Identifying reverse 3PL performance critical success factors

Amir M. Sharif
Brunel Business School,
Brunel University,
Middlesex, UB8 3PH, UK
E-mail: amir.sharif@brunel.ac.uk

Abstract
The reverse and third party logistics operational process is now well known and established to be a vital component of modern day supply chain and product / service-based organizations (Marasco, 2007). Apart from being a vital component of such enterprises, many researchers and practitioners have also been noting the importance of this approach and its impact on customer service, satisfaction, profitability and other key performance indicators (Autry et al., 2001). However, studies relating to reverse 3PL performance are still limited. This research attempts to examine the factors that influence the reverse logistics performance within 3PL, within a specific case study organization in Thailand, which aims to add to work carried out relating to such operations in this part of the world such as by Bhatnagar *et al.* (1999). This research uses a combination of a qualitative case study along with a quantitative approach (Fuzzy Cognitive Mapping) to model and analyse the constructs which underpin the dynamics involved within a 3PL scenario. As such, both the combined approaches are based upon the development and testing of a hypothesis via empirical primary and computational data. Hence, using extant literature, and combined qualitative and quantitative research approaches, the paper identifies significant and pertinent critical success factors for reverse 3PL performance (centred around the indogenous/exogenous relationship between information systems, resource commitment and organizational structure). The paper also explores the deep inter-relationships involved within 3PL operations using the Fuzzy Cognitive Mapping technique, contributing to the existing literature on reverse 3PL and performant supply chains, and identifying critical success factors and underlying determinants of reverse 3PL of use to those industry and investigating the area from an academic perspective.

Keywords: Reverse 3PL, Performance, Fuzzy Cognitive Mapping

1. Third Party and Reverse Third Party Logistics

Supply chains within and across a range of product and service-based series of organisations need to take into account not only the supply but also the response and management of interactions across vendors, suppliers and customers (Vonderembse *et al.*, 2006). Noting the contributing factor of logistics as a principal component Supply Chain Management (SCM), Mentzer *et al.* (2004) highlight the importance of managing not only the forward supply but also the backward or reverse logistics (RL) involved with customer relations, product returns, recycling, reuse, disposal, repair, and remanufacturing – most notably now more well known as “green logistics” also (Carter and Ellram, 1998; Rogers and Tibben-Lembke, 2001; Stock, 1998). Noting the ubiquity of this latter aspect and the complexity of inter-locking supply chain tiers (Chiger, 2007), aided by interstitial third parties (hence third party logistics, 3PL), the growth of reverse 3PL in this context in national and international contexts is an increasingly common and vital part of a supply chain operation logistics activities are outsourced to experienced providers (Bask, 2001; Mitra, 2005; Power et al., 2007; Selviaridis and Spring, 2007).

Without doubt, this level of complexity alluded to is inherent as a result of the interplay between design and generation of a product/service, marketing, production, delivery and customer and channel management – all of which are driven by the commoditisation of information and knowledge across the chain and amongst tier partners (Gunasekaran *et al.*, 2008; Ireland and Webb, 2007). Hence as far as 3PL is concerned, the firms concerned seek to support reverse logistics operations but at the same time ensuring economies of scale as far as leveraging information technology, human resources, cost control and expertise (Closs and Savitskie, 2003; Razzaque and Sheng, 1998). Specifically, this paper attempts to reconcile and analyse the interplay between the first of the two aspects to reverse 3PL – namely information systems and resource commitment which as identified by the literature (Autry *et al.*, 2001; Daugherty *et al.*, 2002; Tibben-Lembke, 2002; Richey *et al.*, 2005) are important determinants of reverse logistics performance. The paper hence seeks to identify those factors of RL which may imply success for 3PL as a result of these two constructs. This is achieved through the development of a theoretical model based upon the literature from which a computational model of reverse 3PL factors are created as a result of interview discussions with supply chain and other managers from a logistics distribution case company from within Thailand. Using the technique of fuzzy cognitive mapping (FCM) relevant analyses are made of the primary and secondary drivers which underpin the information and resource commitment factors inherent within the particular cultural context of the Thai supply chain case. The paper concludes by identifying areas of pertinent research direction and implications for practice.

2. Key factors driving reverse 3PL

Evangelista and Sweeney (2006) as well as Feng and Yuan (2006) and Daugherty *et al.* (2002) note that the "clock speed" of reverse logistics response from the customer back to the originator require accurate and real-time management of information of the current status of shipped or returned orders. This requires a combination of IS support capability, compatibility and technologies. The secondary component of resource commitment noted previously has been highlighted in the literature as consisting of aspects of financial resource management, managerial commitment and technological commitment (Das and Teng, 2000; Richey *et al.*, 2005). Managerial commitment across all supply chain participants is key as without this aspect, stakeholders may become uncoordinated and slip on remaining committed to the supply chain (Richey *et al.*, 2005). Figure 1 shows a conceptual model where the dashed line shows an indirect or direct relationship whilst the arrowed line with the (+) signifies a strong positive relationship.

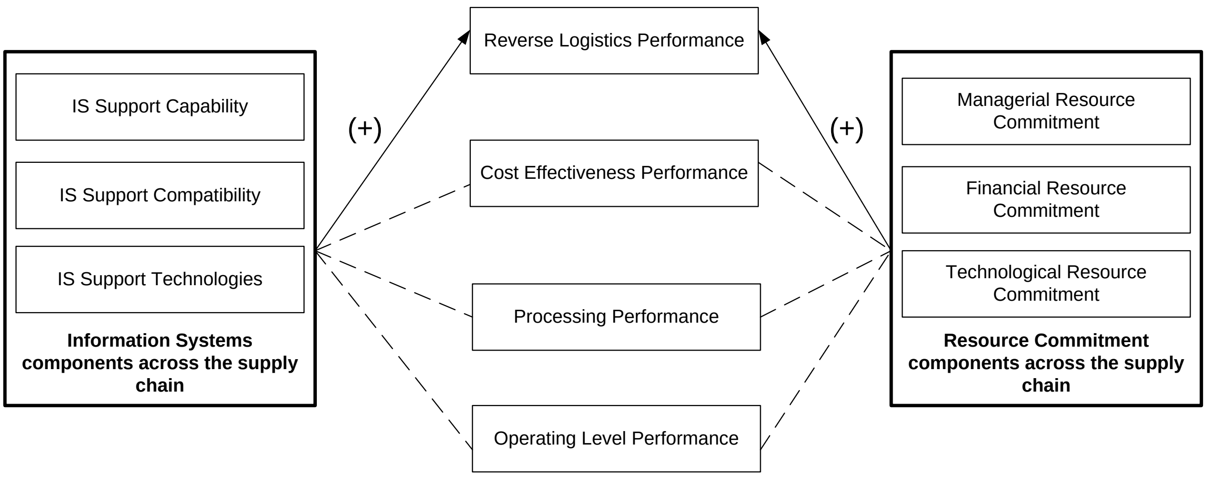

Figure 1. Conceptual model of factors driving reverse 3PL

3. Research methodology and design

This research adopts an interpretivistic mixed-methods, qualitative and quantitative approach (Saunders *et al.*, 2003). A case study organization is used as the research context where using semi-structured interviews responses relating to the components identified in Figure 1 were elicited from supply chain Managers, Supervisors, and Operation Staff with respect their view on how reverse 3PL factors impacted upon their supply chain operation in terms of perceived relationships between information systems and resource commitments and their influence within 3PL operations. A single case study was adopted in this instance (a global 3PL firm sited in Thailand) so that in-depth, context-rich information could be collected as also identified in the literature (Näslund, 2002). Furthermore the usage of the case study approach was deemed to be an appropriate vehicle to be used in order to evaluate and analyse causal inter-relationships which may be affecting the supply chain organization (Yin, 1993). The main aim of the research was however to analyse and identify the factors relating to 3PL and hence RL success. In order to do this, the author applied a cognitive mapping technique in order to identify relationships the deeper relationships highlighted in the conceptual model in Figure 1. Specifically, the technique of Fuzzy Cognitive Mapping (Kosko, 1991) was applied which utilizes and encompasses aspects of artificial intelligence and systems dynamics in terms of simulating a given problem context – the so-called “computing with words” paradigm – and to provide deeper meaning and contextualisation to the qualitative responses.

3.1 Case context

Based on the research performed by the Japan Institute of Logistics Systems (2005), the research has been shown that the RL costs in Thailand were accounted for approximately 3.5% of the total logistics costs in 2004. This number is consistent with that proposed by Rogers & Tibben-Lembke (2001). Currently, the estimation of logistics costs in Thailand is at 16.8% of the countrys GDP (Banomyong *et al.*, 2005). If these percentages are applied to the GDP of Thailand in 2007 which is 8,092 billion baht, the total RL cost in Thailand is expected to be approximately 48 billion baht in 2007 (Thailand Crisis, 2007). This suggests that this level of RL costs attributed to this part of the world is quite significant and cannot be ignored. Hence the focus of this paper relating to 3PL in this country (Logistics Asia, 2008). The case study company, Company T, is one of the largest contract logistics and freight management companies in Thailand and the fourth largest supply chain company in the world. Company T was founded over 60 years ago and has been involved in the freight and logistics business since 1984. Today the company has more than 54,000 employees in over 100 countries and within Thailand, there are over 30 warehouses employing approximately 3,000 people providing a full range of logistics services such as freight management, distribution management, and value-added services – which includes reverse logistics. Hence, the company is a known reverse 3PL provider of repute with experience and reputation in the field. The company is furthermore considered as a pioneer of reverse 3PL operations in Thailand for clients across a diverse range of high technology industries who typically have their major inventories within the Asia-Pacific region, with core distribution hubs based in cities such as Singapore.

3.2 The FCM approach

This section now details and provides additional insight into how the components of the conceptual model in Figure 1, will be investigated using Fuzzy Cognitive Mapping (FCM). This approach builds upon research within operations research and supply chain management which have separately identified the need to get to grips with the complexities involved with contemporary and demand-driven supply chains (Arns *et al.*, 2002); and the need to build and develop simple conceptual models into more feature-rich representations of systems and organizations which can then be simulated.

Over the last 15 years, the operations and supply chain management field has seen a steady and progressive increase in the application of artificial intelligence (AI) techniques as applied to the design, scheduling, process planning and quality / diagnosis lifecycles (Sharif *et al.*, 2008). Within this period, many typical techniques and approaches have included the use of knowledge based systems to capture implicit / tacit design knowledge; neural networks to learn from and control production systems output; genetic and evolutionary algorithms to evaluate and generate a suite of product design options; and lastly, the application of fuzzy logic within decision-making and optimization. A variation and development within the latter technique is Fuzzy Cognitive Mapping (FCM), which is loosely based upon the concept of cognitive mapping. This AI technique seeks to graphically represent components within a given representation of a system or context through a series of cause and effect relationships, augmented through fuzzy or multivalent weights, quantified via numbers or words (Kosko, 1991). There have been many applications of FCMs across a range of applications and disciplines (see for example Aguilar, 2005), where FCMs have be used to investigate and highlight the interaction and inter-relationship between factors which make up a given problem domain or business context.

As such an FCM consists of a series of nodes which define system states; linkages between nodes which define inter-relationships between connecting system states (or even statements); and a series of positively or negatively stated weights between each of the nodes. An FCM is therefore created by a group of subject matter experts who define inter-relationships between what they decide and define to be components of the area under study (which results in a so-called weight matrix), and through the application of fuzzy weights and quantifiers (which define relationships between each constituent system component). Following this, the subject matter experts define a series of scenarios which describe a number of initial states which the FCM describes – essentially “paths” through the system. The FCM is then run as a systems dynamics simulation by carrying out a simple algorithmic iteration of the resulting weight matrix and fuzzy connectivities, as defined in the following equation:

$$C_i^{t+1} = f\left(\sum_{j=1}^{n} W_{ij}\, C_i^{t} \right) + C_i^{t-1} \qquad (1)$$

where C_i is an FCM with a number of nodes where $i = 1\ldots n$, C_i^{t+1} is the value of the node at the $t + 1$ iteration, C_i^{t-1} is the value of the node at the $t - 1$ iteration, f is a given threshold or transformation function, W_{ij} is a corresponding fuzzy weight between two given nodes, i and j, and C_i^t the value of the interconnected fuzzy node at step t (Kosko, 1991). The threshold function, f (x), can be constructed as being bivalent (x = 0 or 1); trivalent (x = -1, 0 or 1); hyperbolic (usually tanh (x)); or the sigmoidal / step function ($x = 1 / 1 + e^{-cx}$, where c is a constant). In order to simulate the dynamic behaviour of the FCM, therefore requires the additional definition of the fuzzy weights, W_{ij}, within a connection matrix, W, and the initial or starting input vector at time t, C^t. As such, the latter is a 1 x n row vector with the values of all concepts, $C_1, C_2, \ldots, C_n$ for n concepts or nodes in the FCM, whilst the former is a $n \times n$ matrix of weights between any two fuzzy nodes, w_{ij}. If there is no direct relationship between the i^{th} and j^{th} nodes, then the value of the connection strength is zero. The simulation proceeds by computing C_i^{t+1} based upon this initial starting vector, and the given threshold function in f, as well as the causal connection strengths in the $n \times n$ matrix, W. Each subsequent $t + 1$ iteration then uses the values of the preceding $t – 1$ row vector in C^0. By calculating each subsequent value of equation (1), the FCM simulates the dynamical system being modelled. The output of the FCM is then as a series of “nodal” responses which highlight the interaction and dynamics of the system whence causality can be inferred and interpreted.

4. Modelling reverse 3PL within the case context

Modelling reverse 3PL proceeded by interviewing respondents within Company T with respect to information system and resource commitment factors identified in Section 2, which were then encoded as elements of fuzzy cognitive map given in equation 1. The elements of the weight matrix, W_{ij}, was generated by Company T interviewees (and facilitated by the researcher) to be based upon the components of Figure 1 and is thus the weight matrix in Table 1 which defines the inter-relationships between each hypothesis. The fuzzy modifiers are defined as follows (where the numerical fuzzy weight is given in brackets for brevity): +++ (1) has a very strong positive relationship; ++ (0.67) has a strong positive relationship; + (0.33) has a moderate positive relationship; 0 denotes a neutral or null relationship; - (-0.33) has a weak negative relationship; -- (-0.67) has a very weak negative relationship; --- (-1) has a very weak negative relationship. The resulting FCM is shown in Figure 2. The initial starting scenarios in vector *C*, are given as the vectors C1 = [1 1 0 0 1 0.67 0] which defines the situation where both IS and resource commitment factors influence reverse 3PL; and vector C2 = [1 0 0 0 1 0.33 1 1] which defines the response from the case participants who highlighted the importance of training staff to be competent in managing both information and resources.

Table 1. Fuzzy weight matrix for RL 3PL commitment factors (numerical weightings)

	IS1	IS2	IS3	IS4	RC1	RC2	RC3	RC4
(**IS1**) IS-RL performance	0	0	1	1	0	-0.33	0.33	0.67
(**IS2**) IS-Cost Effectiveness	0	0	0	0.33	-0.67	1	0	0
(**IS3**) IS-Processing Performance	1	0	0	0	1	0	0.33	0
(**IS4**) IS-Operating Performance	1	0	0	0	0.33	0	0.33	0.33
(**RC1**) Resource-RL performance	0	0	0	0.33	0	0.33	1	1
(**RC2**) Resource-Cost Effectiveness	-1	0.33	-1	0.33	0	0	0	0
(**RC3**) Resource-Processing Performance	0	0	0.33	1	0.67	0	0	1
(**RC4**) Resource-Operating Performance	1	0	0	0	0.67	0	0.67	0

Each of these graphs shows the behaviour-over-time of the FCM and as such the FCM shows stable and convergent behaviour within 11 iterations for each of the starting scenario vectors. For starting vector C1 where the FCM is given the starting scenario where reverse logistics IS as well as resource commitment are deemed to have a positive impact upon the reverse 3PL context, Figure 3 shows that nodes IS2, IS3, IS4 and RC1-4 stabilise to a positive response, whilst node IS3 (IS processing performance) remains slightly negative. The start of the simulation shows rapid interaction within the first 3 iterations amongst all nodes showing a rapid decaying response to a steady state condition. Interestingly node RC4 (Resource Commitment, Operating Performance) rapidly settles to a neutral position (i.e. end state of 0 on the graph) which highlights that this is not a dominant driving factor at all within the FCM. In Figure 4 there is a similar sort of response but with less interaction between the nodes. In this case all nodes and the FCM stabilise very quickly to their steady state positions. Again, node IS3 quickly diverges to a weak negative response (-0.1) as well as IS1 which is state neutral (with a value at 0 again). Table 2 shows the responses grouped across both scenario states. Again it is very clear to see that components of IS operating performance (IS4), Resource Commitment across the RL operation (RC1) and Resource Commitment, operating performance (RC4) denote strong positive relationships; whilst IS as well as Resource Commitment cost effectiveness (IS2 and RC2) and to a certain extent processing performance of resources (RC4) have moderate support. Overall IS performance does not have a direct bearing at all (IS1), and the IS processing performance has little effect as well (IS3). A correlation of Table 1 is also given and is shown in Table 3.

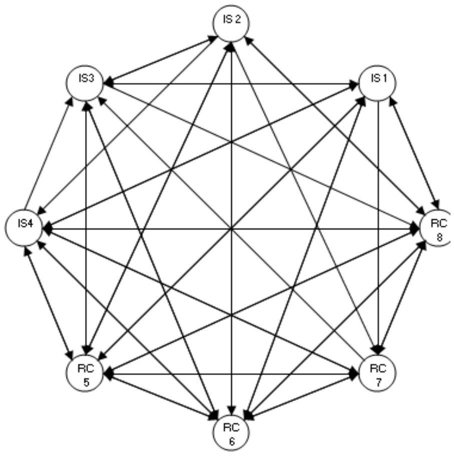

Figure 2. FCM for reverse 3PL

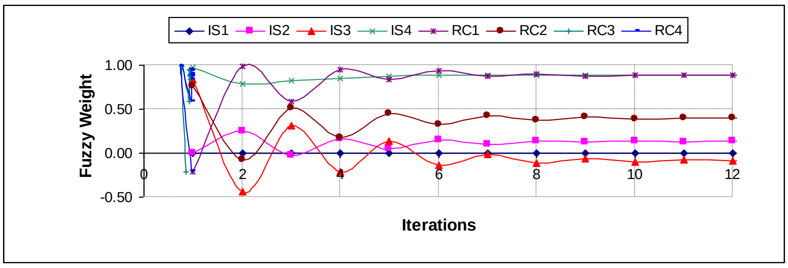

Figure 3. FCM response for vector C1

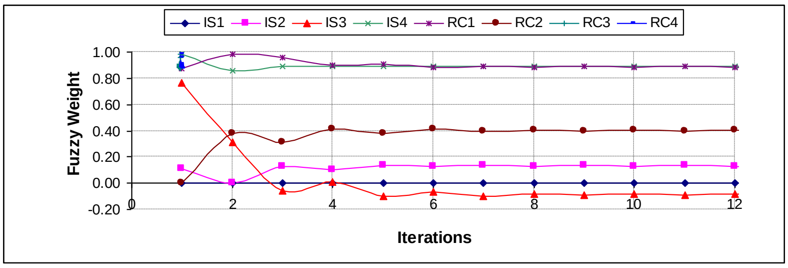

Figure 4. FCM response for vector C2

This also highlights that there is a strong positive correlation between IS processing and cost effectiveness (IS3-IS1, IS4-IS2, IS4-IS3); resource commitment operating performance and RL performance (RC4-IS4, RC4-RC1). Whilst there is weaker correlation between IS cost effectiveness, IS performance and IS processing (IS2-IS1, IS3-IS2); and mixed negative correlation between resource commitment components of cost effectiveness, processing and operating effectivess (RC2-IS3, RC3-IS4, RC2-RC1 and RC4-RC2). Resource commitment performance and IS processing performance has very little correlation at all (RC1-IS3). Thus combining Table 2 with Table 3 gives rise to the re-hypothesis of the conceptual model from Figure 1 and is shown in Figure 5.

Table 2. Grouped responses for FCM scenarios for Reverse 3PL logistics

Relationship / *FCM Context*	**Vector C1**	**Vector C2**
Strong Positive Support	IS4, RC1, RC4	IS4, RC1, RC4
Moderate Positive Support	IS2, RC2, RC3	IS2, RC2
Weak Negative Support	IS3	IS3
Not supported	IS1	IS1

Table 3. Correlation analysis amongst FCM nodes

	IS1	IS2	IS3	IS4	RC1	RC2	RC3	RC4
IS1	1.000						`	
IS2	-0.747	1.000						
IS3	0.658	-0.769	1.000					
IS4	-0.208	-0.043	0.551	1.000				
RC1	0.454	-0.191	0.068	-0.194	1.000			
RC2	-0.343	-0.128	-0.245	-0.230	-0.629	1.000		
RC3	0.357	-0.377	0.161	-0.322	0.169	-0.113	1.000	
RC4	-0.053	-0.335	0.506	0.668	0.017	-0.213	0.294	1.000

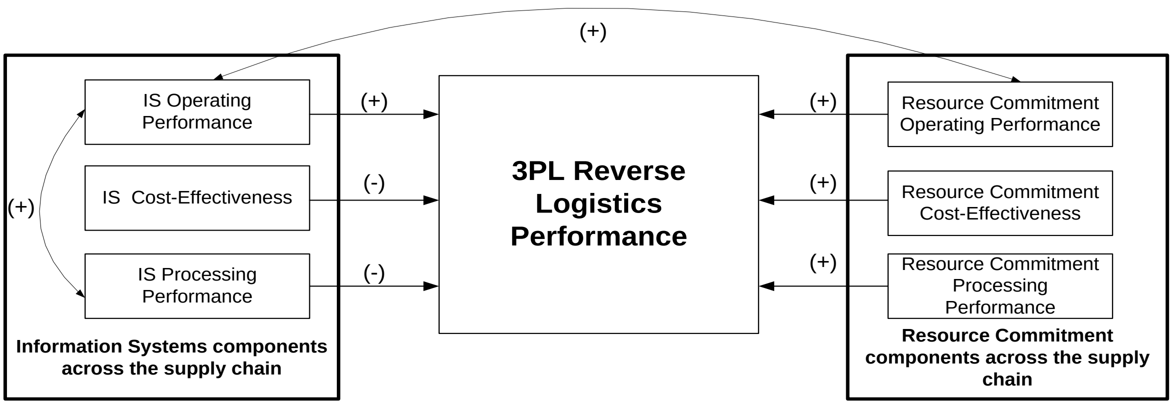

Figure 5. Re-hypothesised framework for 3PL commitment factors

5. Conclusions

Reverse as well as forward-based logistics are a vital component of modern supply chain operations as discussed in this paper. As noted from the extant literature, aspects of the effective management of information and resources appear to be vital to the continuing and future success of reverse third-party logistics (3PL). Bearing these points in mind, this paper has attempted to elucidate and investigate these components of reverse 3PL performance for a case study organisation specialising in this field in Thailand. By adopting a combined qualitative-quantitative approach to identifying the linkages between information and resource commitment factors, the research attempted to further analyse the causal relationships between them through the involvement of case company participant interviews and subject matter expert interviews. Through the application of a Fuzzy Cognitive Mapping (FCM) approach and analysis of the results against a conceptual model and correlation, it was found that operating and cost-effectiveness components appear to be dominant in the minds of supply chain managers in the given context – across performance and training-based scenarios applied. Although the generation of FCM models is subject to a level of bias and subjectivity on the part of the interview respondents, the analysis was able to highlight some interesting avenues of further research and discussion. Principally the research was able to identify that IS operating and resource commitment operating aspects of operating performance has a positive and strong relationship with how reverse 3PL logistics are managed and run. This highlights the importance of understanding and appreciating the human elements of supply chain operations – that even in the best auspices of applying strategic supply chain management principles, in the end resources (be they human, financial or otherwise) must be continually managed and put to the fore of such operations. One aspect of this research not investigated but worthy of future research, would be to extend the study to evaluate the impact of cultural and cross-cultural perspectives within this area, and how it may affect the overall design-distribute-return cycle within reverse 3PL.

References

Aguilar, J. (2005). A survey about Fuzzy Cognitive Maps Papers, *International Journal of Computational Cognition*, 3 (2): 27 – 33.

Arns, M., Fischer, M., Kemper, P., and Tepper, C. (2002). Supply chain modeling and its analytical evaluation. Journal of the Operational Research Society, 53 (8) : 885 – 894.

Autry, C.W., Daugherty, P.J. & Richey, R.G. (2001). The Challenge of reverse logistics in catalog retailing, *International Journal of Physical Distribution & Logistics Management,* 31(1) : 26-37.

Bagchi, P.K. & Mitra, S. (2006). Key Success Factors, Performance Metrics and Globalization Issues in the Third-Party Logistics (3PL) Industry: A Survey of North American Service Providers, *Indian Institute of Management Calcutta*

Banomyong, R., Varadejsatitwong, P. & Prakorpkij, P. (2005). Thailands Logistics Cost per GDP, *Center for Logistics Research,* Thammasat University.
Bask, A.H. (2001). Relationships among TPL providers and members of supply chains – A strategic perspective, *Journal of Business & Industrial Marketing* 16(6) : 470-486
Bhatnagar, R., Sohal, A.S. & Millen, R. (1999). Third party logistics services: a Singapore perspective, *International Journal of Physical Distribution & Logistics Management,* 29(9) : 569-587
Carter, C.R. & Ellram, L.M. (1998). Reverse Logistics: a Review of the Literature and Framework for Future Investigation, *Journal of Business Logistics,* 19(1) : 85-102
Chiger S. (2007). Reverse Logistics: every departments challenge, *Multichannel Merchant,* 24(6): 54
Closs, D.J. & Savitskie, K. (2003). Internal and External Logistics Information Technology Integration, *The International Journal of Logistics Management,* 14(1) : 63-76
Daugherty, P.J., Autry, C.W. & Ellinger, A.E. (2001). Reverse Logistics: the Relationship between Resource Commitment and Program Performance, *Journal of Business Logistics,* 22(1) : 107-24.
Daugherty, P.J., Myers, M.B. & Richey, R.G. (2002). Information Support for Reverse Logistics: The Influence of Relationship Commitment, *Journal of Business Logistics,* 23(1) : 85-106.
Edwards, P., Peters, M. & Sharman, G.J. (2001). The effectiveness of information systems in supporting the extended supply chain, *Journal of Business Logistics,* 22(1) : 1-28
Evangelista, P. & Sweeney, E. (2006). Technology usage in the supply chain: the case of small 3PLs, *The International Journal of Logistics Management*, 17(1) : 55-74
Feng, C.M. & Yuan, C. (2006). The Impact of Information and Communication Technologies on Logistics Management, *International Journal of Management*, 23(4) : 909-924
Gunasekaran, A., Lai, K.-H. and Cheng, T.C.E. (2008). Responsive Supply Chain: A Competitive Strategy in a Networked Economy, *OMEGA*, 36 (4) : 549-564.
Ireland, R.D., and Webb, J.W. (2007). A multi-theoretic perspective on trust and power in strategic supply chains. *Journal of Operations Management*, 25 : 482-497.
Japan Institute of Logistics Systems (2005). *Annual Logistics Costs Survey Report 2004*, Available at: http://www.jetro.go.jp/thailand/e_activity/logilink.html [accessed on 2 February 2008]
Kosko, B. (1991). *Neural Networks and Fuzzy Systems*, Prentice-Hall, Upper Saddle River, NJ, USA.
Logistics Asia (2008). Moving Forward with Reverse Logistics, *Logistics Insight Asia,* Available at: http://www.logasiamag.com/article-265-movingforwardwithreverselogistics-LogisticsAsia.html [accessed on 4 June 2008]
Marasco, A. (2007). Third-Party Logistics: a literature review. *International Journal of Production Economics*, 113 (1) : 127 – 147.
Mentzer, J.T., Min, S. & Bobbitt, L.M. (2004). Toward a Unified Theory of Logistics, *International Journal of Physical Distribution & Logistics Management,* 34(8) : 606-27
Näslund, D. (2002). Logistics needs qualitative research – especially action research, *International Journal of Physical Distribution & Logistics Management*, 32(5) : 321-338
Power, D., Sharafali, M. & Bhakoo, V. (2007). Adding value through outsourcing: Contribution of 3PL services to customer performance, *Management Research News,* 30(3) : 228-235
Razzaque, M.A. & Sheng, C.C. (1998). Outsourcing of Logistics Functions: A Literature Survey, *International Journal of Physical Distribution & Logistics Management,* 28(2) : 89-107
Richey, G.R., Genchev, S.E. & Daugherty, P.J. (2005). The Role of Resource Commitment and Innovation in Reverse Logistics Performance, *International Journal of Physical Distribution and Logistics Management,* 35(4) : 233-57
Rogers, D.S. & Tibben-Lembke, R. (2001). An examination of reverse logistics practices, *Journal of Business Logistics*, 22(2), : 129-148
Saunders, M., Lewis, P. & Thornhill, A. (2003). *Research Methods for Business Students*. 3rd edn. Essex: Pearson Education
Sharif, A.M., Bourlakis, M., Gallear, D., Lee, H., and Gunasekaran, A. (2008). "Operations and Supply Chain Management: Making Sense of the Field". In *Proc. 15th International Annual EurOMA Conference*, June 15th-18th, Groningen, Netherlands. [CD-ROM proceedings].
Stock, J.R. (1998). *Development and Implementation of Reverse Logistics Programs,* Council of Logistics Management, IL: Oak Brook
Thailand Crisis (2007) GDP 2008: the target of +4,5% is maintained, Available at: http://thaicrisis.wordpress.com/2007/09/15/gdp-2008-maintained/ [accessed on 3 June 2008]
Tibben-Lembke, R.S. (2002). Life after death: reverse logistics and the product life cycle, *International Journal of Physical Distribution & Logistics Management,* 32(3) : 223-44
Yin, R.K. (1993). *Applications of Case Study Research*. London: SAGE Publications