creating competitive advantage through increased service and flexibility. This has also gained momentum because of fierce global competitiveness, heightened customer expectations, pressures on profitability and superior supply chain performance. At the sametime, increasing concern about environmental matters, sustainable development and legal regulations has made organizations responsive for reverse logistics (RL) as well.

This special issue focuses on the concept that logistics are not merely a means to cost efficiency, but also a strategic tool for creating competitive advantage through increased service and flexibility. Today, the scope and nature of 3PL is the management of logistic services beyond transportation. The adoption of 3PL is becoming widespread in the industry. The 3PL involves the use of external companies to perform logistics functions that have traditionally been performed within an organization. The functions performed by the third party can encompass the entire logistics process or selected activities within that process.

Similarly, 4PL is the integration of all companies involved along the supply chain. 4PL is the planning, steering and controlling of all logistic procedures (for example, flow of information, material and capital) by one service provider with long-term strategic objectives. These companies are basically 3PL providers that either add these capabilities to their services or form alliances to provide the services. In the development of logistics partnership, 4PLs take these relationships to an advanced level with more integration and the involvement of more partners.

Awareness in the art and science of logistics is continuing to increase. In attempting to better manage the constant flow of returned goods, many retailers and manufacturers have come to realize that an effective RL is an important and strategic part of their business to capture value otherwise unavailable. RL is an issue that has received growing attention primarily about the growing concern about environmental issues and sustainable development besides economic reasons.

This double special issue on "3PL, 4PL and reverse logistics" focuses upon the evolving practice, academic theory and concepts related to the use of the external organizations for outsourcing logistics functions that have traditionally been performed in-house. Today, the scope and nature of logistics outsourcing are greatly

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expanded from select activities to the steering and controlling of all logistics procedures by service providers.

This first part of the double issue features papers on a range of issues and includes authors from countries as diverse as Denmark, Taiwan and India. The second part of the double issue will follow later in the volume and will include papers on the following themes:

- 3PL practices: an Indian perspective;
- a comparative study of the use of 3PL by Singaporean and Malaysian firms;
- a multi-objective 3PL allocation problem for fish distribution; and
- finally, the role of 4PL as the RL integrator: optimal pricing and return policies.

The objective of special issue had been to present a framework for 3PL, 4PL and RL to manage supply chain effectively and efficiently. The special issue has been able to bring together original contributions that provide theoretical insights, empirical observations and case studies into the rapidly growing complex and uncertain business environment. It is anticipated that the double special issue has been able to highlight research challenges and future research directions. The main intent is to make researchers and practitioners aware of the importance of 3PL, 4PL and RL in managing the supply chain profitably in this rapidly growing digital economy.

I would like to express my sincere gratitude to all the editorial board members for providing full support in bringing out this issue. My most sincere thanks go to the paper contributors who shared their knowledge and research outcomes. I am thankful to all the reviewers who spared their valuable time in reviewing the papers and to the staff of *IJPDLM* for their high-quality professional assistance during the pre-publication process.

B.S. Sahay
Guest Editor

Dynamics of relationship governance in TPL arrangements – a dyadic perspective

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Abstract

Purpose – To improve the understanding of the inter-organizational dynamics of the dyadic relationships between a buyer and provider of logistics services (TPL dyads).

Design/methodology/approach – Analyzes the preparation, implementation, and operation of a particular case of third party logistics (TPL) arrangements. Based on a single case study of a dyadic relationship, the paper confronts the static view of the transaction cost approach and the agency theory on "governance structures" and "contracts" by showing how "relationship governance" emerges and develops over time.

Findings – TPL dyads are subject to both controllable and non-controllable forces of change, which may not always have a positive effect on the logistics performance or the relationship itself. Inter-organizational dynamics not only relate to learning, competence development, or adaptation, as suggested by other studies, but also to how the dyadic relationships are governed. As the dyad accumulates experience over time, changes will occur in the balance between the two parties in terms of goal congruence and risk preferences, which has a strong influence on the nature of contracts and other safeguards governing the relationship. Similarly, explanatory power of theories applicable to inter-organizational settings may vary as relationships emerge and develop over time. Focus on core competencies as the logic of outsourcing is followed by a period characterized by a principal-agent relationship. To ensure further prosperity of the relationship, the two companies must direct their efforts towards the logic of the network approach.

Originality/value – Contributes to a cross-disciplinary fertilization of the SCM field, in particular inter-organizational relationships.

Keywords Distribution management, Buyer-seller relationships, Governance, Dynamics, Supply chain management

Paper type Research paper

1. Introduction

During the last decade, third party logistics (TPL) has played an important part in the manifestation of "inter-organizational" issues within logistics and supply chain management. Much literature on TPL is based on a functional explanation of its existence. A range of surveys confirm the number and type of logistics activities outsourced, the motivation for such actions and/or the positive results, if any, of the

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arrangements (Virum, 1993; Novick *et al.*, 1993; Lieb and Randall, 1996; Sink and Langley, 1997; Lieb and Maltz, 1995). Quantifiable numeric results play an important role in the conclusions of these studies. However, contributions from Nordic scholars (Anderson, 1997; Dreyer, 1997: Berglund, 2000; Skjoett-Larsen, 2000; Halldorsson, 2002; Pruth, 2002; Lindskog, 2003; Halldorsson and Skjøtt-Larsen, 2004) seem to have two central features of research. First, they are more oriented towards qualitative research methods such as personal interviews and case studies. Second, their theoretical frameworks build on integrating non-logistics theories into the field of logistics/SCM, e.g. the network approach, the agency theory, transaction cost economics (TCE), the resource-based view of the firm, and the organization theory.

1.1 Background and objectives

Applied within the context of TPL, the logic of TCE offers a comparatively static reasoning for the institutional conditions under which outsourcing of specific logistics activities should be conducted. The primary decision factor for make-or-buy is the degree of "asset specificity" (Williamson, 1985; Rindfleisch and Heide, 1997). The partnership-like, inter-organizational arrangement of TPL corresponds to the hybrid form of governance structures suggested by TCE (Skjoett-Larsen, 2000). Although this reasoning inherently assumes reality to be in a certain mode of equilibrium, more long-term and positive loaded attributes of such an arrangement may emerge over time or even become a prerequisite for succession and development. Examples of such a development include the existence of the win-win spirit and the development of inter-organizational trust.

Logistics researchers have suggested normative and stepwise frameworks for how industrial buyers should approach the procurement of TPL services (Bagchi and Virum, 1998; Sink and Langley, 1997; Lynch, 2000). These models will normally depict a sequence of decisions ranging from identifying the need for outsourcing, solution design, assessing and selecting providers, implementing service agreements, and finally, ongoing service assessments. The arrangement between the buyer and provider is formalized into a contractual relationship aiming to reduce the risk of failure involved in the relationships. The strength of these normative arguments is that they appear ex-ante as the prime mechanism for articulating the needs, perceptions, and abilities of both the logistics buyer and provider. Especially, two sources within the TPL literature have dealt with the contractual aspect. First, Logan (2000) uses the logic of the agency theory to explain the contract design between the two parties. Second, Pruth (2002) investigates the form and function of TPL contracts governing successful alliances, including the contract as a managerial device. But when TPL arrangements are put into action, a broad range of changes and uncertainties may challenge the initial concerns and intents. To the actors involved, these changes are both controllable and non-controllable. Li and Kouvelis (1999) have reviewed several sources of uncertainties of supply contracts, including exchange rate movement, hyperinflation, difficult-to-forecast conditions, and fluctuating prices of components and raw materials that may lead to the design of contracts with some sort of "risk-sharing" features. In a logistics context, such changes may also influence other performance measures, such as inventory turnover, lead-times, and order-quantities. Hocutt (1998), Hertz (1998) and Harrison (2004) have found further evidence of the risk of failures and especially the dissolution of inter-organizational relationships.

It is important to consider the dynamic processes that emerge through the interaction between the buyer and provider of logistics services. These processes may affect the type and applicability of the governance mechanism applied in the specific relationship. In the agency theory, inter-organizational relationships are governed by contract between the two parties. To this condition, transaction cost analysis adds credible commitments and asset specific investments as devices safeguarding against opportunistic and self-seeking interest behavior. Credible commitments, e.g. joint investments or shared equity, create "functional substitutes for trust" (Williamson, 1996, p. 245). However, the network approach questions the completeness of ex-ante contracts and legal enforcement in ex-post situations. Uncertainty in business transactions may be costly if not pointless to cover by formal agreements (Håkansson and Gadde, 1997). "Reciprocal trust" is seen as a prerequisite for the prosperity of long-term relationships. In the present case, the TPL arrangement is governed by multiple means.

This paper tries to create a deeper understanding of the inter-organizational dynamics associated with the dyadic relationships between a buyer and provider of logistics services (TPL dyads). The objective is to identify forces that lead to changes in the "relationship governance" within TPL and consequently reveal by what means the dyadic relationships are governed. The theoretical aim of the paper is to complement the static view of the transaction cost approach and the agency theory on "governance structures" and "contracts" by showing how "relationship governance" emerges and develops over time.

2. Research design

The present research project is based on a qualitative research design (Denzin and Lincoln, 2000) and focuses on gaining an in-depth understanding of a particular phenomenon within its context. Several features of our study are contingent to such an understanding.

2.1 Research method – a single-case study

Given the previous knowledge within the topic and the objectives of the paper, a single case was selected for the study. The case consists of a dyadic relationship between a buyer and a provider of logistics services.

Although the practice of TPL is common in some industries, cases are seldom selected without the researcher's prior knowledge of one or both actors involved. The present case was selected because it represents a comprehensive TPL arrangement, where several contextual factors were new to both parties. The buyer was pursuing an intensive growth strategy on the consumer market and a more deliberate focus on core competence, whereas the provider was expanding their customer segments. This novelty shows the need for developing the dyad. We expected that some kind of "dynamics" would occur in the dyad, but otherwise we applied an inductively inspired approach in our research. Selection of respondents was based on their involvement, competence and scope of responsibility for the strategies and operations implied by the case. On the provider's site, a manager of business development had followed the project from the first contact of the buyer, and played a coordinating role in the setup and future management of the relationship. A logistics manager who was in charge of designing and implementing the strategy of logistics outsourcing represented the

logistics buyer. Although not involved in daily operations of the relationship itself, both managers were involved in discussions of disagreements and solving problems that arose later on. Prior to the data collection, the authors had an opportunity to learn about the case by participating in an executive seminar, where both shipper and TPL-provider presented their views on the implementation of the outsourcing process. Participants in the seminar where high-ranked logistics professionals. The exclusive character of the seminar allowed an open discussion on matters that emerge in inter-organizational relationships, but may be sensitive when discussed and presented to a wider audience. This discussion influenced the choice of the case, and marks as such, the initial stage of the data collection process.

2.2 Data collection and analysis

Four semi-structured interviews of 2-3 hours each were conducted with key managers from both parties. Interviews were recorded and notes made by interviewers. Based on this and secondary data available on the internet, a full description of the case was made based on a timeline. Further discussions with respondents were made in order to fill out holes and prevent misunderstanding of particular issues and events. Updates of the case description were sent to the respondents, who gave both oral and written feedback.

Although this case study is not strictly longitudinal, both parties have been followed over a period of time, which also included questions about the phases of preparation and implementation. Data was collected over a period of six months (starting 14 months after implementation), but the time horizon in the case includes more than two years of managerial decisions and actions. At the initial stages of the research process, the focus on "dynamics" was directed towards competence development, but it soon became clear that mechanisms related to the governance of the relationship were attracting much managerial attention. This change in management focus consequently had an influence on the theoretical emphasis in the paper.

The data has been analyzed with a view to the approach adopted during preparation, implementation and operation of a particular TPL arrangement. A first step was to create a timeline of these phases, which then was filled out with data on decisions (intentions) as well as intended and unintended events that occurred over time. The foundations for the data analysis, the process of linking the empirical data to the theoretical concepts, are embedded relationship between the dyad as the level of analysis and the elements of relationship governance (including relationship incentives and failures). This view corresponds with the logic in "pattern-matching" as a mode of analysis, idea of which is to relate several pieces of information from the same case to some theoretical propositions (Yin, 1994, p. 25). From the case study, we will derive implications for research and practice.

3. Theoretical frame of reference

Stock (1997) suggests that logistics might borrow from the field of economics to solve managerial problems of inter-organizational nature. Halldorsson *et al.* (2003) reflect upon the theoretical development of SCM demonstrating how the theories of the firm may contribute to TPL with various units and levels of analysis. TCE argues for the existence of TPL together with the logic of "core competence" from the resource-based perspective. The network approach provides an insight into development and management of inter-organizational relationships – a central feature of TPL. In developing a typology

of interorganizatoinal governance, Heide (1994) draws on cross-disciplinary literature, including the marketing channels perspective, the resource dependence theory and the relational contracting theory.

The agency theory focuses on incentives and contract types as a means to reduce the negative impact of goal divergence among the parties in the supply chain. Although the agency theory to some extent draws on the concept of transaction costs, Hoskisson *et al.* (1999, p. 433) argue that its primary theoretical building blocks are based on Berle and Means' discussion of the separation of ownership and control in 1932 and the work on property rights by Alchian and Demsetz in 1972. The main issues stressed by the theory include the principal's (a buyer of TPL services) and the agent's (a TPL provider) "conflicting goals" the existence of asymmetric information, and the principal's and the agent's different attitudes towards risk, i.e. "risk preferences" (Jensen and Meckling, 1976; Eisenhardt, 1989). The contract is the basic unit of analysis, and the domain of the theory deals with describing the governance mechanisms and identifying the most efficient incentives to solve the agency problems (Eisenhardt, 1989, p. 58). The incentive structure governs the relationship between the principal and the agent, and the firm itself is viewed as a nexus of contracts (Hoskisson *et al.*, 1999, p. 435). The incentives may be outcome-based or behavior-oriented, depending on a range of theoretical presumptions such as outcome uncertainty, self-interest behavior, goal conflict, bounded rationality, information asymmetry, difference in risk preferences, pre-eminence of efficiency, and whether information is treated as a commodity (Eisenhardt, 1989, p. 63).

3.1 Agency in TPL arrangements

The agency theory has been widely applied in logistics, especially in the buyer-supplier relationships (Stock, 1997). Concepts such as strategic alliances, partnerships, supplier relations, and supply chain management all indicate a formal, contract-based relationship and to a great extent a separation of ownership and control. As the interests of the principal (buyer) and the agent (TPL provider) might differ, the agency theory helps to understand the impediments involved in TPL. It should by no means be taken for granted that the logistics infrastructure possessed by the TPL provider fully supports the buying firm's objectives in terms of customer service or costs. For example, do TPL providers optimize their own logistics infrastructure and problem solving capability or are they highly motivated to adapt to customer needs (Hertz and Alfredsson, 2003)?

3.1.1 Risk. Various types of risks are related to a TPL relationship. LaLonde and Cooper (1989, pp. 116-7) assert that the buyers are keenly concerned about loss of control over the materials flow in the logistics channel. This is especially the case when the TPL provider has direct contact to the buyer's customers. A direct linkage between the buyer's and provider's IT systems may reduce the drawbacks of the situation. Today, most TPL providers offer track-and-trace services to their customers. But how the buyer can assess the cost performance of the TPL provider remains an issue. An initial step is to operate with transparent fee structures such as cost plus percentage, activity-based costing, and cost plus management fees (Lynch, 2000, p. 89). However, an important part of the ongoing management of the TPL relationship is performance measurement, which includes decisions on what should be measured and methods of measurement (Lynch, 2000, p. 186). Another concern of the buyer is "continuity of

services", i.e. the risk that the service performance of the TPL provider will erode over time. According to LaLonde and Cooper (1989:117), the buyer may prevent such a situation by emphasizing a close working relationship, good communication, and openness. But seen from the provider's perspective, the types and levels of investments required to achieve such a relationship might induce a certain risk. This applies especially if the investment, or even accumulated experience, is specific to the buyer's operations and hence difficult to transfer to other accounts (LaLonde and Cooper, 1989, pp. 117-8).

3.1.2 Relationship failures. Logan (2000) addresses failures of outsourcing relationships with reference to the agency theory. At least four aspects of the agency problem are identified. First, an agency problem may arise in TPL relationships because "... outsourcing customers doubt and fear ...[that]... they will get the same high levels of service that their internal operators provide" (Logan, 2000, p. 21). Second, customers may fear "... that over time, the providers' will take steps to protect their margin" (Logan, 2000, p. 21). Third, the logistics literature is preoccupied with the customer's criteria for selecting provider, but does not consider the providers' criteria for selecting customers. The fourth aspect addresses the idea that conflicts may develop as both the TPL provider and the customer are trying to act on the principles of the transaction cost analysis and the resource-based view by applying their own perspectives.

3.1.3 Relationship incentives. Logan (2000) derives two sets of solutions to the problems addressed above from the agency theory. First, he suggests that both parties of the contract should "diagnose" the relationship, i.e. provide a dyadic perspective. Second, contract design should be based on criteria that promote an environment of trust. Loss of control, potential goal conflicts, the issue of continuity, and specific investments are factors that all limit the scope of TPL, i.e. the types and number of services desired and supplied on the market for logistics services. LaLonde and Cooper (1989, p. 118) support these proposals:

> The number of value-added services should be approached in an incremental manner if the third-party provider does not have extensive experience and expertise in the particular service. Light assembly, which uses primarily space, personnel, and tools, may be a good beginning rather than requiring expensive assembly machinery, which the third-party would be expected to supply.

Here, both parties are advised to be cautious in terms of expanding the scope of TPL too fast, because they do not know whether or how the other party will react to future changes. It is assumed that their rationality is bounded and the risk of opportunistic behavior is present.

The focus and assumptions of the agency theory highlight issues that are of utmost concern to both parties involved in a TPL relationship. Note that the concept of "ownership" takes on a different role in TPL compared to conventional buyer-supplier relationships. The ownership of a product usually changes hands as the product moves down the supply chain. However, in the TPL segment of the supply chain, the agency problem deals with the separation of the ownership of the logistics flow (logistics infrastructure) from the ownership of the product. In other words, the boundaries of TPL in the supply chain are not determined by the product ownership or other product related property rights. Another limitation of the agency theory in relation to TPL is that it fails to consider the existence of other parties that may affect the performance

and needs of the buyer and the TPL provider, e.g. the buyer's customers or suppliers. Broadening the scope of an existing dyad consisting of a buyer and a supplier by introducing TPL into the picture has been referred to as logistics triads (Larson and Gammelgaard, 2001).

4. Case analysis

4.1 A dyadic TPL relationship

This case deals with the dyadic relationship between an international provider of logistics services (hereafter P) and a buyer of logistics services (hereafter B) operating at the market of fast-moving consumer goods (FMCG). The core operations of the logistics buyer B are development, production and sales of FMCG sold at various types of retail outlets. During the last decade, the company has expanded its product offerings by acquiring brands and facilities of related manufacturers. Today, the company is a market leader in Denmark with a 33 percent market share, but it also focuses on similar markets in the Nordic region, the UK, North America and South East Asia. The product assortment consists of strong brands generating a yearly turnover of EUR 0.2 billion. The majority of the 2,000 employees work at the production plants in Scandinavia and England. As the company has a considerable proportion of the category's retail shelf space on its core markets, logistics becomes an important factor in enhancing the value of this quality effort.

The current structure of P reflects the intense consolidation in the logistics service industry during the last five years. Today, it represents one of the largest logistics providers in Scandinavia within sea, road and air transportation as well as parcel distribution. Owning and operating warehouses at several locations in Scandinavia, the company has established a division of "logistics" focusing on TPL arrangements. This case focuses on the logistics division of P, which offers a broad range of transportation and logistics services and solutions to customers within various industries, including spare parts, fashion goods, electronics, and FMCG. Prior to the contract with B, P was already working with customers within this segment. The contract with B was an important step towards attracting more clients from this segment and obtaining economies of scale and scope through a separate business unit.

4.2 Driving forces of logistics outsourcing

Prior to outsourcing, B had its own shipping department buying all international transportation from various providers. For more than 16 years, the same provider conducted the outbound distribution of finished goods from two warehouses in Denmark. This distribution was not consolidated. The main selection criterion for choosing a provider was the provider's ability to cover particular destinations. P conducted transportation to the UK and Norway, but the transport to other international destinations were spread on several providers. As a consequence, B spent a good deal of time controlling invoices and performance related to the various destinations.

To cope with the bargaining power from a highly concentrated retail industry, B had to consolidate through acquisitions. Furthermore, B's current warehouse capacity was insufficient and the layout inadequate with long internal distances and a low stacking height. The cost of investing in a new warehouse was approximately EUR 8 million. Originally, the current contract provider P was expected to operate as a "facility manager" for the operations in B's warehouse, but top management in B made a

strategic decision to invest in acquisitions of firms in related businesses rather than spend their capital investments on warehouse buildings. The savings were estimated to be EUR 0.5 million during the first year and subsequently EUR 1.2 million per year. Both companies pointed to a number of "lessons learned" as a positive result of the start-up period. Yet another objective was to maintain the current service level.

The particular TPL agreement reveals three key indicators supporting the achievement of mutual orientation, which at an early stage in the relationship were seen as a contribution to both cost savings and learning (Figure 1).

4.3 Provider selection and implementation

Potential TPL providers were assessed according to size, location, reputation, strength and ability to deal with a variety of logistics tasks. Eventually, the number of providers was reduced to two: P and another niche provider specializing in servicing the retail stores in FMCG. A niche provider is known for its focus on cost efficiency, but without an advanced IT system. The distribution center of this particular provider was located in an area with relatively cheap labor, but in some distance from B's plants necessitating an extra internal transport between the distribution center and B' plants. The primary reason for selection of P was their advanced IT system and reputation from other TPL projects. Speed of implementation was given a higher priority than certainty during implementation. During the first month, top-level management was directly involved and daily informed about the performance of the warehouse operations. It took about three months to achieve a satisfactory operation and another two months before the IT system and the comparison of inventory data between the two companies were working well.

4.4 Letter of intent as credible commitment

It took almost one year to prepare the main contract. At the beginning of the agreement, the two parties had signed a "letter of intent". It started with an oral acceptance and three months later a letter was signed committing B to pay a penalty fee of EUR 1.2 million if the company withdrew from the project. The fee should cover some of the risk and expenses involved in renovating the warehouse to suit B's demand. In addition, P had to give a firm order on cranes dedicated to the warehouse operation. The main contract included the conventional paragraphs on the rights and obligations of each party, conflict resolution, terms of payment and definition of terms. The contract between P and B included the following services:

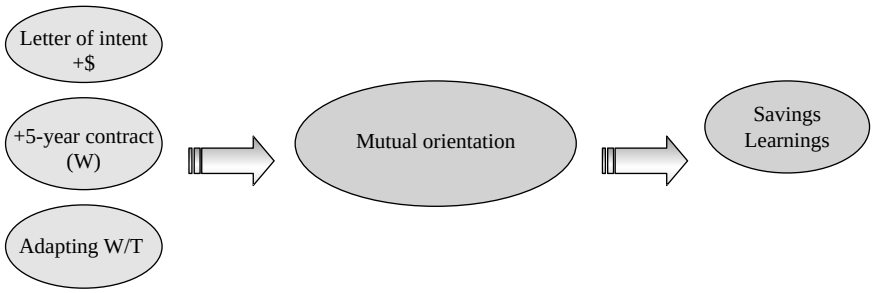

Figure 1.
Indicators of "mutual orientation"

- international and national distribution;
- internal transportation (from manufacturing site to warehouse storage of finished goods); and
- warehousing.

The contract for warehousing services covered ten years, but the contract on distribution services from the warehouse to the customers was running on a continuous basis, i.e. it could be cancelled by both parties with a six months notice. For P, the arrangement involved the risk that B might cancel the most profitable part of the contract – namely distribution – and leave P with the least profitable part – the DC operations.

4.5 Documenting logistics spending

B is a sales oriented organization that puts more emphasis on marketing issues such as category management than on logistics when they negotiate with customers. As a results of B's collaboration with P, the company gained an insight into activity-based costing of individual customers and their respective shipments, e.g. in terms of picking half or whole pallets. From the information on the invoices from P, the whole organization of B gained a better confidence, as it was able to document to various departments the consequences of their actions. However, after 18 months, B was unable to estimate exactly whether they had achieved the goal of EUR 800.000 savings, but they confirmed that savings had been achieved, primarily on labor cost at the warehouse. The national transportation turned out to be more expensive compared to the previous provider, but it was not viable to B to replace P with another provider regarding this activity. From the customers' (B's) point of view, the shift of transport provider during the outsourcing project was rather painful. New truck drivers were not used to the specific and maybe not so obvious requirements at each customer site. At present, B gives a high priority to stability within this area.

4.6 Dynamics of the relationship

The object of change is not the environment of the dyad, but rather the dyad itself as an "institutional arrangement". The following two sections will provide an overview of the decisions and incidents supporting the idea that contracts are incomplete in ex-ante situations and should be adjusted or even replaced by other governance devices.

4.6.1 Costs, prices, and co-packing – interests diverging over time. Eighteen months after implementation it was recognized that the relationship had failed to develop as expected. One reason might be that B did not spend sufficient time on developing the relationship, another that P simply did not profit by the agreement. According to B, they did not buy P's services at a price that was lower than market prices in general. B had recently compared prices (on inbound transportation, materials handling in the warehouse, and outgoing distribution) with another TPL provider that appeared to achieve effects of synergy by focusing entirely on the FMCG market, hence servicing some of B's competitors. The price advantage at the market does not lie in the materials handling, but is primarily achieved through low cost storage facilities. And as the inventory turnover at B was relatively low, the costs of materials handling were outweighed by the low cost of warehouse storage. Apart from the cost savings potential, B also identified a need for an extended service, namely co-packing.

B claimed that co-packing of finished goods, and even displays for merchandizing purposes, on quarter-pallets would contribute to reduce the inventory of finished goods and improve their customer service, especially during marketing campaigns. B will be met by high penalties if deliveries are delayed or incomplete. P was able of offer the co-packing service to B and actually delivered the service to other clients. But according to P, B was not willing to pay the extra costs involved in co-packing. As a result, B had to cope with the dynamics through a larger inventory, which was by no means satisfactory to them. Placing co-packing at the finished inventory level might save costs, but at present all co-packing is done at the manufacturing site.

4.6.2 Contract foundations changing.

4.6.2.1 No practice of open-book. Initially, the intention was to operate with the so-called open-book procedures. After a trial period, P changed its mind before the actual implementation of the project and the contract was chanced accordingly. P explained that:

> B is benchmarking our activity-based costs with costs from a one-to-one relationship with another firm that has its own trucks and stores. The cost structure of a TPL provider is very different and cannot be compared in such a manner.

Consequently, if P used open-book calculations, they might be squeezed by charges of some activities and fail to get full cost coverage on other activities. The charges are fully activity based, but they do not necessarily reflect the actual costs; they are more based on benchmarking and negotiation.

4.6.2.2 Controlling the contract – ever changing reality. Although the contract included some pre-defined activities, it had failed to anticipated the need for additional work caused, e.g. by seasonal variations or express orders. Nearly 18 months after signing the contract, the parties discussed intensively the hourly charges for additional work; P had found that it was necessary to do more work than expected in the contract, and B asked P to provide documentation for the extra work. Changes in volume might cause problems for P in their warehouse activities. A volume flexibility of ± 20 percent in the contract provided B with a great flexibility, but might cause problems for P in their warehousing management in terms of physical capacity and labor. The variations in picking and packing pallets for deliveries may be large, sometimes 40 pallets in one week and 140 pallets the following week.

4.6.2.3 Anticipating the need of capacity vs reacting upon actual orders. It is costly to find additional labor for specific and unanticipated tasks and volumes in the warehouse at a short notice. The contract did not guide the two parties in this situation, but P's approach to the matter differed from B' practice before the outsourcing. Prior to outsourcing, B's inventory manager followed the incoming orders closely in the ERP system, which helped him to estimate what probably had to be picked, packed and shipped the next one or two days. P, on the contrary, only reacted upon deliveries already created by the system. And to cope with delivery service agreements and observe the time of delivery, P had to operate with a nightshift at the warehouse.

4.6.2.4 No more one-stop shopping – using multiple logistics provider again. The contractual relationship seemed to be sliding from one-stop shopping towards the use of multiple TPL providers. In Sweden, distribution activities were developing in another direction than expected. The Swedish warehouse was closed down in the fall 2001 in connection with the present outsourcing project. However, in January 2003,

B was again operating with a warehouse of finished goods at their manufacturing plant in Sweden. It is difficult to assess whether this is an optimal solution, but a demand for a national warehouse from the sales organization was the driving force behind the decision. While the general trend moves towards centralized distribution with only one distribution center supplying the entire Nordic market, B now operated with two distribution hubs, one in Denmark servicing Scandinavia except Sweden and one in Sweden for national distribution. P provided the internal transport between the two locations, but B had linked up with another large TPL provider in Sweden to cover the national distribution activity. In addition, B also negotiated with another TPL provider to cover the transport from the manufacturing outlets in the UK to the warehouse location in Sweden. Although it is more expensive to have two inventory locations than one, B was surprised that the costs were somewhat compensated by savings in transportation from Denmark to Sweden and by lower costs of storage in Sweden.

4.7 Exchange and adaptation processes

According to the network perspective (Ford, 1997), a relationship can be characterized by exchange and adaptation processes. During these interactions, bonds will be established between the actors. It may be human bonds between the personnel in the interacting organizations or technical bonds, e.g. information systems, administrative bonds, juridical bonds – etc. The network perspective also assumes that over time trust will be established between people who interact with each other during the exchange and adaptation processes. Positive experiences will build up trust relationships, while negative experiences will result in distrust between people and organizations. If we look at the interaction between shipper B and TPL provider P, the large operating problems in the implementation phase were apparent from the beginning. The start of the operations had to be postponed two months, and during the first month Murphy's Law was confirmed. What could go wrong went wrong. This is not uncommon in TPL contracts. Experience from other TPL contracts shows the same pattern, but unfortunately it is seldom documented through research. However, in this case, a number of factors deteriorated the relationship between the two parties.

First, in the former distribution system, the retail customers were used to receiving their goods from company B in the morning. In the new set-up, some retailers had to wait to the afternoon to get their goods, because P's trucks first delivered goods to Jutland (DK), then filled the trucks with products from one of the large retail companies and returned to Zealand (DK). Not until then did the trucks deliver the products of company B to its customers. The lesson here is that it takes time to change customers' habits.

Second, P normally operated in the warehouses according to the FIFO (first in-first out) principle. However, in FMCG, some customers are extremely demanding in terms of high service levels and fresh products. The large retailers were dissatisfied with delivery of their orders according to the FIFO principle; they wanted to get the products with the latest due date. The competence of monitoring batches was something that P had to acquire. However, today, batch monitoring is one of P's core competencies, and P has a high track-and-trace ability compared to most competitors in the TPL industry.

Third, the retail customers demanded co-packed shipments. Instead of getting full pallet loads, they wanted to get quarter pallets with assortment packages. B wanted P to perform the co-packing at the distribution center to postpone their dedication to specific customers until the actual customer orders and point-of-sale data were known. However, they were not willing to pay the extra costs demanded by P to provide this service.

Fourth, the open-book principle was not included in the TPL contract. The TPL provider had found it costly to use this principle with other customers and did not want to be squeezed on every possible margin of revenue. Instead, the prices were normally set based on negotiations about individual activities such as pick and pack operations, deliveries of full pallets, half pallets, quarter pallets, etc. The prices were to some extent benchmarked with similar activities in another warehouse operation. There was a quantity discount when the volume increased by more than 10 percent. The scale was symmetrical, i.e. B had to pay more if the volume was reduced by more than 10 percent.

Fifth, the demand was very unstable. Owing to promotion campaigns and a fast response to competitors' prices and special offers, the customers' orders might change at a short notice. P had accepted to be very flexible in terms of changes in capacity utilization of the warehouse within ± 20 percent of the budgeted volume. For changes exceeding these limits, they required two months warning. This arrangement was costly to P as they had to hire or layoff people at a short notice. P also had to introduce a night shift to cope with the short order cycle and the large variations in order volume from week to week.

Sixth, there were major changes in the ownership of P and in the key personnel related to the outsourcing project in both companies. From the start, B's logistics manager was against outsourcing to P and left the company before the agreement was implemented. After the letter of intent had been signed, a new project manager was appointed. He had to negotiate prices and terms with the TPL provider, knowing that if he cancelled the agreement, B would have to pay a penalty of 10 million DKK. The TPL-provider was sold to another TPL-operator during the implementation phase. The event changed the attitude in P from looking at the contract with B as a strategic investment in future business within the FMCG to a more cost-oriented and revenue conscious approach. However, the change of staff members may also be seen as an opportunity to get a new and dynamic perspective on the relationship. After a while, the range of daily tensions and problems tends to tire the managers involved.

In the beginning, both parties were bound to the original letter of intent. When the contract was signed, it replaced the letter of intent. Neither of the two parties was fully satisfied with the situation. Many resources had been used to discuss claims and who was responsible for service failures. The two parties appeared to be stuck in daily operating problems, and the relationship seemed to change gradually from a trust-based relationship into a relationship resembling a principal-agent relationship. However, the latest development has been characterized by increased meeting activity on top management level. The parties have acknowledged the unintended development and are now making an effort to revitalize the relationship. Figure 2 shows the key indicators pointing to a principal-agent oriented relationship.

4.8 Summary

A change in the "institutional environment" affects the comparative costs of the three modes of governance (Williamson, 1996, p. 112). But, as the present case illustrates, the

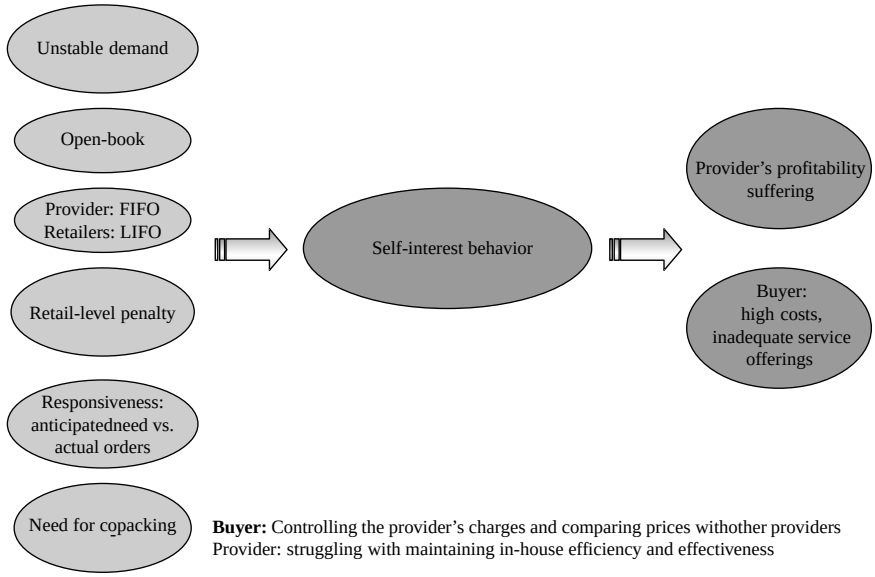

Figure 2.
Indicators of "self-interest behavior"

"institutional arrangement" (Williamson, 1996, p. 112), i.e. attributes governing the two actors' interaction, also varies over time. The frameworks in the logistics literature referred to above, which suggest how to purchase logistics services, consider changes in the form of "ongoing service assessment" related to what we have termed "adaptation processes".

As the four main sources of agency problems reviewed above (Logan, 2000) can be related to the empirical evidence, it supports the argument that the TPL arrangement is an example of an incomplete contract. For example, both parties admit that their own margins play an important role. B was comparing current prices with another provider while P was constantly striving for economies of scale in their warehouses. Balancing the latter dimension is viewed as a major strategic issue at the TPL provider's site today.

These conditions raise questions about the current frameworks for buying TPL services, assuming that the buyer has the capacity to ex-ante make a complete bidding material and the provider is able to receive this information and analyze it without disturbance. Although "credible commitments" are created in ex-ante, it may evolve into "credible threats" as the relationship evolves over time.

5. Conclusions and implications

The previous sections have not focused on the level of governance (market-hybrid-hierarchy), but rather on decisions and incidents in the particular TPL dyad – the hybrid mode – explaining by what means the relationship is governed and why the managerial devices may change over time. The TPL arrangement confronted both parties with new managerial tasks. To P, the arrangement was an important step into the FMCG business segment, and to B, the arrangement implied that a substantial part of their logistics was operated by an external organization.

This section reflects upon several issues that have furthered motivation as well as de-motivation in the relationship.

The two parties have focused keenly on interpreting the clauses in the contract and discussing prices and service failures instead of concentrating on developing improvements and win-win situations. The reason for this focus on the contract relates to the fundamental idea and intention of the outsourcing project. Both parties acknowledge that is not so much a matter of "relationship management". To achieve a better TPL arrangement, both parties must have a clear rationale for entering the arrangement and know how to create logistics synergies among the customers of both parties. Both the strategic consideration about entering the arrangement and the selection process, in which IT capability was a major criterion, seem to have followed the expected path. From the outset, however, the relationship has been subject to both controllable and non-controllable forces of change. This has not always had a positive effect on the logistics performance or the relationship itself.

The letter of intent (later replaced by a clause in the contract), which initially served as a safeguard for the provider's investment in dedicated automated cranes and warehouse activities, took on an important role in management of the relationship. The monetary consequences of terminating the relationship were a common point of reflection when the two parties argued on some specific matter. Also, the time and resources invested in changing from one logistics provider to another may be seen as switching costs in a current perspective. Unanticipated increases in volume limited the provider's opportunity to fully utilize the warehousing capacity – a cost that the contract did not consider. As a result of outsourcing, the customer acquired more knowledge about the costs of individual operations, which gave the customer the opportunity to compare the costs with prices of other logistics providers. The mutual search for optimizing their own operations may have the character of what Løwendahl (1997, p. 39) calls the "double moral hazard problem"; for both parties there is a hazard involved due to private information.

The mechanisms of governance have changed throughout the relationship. The governance of the relationship has been "dynamic" in the sense that the letter of intent served as the main device of governance in the beginning and later was replaced by the written contract. However, contrary to what has been termed development of "trust" as a common point of reference, this particular relationship decided not to operate with open-book contracts. Also, the buyer made several efforts to control what the provider charged for various services. Seen in a long-term perspective, the basis of the relationship might be more characterized by what Williamson (1993) defines as "calculative trust" than by "personal trust" and "reciprocal trust" introduced by the network approach (Håkansson and Gadde, 1997). Figure 3 shows an overview of how the theoretical logic of the various decisions made by management of the inter-firm relationship may vary over time.

From focusing on core competencies as the initial logic of outsourcing, there is evidence of mutual orientation in the initial period of implementation and operation. This is followed by a period characterized by a principal-agent relationship. To ensure further prosperity of the relationship, the two companies must direct their efforts towards the logic of the network approach.

The approach developed above is limited in the sense that it fails to reflect on how costs of governance vary with different means. A further test of governance

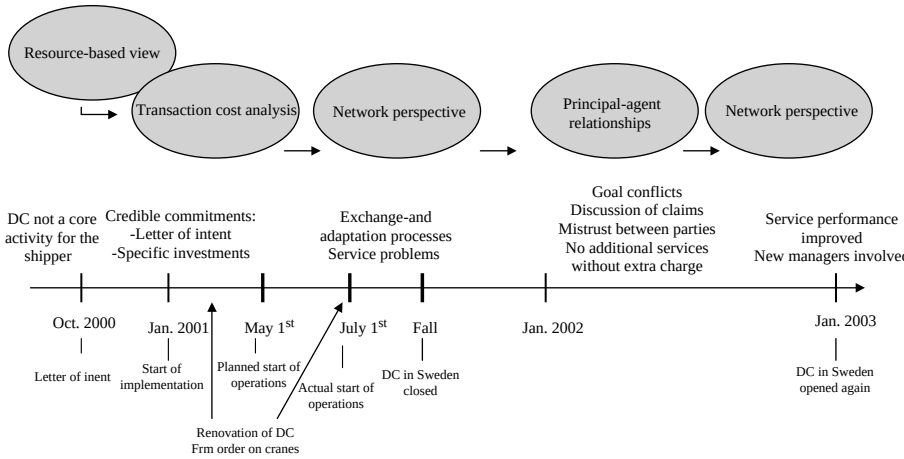

Figure 3.
Key decisions and changing role of theoretical explanation

mechanisms and their subsequent dynamic forces should be worked into the current models of TPL arrangements, which mainly view "ongoing service assessment" as the primary attribute of dynamics in TPL arrangement. The current case and theoretical evidence prove that this is not the case.

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Reverse logistics in the publishing industry: China, Hong Kong, and Taiwan

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Abstract

Purpose – This paper compares the characteristics of reverse logistics in the publishing industry among China, Hong Kong, and Taiwan.

Design/methodology/approach – A multiple-case approach in combination with EIQ (entry of order, items, and quantity) analysis is selected to allow analytical generalization of the findings.

Findings – The research findings show that the reverse logistics of Chinese publications is still in early stage and is not mature enough to be interconnected in China, Hong Kong, and Taiwan. The reverse logistics cost in these areas is unlikely to be significantly reduced in the near future.

Practical implications – Instead of making effort to process returned goods, logistics firms or publishers may consider discarding the returned goods directly. The loss on material cost is far less than the manpower spent on processing. Also, publishers can sort returned goods in off-peak season to save cost on reverse logistics.

Originality/value – This research provides the first empirical study by applying EIQ analysis to understand the challenges of reverse logistics in the publishing industry in China, Taiwan, and Hong Kong, which has been rarely discussed in the past.

Keywords Supply chain management, Distribution management, China, Hong Kong, Taiwan

Paper type Research paper

Introduction

Asia is now the world's largest manufacturing base, and is closing in on becoming the world's largest market. Cheap labor has led the region to become the "world factory." A number of factors lead to economic growth, among which logistics is most concerned in the twenty-first century today. It is long believed that superior supply chain capabilities exist in only a few of Asia's more-developed countries, most notably Singapore and Hong Kong (Easton and Zhang, 2003). In Asia, the focus has been on squeezing costs out of production, but the future potential for cost reduction now lies in logistics and distribution (Easton *et al.*, 2003).

The population Chinese speakers continues to increase in Asia and around the world, as Asia is expecting to become more influential to the global economy in the near future, and China is likely to become one of the economically powerful countries after accession to WTO. Besides the "Greater Chinese Economic Zone" (China, Hong Kong, and Taiwan), large Chinese population spread over in Singapore, North America, Australia, and New Zealand. The estimated population has exceeded two billions. Therefore, this large publishing market has prominent effect to the entire world.

After entry into WTO, China and Taiwan have been granted access to foreign investors to enter Chinese publishing market in those two regions. The publishing industries of China and Taiwan are now playing on the global platform so the dramatic

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changes in the future market channels of Chinese publications are foreseeable. However, poor logistics system performance in these areas can impede the development of publishing industries.

Chinese publishing presently concentrates in China, Hong Kong, and Taiwan. Taiwan, in a relative term, is more experienced in publishing and offers a variety of services. Hong Kong, on the other hand, focuses on transit trade while many international publishers take advantage of Hong Kong as a gateway to enter the Chinese publishing market. China is the ultimate marketplace of every publisher, but marketing and distribution channel are the major challenges to all publishing firms. The quantity of books to be published in China will occupy the majority share of all Chinese publications. Therefore, the study of supply chain management of Chinese publishing industry shall be in large part based on thorough understanding of the China market; existing experience and advantages of Taiwan and Hong Kong can be integrated to create a win-win outcome in Chinese publications.

A majority of logistics literature mainly deals with forward logistics; on another hand, reverse logistics is far under-researched, in particular in the publishing industry. Little empirical work has addressed other reverse processes such as returns, recalls, refusals, reworks, rejects, and returnable shipping containers and pallets (Marien, 1998). Therefore, the current research was undertaken to empirically examine involvement in reverse logistics activities. The research specifically addresses the relationship between reverse logistics systems and program performance.

Reverse logistics consumes considerable amount of cost. The cost for reverse logistics is five times of forward logistics. Reverse logistics indeed calls for urgent attention as well as solution. The purpose of this research is to probe the problems existed in the supply chain of Chinese publishing industries of China, Hong Kong, and Taiwan. The discussion on similarities and differences of reverse logistics of Chinese publishing industry in China, Hong Kong, and Taiwan can deduce a collective model for solution to reverse logistics.

Reverse logistics literature

Reverse logistics has received more attention in recent years because of its strategic implications. A well managed reverse logistics program can result in savings in inventory carrying transportation, and waste disposal costs as well as improving customer service (Rogers and Tibben-Lembke, 1999).

A widely used definitions of reverse logistics is provided by Stock (1998):

> Reverse logistics refers to the role of logistics in product returns, source reduction, recycling, materials substitution, reuse of materials, waste disposal, and refurbishing, repair, and remanufacturing; from an engineering logistics perspective, it is referred to as reverse logistics management (RLM) and is a systematic business model that applies best logistics engineering and management methodologies across the enterprise in order to profitably close the loop on the supply chain.

A comprehensive literature review on reverse logistics by Carter and Ellram (1998) shows that most of the research has focused on environmental aspects (Kroon and Vrijens, 1995; Wu and Dunn, 1995) and that the factors influencing reverse logistics activities differ from those of traditional logistics. Daugherty *et al.* (2002) argue that there is another aspect of reverse logistics that is equally as important as environmental issues. Carter and Ellram (1998) propose that resource reduction should

be the ultimate goal in the reverse logistics process. After the resource reduction effort has been made, the firm should try to maximize reuse, followed by recycling. Disposal should be the last choice adopted by the firm.

A conservative estimate is that reverse logistics accounts for approximately four percent of their total logistics costs (Rogers, 2001). In the retail and manufacturing sectors, it is estimated that reverse logistics accounts for 5-6 percent of total logistics costs (Raimer, 1997). In contrast, a later empirical study of Daugherty *et al.* (2001) indicates that, on average, reverse logistics costs account for 9.49 Percent of their firms' total logistics costs. Thus, reverse logistics should be a critical issue for many firms.

Table I shows the comparison between forward and reverse logistics provides by Rogers (2001). Similarly, Kokkinaki *et al.* (2000) also state that there is a fundamental difference between forward and reverse logistics, namely reverse logistics is in many situations an exception-driven process. In addition, data for the goods entering the recovery chain are often of poor quality. Thus, a different overall perspective is required for developing reverse logistics systems.

Reverse logistics programs can also result in significant savings. To name a few, AT&T Network Systems Division has saved nearly $100 million in the 19 months it has been operating a reverse logistics program for its telephone switching equipment. A similar successful example is HP's LaserJet Toner Cartridge Recycling Program, called HP Plant Partners™. HP has recycling programs throughout the world and claims that since 1990, HP was able to divert over 18 million pounds of material from landfills by recycling every toner cartridge received by providing consumers with pre-paid UPS label to send the used toner cartridge back to HP. In addition to environmental and cost benefits, a reverse logistics program can proactively minimize the threat of government regulation particularly in Europe and can improve corporate image. The findings of the research by Blumberg (1999) also suggest that reverse logistics services need to be integrated on a seamless basis. However, readers should bear in mind that reverse logistics programs are resource intensive in terms of implementation and maintenance. Significant time and resources must be committed (Daugherty *et al.*, 2001).

The study of Rogers and Tibben-Lembke (1999) suggests that the relative unimportance of reverse logistics issues is the largest barrier to good reverse logistics

Forward	Reverse
Product quality uniform	Product quality not uniform
Disposition options clear	Disposition not clear
Routing of product unambiguous	Routing of product ambiguous
Forward distribution costs more easily understandable	Reverse costs less understandable
Pricing of product uniform	Pricing of product not uniform
Inventory management consistent	Inventory management not consistent
Product life cycle manageable	Product lifecycle less manageable
Financial Management issues clearer	Financial Management issues unclear
Negotiation between parties more straightforward	Negotiation less straightforward
Type of customer easy to identify and market to	Type of customer difficult to identify and market
Visibility of process more transparent	Visibility of process less transparent

Source: Rogers (2001)

Table I.
A comparison between forward and reverse logistics

management. Many companies have devoted too few resources and too little effort to effectively forecast for and handle reverse logistics (Andel, 1997). This is especially true in the publishing industry. Product returns are heavily driven by customer returns and vary in volume by industry. This is especially serious for the publishing industry with an incredibly high return rate ranging from 20 to 50 percent (Schwartz, 2000).

In the publishing industry, reverse logistics has traditionally not been recognized as an important factor. Rogers and Tibben-Lembke (1999) show that the publishing industry is currently fighting over some long-standing problems including record-breaking returns of unsold copies, a steady decline in adult trade sales, and a compressed shelf life for new titles. Reverse logistics is now more critical in the publishing industry than ever.

Reverse logistics of publishing in China, Taiwan, and Hong Kong

Despite their differences in business models among China, Hong Kong, and Taiwan, the fundamental network structure of the forward/reverse logistics process in the three regions are almost identical. Figure 1 shows the general network structure for readers' reference.

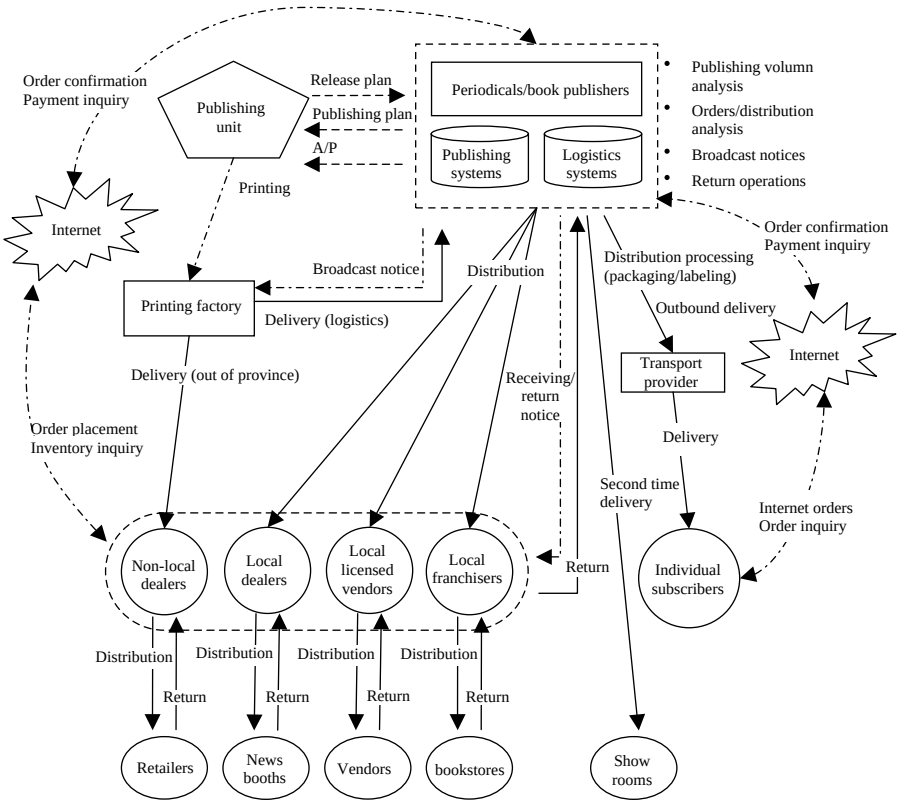

Figure 1.
Network structure of the logistics process in the publishing industry

The main reason why a book or magazine needs to travel all the way back to the publishing center is for the accounting purpose even though it is defective or unsalable. There are two reasons for not destroying the defective or unsalable ones on the spot. First, it will pose a serious problem if these defective books are "smuggle" out or bought out at a very cheap price first by unethical employees or booksellers and later on illegally ask for another regular return, which will undoubtedly cause the upstream publisher a significant loss in sales. Second, the destroy operations also require accounting/finance activities and are required by law to be audited by CPA. Although these two reasons have little to do with logistics, they are the major reasons for the need of reverse logistics in the publishing industry. In addition, after properly processed, defective books can still return to a good condition. Recycling and increasing environmental awareness also help justify the need of reverse logistics.

Logistics development of publishing industry in Taiwan is superior among the three regions. The promotion of commerce automation by the government since 1990s has established solid foundation for logistics in the later years. The establishment of bookstore chains, such as Kingstone, Elite, Hess, and Senseio has promoted logistics, and the foundation of automation established previously is brought into fully to develop logistics center for those bookstore chains. For example, Kingstone has established Kingsmeng Logistics while Elite has established Elite Logistics. Publishing Channel Commerce and Agriculture Association has also established self-contained logistics center.

On another hand, Hong Kong has been focusing on traditional warehousing operated manually, product selection, and transportation, instead of modern logistics system, due to insufficient land space. As China is in great need of logistics professionals, a large number of students in Hong Kong have enrolled in logistics program, and the program is now the number one program in recruitment. The average monthly salary for logistics graduates is about $1,795 USD whereas graduates of other majors receive only about $1,154-1,539 USD per month.

Since, the structural reform in China occurred relatively late, the logistics technology is behind that of other countries, and mostly exists in theories. Owing to lack of practical experience, related literatures concerning logistics are scarce. One success example of publishing logistics center is the logistics center established by Shanghai Century Publishing which is closely associated with a logistics firm from Taiwan.

Reasons of return

As far as the publishing industry is concerned, book return refers to return of the ordered books or magazines from the downstream customer (bookstores) to the original supplier (publisher or wholesaler) for various reasons. Reverse logistics of book return refers to the process and management activities of reverse logistics occurred after the act of book return. The entire process involves bookstores and wholesalers, as well as the publishing houses.

Cheng (2004) conducts an AHP analysis on reverse logistics in the publishing industry in China, Hong Kong, and Taiwan, and identifies many reasons for returns which are listed below. The findings of Cheng's survey indicate that the most important reasons for returns are "unclear product market positioning" "quality" "design and binding problems" "inaccurate forecasting" "weak logistics support" "Frequent promotional activities" and "weak transportation support."

Reasons for return:

- unclear product market positioning;
- quality problem;
- design and binding problems;
- inaccurate forecasting;
- unreasonable pricing;
- slow information flow;
- lack of marketing support;
- weak sales function;
- bad store presentation;
- weak logistics support;
- weak transportation support;
- lack of control over return frequency, quantity, and items;
- serious back order and late delivery due to the small order quantity;
- long return process cycle;
- returned products in large variety yet in small quantity;
- a large quantity of returned products due to the fixed return period;
- significant increase in returns at the terminal period of sales for best-sellers;
- cash flow problem;
- oversupply of new book titles to the current market demand;
- inappropriate selection of a product mix;
- discrepancy between the return list and actual items and quantities;
- long distribution channel;
- frequent promotional activities resulting in lots of returns at the end of promotion;
- different consumer preference among different geographic regions;
- high transportation costs due to difficulty in transportation arrangement in advance;
- no rigid discipline in stock-taking and stocking activities; and
- too many distributors involved.

Reverse logistics in China

Owing to vast geography in China, the business model is quite different from that of other regions. The state-owned publishing enterprises are located in Beijing, and spread from Beijing to other regions. Local publishing spread from the local area to the whole nation. The picture is quite complicated. Circulation of publications requires partnership with regional distributors and dealers. However, the distributorship involves the following structural difficulties: the resupply between customers or regions impedes the publishers from having updated information on flow of the merchandises. Publishers often have no idea of where the merchandises are sold and

how returned merchandises are processed. Such phenomenon has resulted in irregular return of merchandises, and intensified the difficulty of reverse logistics.

In terms of transportation, the commonly used means of transportation are trucks for short distance, and trains for long distance. Door-to-door delivery service is unable to be realized because:

- some highways are not yet in use;
- tolls are expensive;
- it is difficult to control the drivers, overtime work, overload, and traveling time;
- vehicles are restrained from movement and are only allowed for transport within its license plate registration region; and
- weather conditions vary across the country.

The abovementioned factors have attributed to difficulties in logistics and reverse logistics, and held back the feasibility of delivery by specific vehicles.

Most publications in China have adopted ISBM code system, yet the number of bookstores using computers is scarce. The return purchase invoices are often written by hand, and resulted in high errors. The efficient management of return purchase is not easy at this stage.

Reverse logistics in Taiwan

Reverse logistics of publication in Taiwan initiates from retail stores, and goes through logistics center to warehouses of publishers. In most cases, publishing firms set a return ratio from the retailer. Thus, retailer determines the amount of return by multiplying the amount of stock of the current month to the return ratio. Most returned products are unsalable or defective products, and books that have been on the shelf for a long time and sold out slowly. At last, retailers adjust the quantity based on the allowed return ratio.

After taking in consideration the book popularity and account receivable issue, the return ratio is often negotiated among stakeholders along the supply chain. Instead of resorting to a written contract, the allowed return ratio in many cases is simply built upon an oral agreement between the publishing firm and the retailer before starting doing business. Nevertheless, in reality, it is not uncommon that the retailer does not abide by such unwritten agreement, resulting in uncontrollable return rate.

Taiwan's Ministry of Education has recently announced its plan to establish textbook exchange logistics center in 25 counties and cities to recycle used and usable textbooks, reference books, and composition books. Hence, students from low-income family no longer have to worry about textbook fees. It is obvious that increasingly book return is demanding for more frequent and complicate reverse logistics.

The region where reverse logistics occur is wide, and the time of occurrence is unpredictable. The work of sales representatives, logistics center, and accounting can fluctuate during peak time and off-peak time, and thus affect the efficiency. Since, land size of Taiwan is fairly small, transportation of publications is often by road transportation; drivers have to bring back the returned merchandises in the same trip of delivery. Owing to work variations in peak time and off-peak time as mentioned previously, the return is irregular and the return trip is often not loaded. Thus, transportation is lack of efficiency and the cost is unable to be reduced.

Reverse logistics in Hong Kong

Circulation of publications in Hong Kong is often through dealers, or sharing one warehouse with several other publishing firms. The cause behind this phenomenon is due to undersized market, so means of resource sharing is employed to reduce the high cost of independent operation. In addition, despite being a major business hub in Asia, Hong Kong is also severely constrained by its space availability. Nevertheless, unlike in China, the entry barriers into the publishing industry in Hong Kong barely exist. However, with a view to cost reduction, it is a common practice for several small publishers to share a warehouse. Each publisher is operating independently of each other. As for the cost sharing issue, since the main focus of this study is on the key characteristics in reverse logistics, the contract details in cost sharing will not be dealt with here. Readers are suggested to conduct this research topic in depth if interested.

Return of merchandise is initiated from retailers, to warehouses of dealers, and sent to publishing firms after sorting. Publishers often process the returned merchandises by discarding. The entire process is time consuming, so in most cases, while the returned merchandises are still stocked in warehouse, and the publishing houses have started reprinting. The cost wasted is considerable. On another hand, the organization of returned merchandises require manpower so the speed is slow and the mistakes occur often. The overall reverse logistics process is not yet comprehensive.

Research methodology

Reverse logistics are real phenomenon existed in publishing industry. According to Yin (1994), the case study approach is mostly appropriate when a "how" or "why" question is being asked about a contemporary set of events over which the investigator has little or no control though there are some challenges in conducting case research including time-consuming, experienced interviewers, and generalizable conclusions from a limited set of cases (Voss *et al.*, 2002). However, the risk of low response rates and the complexity and emergent nature of the issues involved, weighed against other approaches. Therefore, the exploratory nature of the research and the problems of conducting research with companies based in "Greater Chinese Economic Zone" led to the choice of case study methodology. Voss *et al.* (2002) and Eisenhardt (1989) both provide excellent guidelines on how to conduct case studies. Ellram (1996) shows that how the case study methods can be used in logistics research and indicates that excellent opportunity exists for using case study methodology in many areas of logistics and purchasing.

A multiple-case approach in combination with EIQ analysis was selected in the research to allow analytical generalization of the findings. To conduct effective case studies, on-site visits were arranged by the researchers. These enabled logistics operations to be inspected, detailed discussions to be held with multiple informants (managers) and company documentation, products and processes to be seen first-hand together made a range of data available to the researchers.

The case samples selected in this study are from logistics companies of China, Hong Kong, and Taiwan, and based on their significance and representation. The number of publishers is sizeable, so only the most represented publisher of the region or most appropriate for case study is selected. The three regions are compared for analysis in order to understand the characteristics of product return in the three areas and offer appropriate suggestions.

EIQ analysis

EIQ analysis was developed by Shin Suzuki, is well adopted by researchers for logistics systems/distribution planning purpose (Usuki *et al.*, 1999). In EIQ analysis, individual and cross comparison of E (order entry), I (item), and Q (quantity) are performed. The accumulated transactions and sales analysis are used as reference to logistics planning and management in the future.

According to Susuki (2005), EIQ technology is a new technology to design warehousing/logistics systems based on complex concept. EIQ technology is different from theoretical traditional design method. Traditional method is based on linear concept such as induction and deduction method. EIQ technology is same as "Sketch" which draws outline of object and then brush up the object. EIQ technology designs outline of logistics system and brushes up the system to final one. Susuki divides EIQ technology into EIQ concept and EIQ analysis.

EIQ concept

Logistic system is complicated and requires complex concept. EIQ concept is based on complex concept which is not theoretical and sometimes has contrary for linear concept. Linear concepts some times miss lead the solution in Logistics. EIQ concept apply both concepts depend on the characteristics of problem.

EIQ concept consists of:

- confirm mission of the logistics system;
- EIQ data are key factors of logistics system;
- find characteristics of logistics system;
- macro and micro (Mamicro) view;
- Yoikagen concept;
- circulation method; and
- flexible concept.

Susuki (2005) maintains that EIQ is a key factor in logistics and emphasize that the focus of logistics is on material flow, which can be significantly improved by using EIQ data.

EIQ analysis

EIQ analysis is a data analysis of order sheet (EIQ data). EIQ Key factors include:

- order quantity (Q) from each customer E (EQ);
- number of items (N) ordered by each customer E (EN)
- ordered quantity (Q) of each item I (IQ);
- frequency of order (K) of each item I (IK);
- order size (a size of quantity for each item from each customer); and
- order pattern (distribution of order sizes).

Traditional ABC or POS data analysis is based on items (I) and quantity (Q) which are two key factors. EIQ data have three key factors (E, I, Q) which contain more information than ABC and POS data. Susuki (2004) later proposes a number of

EIQ-based analyses (e.g. FEIQ for forecasting, EDIQ for time series analysis, GI-DEQ and GE-DIQ, E-DEQ, E-DIQ for different order scenarios) to solve specific logistics issues. If interested, readers are advised to visit the dedicated EIQ website by EIQ Research Center in Japan (www.eiq.jp: in Japanese) (Susuki, 2003).

Susuki (2005) claims that EIQ techniques are an effective analysis tool for:

- logistics systems;
- more effective than POS data analysis;
- warehousing systems design;
- selection of material handling equipment;
- bench marking for logistics;
- inventory control; and
- forecasting.

EIQ is also commonly used to analyze outbound delivery. In this research, E (order entry) is replaced by product return instead. I (item) is defined as item of returned merchandise, and Q (quantity) is defined as quantity of returned merchandise. The quantitative data is studied to reach conclusion on improving reverse logistics.

The means of analysis include data collection and sampling, charting the data, generalization and comparison, interpreting the results, and proposing conclusion. The objective of generalization and comparison is to find out whether characteristics of reverse logistics are similar in China, Hong Kong, and Taiwan.

China: Shanghai Century Publishing Corp.

Shanghai-Pudong areas have been designated by the Chinese Government as the region for high technology and other industrial development. Most of the heavy or high technology investments in China are handled directly by the government and the huge multi-national firms with operations mainly located in Shanghai-Pudong region or other northern provinces (Yam and Tang, 1996).

Shanghai Century Publishing Corp. was established on February 24, 1999. It is an experimental company for publishing reform in China, and has considerable influence and symbolic purpose for the government of Shanghai. This case sample is selected because of its modern business concepts and reputation in China. Its management concept is close to that of Taiwan and Hong Kong, and it is located in the most advanced city in China – Shanghai.

Until the year of 2003, Shanghai Century Publishing has covered publishing of books, newspapers, magazines, audio and video, advertisement, and the internet, and is truly a publishing corporation. The publishing areas range from Shanghai People's Publishing, Shanghai Education, Shanghai Translation Publishing, Chinese Dictionary Publishing, Shanghai Bookstore Publishing, to others. The number items published every year has reached 3,000, and the annual sales revenue is about $43.5 million USD.

The logistics center for publications was planned in 2001 and officially in use in November of the same year. It is now viewed as the model enterprise in publication logistics in China, and it has significantly increased its productivity and efficiency. It now employs 80 workers, and its circulation areas cover the entire nation. In other words, reverse logistics can come from any corner of the nation. The number of books

in the logistics process is about 1.5 million to 2 million, the number of books in the reverse logistics process is about 0.3 million.

Taiwan: Choice Logistics Corp

Logistics firms in Taiwan can be grouped into:

- self-contained logistics centers established by chain stores;
- logistics centers established by dealers; and
- independent third party logistics providers.

This research paper focuses on independent reverse logistics service providers, among which Choice Logistics Corp. is chosen to represent Taiwan's publishing logistics.

Choice Logistics Corp. was established in 1997. Its logistics center is officially in use in June 1999. The parent company of Choice Logistics is Choice Printing Corp. Choice Logistics is established to integrate publishing, printing, and logistics process, so the media interface can provide a complete supply chain. The business aspects of Choice Logistics include delivery of magazines to convenient stores, logistics process for other publishers, and warehouse delivery of game card.

The case sample selected for this research is consigned publishers. The business aspects include warehousing, merchandise sorting, arrangement and process, delivery, reverse logistics, verification, classification, restock, disposal, and re-circulation. In other words, publishers only have to concentrate on editing, production, and marketing; the market channels only have to concentrate on store display and customer service; the rest is taken care by the independent logistics provider.

Choice Logistics currently has 70 employees. They are divided into two shifts, and each shift takes turns running 12 hours, excluding meal time and break time, and 6 days per week. About 20-30 thousand returned merchandises are processed every day. The reverse logistics process from market channel to Choice Logistics to publishers is outsourced to a transportation company.

A Hong Kong case

Hong Kong is strategically important as an entrepôt for China and a trans-shipment port for intra-Asian and world trade. Both multinational and local firms are benefiting from the entrepôt role of Hong Kong, however, they also face problems caused by the inadequacies of the transportation system in the region (Yam and Tang, 1996).

For the confidentiality issue, Company K is selected for the study but not disclosed to the pubic for it's identity. Company K has been in publishing industry in Hong Kong for 45 years. The main business aspect is middle school and elementary school textbooks, as well as popular books. The ratio of textbooks to popular books is two to one. The total number of publishing distributors is 1,000; delivery and return of textbooks occur before and after winter and summer breaks, while that of popular books occur regularly. This case sample is selected because the company has had long-term experience in the industry, and can provide more accurate data for reference.

Research results

This section discusses the similarities and differences found in the reverse logistics process of the three case samples by using the EIQ approach. As shown in Table II, at least one item is returned from the distribution channel every day; but the similarity

is that the frequency of return is unpredictable and fluctuates often. This phenomenon suggests that the return at retail stores is irregular, and many objective or subjective factors can affect the managers' consent on return. It is foreseeable that the quantity of return is not consistent and transportation cannot be arranged on a regular basis, and the manpower of a warehouse or logistics center cannot be scheduled effectively. Those problems can certainly result in excessive cost.

Table III presents the daily return item analysis. This analysis shows the process productivity of the warehouse or logistics center because a more variety of publications can result in more returns. According to the data, the maximum number of return in one day is 3,002 in the case of China. The items come from different areas of the nation. Though the work load from every distribution channel is minimal, the manpower, facility, work hours spent by the warehouse or logistics center to identify, sort, restock, resale or discard the merchandises can be accumulated together, resulting in considerable cost. The comparison among the three areas indicates that the return occurred in Hong Kong is more severe than its counterparts. In other words, Hong Kong has to bear higher cost in return. This finding is interesting since many may think that Hong Kong should have the most efficient logistics performance among the three regions. Obviously, it certainly is not the case in the publishing industry.

A high sales return rate means a high rate of invalid or non-valued-added delivery. Thus, proper distribution of merchandises should become the concern for dealers. Sales representatives under the pressure of sales quota often neglect proper distribution arrangements. This situation later becomes the major reason for a high return rate. In addition, careful production and title selection can reduce the return rate as well. As we can see from Table IV, after comparing the three regions, the case sample of Hong Kong has the highest returns, followed by Taiwan, then China. The phenomenon is caused by the fact that return in Hong Kong and Taiwan is indeed true reflection of the free market economy as merchandises that are unsalable are returned to the publisher. However, return of China is planned and controlled, so the return rate might increase in the near future.

Table II.
Daily return order analysis

	China	Hong Kong	Taiwan
Number of days analyzed	85	56	47
Number of return order	1,231	392	146
Maximum number of daily return order	99	31	9
Minimum number of daily return order	1	1	1
Average number of daily return order	14	7	3
Standard deviation	20	7	2

Table III.
Daily return item analysis

	China	Hong Kong	Taiwan
Number of return item	1,231	392	648
Maximum number of daily return item	3,002	921	504
Minimum number of daily return item	1	2	1
Average number of daily return item	733	147	78
Standard deviation	783	164	116

Order entry and quantity (EQ) analysis is shown in Table V. It may be the case that a return purchase invoice is written for return of one single book but the total cost of packaging, shipping, handling, and sorting may exceed the price of the book. It is necessary to datamine the reasons behind the return, and the solution to saving cost and at the same time meeting customer's satisfaction. The average return quantity on each return purchase invoice for Hong Kong is the highest among the three areas. It proves that the high return rate is related to the product content. As a result, it is important to take the publication content factor into consideration so as to meet the market demand.

Table VI deals with order entry and item analysis. The number of average accumulated return items (Table VII) has exceeded the number of the average return items in China and Taiwan (Table VI). The difference ratio is significant in case sample of Taiwan. The phenomenon suggests that a number of items are included in single merchandise. In other words, the return is less quantity yet large variety. The return reason of retailers is merchandises that have been shelved for too long, yet scheduled display time can regulate return rate and change reverse logistics to planned process.

As shown in Table VII, the relationship between item and quantity is obvious. A high quantity of items means oversupply of the merchandise so oversupplying unattractive books is a reason for return. Based on average amount of accumulated

	China	Hong Kong	Taiwan
Total number of return quantity	650,410	910,167	784,070
Maximum number of daily return quantity	39,713	687,651	29,913
Minimum number of daily return quantity	3	4	3
Average number of return quantity	7,652	16,253	1,668
Standard deviation	8,689	90,846	4,732

Table IV. Daily return quantity analysis

	China	Hong Kong	Taiwan
Number of return quantity	1,231	392	146
Maximum quantity per return order	14,900	101,776	9,971
Minimum quantity per return order	0	1	1
Average quantity per return order	528	2,322	537
Standard deviation	1,073	9,550	1,715

Table V. Order entry and quantity (EQ) analysis

	China	Hong Kong	Taiwan
Number of return order	1,231	392	146
Maximum return item per order	1,670	159	504
Minimum return item per order	1	1	1
Average return item per order	62	29	37
Standard deviation	127	34	94

Table VI. Order entry and item (EI) analysis

return, the average amount of case sample of Hong Kong is 372, which is higher than that of China and Taiwan. It can be deduced that the Hong Kong case has been overproducing.

The frequency of return shows whether the marketplace accepts the content, whether the books are defective, or whether the impact of design on display is effective. In general, those factors descend proportionally during a certain period of time after the first release. As indicated in Table VIII, the average frequency of return per time has no significant difference among the three areas. It shows that the characteristics of the books are stable.

Conclusions

The establishment of logistics and distribution trading hubs is a hot topic in Asia. China, Hong Kong, Taiwan are now competing head-to-head to develop the supply chain network that will control and shape the movement of goods in and around Asia (Easton and Zhang, 2003).

The majority of logistics research seems to place a heavy emphasis on forward logistics topics instead of reverse logistics issues. However, today reverse logistics is viewed as an area that offers great potential to reduce costs, increase revenues, and generate additional profitability for firms that manage the process well (Stock, 1998). This is truly important, as reverse logistics remains a critical issue for many industries such as automotive, electronics, and publishing.

The research results provide the first empirical study to understand the characteristics and challenges of reverse logistics in China, Taiwan, and Hong Kong, which are summarize below.

- The location, time, and quantity of reverse logistics of Chinese publications are unpredictable. Forward logistics, on another hand, are punctuated in quantity and delivery location.
- The locations where reverse logistics of Chinese publications occur are scattered and irregular, and cannot be centralized for transfer.

Table VII.
Item and quantity (IQ) analysis

	China	Hong Kong	Taiwan
Number of return item	9,637	2,445	648
Maximum accumulated return item	50,000	15,870	2,391
Minimum accumulated return item	1	1	1
Average accumulated return item	67	372	121
Standard deviation	542	918	270

Table VIII.
Items and return frequency (IK) analysis

	China	Hong Kong	Taiwan
Number of return items	9,637	2,445	648
Maximum return frequency per item	88	45	31
Minimum return frequency per item	1	1	1
Average return frequency per item	8	5	8
Standard deviation	9	6	6

- The causes of reverse logistics of Chinese publications are due to merchandise quality and abnormal distribution quantity.
- The system and process of reverse logistics of Chinese publications are more complicated and diverse than that of forward logistics.
- The reverse logistics of Chinese publications is a result of defect in quality of forward logistics.

Based on the abovementioned reasons, the cost on reverse logistics in these areas is unlikely to be reduced in the near future. Thus, publishers can take the following suggestions into consideration. First, instead of making effort to process returned merchandise, logistics firms or publishers can discard the returned merchandises directly. The loss on material cost is far less than the manpower spent on processing. Secondly, publishers can sort returned merchandises in off-peak season to save cost on reverse logistics. Readers may refer to the guidelines by Krumwiede and Sheu (2002). Krumwiede and Sheu propose a decision-making model which help third-party logistics companies desiring to pursue reverse logistics as a potential new market. The model provides six key steps necessary for taking part in reverse logistics business. First, a third party logistics firm needs to research existing reverse logistics issues and identify customers. The second step is to survey existing repeat customer needs. Third, the company should survey competitors and competitors' customers. The next step is to conduct gap analysis. Fifth, feasibility study should be performed thoroughly. Finally, the third party logistics company needs to develop a positioning strategy.

To sum up, the reverse logistics of Chinese publications is still in early stage in those regions, and is not mature enough to be interconnected in China, Hong Kong, and Taiwan. Improvement of reverse logistics system and its link to the supply chain will immediately enhance logistics efficiency.

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Managing product returns for reverse logistics

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Abstract

Purpose – The purpose of this paper is to present a framework to manage product returns for reverse logistics by focusing on estimation of returns for select categories of products in the Indian context.

Design/methodology/approach – The paper develops a conceptual model and thereafter an integrated modeling framework borrowing from existing literature and industry practices. It utilizes product ownership data, average life cycle of products, past sales, forecasted demand and likely impact of environmental policy measures for estimating return flows. Informal interviews with 84 stakeholders are carried out to estimate significant parameters. Software packages, decomposition methods and heuristics are utilized for solution.

Findings – The integrated framework helps in estimating returns for select categories of products and thereafter taking simultaneous decisions on their disposition, location and capacity of facilities and flows of returned products for a given time horizon under various strategic, operational and customer service-related constraints.

Research limitations/implications – A "push" system where the volumes of returns drive the decisions. Estimations and optimization have been carried out for select product categories and not brands or original equipment manufacturers (OEMs). No free choice of facility locations.

Practical implications – The insights and learning under different scenarios may be utilized as inputs for decision making by various stakeholders such as OEMs and their consortia, local remanufacturers and third party service providers.

Originality/value – At methodological level, our framework combines descriptive modeling with optimization technique, while at topological level; it provides detailed solutions for network configuration and design.

Keywords Distribution management, Returns, India, Reverse scheduling

Paper type Research paper

Introduction

Effective and efficient management of product returns is an intriguing practical and research question. Growing green concerns and advancement of reverse logistics (RL) concepts and practices make it all the more relevant. Three drivers (economic, regulatory and consumer pressure) drive product returns worldwide. This has also gained momentum because of fierce global competitiveness, heightened customer expectations, pressures on profitability and superior supply chain performance.

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Concerns about environmental issues, sustainable development and legal regulations have made organizations responsive to RL. Increased competition, growing markets and a large base of product users in developing countries imply that buyers are getting more power in the supply chain even in these countries. Thus, managing product returns in an effective and cost-efficient manner is of increasing interest in business as well as in research. It leads to profits and at the same time increased customer service levels and higher customer retention.

Consumers expect to trade in an old product when they buy a new one. Different products may be returned at different stages of their life-cycles. They may go for remanufacturing, repair, reconfiguration, and recycling as per the most appropriate disposition decision. This creates profitable research and business opportunities. Consequently, original equipment manufacturers (OEMs) are expected to undertake RL activities in an effective and efficient manner. They may do so independently or by outsourcing. Estimation of returns is a pre-requisite for establishment of an effective and efficient RL network and hence becomes very crucial in this context.

RL issues are mainly regulatory-driven in Europe; profit-driven in North America and in incipient stage in other parts of the world, including India, where both consumer awareness and globalization are likely to lead to greater economic, consumer and regulatory pressures in the coming future. Society in general and particularly in Indian context is still price sensitive and to a little extent quality sensitive (quality for a given price) but not environment sensitive in its buying and promotion behavior. Lack of incentives/disincentives from regulatory authorities and lack of pressure from prospective customers and consumers on the manufacturers/service providers is inhibiting these initiatives in India. Therefore, RL has not received the desired attention and is generally carried out by the unorganized sector for some recyclable materials such as paper and aluminum.

Only recently, some companies in consumer durables' and automobile sectors have introduced exchange offers to tap customers who already own such products. Presently, these returns are either resold directly or after repair and refurbishment by firm franchisee/local remanufacturers in the seconds' market. They are not remanufactured or upgraded by OEMs. In fact, present work is motivated by increasing sales potential of white goods/brown goods and automobiles and the good response exchange offers by OEMs or retailers have generated so far.

Our study covers different categories of products (Table I) covering a spectrum from cellular handsets and personal computers (low volumes and growing markets) to black and white televisions (high volumes and declining markets). We cover television sets, passenger cars, refrigerators, washing machines, cellular handsets and personal computers. The cumulative annual growth rates (CAGR) in the Table I are for past ten years sales and for next ten years projected demand.

Our methodology consists of a brief literature review wherein we find out some significant issues and gaps as well as challenges and opportunities in the area of reverse logistics network design (RLND), especially in context of estimating and managing product returns. This is followed by conceptual model development in practical settings. The problem being intrinsically complex, the broad solution approach is to partition it into a main model with spot decisions and parameter estimations by various sub-models using appropriate tools and techniques. To actualize this, we develop an integrated modeling framework for an effective and efficient RLND. We conduct informal

Table I.
Characteristics of the categories of products covered in the study

Product category	Product variety	Product ownership	Sales CAGR (percent)	Demand CAGR (percent)	Market characteristics
Televisions (combined)	Large	High	6.5	4.5	Large and still growing. Highly segmented. Features being added. Stiff competition. Many Players
B&W televisions	Small	High	1.4	−6.6	Large and declining. Highly segmented. Saturated Technology. Price based competition
Color televisions	Large	Medium	14.4	8.6	Large and growing. Segmented. Technological enhancements. Stiff competition. Many Players
Passenger cars	Medium	Low	11.7	11.8	Medium and growing. Clear Segmentation. Enhancements. Established players and new entrants
Refrigerators	Large	Medium	7.8	9.7	Large and growing. Segmented. New features. Stiff competition
Washing machines	Medium	Low	20.9	6.4	Medium and growing. Technological enhancements. Stiff competition
Cellular handsets	Large	Very low	69.5	18.1	Small and growing rapidly. Highly emergent technology. Many entrants
Personal computers	Medium	Very low	35.0	17.4	Small and growing rapidly. Highly segmented. Emergent technology. Stiff competition. Many Players

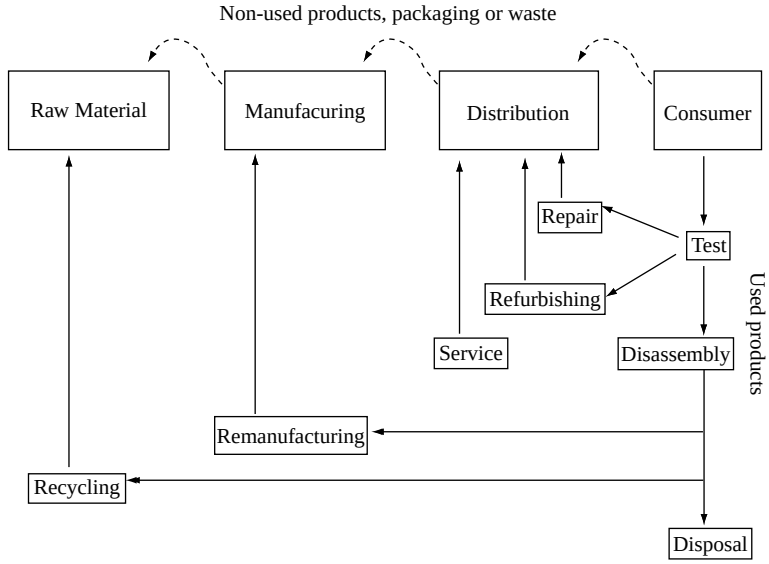
interviews with 84 concerned stakeholders (28 dealers, 12 distributors and 44 consumers in North India for our select category of products) to gauge and capture real life practices and requirements and to estimate various costs and operations related parameters as well as the maximum distance of the collection center locations from prospective return sources. Further, existing literature sources, company web sites (OEMs for our relevant category of products) and other web sources are also utilized as additional inputs to estimate certain parameters such as range of resolution prices for returns, number of product grades, costs and available capacities of facilities, average salvage rates, etc. Finally, we carry out some preliminary experimentation and analysis to draw a few insights and to find out scope for future work.

Literature review

Figure 1 shows the basic flow diagram of RL activities. The complexity of operations and the value recovered increase from bottom-left to top-right in the figure.

The pattern of quantity, quality and time of arrival of returns is of paramount importance in RLND. The location of facilities relative to process inputs, customer markets or waste disposal locations has been considered both analytically and empirically in literature (Schmenner, 1982; Brandeau and Chin, 1989; Appa and Giannikos, 1994; Giannikos, 1998; Pushchak and Rocha, 1998).

Collection is the first and a very important stage in the recovery process, where product types are selected and products are located, collected, and, if required, transported to facilities for rework and remanufacturing. Used products originate from multiple sources and are brought to a product recovery facility, resulting in a converging process. Cairncross (1992) suggests classifying schemes for collection based on whether the initial transport is performed by the consumer (i.e. bring schemes) or by a waste manager (i.e. kerbside collection).



Source: Krumwiede and Sheu (2002)

Figure 1.
Flow diagram of reverse logistics activities

Inspection/Sorting may be carried out either at the point/time of collection itself or afterwards (at collection points or at rework facilities). Collected items generally need sorting. Inspection/sorting illustrates the need for skill in the sorting of used products (Ferrer and Whybark, 2000). This may or may not be combined with pre-processing. Jahre (1995) found that the converse to sorting complexity is collection complexity.

Pre-processing may be in the form of sorting, segregation, partial or complete disassembly or minor repair and refurbishing activities. It may be carried out either at collection centers or at rework facility depending upon the technological and economic factors. Louwers *et al.* (1999) discuss it in detail while developing a facility location allocation model for reusing carpet materials. They include the operational costs related to energy, labor, maintenance costs and the loss of interest related to the facilities.

Location and Distribution (*Network Design*) is the most important and critical area of RL that is assuming greater importance day by day. In many cases, recovery networks are not set up independently "from scratch" but are intertwined with existing logistics structures. In particular, this is true if the OEM recovers products. Location and configuration of facilities frequently affect and are affected by the external natural environment, mainly the estimated returns.

Capacity decisions in general aim at providing the right amount of capacity (i.e. how much) at the right place (i.e. facilities location) and at the right time (i.e. when). Long-range capacity is determined by the size of the physical facilities that are built (Schroeder, 1993). In general, facility decisions are affected by estimated returns (assuming infinite markets), costs, competitors' behavior and other strategic and operational considerations. Operations strategies that entail the installation of new capacity also become more complex as regulatory and consumer demands for returnable/recyclable products increase.

Bellman and Khare (1999, 2000) develop the concept of "critical mass" of returns for profitable remanufacturing/recycling. They argue that the efficiency of RL could be improved by ensuring that product design takes into account the requirements of post-use/post-consumption collection, sorting and recycling.

Research issues and gaps

Major issues that emerge are related to conceptual and contextual clarity about RL, important functional aspects such as collection, inspection, pre-processing and logistics, estimation of returns, location and configuration of rework facilities and implications of important exogenous factors such as government policies, consumer behavior and emergent technologies.

There is little literature on empirical analysis of data with reverse flows (de Brito and Dekker, 2003). Coupled with the rapidly increasing return volumes, the complexity of return logistics becomes problematically complex. Meade and Sarkis (2002) suggest that a RL chain that depends on product life cycle (PLC), industry and design of RL network needs to be available for customer service. Companies take pains to develop efficient logistics processes for new goods. Similarly, they must do the same for returned goods, understanding that the processes may be quite different from those defined for forward distribution (Stock *et al.*, 2002). Besides, there may be little or no historical data available. Krikke *et al.* (1999a, b) call for a need to forecast return flows and seconds' market more scientifically by developing appropriate models and

techniques. Guide (2000) also sees forecasting models to predict return rates and volumes as a major research issue.

Conceptual model

A three-echelon (consumers' returns → collection centers → rework sites) multi-period model designed for product buy-back (generally for exchange offer) is conceptualized as shown in Figure 2. We assume a "bring scheme," i.e. the customers bring the product to collection/buy-back center (generally in a given time-window known a priori by telephone/internet). The company makes the decision about allocation of customers to collection centers. They receive resolution (refund, cash, exchange offer, etc.) if the return is accepted. There is no take-back obligation. Testing facility and clear-cut return product valuation charts are available at all collection centers. Testing time is negligible and customers are not charged for it. Manpower is skilled for inspection, scanning, sorting and resolution decision. Recovery strategies and costs for various categories of products are known a priori.

For simplicity, we restrict the choice for a collection center to the existing distribution/retail outlets, some or all of which may act as prospective facility location. Further, the differentiated complexity of operations leads to two distinct rework sites: repair and refurbishing centers and remanufacturing centers. Repair and refurbishing centers require lower capital investment, are more skill-based and generally repair/refurbish goods in order to make them almost as good as new. Remanufacturing centers require very high capital investment, are more technology-based and produce upgraded remanufactured goods. The rework facilities will come up at some or all of collection centers, i.e. some locations will have only collection centers, some will have

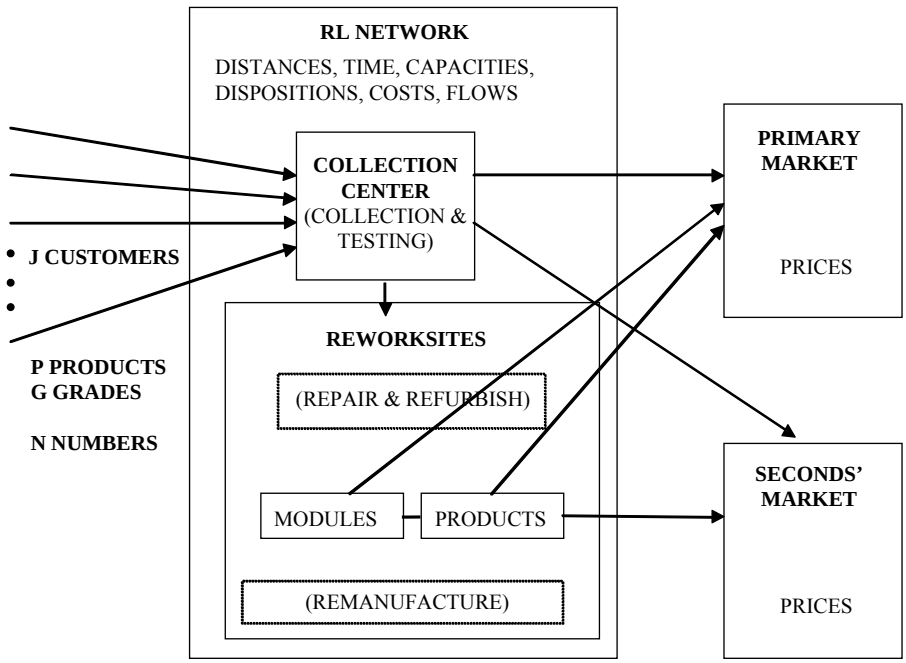


Figure 2.
Conceptual reverse logistics model

collection centers with either of the two rework facilities, while some may have all the three co-located. Co-locating facilities is preferred as this leads to some savings in capital and manpower investment as well as transportation costs. The disposition decisions are guided by profit motive and all the returned goods are resold in primary or seconds' market after necessary disposition. The first disposition (sell directly without rework) is carried out at collection centers themselves, as this involves no substantial investment. Balance returns go to rework sites as per disposition decisions.

We assume that various costs, distances, processing times, input parameters and conversion factors (including salvage rates) associated with the activities are known or have been estimated a priori. Prices of various products and modules in primary and seconds' markets in a particular time interval are also known or estimated a priori. There is infinite storage capacity at each facility. Transportation times are negligible in comparison to a single time-period. Different grades of product deteriorate at a fixed rate with time. Inventory is carried to the next period.

Definitions of various terms used in the model

Collection center. A facility where customers bring their products for resolution/exchange. Collection includes inspection, purchase, storage and reselling if desired. Inspection denotes all operations determining whether a given product is in fact re-usable and also grading it. The model takes the disposition decision about an accepted return based on a number of input parameters, variables and constraints.

Disposition option. The decision about what is to be done for the returned product next. There are three types of disposition options for products returned: resell directly at the collection center; repair and refurbish; remanufacture. They are mutually exclusive.

Modules. A particular set of items (assembly/sub-assembly) that serve a particular purpose and may be used in generally more than one product category. Transducers, switches, relays, sensor units, printed circuit boards, battery, compressors, motors, video display unit, central processing unit, tires, timers, etc. are some such modules.

Primary market. An outlet for sale of new and premium goods.

Product categories. The types of products and their different models. For example, refrigerators, washing machines, air-conditioners of various types, models and sizes.

Product grades. The classification of various returned product categories based on their quality and the type of rework they require. It is a nominal measure of the condition that a product is returned in and consequently its disposition option.

Remanufacturing center. A rework facility using advanced technology for processing returned products. The resultant final products are "as good as new" or even better.

Repair and refurbish center. A rework facility using appropriate level of technology and skills for repairing/refurbishing returned products. The resultant final products are "almost as good as new."

Reverse logistics (*RL*). The process of planning, implementing, and controlling the efficient, effective inbound flow, inspection and disposition of returned products and related information for the purpose of recovering value.

Rework center. A facility where returned products are worked upon to make them ready for sale. There are two types of such centers depending upon the disposition decision and the level of technology and skills for processing returned products into final products: repair and refurbish center and remanufacturing center.

Second's market. An outlet for sale of repaired and discounted goods.

The integrated modeling framework

For an effective and efficient returns management based on the conceptual model, we develop an integrated modeling framework as shown in Figure 3. It estimates returns and determines location, disposition, capacity and flow decisions for our conceptual RL network through a set of hierarchical models under various scenarios. Our integrated framework also introduces penalty for inventory deterioration and obsolescence and measures capacities in terms of total processing times. It combines descriptive modeling with optimization techniques and covers costs and operations activities across a wide domain.

First, we develop a system dynamics sub-model for estimating return flows over a period of time at various candidate collection center locations based on products-in-use, average life cycle of products and forecasted demand. We also consider impacts of environmental protection policy index (EPPI) and green image and utility factor (GIUF). Next, we use a simple optimization model using certain strategic and customer service related constraints to determine the collection center locations. It is an investment-minimizing model based on certain strategic and customer service level constraints. We use notional per unit transportation costs for this since the actual costs are to be borne by those bringing the returns. These are, therefore, lower than actual and are shown later. This model also calculates the estimated returns at these locations. Further, the open sites at a particular point of time act as rigid constraints in the main model for opening rework facilities.

The main optimization model determines the disposition decisions; location and capacity addition decisions for rework sites (remanufacturing centers and repair and refurbishing centers) at different time periods as well as the flows to them from collection centers. The framework allows experimentation under various scenarios

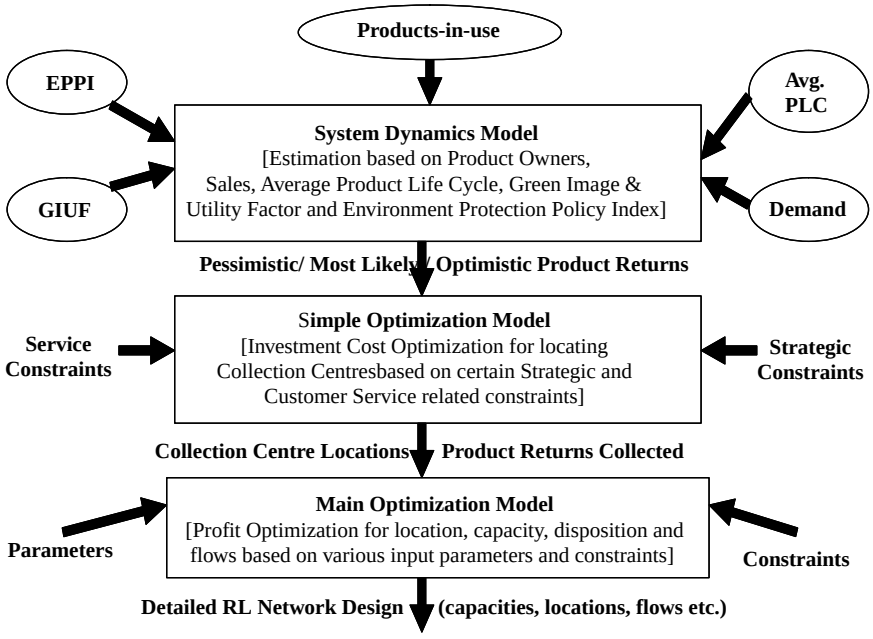


Figure 3.
The integrated modeling framework for RLND

for different categories of products. The insights and learning provided by these results to various stakeholders and decision makers can be utilized for decision making.

Data collection and estimation of returns

For real-life application of the proposed framework, the input data may be classified into two groups:

(1) Returns data which include the types and the time-varying amount associated with each type of returned product.

(2) Operations and cost related parameters such as costs of facilities, capacity block sizes, processing times, penalty rates for inventory deterioration, fraction recovery rates, average number of recoverable modules, storage costs, processing costs, transportation distances, transportation costs, procurement costs, resale prices and so on.

Many of these have high variances.

Forecasting techniques are mainly dependent on historical data for the underlying process or similar process. The existing literature groups quantitative techniques into two categories, time series and causal analysis (Jeong *et al.*, 2002). Further, in case of returns, take-back rates are either estimated as percentage of sales under different scenarios (Shih, 2001) using or estimated by distribution models (Jayaraman *et al.*, 1999). Further, Marx-Gómez *et al.* (2002) use neuro-fuzzy approach to forecast returns of scrapped products whereas Jeong *et al.* (2002) device a computerized causal forecasting system using genetic algorithm. Both these works use historical data. Most papers (Kiesmuller and van der Laan, 2001; Vlachos and Dekker, 2003; Mostard *et al.*, 2005) consider random returns dependent explicitly on demand, whereas Sheu *et al.* (2005) assume time-varying quantity of product-returns controllable.

We neither consider returns explicitly dependent on demand nor do we use any approach that explicitly needs historical data of returns. Instead, we develop a causal system dynamics model that associates returns with number of products-in-use, estimated demand and PLC. It also considers impact of environmental protection policies and "green index and utility factor." We estimate most of relevant parameters through informal interviews with concerned stakeholders due to unavailability of historical data.

Estimation of products-in-use

National Readership Survey (NRS) is carried out each year in India to estimate the number of product owners for certain categories of products. We use the data for the year 2001-2002 (NRS-2002) that estimates product ownership for a select category of products in cities over one million populations (199 in number) as per 1991 census. This data was then divided by average number of people who claim ownership for such products to arrive at products-in-use for the year 2001-2002. Table II summarizes the total product ownership and the estimated products-in-use for relevant items. Analyzing the cumulative past sales (www. indiastat.com/), market segmentation, NRS 2002 data and data/feedback from informal interviews, we arrive at the average ownership claimant size. For example, this is only 0.67 for computers, as market segmentation data shows that still about 60 percent computers are in offices and institutions and people do not claim their ownership in surveys. Further, the distribution of all these products was

Product category	NRS 2002 ownership ('000)	Average ownership claimant size	Estimated products-in-use ('000)
B/W televisions	203,995	4	50,999
Color televisions	101,132	4	25,283
Total televisions	305,127	4	76,282
Passenger cars	11,746	2	5,873
Refrigerators	78,313	3	26,104
Washing machines	19,806	4	4,952
Cellular handsets	2,312	1	2,312
Personal computers	3,864	0.67	5,796

Table II.
Products-in-use for select product categories

apportioned in the same proportion as in the NRS data (clubbing a few locations with nearest ones) so as to arrive at final 117 candidate collection center locations shown in Figure 6. These were then used as an input in our SD sub-model.

Estimation of demand

The previous sales data and the estimated demand data for the next ten years for the selected product categories is taken directly from www. indiastat.com/ and used as an input in the SD sub-model for estimating returns. The same for one product category (refrigerators) is shown in Table III.

Estimation of average product life cycles

It is imperative that we understand that while the product will have an extended life cycle before it is disposed, the average time-span for one loop of RL will be relatively shorter than the designed PLC. It depends on a host of factors such as the product design, usage, consumer behavior, ambience of usage, state of economy, etc. Shih (2001) estimates the lifetime of computers at five years and that of four consumer durables at 7-10 years. However, it does not consider repair and remanufacturing. Besides, PLC's for consumer durables in Europe and US are generally more than that in tropical and sub-tropical humid climates such as India.

Past sales		Future demand	
1992-1993	1.26	2002-2003	3.34
1993-1994	1.39	2003-2004	3.64
1994-1995	1.64	2004-2005	3.96
1995-1996	1.96	2005-2006	4.36
1996-1997	1.93	2006-2007	4.79
1997-1998	2.18	2007-2008	5.27
1998-1999	2.43	2008-2009	5.79
1999-2000	2.62	2009-2010	6.37
2000-2001	2.83	2010-2011	7.00
2001-2002	3.06	2011-2012	7.70

Note: All figures are in millions
Source: www.indiastat.com

Table III.
Past sales and future estimated demand for refrigerators

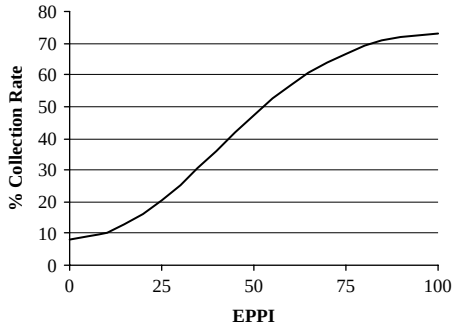
For our model, we have estimated the average PLC based on informal interviews with various dealers and consumers of these products. A typical additional feature that emerged during these besides the ones already stated was the ingrained behavioral pattern among Indians to overstretch use of things before finally disposing them. Many times, the usage extends by change/transfer of ownership. We also estimated the critical range of PLC for these categories of products where maximum returns are likely to arise. The lower value represents early adapters and the emergent consumer trends while the higher values represent the followers and the past trends. The estimated average PLC values for relevant items are given in Table IV.

Estimation of EPPI

Environmental policies impact the amount of product returns to a great extent. The manufacturers and consumers are forced by many environmental laws and legislation to pay more attention to the environmental issues. In many countries, the environmental protection laws, regulations and tax implications are already in place or in the works (Gungor and Gupta, 1999). Many regulations in Europe, US and other countries prescribe a minimum return/recycling limits for different materials and different products (Owen, 1993; Frosch, 1995; Nasr, 1997). In the Indian context, such laws are virtually non-existent (Srivastava, 2004). However, they are likely to come up in near future. Based on literature review about such policies in other countries and a recent paper by Giorgiadis and Vlachos (2004), we envisage the impact of environmental policies on returns as shown in Figure 4. A value of zero EPPI

Product category	Lower value	Average value	Upper value
B&W televisions	10	12	14
Color televisions	10	12	14
Passenger cars	12	15	18
Refrigerators	8	10	12
Washing machines	8	10	12
Cellular handsets	2.5	3	3.5
Personal computers	3	4	5

Table IV.
Average PLCs for select product categories in years



EPP Index	% COLLECTION
0	8
10	10
20	16
30	25
40	36
50	47
60	57
70	64
80	69
90	72
100	100

Figure 4.
Impact of environmental policy protection index on collection rate

implies that there are practically no environmental regulatory policies for recycling/reuse/recovery/return of products or materials while a value of hundred implies very stringent regulations.

Estimation of GIUF

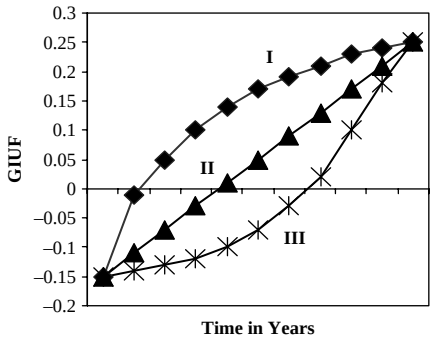
Besides the environmental policies, consumer awareness and increased economies of scale, improved technologies, etc. are likely to increase returns for refurbished/remanufactured products. Giorgiadis and Vlachos (2004) call it green image effect and use it in their SD model. We feel that in the Indian context, utility factor will also play a key role besides the above. We incorporate this as GIUF in our model and assume that it increases progressively with time.

The present value of GIUF is -0.15 due to the societal attitude over the use of non-virgin and seconds' products. Based on the assumption of increased greening awareness and greater utility (better and cheaper products due to a host of factors such as economies of scale, improved skills due to learning curve and emergent technologies, etc.) the societal outlook is expected to change. So, we assume the GIUF to change to $+0.25$ in coming ten years. Three patterns of change of GIUF have been considered in our SD model. These are shown in Figure 5.

Estimation of product grades

The SD sub-model estimates product returns at various candidate collection center locations based on the inputs described earlier. However, due to unavailability of past data, changing consumer behavior patterns, likely greening concerns, future regulations and emergent product varieties and technologies, the estimation of percentage of product grades among a particular type of product returns remains a matter of conjecture. The best possible way was to utilize feedback from informal interviews with various dealers and consumers of these products and make a rough estimate of the likely distribution of returns along the envisaged grades. The point to be taken care of is that these should be mutually exclusive and exhaustive.

On the basis of informal interviews after searches on internet to make the discussions meaningful and beneficial, we were able to allocate returns to within 3-6 broad grades for all product categories for the coming ten years. Actually these



Time (Years)	Pattern 1	Pattern 2	Pattern 3
0	–0.15	–0.15	–0.15
1	–0.01	–0.11	–0.14
2	0.05	–0.07	–0.13
3	0.1	–0.03	–0.12
4	0.14	0.01	–0.1
5	0.17	0.05	–0.07
6	0.19	0.09	–0.03
7	0.21	0.13	0.02
8	0.23	0.17	0.1
9	0.24	0.21	0.18
10	0.25	0.25	0.25

Figure 5.
Patterns of GIUF

would be continuous over a long spectrum, but we do so in order to facilitate analysis and decision-making. One such grade-wise distribution for passenger cars is shown in Table V.

Estimation of operations and cost-related parameters

Due to lack of field data, uncertain economies of scale and undeveloped/underdeveloped markets in the Indian context, we go by the argument of Listes and Dekker (2005) and rely on experience and guidance of domain experts for parameter estimations. For this, we conduct informal interviews with 84 concerned stakeholders to estimate various costs, operations related and other relevant parameters. Prior reference to existing literature sources, OEM web sites and other web sources are utilized for framing the questions and for getting inkling about the expected parameter values. The interviews included both open- and closed-ended questions relating to many aspects of repackaging, repair, refurbishing, remanufacturing, consumer behavior patterns and facility location design. These collected raw interview data were then analyzed and processed to generate upper bound and lower bound values for various desired parameters. The relevant parameters for three categories of products (computers, washing machines and passenger cars) are shown in Table VI. The main emphasis in this activity was to make them as close to real-life instances as possible. For example, resolution would be much lower in value for washing machines (most returns at end-of life) than for cars or computers. Correspondingly, its sale price/resolution ratio would be higher after rework. Similarly, the average product deterioration and obsolescence would be higher in computers than cars, which in turn would be higher than washing machines, and so are their penalty rates.

Estimation of distances between probable candidate facility locations

We arrived at probable candidate collection center locations by examining the commonality between the NRS 2002 data and a few reliable secondary data sources such as Srinivasan (1999) and www.mapsofindia.com/roads/index.html. One hundred and seventeen common locations were found. All distances between these 117 locations are based on the data from the Survey of India and other reliable publications related to this field. Distances between these were arrived at giving priority to national highways, state highways and all weather roads over other roads. These candidate collection center locations are shown in Figure 6.

System dynamics sub-model for estimating returns

Our SD model to study the dynamics of the product returns is based on number of product owners, estimated demand, GIUF, environment protection index and average

Table V.
Estimated grade-wise distribution of passenger car returns over the years

Time →	1	2	3	4	5	6	7	8	9	10
Grade 1	0.03	0.04	0.06	0.09	0.10	0.12	0.15	0.20	0.23	0.25
Grade 2	0.12	0.18	0.20	0.22	0.24	0.26	0.26	0.25	0.25	0.24
Grade 3	0.34	0.30	0.28	0.26	0.25	0.22	0.20	0.19	0.19	0.18
Grade 4	0.31	0.30	0.29	0.28	0.28	0.27	0.27	0.26	0.25	0.25
Grade 5	0.11	0.12	0.13	0.11	0.10	0.10	0.10	0.08	0.07	0.07
Grade 6	0.09	0.06	0.04	0.04	0.03	0.03	0.02	0.02	0.01	0.01

Parameter	Computers	Washing machines	Passenger cars
Number of product grades	4	3	6
Unit transportation costs per km	0.3 (0.15)	0.5 (0.2)	1.0 (1.0)
Number of modules recoverable	15	4	30
Max. distance in km from potential sites of returns	250	200	200
Fixed cost in million rupees for min. capacity for remanufacturing	750	300	1,000
Fixed cost in million rupees for min. capacity for refurbishing	0.75	3	10
Variable cost per unit in rupees for remanufacturing	5	4	60
Variable cost per unit in rupees for refurbishing	2	1	20
Sale price in rupees for modules	50-4,000	150-2,000	100-14,000
Processing cost per unit in rupees for remanufacturing	1,800-6,680	1,800-3,700	13,800-35,650
Processing cost per unit in rupees for refurbishing	1,000-6,300	1,500-3,600	10,600-30,650
Resolution in thousands of rupees	6.12-18.02	1.00-6.00	40.0-200.0
Salvage rate during remanufacturing	0.80-0.97	0.94-0.99	0.94-0.99
Salvage rate during refurbishing	0.80-0.99	0.93-0.98	0.96-1.00
Processing time in hours per unit during remanufacturing	1.00-1.24	1.01-1.42	5.71-11.91
Processing time in hours per unit during refurbishing	1.12-2.14	0.92-1.44	6.71-10.41
Sale price/resolution ratio at collection center	0.95-0.98	0.90-0.95	0.92-0.99
Sale price/resolution ratio at remanufacturing center	1.10-2.10	1.55-5.10	1.10-1.50
Sale price/resolution ratio at refurbishing center	1.07-2.05	1.50-5.08	1.08-1.46
Penalty rate for product deterioration and obsolescence	0.05-0.18	0.03-0.06	0.03-0.09

Table VI.
Select relevant parameters and their ranges

PLC as shown in Figure 7. Its objective is to evaluate the impact of important variables on the model and estimate returns at various sites at different time-periods under different scenarios. Here, the retired products refer to total number of products that the consumers no longer use. These may be either returned and reused (returned products) or disposed (disposed products).

Our motivation in using SD is manifold. An SD model is built from elementary feedback structures with statistical data playing at most a minor role; it does not depend too much on past data, as do the econometric models. It allows the modeler to mix intuition, theory and method. Further, an SD model can easily capture many cause-effect non-linear relationships. In socio-technical settings, it draws from both the experimental and non-experimental modes of research as well as the participant's perception of purpose and validation (Starr, 1980). Further, it might be less sensitive to data error (Johnson, 1980). All this suits our problem context. However, there is hardly any literature using system dynamics as a forecasting tool. Legasto (1980) suggests that it is better for short term forecasting and may be used for longer term if the model purpose is pre-stated and explicitly expressed. In light of the lack of historical data in our context and the arguments above, we find it appropriate to use system dynamics for estimating product returns.

However, an SD model cannot fully represent the complex reality. The model needs to be viewed in its proper perspective. It must be supplemented by the intuition, judgment, and experience of managers and planners. We try not to miss any important feedback relationship and focus on causes rather than consequences. In the process of building the model, we resolve many contradictions and ambiguities. We use *iThink* ®

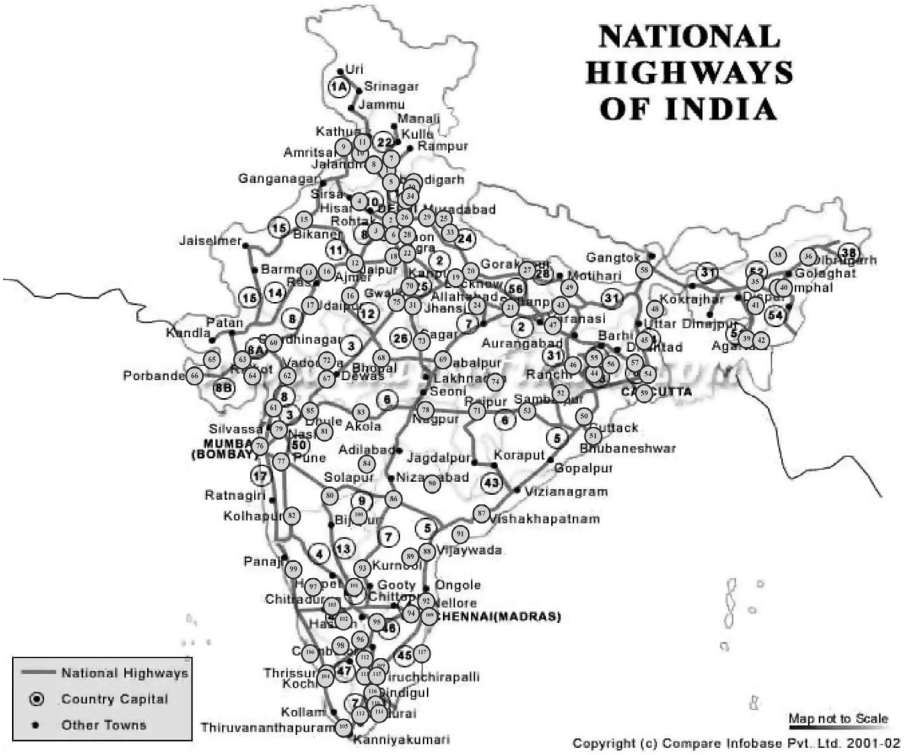


Figure 6.
One hundred and seventeen candidate collection center locations

Note: Reproduced from best available original

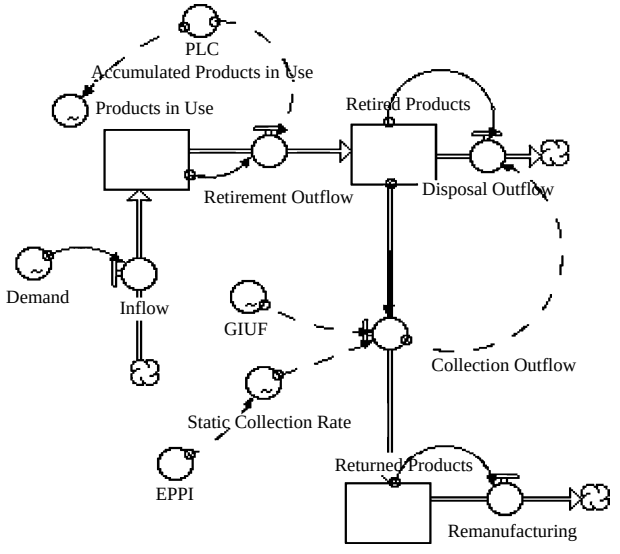


Figure 7.
System dynamics sub-model for estimating product returns

Note: Reproduced from best available original

for programming and running our returns estimation model. The SD program for estimation of returns is given in the Appendix. The model uses various input parameters and generates output for different categories of products. Table VII shows one such output for one such product category (washing machines).

We generated a number of scenarios using different GIUF, EPPI and average PLCs. The experimentation with all the categories shows that the impact of EPPI is the maximum. The average PLC affects the quantity of returns in all the time-periods while GIUF affects the quantity of returns in the intervening time-periods that in turn affect certain decisions and overall profits. The outputs can be copied in MS Excel for further analysis and use (obtaining grade-wise input for the optimization models after multiplying them with estimated grade-wise distribution).

As our integrated approach uses the returns data as input in the optimization model, we adopt the following strategy to reduce scenarios to 54 for each product category:

- Impact of EPPI (six values – 0, 20, 40, 60, 80 and 100 percent as shown in Figure 4).
- Impact of average PLC (three values as shown in Table IV).
- Impact of GIUF (three patterns as shown in Figure 5).

Thereafter, we found the minimum, average and maximum for these 54 scenarios to generate three input scenarios for the optimization model:

(1) pessimistic scenario (PS: minimum estimated returns in each time-period);

(2) most likely scenario (MLS: average estimated returns in each time-period); and

(3) optimistic scenario (OS: maximum estimated returns in each time-period).

Table VIII shows the three input scenarios for televisions for the ten-year time horizon.

An interesting finding from estimation of returns for various categories of products is that while the products-in-use, average PLCs and expected sales growth rates differ appreciably for the select categories of products, the CAGR for most of them is more or less comparable (approx. 20-30 percent). This is not in agreement with Rogers and Tibben-Lembke (1999) who argue that product return rates differ greatly according to

Washing machines (numbers in thousands)
(For EPPI = 100; GIUF = 3; avg. PLC = 12 years; base year 2001-2002)

Year	Products-in-use	Retired products	Returned products	Disposed products
0	4,951.50	412.98	259.96	153.02
1	6,327.22	594.28	367.00	227.28
2	7,394.59	1,040.63	656.03	384.60
3	8,249.15	1,400.44	895.66	504.78
4	8,955.90	1,703.25	1,115.55	587.70
5	9,565.85	1,970.01	1,334.25	635.76
6	10,091.42	2,209.27	1,561.37	647.90
7	10,558.37	2,431.94	1,808.08	623.86
8	10,984.44	2,646.75	2,122.06	524.69
9	11,381.51	2,860.12	2,460.02	400.10
10	11,794.31	3,039.82	2,770.12	269.70

Table VII.
Typical output for a system dynamics sub-model run

Year	B&W television MLS	B&W television PS	B&W television OS	Color television MLS	Color television PS	Color television OS	Television (combined) MLS	Television (combined) PS	Television (combined) OS
0	400	62	799	199	31	396	599	93	1,195
1	555	85	1,161	699	106	1,466	1,254	190	2,627
2	849	129	1,763	1,308	197	2,739	2,157	326	4,502
3	1,037	158	2,130	1,842	277	3,827	2,879	435	5,958
4	1,155	177	2,331	2,330	352	4,780	3,485	530	7,110
5	1,226	192	2,419	2,806	430	5,649	4,032	622	8,068
6	1,259	202	2,412	3,285	514	6,460	4,544	716	8,872
7	1,267	210	2,356	3,795	608	7,288	5,062	818	9,644
8	1,266	219	2,271	4,375	730	8,156	5,641	949	10,428
9	1,246	224	2,167	4,993	865	9,014	6,239	1,090	11,167
10	1,226	225	2,088	5,563	993	9,757	6,789	1,221	11,811

Note: All figures are in thousands

Table VIII.
The three input scenarios (expected returns) for televisions

the type of product. Even in case of B&W TV, where the sales are declining, the CAGR comes out to be 9.2 percent and the returns reach a plateau only around seventh-eighth year. This may be attributed to long PLC, high number of products in use and impacts of EPPI and GIUF. A summary of relevant data regarding estimated returns for various product categories is shown in Table IX.

Some initial findings from optimization

We used generalized algebraic modeling system software for optimization for a ten-year time horizon under various strategic, operational and customer service-related constraints. The candidate locations for collection centers were found from simple optimization model, while that of rework facilities were found from the main optimization model. Initial findings show that the decisions about location and capacity are sensitive to a few input parameters and variables such as product returns (timing, quality and quantity), transportation costs, size of capacity blocks, product ownership and future demand for products. The disposition decisions are impacted both by the above as well as various cost-related parameters. Small changes in many input parameters and variables change the decisions but do not affect the overall profits appreciably. Emergent technologies are likely to reduce the size of blocks in which capacities may be added as well

Product category	Products in use in base year (in '000)	Average PLC (in years)	CAGR of forecasted sales (percent)	Estimated returns (in thousands) First year	Tenth year	CAGR (percent)
B&W TV	50,999	10-14	−6.6	555	1,226	9.2
Color TV	25,283	10-14	8.6	699	5,563	25.9
TV (combined)	76,282	10-14	4.5	1,254	6,789	20.6
Passenger cars	5,873	12-18	11.8	80	833	29.7
Refrigerators	26,104	8-12	9.7	498	3,614	23.2
Washing M/C	4,952	8-12	6.4	259	1,690	24.6
Cellular handsets	2,312	2.5-3.5	18.1	223	2,474	30.7
Computers	5,796	3-5	17.4	540	4,760	27.4

Table IX.
Relevant data regarding estimated returns for various product categories

as many other rework parameters such as processing costs and processing times. Economies of scale and learning effects too will have their impact. All these are likely to result in greater flexibility in design of RL networks and higher profits in future.

Conclusions and scope for future work

Literature that covers both the remanufacturing and RL in an integrated manner is few and far between. We provide a framework that covers a wide domain of activities ranging from estimation of returns at different locations at different time-periods to their actual collection and disposition till modular stage. It has been implemented in the form of a streamlined integrated multiple time-period model that takes care of statutory requirements and consumer preferences and simultaneously respects strategic and operational constraints for optimizing profits. Standard software packages, decomposition methods and heuristics have been utilized for solution.

Klausner and Hendrickson (2000) describe product returns through third party logistics providers. They suggest that buy-back would be a better option. Fleischmann *et al.* (2001) also suggest that buy-back may lead to higher rates of returns and thereby lead to economies of scale. Recently, Jayraman *et al.* (2003) have used resolution to customers in their model. Our framework too considers resolution price. Besides, it also considers sale of recovered modules. This is a step further to the consideration of revenue from sale of reclaimed material (Shih, 2001).

We also use customer service-related constraints in our model for collection center opening decision from a given set of candidate locations. These take care of customer convenience by stipulating the maximum distance for carrying the returns. Bloemhof-Ruwaard *et al.* (1996) and Hirsch *et al.* (1998) have used such types of constraints earlier, but in slightly different contexts. Recently, Krikke *et al.* (2003) have used similar constraints. Guide and Pentico (2003) propose a framework for re-manufacturing using a closed-loop hierarchical model to aid in the designing, planning and controlling of logistics and related activities. This allows financial incentives to control product returns. That way timing, quantity and product quality as well as associated logistics functions become more predictable. We consider product returns uncontrollable, but at the same time estimate them. We consider average inventory for holding costs unlike the prevalent literature practice of using end-of-the-period inventory. We also use discount factor to optimize the net present value for objective functions in our MILP models.

Our study shows that the impact of quality, quantity and timing of returns on the overall RLND and profits are significant and hence the estimation of returns is important. EPPI and GIUF directly impact returns in ratio of EPPI*(1 $\pm$ GIUF), the ratios of pessimistic: most likely: optimistic scenarios are found to be of the order of 0.15:1:2 approximately. Thus, we agree with Listes and Dekker (2005) that data assumptions have direct implications on the construction of the underlying scenario.

The government policies and consumer behavior impact returns and thereby, RLND a great deal. These should be analyzed and modeled carefully. Industry should work to increase product recyclability, develop Life-cycle-analysis capabilities and improve communication among its segments. Efforts should be undertaken to strengthen and expand industry coalitions and link with third party providers. The existing infrastructure needs expansion, policy makers and citizens need education

and there is a need to extend producer responsibility. We need to replace manufacturing, focused on use of virgin materials, by a new holistic approach that unleashes synergy between economic development and the environment.

Our work has a few limitations. There is uncertainty of system parameters due to lack of actual historical data. Uncertain economies of scale and undeveloped/underdeveloped markets too limit the applicability. We deal with supply side (returns) and returns' disposition but do not consider in any detail the co-ordination of the two markets. We still follow a PUSH system where the volumes of returns drive the decisions and do not consider controlling product returns. We also do not consider promotion of goods in exchange offers explicitly. A recent paper (Savaskan *et al.*, 2004) considers many of these issues explicitly, assuming closed loop supply structures as given. Our present work is more or less complementary to this paper.

We have carried out estimations and optimization for product categories and not brands or OEMs *per se*; however, inferences can be drawn for them by simply using percentage of returns equal to the market share of the brand or OEM. The facilities are chosen from given location options, there is no free choice. Further, we consider a profit maximization model that does not incorporate any penalty for lost returns and customer dissatisfaction.

To conclude, this paper considers several practical issues and describes a framework that provides near optimal profitable solutions for managing product returns in India. Our application of system dynamics for estimating returns is a novel one and we pre-state the model purpose explicitly. This has significant theoretical and practical implications in terms of applicability and utility that needs to be explored further. At methodological level, our framework combines descriptive modeling with optimization technique, while at topological level; it provides detailed solutions for network configuration and design. This framework and solution approach may be extended further to meet specific requirements. It can easily incorporate multiple cost structures, market side considerations and constraints related to resource conservation perspective. It may be easily used for other potential products such as tires and batteries. Although, study was done in the Indian context, the framework may easily be applied to situations in other developing countries.

Our next phase of study will mainly focus on experimentation with the optimization models using variations in processing times, processing costs, salvage rates and other sensitive and significant input parameters for these select categories of products to provide companies insights for various decisions related to RLND. The integrated model will be used to calculate the break-even values of returns for setting up various facilities for these categories of products in order to maximize overall profit during a ten-year period time-horizon. The insights and learning provided by results under different scenarios may be utilized as inputs for decision-making by various stakeholders and decision-makers.

Developing and further improving RL concepts means that it will be (more) beneficial for manufacturing companies to implement recycling, refurbishing and remanufacturing operations for economic reasons alone besides meeting the consumer pressures and regulatory norms. By determining the factors that most influence a firm's RL undertakings, it can concentrate its limited resources in those areas. Areas and topics such as integrated logistics for network design – under which circumstances should returns be handled, stored, transported, processed jointly with

forward flows and when should they be treated separately, comparing cost of remanufacturing with cost of production from virgin materials, potential attractiveness of postponement strategies in RL, change in a firm's RL strategy for a particular product over the course of the product's life and modeling for situation when customer returns cannot be turned down (cost minimization model) may be explored for further research.

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Appendix. System dynamics program for estimation of returns

Products_in_Use (t) = Products_in_Use (t − dt) + (Inflow − Retirement_Outflow)*dt

INIT Products_in_Use = 5873 (passenger cars in thousands)

INFLOWS:

Inflow = Sales

OUTFLOWS:

Retirement_Outflow = Products_in_Use/PLC

Retired_Products (t) = Retired_Products (t − dt) + (Retirement_Outflow − Collection Outflow − Disposal_Outflow)*dt

INIT Retired_Products = Retirement_Outflow

INFLOWS:

Retirement_Outflow = Products_in_Use/PLC

OUTFLOWS:

Collection_Outflow = Retired_Products*Static_Collection_Rate*(1 + GIUF)/100

Disposal_Outflow = Retired_Products-Collection_Outflow

Returned_Products (t) = Returned_Products (t − dt) + (Collection_Outflow − Remanufacturing)*dt

INIT Returned_Products = Collection_Outflow

INFLOWS:

Collection_Outflow = Retired_Products*Static_Collection_Rate*(1 + GIUF)/100

OUTFLOWS:

Remanufacturing = Returned_Products

EPPI = (0, 20, 40, 60, 80, 100)

PLC = (120, 144, 180)

GIUF1 = GRAPH (TIME)

(0.00, −15.0), (52.0, −1.0), (104, 5.0), (156, 10.0), (208, 14.0), (260, 17.0), (312, 19.0), (364, 21.0), (416, 23.0), (468, 24.0), (520, 25.0)

GIUF2 = GRAPH (TIME)

(0.00, −15.0), (52.0, −11.0), (104, −7.0), (156, −3.0), (208, 1.0), (260, 5.0), (312, 9.0), (364, 13.0), (416, 17.0), (468, 21.0), (520, 25.0)

GIUF3 = GRAPH (TIME)

(0.00, −15.0), (52.0, −14.0), (104, −13.0), (156, −12.0), (208, −10.0), (260, −7.0), (312, −3.0), (364, 2.0), (416, 10.0), (468, 18.0), (520, 25.0)

Sales = GRAPH (TIME)

(0.00, 678), (46.8, 745), (93.6, 827), (140, 918), (187, 1,028), (234, 1,150), (281, 1,288), (328, 1,443), (374, 1,616), (421, 1,810), (468, 2,027)

Static_Collection_Rate = GRAPH (EPPI)

(0.00, 8.00), (10.0, 10.0), (20.0, 16.0), (30.0, 25.0), (40.0, 36.0), (50.0, 47.0), (60.0, 57.0), (70.0, 64.0), (80.0, 69.0), (90.0, 72.0), (100, 73.0)

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A conceptual model for quality of service in the supply chain

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Abstract

Purpose – The objective of this paper is to propose a model for assessing the quality of service at various interfaces of supply chain using third party logistics.

Design/methodology/approach – Based on a rich combination of extensive literature review and insights gained through exploratory interviews, gap analysis methodology is used in developing the model. This was followed by an in-depth analysis of gaps at various interfaces in supply chain. Further, both qualitative and quantitative techniques are suggested for data collection and analysis.

Findings – The key gaps in both the directions (forward and reverse) that are likely to affect the service quality at different levels are extensively defined. These gaps may exist between a 3PL service provider and the manufacturer, the marketing function and the 3PL service provider, etc. The paper also proposes frameworks such as data envelopment analysis for measurement of these gaps. A set of possible performance indicators is also proposed at various interfaces in supply chain.

Practical implications – This proposed model is an attempt to explore the relatively less explored area. It is expected that this research will further motivate researchers to work in this area. This supply chain service quality tool will be beneficial to practising managers in identification of opportunities for improvements in service quality.

Originality/value – This paper explores some critical issues in the less explored area and offers practical help to researchers and practitioners in providing a direction for supply chain service quality improvement.

Keywords Customer services quality, Supply chain management, Gap analysis, Performance measures, Trust

Paper type Research paper

Introduction

In today's global marketplace, individual firms no longer compete as independent entities, but rather as an integral part of supply chain links. The ultimate success of a firm will depend on its managerial ability to integrate and coordinate the intricate network of business relationships among supply chain members (Drucker, 1998; Lambert and Cooper, 2000). In this era of intense competition, the key to sustainable competitive advantage lies in delivering high quality service that will in turn result in satisfy customers (Shemwell *et al.*, 1998).

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Logistics is recognized as a critical factor in gaining competitive advantage (Christopher, 1992). Globalization and the shift towards outsourcing further added to the need for strong relationship between third party logistics (3PL) and supply chain. Aligning with a third party may not only results in getting cost reduction alone, but also helps in a combination of service improvement and efficient operation. There has been a general acceptance of relations of service quality with improved supply chain performance (Mentzer *et al.*, 1999, 2001; Pery and Sohal, 1999; Stanley and Wisner, 2002; Kearney, 1994; Chow *et al.*, 1994). The proven relationship of service quality with business performance, lower costs, customer satisfaction and profitability (Cronin and Taylor, 1992; Rust *et al.*, 1995; Lee *et al.*, 2000; Sureshchander *et al.*, 2002) has further motivated both researchers and practitioners to explore this area. Primarily, majority of these studies have focused on service industries or parts of supply chain, with a less or marginal orientation given to supply chain as a whole.

It is evident in the context of supply chain that service quality has impact not only on supplier/distributor, employees, customer but also it affects the over all business and growth of the organization.

In this paper an attempt is made to study quality of service in supply chain with a reference to 3PL. The organization of the paper is as follows: after presenting a brief literature review, a conceptual model is proposed based on gap analysis. Some issues related to measurement are also spelt out. Finally, some research directions are also identified.

Need for present study

Strong commitment and close relationship among trading partners is needed in order to attain lowest cost and maximizing service (Stank *et al.*, 2001). Bowersox *et al.* (1999) also highlighted the importance of achieving integration not only across internal operations but also with customers, material and service suppliers. In spite of general acceptance for realizing the importance of service quality in supply chain, it is very less researched (Nix, 2001).

The concept of service quality is so far regarded mainly as a unidirectional construct in its measurement and evaluation (Parasuraman *et al.*, 1988; Dabholkar, 1996; Beinstock *et al.*, 1997). Even so it is frequently emphasized that service quality is the outcome of the interactive process in a specific service encounter. The service provider's perception in the service encounter is often neglected or seldom acknowledged in literature. Seth *et al.* (2005, 2006) also pointed that there is a need to study service quality with a wider domain considering all the processes and operations associated in delivery of product or service.

A majority of studies on service quality have focused on service industries, not supply chain as a whole. There are still white spots to be explored, since there are certain service quality domains that have not been investigated sufficiently. It appears that measurement of quality of service in the context of supply chain management presents a challenge for researchers since:

- effective management of supply chain involves delivery of products as well as services;
- quality of service has both the dimensions: quantitative and qualitative; and
- quality of service involves interplay of a variety of factors spanning suppliers, manufacturers, distributors, retailers and customers.

Literature review

Supply chain and third party logistics

The development of the subject of supply chain has undergone major changes starting from a narrowing purchase/logistics and transportation point of view to a much broader holistic systems approach focusing on customer service. Logistics has a tremendous potential to play a strategic role in a supply chain it can be defined as a process of operation that includes the purchasing, storing, transporting, and distributing of physical goods. In this scenario of intense competition an globalization the relation between supply chain and third party (3PL) becomes extremely important, as 3PL involves the use of external companies to perform logistics functions that have traditionally been performed within an organization (Lieb *et al.*, 1993). Bagchi and Virum (1996) view logistics alliance as a close and long-term relationship between a customer and a provider encompassing the delivery of a wide array of logistics needs. Larsen (2000) views 3PL as logistics service relationships that include partnerships, third party agreements and integrated service agreements. 3PL helps an organization to concentrate on its core activities and thus may result in lower costs and better customer service. However, to achieve this, one must have proper mechanisms to measure, monitor and control quality of service.

Service quality definitions, models and measurement

The concept and definition of service quality has been greatly influenced by the works of Parasuraman *et al.* (1985, 1988, and 1991). They conceptualize service quality as the relative perceptual distance between customers' expectations and evaluations of service experiences and operationalize service quality using gap model and a multi-item scale called SERVQUAL (Parasuraman *et al.*, 1988, 1991). SERVQUAL is a 22 item instrument that includes the five dimensions (tangibles, reliability, responsiveness, assurance and empathy), SERVQUAL was developed based on the data gathered from service industries including credit cards, telephone service, retail banking, security broker, appliance repair and maintenance. Numerous authors developed and tested service quality models for different applications (for example Frost and Kumar (2000) – for internal service quality measurement, Zhu *et al.*, 2002 – it based service delivery, Santos (2003) – E – service quality model). Also, there seem to be no agreement on the measurement side (attributes) of service quality; researchers propose different attributes for different applications. Some of the attributes of service quality proposed by various researchers are given in Table I. Seth *et al.* (2005) in a comprehensive review on service quality models presented that majority of the studies in the field of service quality till date are dominated with the work of Parasuraman *et al.*(1985, 1988).

Gap analysis

The measurement of service quality using the gap model and SERVQUAL as a tool has been tested and used by several researchers (Frost and Kumar, 2000; Rosen and Karwan, 1994) gap analysis is the comparison of an entity's ultimate objective with the sum of projection and already planned projects, identifying how the consequent gap might be filled. Gap analysis as a tool is also appreciated and used by researchers in different application areas. Gunasekaran *et al.* (2002) used this tool to study the gap

Table I.
A select list of service quality attributes

Researchers					
Grönroos (1984)	*Gronroos (1988)*	*Parasuraman et al. (1985)*	*Parasuraman et al. (1988)*	*Haywood-Farmer (1988)*	*Lehtinen and Lehtinen (1991)*
Technical quality	Recovery	Credibility	Assurance	Behavioral aspects Timeliness, speed, Communication (verbal, non-verbal), courtesy, warmth, friendliness, tact, attitude, tone of voice, Dress, neatness, politeness, Attentiveness, anticipation, Handling complaints, solving problems	Physical quality (Physical products + Physical environment)
Functional quality	Attitudes and behavior	Access	Responsiveness	Professional judgement Diagnosis, Advice, skill, guidance, innovation, Honesty, confidentiality, Flexibility, discretion, Knowledge	Interactive quality (Interaction with persons and equipment's)
Corporate image	Accessibility and flexibility	Reliability	Tangibles	Physical facilities and processes Location, layout, décor, Size, Facility reliability, Process flow, capacity Balance, Control of flow, Process flexibility, Timeliness, speed, Ranges of services offered, Communication	Corporate quality
	Reputation and Credibility	Communication	Reliability		Process quality

(*continued*)

Table I.

Researchers						
	Professionalism and skills Reliability and trustworthiness	Understanding the customer Courtesy Competence Responsiveness Tangibles Security	Empathy		Output quality	
Mersha and Adlakha (1992)	*Ennew et al. (1993)*	*Ghobadian (1994)*	*Rosen and Karwan (1994)*	*Johnston (1995)*	*Philip and Hazlett (1997)*	*Dabholkar et al. (2000)*
Knowledge of service	Knows business	Competence	Reliability	Responsiveness	Pivotal attributes: Acquired information	Reliability
Thoroughness/accuracy of the service	Knows industry	Access	Responsiveness	Care	Core attributes: Reliability, Responsiveness Assurance, and Empathy	Comfort
Consistency/Reliability	Knows market	Reliability	Tangibles	Availability	Peripheral attributes: Access, Tangibles	Features
Willingness to correct errors	Gives helpful advice	Responsiveness	Access	Reliability		Personal attention
Reasonable cost	Wide range of services	Credibility	Knowing the customer	Integrity		
Timely/prompt service	Competitive interest rates	Understanding the customer	Assurance	Friendliness		

(continued)

Table I.

Researchers			
Courtesy	Competitive charges	Courtesy	Courtesy
Enthusiasm/Helpfulness	Speed of decision	Communication	Communication
Friendliness	Customized finance	Tangibles	Competence
Observance of announced business hours	Deals with one person	Security	Functionality
Follow up after initial service	Easy access to sanctioning officer	Customization	Commitment
Pleasant environment			Access Flexibility Aesthetics Cleanliness/tidiness Comfort Security

between production and marketing functions. Rho *et al.* (2001) used gap analysis to study the gap between manufacturing strategy and implementation practices and its impact on business performance. Kontzalis (1992) used gap analysis to identify different attributes physicians consider important in selecting products for treatment of certain condition. Several other researchers (Leminen, 2001; Guo, 2002; LaBay and Comm, 2003; Hatch and Schultz, 2003; Hwang *et al.*, 2003) used this tool for different purposes (understanding the dynamics of gaps in buyer-seller relationships to assessing the expectation and perception gap in quality of services for patient meal services). Although there are some questions in the literature about the dimensionality and measurement of service quality using the gap model (Cronin and Taylor, 1992), still it is commonly used for the measurement of service quality. Since, it is well documented and its strengths have been extensively explored in many studies including service industries.

Service quality in supply chain

It is seen that most of the service quality research has focused on the consumer with limited investigation on the applicability of service quality in supply chain context (Nix, 2001). Some of the studies in the field of service quality in supply chain are compiled in Table II.

It seems that the studies in the context of quality of service in supply chain have either focused on purchase or distribution activity and further these studies have considered only one directional view (keeping in view of basic firm only). A bi-directional study (i.e. impact of service quality on both supplier/distributor and the organization) can provide win-win situation and may help to fulfill the basic objective of supply chain.

Based on the review of literature, the following observations are in order:

- It seems that there is general agreement on the importance of third party service provider and service quality in supply chain.
- There seem to be a general agreement over the acceptability of gap model for variety of applications including service quality.
- Although a lot of work has been reported on service quality models and applications, but there seems to be a major gap in the application of quality of services models in supply chain.

It appears that modeling for quality of service with in the context of supply chain is a challenging area for research.

Exploratory investigation

The literature on service quality provided a sound conceptual foundation for understanding service quality in service industries, but the less support is available for studies for supply chain as a whole. An exploratory qualitative study is undertaken to investigate the concept of service quality in supply chain. The methodology adopted for this study is based on Parasuraman *et al.* (1985) and Zeithml (1988). Specifically 15 in-depth open-ended interviews with academicians (4), consultants (3) and practitioners from different organizations at different levels (8) were conducted. The interviews were conducted to gain the following insights:

Table II.
Select studies on quality of service in supply chain

S. No.	Author (Year)	Focus	Brief description
1	Beinstock *et al.*(1997)	Distribution	Conceptualizes physical distribution service quality (PDSQ) comprising of three factors namely timeliness, availability and condition
2	Sinha and Babu (1998)	Distribution	The study was oriented towards measurement and improvement of service quality from factory to distribution network. They developed DSI (Depot Service Index)
3	Mentzer *et al.* (1999, 2001)	Logistics	Identified nine potential components of logistics service quality (LSQ) (personnel contact quality, order release quantities, information quality, ordering procedures, order accuracy, order condition, order quantity, order discrepancy handling and timeliness
4	Pery *et al.* (1999)	Quick response	Studied quick response performance of Australian industries and identified "delivery time" as the most important factor for competitiveness
5	Stanley and Wisner (2002)	Purchasing	Attempted the issue of identifying the dimensions of service quality for purchasing and internal transactions based on empirical study of purchasing executives of different manufacturing and service organizations

- understand the importance of quality of service in supply chain;
- identify different factors that affect quality of service in supply chain;
- derive a methodology for identification and measurement of quality of service levels at various interface levels and further with in various interfaces of supply chain, so that a suitable improvement program can be launched.

Insights from exploratory investigation

Remarkably consistent patterns emerged from the in-depth interviews and the subject was clearly highlighted by all academicians, consultants and practitioners owing to its positive proven relationship with customer satisfaction and profitability. Some of the key outcomes of the interviews are presented below:

- It is visualized that service quality in supply chain can also be modeled through gap analysis similar to Parasuraman *et al.* (1985) model.
- The model should consider gaps in both the directions (forward and reverse) simultaneously as the gaps may have different implications in supply chain context.
- Unlike other services, service quality in supply chain has both the aspects quantitative and qualitative, thus there is a need to develop a method which not only collects both types of data but helps in further analysis.

Research methodology

Based on the literature review, and discussions with academicians/industry professionals at various levels, a framework is visualized as shown in Figure 1, which will enhance the quality of services in the supply chain.

Proposed model

A conceptual model is proposed for the quality of service in the context of the supply chain of comprising of the following: supplier – third party logistic provider – focal firm – third party logistic provider – distributor – third party logistic provider – customer. This model is based on the concept of quality of service as proposed by Parasuraman *et al.* (1985). This model uses the framework of Gunasekaran and Ngai (2003) and accordingly, has categorized the logistics into two categories:

(1) Logistics Users (LU), i.e. suppliers, manufacturers and distributors; and

(2) Logistics Service Providers (LSP), i.e. third-party logistics service providers such as logistic companies, couriers, transporters, etc. For convenience, these are labeled as TPL1 (i.e. third party logistic service provider between Supplier and the Focal Firm), TPL2 (i.e. third party logistic service provider between the Focal Firm and the Distributor), and TPL3 (i.e. third party logistic service provider between Distributor and the Customer).

Using this categorization, the transactions between suppliers to the focal firm is treated as the transaction between LU and LSP and similarly the transaction between Focal Firm and the Distributor is treated as the transaction between LU and LSP. The basic objective of the model is to assess the quality of service provided and perceived by various LU and LSP.

The Conceptualization of the model is done using gap analysis as a tool. The gaps in this model are divided into of two types:

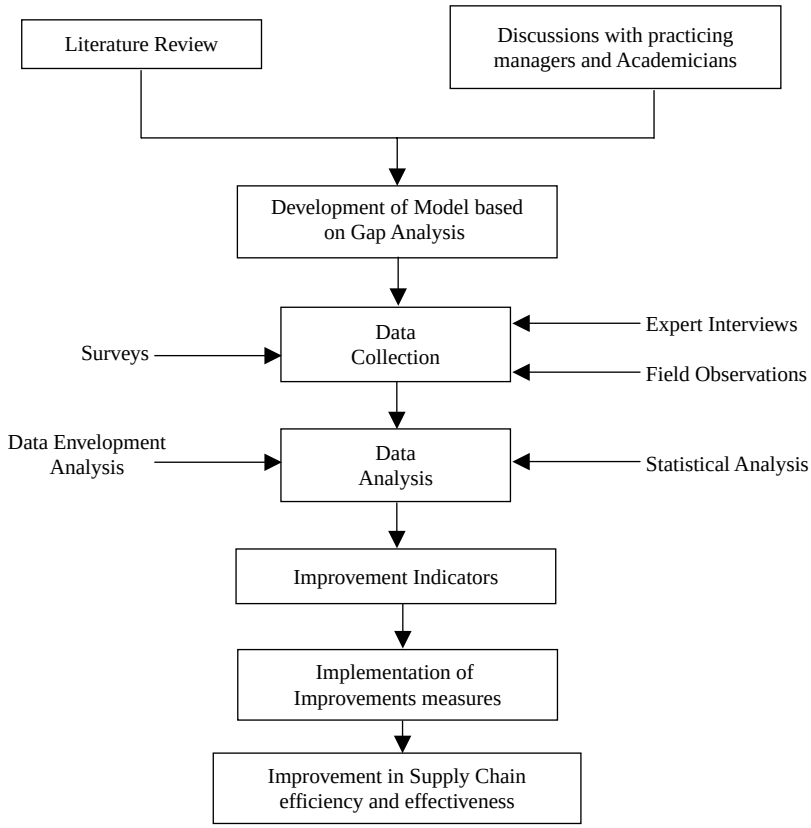

Figure 1.
Proposed framework

(1) *Forward gap.* This gap is defined in the context of basic supply chain direction (direction of movement of product). That is from supplier to focal firm, focal firm to distributor and from distributor to customer.

(2) *Reverse gap.* The reverse gap in this study is considered as the reverse direction of the basic supply chain process (reverse to the physical movement of the product), i.e. from focal firm to supplier, distributor to focal firm and from customer to distributor.

Figure 2 depicts two entities "A" and "B" representing various functions in the supply chain under consideration. A forward gap from entity "A" to entity "B" may result from poor processes, inadequate infrastructure facilities, etc. of entity "A" and will

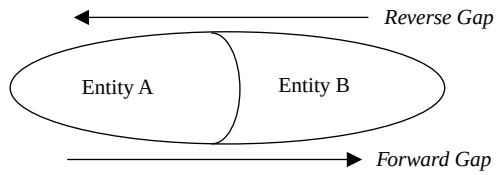

Figure 2.
Entity gap relation

have an impact on entity "B". Similarly reverse gap from entity "B" to entity "A" is resulting owing to inefficiencies of processes at entity "B" and will have an impact on entity "A".

In the proposed model, the basic supply chain is considered from the first supplier to the first customer. It comprises of the following entities:

- Supplier is one who supplies goods and service to the focal firm.
- A third party is the external agency, which is responsible for handling different transactions between Logistics user and Logistics service provider.
- Focal firm is the firm whose product/services are considered for study.
- Distributor is the one who distributes the products of the focal firm to the customers as per the requirements. He also owns the responsibility of inventory.
- Customer is the one who finally receives the products/services of the focal firm from the distributor.

Satisfactory level of service quality is the level of services delivered, when the difference between perception and expectation by a customer towards product/process/service/organization is zero or positive. Customer satisfaction is the result of customers' perception of the value received in a transaction or relationship.

These forward and reverse gaps are identified at various interfaces, i.e. supplier – TPL1; TPL1 – focal firm, focal firm –TPL2, etc. Various sources affecting each interface gap are identified and termed as service quality gaps. The interface gaps cover at a broader level the performance objective at each level and the service quality gap would present the sources with in each level.

Main model based on gap analysis

This model analyzes the various interface gaps between the, logistics user, logistics service provider and customer, i.e. supplier, TPL1, focal firm, TPL2, distributor, TPL3 and customer. The interaction between various activities is shown in Figure 3. The model identifies the linkages between the key activities, which are essential to the delivery of a satisfactory level of service quality to the customer. The various interface gaps in the main model are summarized as given below.

Interface gap 1.1F: (forward): logistics user (S) – logistics service provider (TPL1): (supplier – TPL1)

This gap covers the transactions of supplier as well as the transaction between supplier and the TPL1.The main reasons for this gap may be attributed to improper communication, incomplete technical specifications, poor co-ordination between supplier and TPL1, improper tools/equipment's, inadequate procedures, etc. at the supplier's end.

Interface gap 1.1R: (reverse): logistics service provider (TPL1) – logistics user (S): (TPL1 – supplier)

This gap covers the transactions between TPL1 and supplier. This gap may result on account of poor transaction mechanisms at TPL1, communication problems, improper delivery terms, and delays in response to supplier, etc.

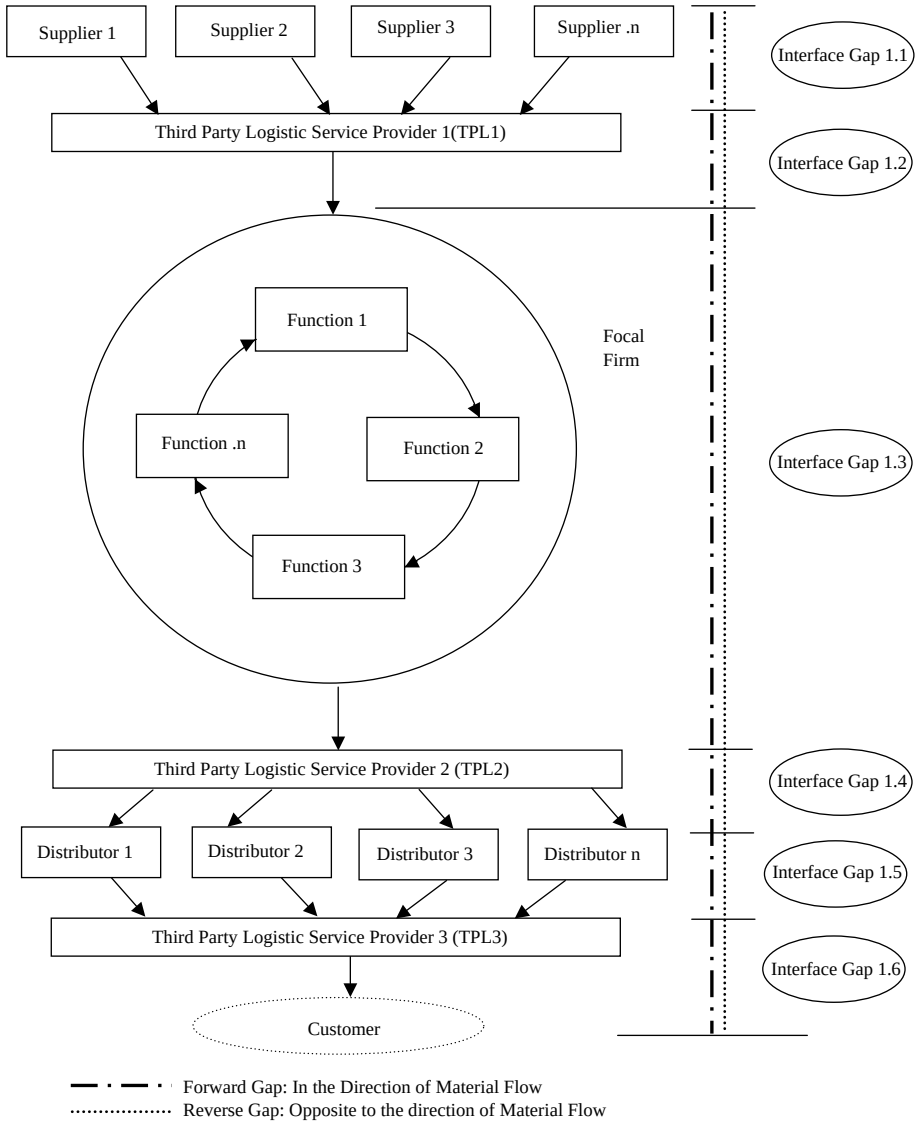

Figure 3.
Gap analysis model: main module

In either of the cases existence of this gap violates the supplier – partner objective of efficient and effective supply chain resulting in poor quality of service.

Interface gap 1.2 F: (forward): logistics service provider (TPL1) – logistics user (F): (TPL1 –focal firm)

This gap covers the processes of TPL1 as well as the transactions between focal firm and TPL1.This gap exists due to lack of co ordination between various functions of the TPL1,

lack of organizational shared vision, poor management procedures and policies, improper communication between functions, poor planning, lack of facilities, etc. at the TPL1.

Interface gap 1.2R: (reverse): logistics user (F) – logistics service provider (TPL1) (focal firm – TPL1)

This gap covers the transaction between the focal firm and TPL1 and also reverse transactions between various departments with in focal firm. Some of the reasons of this gap may be attributed to rigid hierarchical system, poor communication mechanism, poor work culture, inadequate wage structure, etc. at the focal firm and thus affect the relation/deal/contract with TPL.

In the similar manner the other interface gaps of main model can be defined and their impact on the overall supply chain can be visualized. An attempt is made to analyze various interface gaps highlighting their impact on supply chain and their select indicators, this is presented in Table III. In either of the interface gap 1.1F to 1.6R, this results in the loss/distrust/dissatisfaction of the customer, thereby incurring a loss to the efficiency of supply chain. Thus, they need to be monitored on real time basis so that a suitable and timely action can be taken.

Interface gap 1.1 analysis module: logistics user (S) – third party service provider (TPL1)

This module will analyze the Interface gap 1.1, between the logistics user (S), i.e. supplier and the TPL1 and thus highlights the various sources of interface gap 1.1. The various service quality gaps at interface 1.1 are shown in Figure 4. Table IV describes the various service quality gaps along with their select measures and impact on supply chain.

Measurement of gaps

The measurements of the various interface and service quality gaps in supply chain as proposed in the main model (Figure 3) and subsequent sub modules (sub module 1-6) involves dealing with both qualitative and quantitative data. Some of the approaches for qualitative and quantitative data collection and analysis are depicted in Table V.

The choice of above aspects for data collection and analysis is derived from their rich proven base of towards measurement in the context of service quality and supply chain management. The data collection approaches (survey, modeling and expert interviews) have been used by numerous researchers (Parasuraman *et al.*, 1988; Cronin and Taylor, 1992; Teas, 1993; Mentzer *et al.*, 1999, 2001, etc.) in service quality and supply chain context.

Also as regards to the tools envisaged for analysis (Statistical analysis and Data Envelopment Analysis (DEA) and) are also proven techniques in several researches in different fields.

Statistical analysis (Parasuraman *et al.*, 1988; Cronin and Taylor, 1992) and DEA techniques have been used by numerous researchers (Mathiyalakan and Chung, 1996; Madu and Kuei, 1998; Tsang, 1999; Weber *et al.*, 2000; Harbi al, 2000) in evaluating the performances/benchmarking of many different kinds of entities engaged in many different activities in many different contexts in supply chain and quality. Thus, it seems that the above tools have a proven research base in different applications in service quality and supply chain, hence these can be adopted for measurement of quality of service in supply chain.

Table III.
Various interface gaps along with their impact on supply chain

S.No.	Model name/Gaps covered	Model activity	Major supply chain impact	Select indicators
1	Main model (Figure 3) All interface gaps from 1.1 to 1.6	Transaction with in basic supply chain at all interfaces	Poor quality of product/services delivered Loss in credibility, reputation and image of the organization Loss in market share	Percentage variation in market share Percentage orders unlifted by customers
2	Sub Model 1 (Figure 4) Interface gap 1.1: Logistics user(S) and Logistics service provider (TPL1)	Transactions from different suppliers to the 3 PL service provider	Dissatisfaction of the TPL1/supplier towards each other on account of poor product/services rendered at respective level May reflect in producing poor quality products May lead to dissatisfaction of supplier and affect loyalty towards the focal firm	Percentage orders delayed in transactions Number of repeat transactions at supplier and at TPL1 Overall percentage orders delayed by TPL1 towards supplier and vice versa
3	Sub model 2: Interface gap 1.2: Logistics service provider (TPL1) and Logistics user (F)	Transactions from 3PL service provider to Focal Firm	Dissatisfaction of focal firm/TPL1, towards each other on account of poor processes at respective level May lead to termination of contract with TPL1	Timely delivery of material per supplier Number of repeat transactions per supplier Over all percentage orders delayed by TPL towards focal firm
4	Sub model 3: Interface gap 1.3: Logistics user (F) and Logistics service provider (TPL2)	Transactions from Focal Firm to the 3 PL service provider	Distrust/Dissatisfaction of TPL2, towards the focal firm, or of the focal firm towards TPL2 on accounts of poor operations at respective levels May lead to poor coordination of TPL2 with focal firm and ultimately lowers Supply chain efficiency and effectiveness	Numbers of orders unlifted Breakage/spoilage of components by TPL2 Number of orders reworked

(*continued*)

S.No.	Model name/Gaps covered	Model activity	Major supply chain impact	Select indicators
5	Sub model 4: Interface gap 1.4: Logistics service provider (TPL2) and Logistics user (D)	Transactions from 3 PL service provider to the different distributors	Distrust/Dissatisfaction of distributor, towards the TPL2 or of TPL2, towards the distributor on account of poor processes/systems at respective level May lead to poor performance of TPL2/distributor and ultimately lowers Supply chain efficiency and effectiveness	Percentage of orders wrongly delivered Percentage of orders delivered late Number of customers lost by distributor on account of non availability of material
6	Sub model 5: Interface gap 1.5: Logistics user (D) and Logistics service provider (TPL3)	Transactions from different Distributors to the 3 PL service provider	Distrust/Dissatisfaction of TPL3, towards the distributor or of distributor, towards the TPL3 on account of poor coordination between TPL3 and distributor May lead to request for change of distributor by TPL3 to focal firm or breakage of contract of TPL3 or results in poor performance of distributor and ultimately lowers supply chain efficiency and effectiveness	Percentage orders unlifted (inventory) at distributors end Percentage of orders delayed Numbers of unsatisfied customers/day Waiting time of TPL3 for lifting order

(*continued*)

Table III.

Table III.

S.No.	Model name/Gaps covered	Model activity	Major supply chain impact	Select indicators
7	Sub model 6: Interface gap 1.6: Logistics service provider (TPL3) and Customer	Transactions from 3 PL service provider to Customer	Distrust/Dissatisfaction of Customer towards the TPL3/Focal firm on account of poor processes/systems at TPL3 May result in the dissatisfaction/distrust of the customer towards the good/services of Focal firm on account of poor understanding of the customer's needs/requirement by TPL3 Affects the credibility, reputation and image of the focal firm in the market and thus has a major supply chain impact	Number of customer complaints about product/services Number of orders lost/number of orders available Number of repeat transactions/day Average waiting time of customer

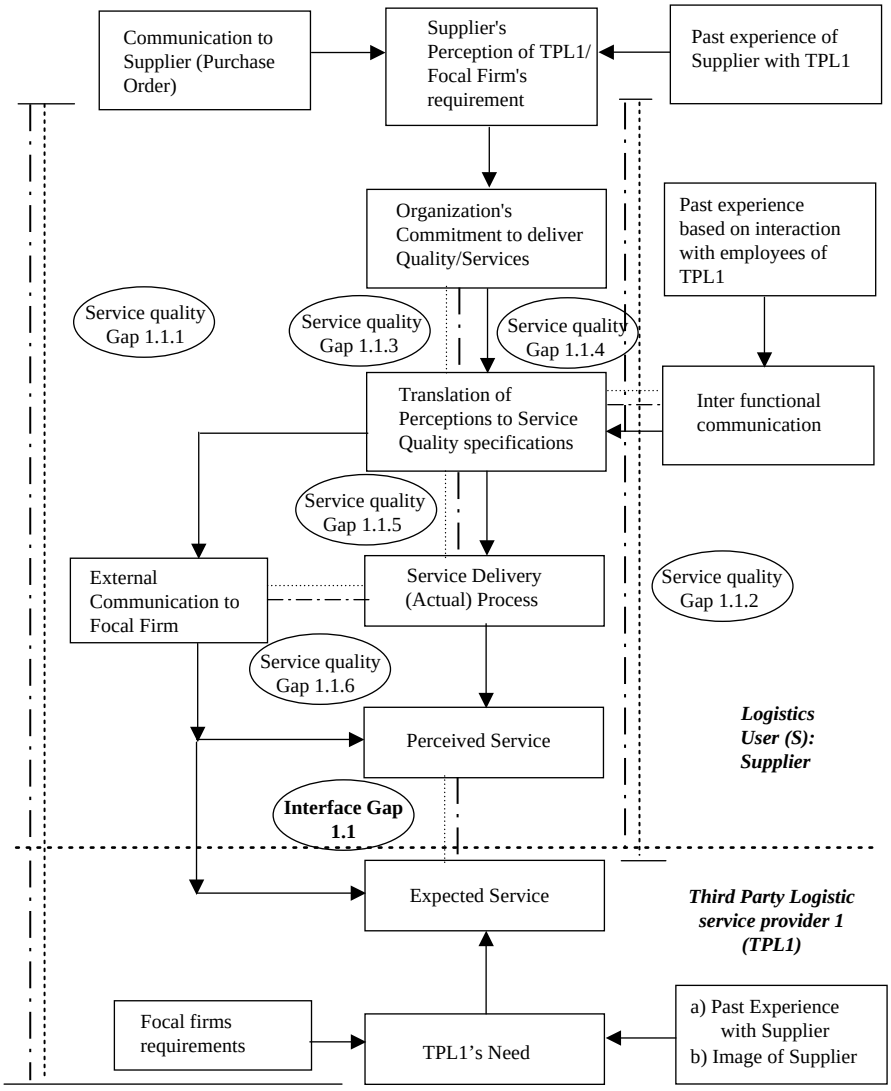

Figure 4.
Interface gap 1.1 analysis model: Logistics User (S) – Logistics service provider (TPL 1) module

Data analysis

(1) *Statistical analysis.* For analyzing the data so collected by conducting survey/expert interviews, the analysis of the data using any statistical package (SPSS, LISREL, etc.) may be carried out. Statistical techniques have been used by researchers since past for:

- data reduction (factor analysis); and
- finding out relation among different entities and for other applications indifferent contexts.

Table IV.
Analysis of various gaps at interface 1.1 (logistics user (S) – logistics service provider (TPL 1)) level (Figure 4)

S.No.	Service quality gaps	Major reasons for service quality gap	Major supply chain impact	Typical measures
1	1.1.1F: (Forward): Communication Gap (Supplier – TPL1)	Resulting on account of the improper attention to focal firm's job, poor vision, poor training, poor communication mechanisms, poor order acknowledgement, etc. from the supplier to the TPL1. This gap incorporates the mechanism of transfer of information at the supplier end	This gap may result in building up of dissatisfaction of TPL1 towards supplier and thus resulting in poor supply of goods/services and ultimately has a deteriorating effect on the quality and efficiency of supply chain	Percentage of orders delivered in time Percentage reworks/rejects at TPL1 and supplier's end Information sharing assessment survey at both ends Percentage delays in purchase order process (Preparation, transfer, receipt, and process) Training/education assessment survey at each level
2	1.1.1R: (Reverse): Communication Gap (TPL1 – Supplier)	Resulting on account of the improper communication from TPL1 to the supplier. Some of the reasons for this gap may be attributed as poor understanding of requirement of focal firm by TPL1, poor communication mechanisms, poor training of staff, etc. at TPL1's end, lack of support mechanism, poor infrastructure facility, etc. at supplier's end	This gap has an impact of developing distrust of supplier for focal firm's job	
3	1.1.2F: (Forward): Supplier perception – TPL expectation	Supplier may have inaccurate perceptions of what TPL1's expects this result in a gap. Some of the reasons for this gap are lack of proper market/customer focus, improper training, improper customer focus, inadequate facility, poor communication system, poor past experience, etc. at supplier end	This gap may result in loss to the TPL1 in the form of delayed schedules and disturbed planning and to focal firm in the form of unfulfilled or wrong orders	Supplier satisfaction survey TPL1 satisfaction survey Information sharing assessment survey at each level Training imparted at each level Market feed back assessment survey at different levels Inventory status auditing

(*continued*)

Table IV.

S.No.	Service quality gaps	Major reasons for service quality gap	Major supply chain impact	Typical measures
4	1.1.2R: (Reverse): TPL expectation – Supplier perception	The TPL may expect the things, which are difficult to supply, in terms of delivery schedules, coordination, etc. by the supplier. Some of the reasons for this gap may be attributed as enthusiastic approach, poor supplier coordination and assessment, and poor planning and training of the concerned person at TPL1	This gap result in excessive loss to TPl1 and focal firm in the form of failure of commitments to customer, delayed production, increased inventory, etc. Thus, may affect the contract with TPL1	
5	1.1.3F: (Forward): Service quality specification gap (Top management – Function heads)	Results on account of inability on the part of the supplier's management to translate supplier's perception into service quality specifications. Some of the major reasons for this gap may be attributed as poor organizational systems, focus on other priorities, lack of trained professional, lack of planning, poor past experience, poor transfer mechanisms, improper organizational structure, etc.	This gap may result in the dissatisfaction of the functional heads towards top management ultimately results in loss to the efficiency and quality of services delivered by supply chain	Employee satisfaction survey for different functions and at supplier's end Motivation assessment survey in different functions Percentage of orders delayed owing to improper communication Information sharing assessment survey at different levels
6	1.1.3R: (Reverse): Service quality specification Gap (Functional heads – Top management)	The functional heads may have different perception towards management's objective of delivering as per the requirements of the focal firm, this result in a gap. Few reasons for this gap may be poor salary, lack of proper incentive schemes, lack of motivation, poor organizational policy, poor culture, poor organizational systems, etc. at functional head's end	This gap may lead to unfulfilled objective of the top management and in turn affect the business of supplier and ultimately loss to efficiency and quality of services in supply chain	

(*continued*)

Table IV.

S.No.	Service quality gaps	Major reasons for service quality gap	Major supply chain impact	Typical measures
7	1.1.4 (F & R): (Forward and Reverse): Inter functional communication gap	This gap may result from poor communication and coordination between different functions in the organization. This is a gap resulting from fragmented approach of different functions. Some of the reasons for this gap are giving priorities to the individual objectives rather than the organizational, distrust amongst the functions, improper resources distribution, lack of infrastructure, poor coordination, lack of coordination, lack of education, poor organizational vision, etc. at supplier end	This gap may also exist at different levels with different functions and may have different magnitude and nature (forward or reverse) from function to function and level to level. This gap results in complete failure of the system and ultimately lowers the quality of services delivered by supply chain	Infrastructure assessment survey Percentage orders completed in time Percentage payments received in time Employee motivation assessment survey for different functions Training/education assessment Information transfer mechanisms assessment No of inter functional repeat transactions
8	1.1.5F: (Forward): Service delivery gap (Functional heads – Concerned employees in different functions)	Reasons of this gap include lack of sufficient support for the frontline staff, process-related problems, or frontline/contact staff performance variability, lack of motivation, quality related problems, management of individual relationship, etc. by functional heads	This gap may result in dissatisfied employee and hence lowering the efficiency and quality of services delivered by supply chain	Analysis of quality assurance data at different functions Employee satisfaction survey Training/education assessment survey Infrastructure/tools assessment Percentage orders failures at each level Percentage Inventory blocks up in the departments Percentage orders delayed at each level

(*continued*)

S.No.	Service quality gaps	Major reasons for service quality gap	Major supply chain impact	Typical measures
9	1.1.5R: (Reverse): Service delivery gap (Concerned employees in different functions – Function heads)	Resulting on account of non-performing employees in different functions of the firm. Some of the reasons of this gap may be attributed as lack of motivation, lack of infrastructural facilities, lack of support from top management, poor salary, personal problems, non – cooperative nature of operating persons, etc.	This gap may have an impact of unfulfilled commitments, lack of support from work force towards leadership, etc. thus in turn reducing the efficiency of the supply chain	
10	1.1.6F: (Forward): External communication gap (Marketing function of supplier – TPL1 and Focal firm)	Customer expectations are fashioned by the external communications of an organization. This is a gap resulting on account of enthusiastic or neglected approach by the marketing function of supplier to the TPL and focal firm for the status of delivery product or services offered. Some of the key reasons for this gap may be attributed to lack of education/training of marketing persons, poor organizational policy, lack of customer orientation, etc.	This gap may have a significant impact on the TPL1 and focal firms' performance in the form of delays in delivery, excessive inventory, etc. and leading to the loss in the efficiency and quality of services delivered by supply chain	Percentage payments collected in time Percentage payments processed in time Number of Training/education programs conducted Supplier motivation assessment survey Information assessment to the supplier Motivation assessment survey Percentage undispatched in time Percentage order failures
11	1.1.6R: (Reverse): External communication gap (TPL1 – Marketing function of supplier)	Resulting in response to the communication made by focal firm and the marketing function of the Supplier. This gap covers the communication aspects of the TPL1 towards the marketing function of the supplier. This gap covers the delivery requirement of the product. This gap depends on the planning, training, coordination, etc. of the TPL1 towards supplier and Focal firm, etc.	This gap may have an impact of loss in the faith of supplier to TPL1/focal firm's job and thus may lead to termination of contract of TPL1 by focal firm. This gap may finally lowers the efficiency and quality of services delivered by supply chain	

Table IV.

(2) Data envelopment analysis (DEA): It is difficult to evaluate an organization's performance in the presence of multiple inputs and multiple outputs to the system. The difficulties are exaggerated when the relationships between the inputs and the outputs are complex and involve unknown tradeoffs. DEA (data envelopment analysis) is a mathematical programming model applied to observational data (that) provides a way of obtaining empirical estimates of relations – such as production functions and/or efficient production possibility surfaces – that are cornerstones of modern economics (Charnes *et al.*, 1978). DEA is based on linear programming models for assessing the efficiency and productivity of decision-making units which convert multiple inputs to multiple outputs. Over the last few years DEA has gained considerable popularity and managerial attention for measuring performance and efficiencies of the organizations. In the current context this technique can be used to maximize the efficiency and effectiveness of the QoS in the supply chain under consideration.

As an illustration, some of the measures for analyzing the various interface and service quality gaps at different levels in the supply chain are depicted in Table VI along with their respective category.

Envisaged benefits of the proposed model

This proposed model, along with the necessary sub modules will be highly beneficial to the organizations in leveraging the efficiency of the supply chain. The following key benefits are envisaged:

- The model will help in understanding gaps related to the quality of service existing between logistics users, logistics service provider, focal firm and customers. It will also suggest measures to reduce them and will help in providing direction for improvements in the quality of service in supply chain. Based on the analysis of the gaps, the model may provide guidance on which activities need to be outsourced.
- The model can also be used as a diagnostic tool to understand the weaknesses in the existing supply chain and thus help in identifying the key areas for improvements within the organization.

Table V.
Proposed methodology for data collection and analysis of supply chain gaps

S. No.	Proposed tool	Proposed methodology
Data collection		
1	i) Survey	a) Through a customer survey of both internal and external (supplier, Focal firm and Distributor) customers
	ii) Expert interviews	b) Carrying out expert interviews on assessment of various parameters of quality of service at various level in the supply chain
	iii) Field modeling	c) Modeling through field observations and recording the relevant facts
Data analysis		
2	i) Statistical software	a) Statistical analysis of the data collected trough above observations
	ii) DEA software	b) Data envelopment analysis (DEA)

- The model can help the organizations to evaluate a suitable 3PL service provider. It may also be used as a tool for benchmarking. The logistics service provider with minimum gaps can be benchmarked for improvements in the processes. Similarly, the relative performance of suppliers and distributors *vis-à-vis* that of a 3PL can be assessed.
- The proposed model can also be used for internal benchmarking with in the organization between various functions.

The expandability of the model both upstream and downstream the supply chain provides an opportunity for seamless integration of resources through out the supply chain for improvement in its efficiency. The proposed model will also be helpful in identifying the key parameters for improvement in the efficiency of supply chain at all ends (supplier, third party logistics service provider, focal firm, third party logistics, distributor, third party logistics and Customer) thereby leading to increased productivity and profitability of every member in the supply chain. This may result in increased customer satisfaction and finally improving efficiency and quality of services delivered through supply chain.

S. No.	Measures	Preferred choice of indicator		
		Nominal	Larger	Smaller
1.	Percentage of orders delivered in time at all levels in supply chain	–	√	–
2.	Percentage reworks/rejects at all levels in supply chain	–	–	√
3.	Total supply chain cycle time (Gunasekaran *et al.*, 2001)	–	–	√
4.	Total cash flow time (Gunasekaran *et al.*, 2001)	–	–	√
5.	Customer query processing time	–	–	√
6.	Inventory status reporting to links of the supply chain	√	–	–
7.	Net profit v/s productivity ratio (Gunasekaran *et al.*, 2001)	–	√	–
8.	Delays in purchase order process (Preparation, transfer, receipt, and process)	–	–	√
9.	Logistic User/service Provider satisfaction (Motivation for job, satisfied with procedures, training need assessment, technology need, price, etc.) at levels	–	√	–
10.	Supply chain capacity utilization (Gunasekaran *et al.*, 2001)	√	–	–
11.	Percentage of orders delayed by logistic service provider (TPL) and logistic user (supplier, focal firm, and distributor)	–	–	√
12.	Percentage orders completed in time for all the members of supply chain	–	√	–
13.	Percentage payments received in time for all the members of supply chain	–	√	–
14.	Number of inter party repeat transactions (for different queries/requirements) at different levels	–	–	√
15.	Percentage payments collected in time for all the members of supply chain	–	√	–
16.	Number of orders unfulfilled by supply chain	–	–	√
17.	Percentage orders unlifted/delayed by logistic service provider and logistic user	–	–	√
18.	Percentage Orders still to be taken in for action by LSP and LU	–	–	√

Table VI.
A select list of quantitative indicators for various gaps

Some observations

- The proposed model covers the transactions only in the basic supply chain (from the first supplier to its first transaction with third party logistics service provider), but the similar structure can be extended up and down stream for the analysis of ultimate supply chain.
- Different organizations may have different structures and different ways by which different functions are being performed; accordingly the model needs to be modified to suit the organization in consideration. Different types (nature and magnitude) of gaps may exist according to the working and hierarchical structure of the organization in consideration.
- It is assumed that the suppliers and distributors deal only with third party logistics service provider and the gaps are considered accordingly. Supplier or distributor may deal with multiple organizations, accordingly for each such case the (nature and magnitude) of gaps is to be computed, and also the procedure is similar for multiple suppliers and distributors communicating directly to the focal firm (in absence of TPL) in consideration. The proposed model has the flexibility to account for this by replicating the same procedure for different organizations under consideration.
- It will be advantageous if the same logistic service provider performs TPL1, TPL2 and TPL3 activities. This may instill a greater confidence and a sense of responsibility between the logistic user and the service provider. This will ultimately benefit the end customer.

Directions for future research

The proposed service quality model in supply chain provides a conceptual framework for assessing the quality of service of 3PL service providers and the supply chain as a whole. The proposed model is based on the qualitative data generated through series of discussions with the academicians and professionals at various levels. The conceptual model and the propositions emerging from it imply a rich agenda for future research:

- There is a need and an opportunity to develop standard instrument to measure service quality of 3PL-service provider and supply chain as a whole, there by aligning all the processes to deliver customer satisfaction and to gain customer profitability.
- There is a need to examine how quality of service interface influences the behavior towards both upstream and down stream of supply chain.
- It will be interesting to study whether the different bi-directional gaps (1.1(F & R)-1.6(F & R)) and corresponding sub gaps vary with the products, functional responsibilities/classification or with organization/industry. There is a need to establish the impact of each gap on the quality of services delivered by various agents in the supply chain.
- Research is needed to generate various Rust *et al.* (1995) and Lee *et al.* (2000) dimensions of service quality with 3PL-service provider and for supply chain. There is a need to find out whether these dimensions are different at different levels in supply chain. These dimensions should be such that with appropriate

changes in the wordings the same instruments should cater the requirements of variety of application areas.

- Research is needed in the area to examine the gaps at various levels in the supply chain (main model and sub models). This may help the organizations in deciding the priorities, deciding for making a 3PL contract and this is also essential form the customer's point of view. There is a need to examine the magnitude of the specific gap and its impact to the quality of services at each level and to the supply chain as a whole. Also there is a need to establish difference between the critical and the non-critical gaps in the total sequence.

Concluding observations

A basic model is proposed on the service quality in the supply chain based on the gap analysis. The key gaps likely to affect the service quality at different levels are extensively spelt out. It may be noted that these gaps may be interrelated. An acceptable quality of service can be thought, through out the supply chain as a prerequisite for successful delivery to meet the customer's expectations.

This model provides guidelines for the organizations to understand the factors, which influence outsourcing decisions in a supply chain. The third party logistic role in the supply chain is influenced by:

- the extent to which the logistics process needs to be outsourced;
- the perception of the service provider and receiver; and
- relationship with the client, upstream and downstream the supply chains.

The paper highlighted some of the major consequences of service quality in supply chain; they further need to be determined empirically along with their relative impact on supply chain. The bi-directional gaps at different levels will have different impact on supply chain performance.

The conceptual service quality model proposed in supply chain will be useful to both the academicians as well as the practitioners for visualizing and measuring the quality of services delivered by various stakeholders in the supply chain.

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