Naim, M. M., Potter, A. T., Sanchez Rodrigues, V. A. and Marques, V. L. (2011), ' Base and Surge strategies for controlling environmental and economic costs in logistics triads', Proceedings of the 16th International Symposium on Logistics (ISL), Berlin, Germany, 10-13 July.

'BASE' AND 'SURGE' STRATEGIES FOR CONTROLLING ENVIRONMENTAL AND ECONOMIC COSTS IN LOGISTICS TRIADS.

M. M. Naim[1], A. T. Potter[1], V. Sanchez Rodriguez[2] and V. L. Marques[1]
[1]Cardiff University, United Kingdom
[2]Plymouth University, United Kingdom

ABSTRACT
The aim of this paper is to determine the extent to which it is possible to establish a 'base' and 'surge' strategy for logistics provision with a particular emphasis on minimising environmental and economic costs. Our method is the combination of empirical research outputs on the impact of uncertainty on economic and environmental costs, and a synthesis of the literature on resilience and the role of flexibility therein. We find that logistics planners either build contingents into their schedules (a priori) or they respond with contingencies (a posteriori). The former is associated with a 'base' approach; an example of which may be the incorporation of 'slack time' into a schedule to accommodate expected delays due to road congestion. The latter is equivalent to a 'surge' approach where as an example the logistics provider may have capacity flexibility, in the form of acquiring additional vehicles, to accommodate post-plan changes in shipper volume requirements. This paper explicitly rationalises the links between uncertainty, 'base' and 'surge' supply chain strategies, and the strategic use of logistics flexibility, in minimising environmental and economic costs in a logistics triad. The output is in the form of a conceptual managerial feedback control system.

Introduction:

The challenges facing supply chain managers due to uncertainty are well documented (Davis, 1993, Mason-Jones and Towill, 1998, Peck et al, 2003, Van der Vorst and Beulens, 2002). Only recently has the concept been extended to focus specifically on the impact of uncertainty on logistics operations (Sanchez Rodrigues et al, 2008).

In meeting the challenges afforded by uncertainty, strategies adopted may potentially lead to increased costs in the supply chain. More specifically 'base' (lean) and 'surge' (agile) manufacturing strategies have been advocated as ways to cope with demand uncertainty (Christopher and Towill, 2001, Christopher and Towill, 2002). Hence, manufacturing companies in the supply network will typically either aim to track the variations by creating a 'surge' in capacity, hence leading to increased production on-costs, or else buffer themselves against such variations through inventory which, although ensuring a level or 'base' capacity requirement, increases the risk of stock holding and obsolescence costs. More recently, empirical research on logistics operations has shown that uncertainty leads to increases in both economic and environmental costs (Sanchez Rodrigues et al, 2010c).

The aim of this paper is to develop a model that incorporates 'base' and 'surge' strategies to accommodate the particular characteristics of uncertainty associated with logistics provision. More specifically, the model is to be in the form of a management feedback system that focuses on minimising environmental and economic costs.

Logistics uncertainty:

Sanchez Rodrigues et al (2008) have undertaken a synthesis of the literature on supply chain uncertainty from which they have developed an uncertainty model focussing specifically on freight transport operations. The model may be conceptualised as in Figure 1 which highlights the areas where uncertainty may occur; anywhere in the logistics triad (customer, supplier or carrier) control systems and the external environment. The model of Figure 1 has subsequently been tested via focus groups and a survey with participation from practitioners and policy makers (Sanchez Rodrigues et al, 2010a, Sanchez Rodrigues et al, 2010b).

The uncertainty model of Figure 1 focuses on the logistics triad, arguably the minimum unit of analysis for any supply chain study (Beier, 1989, Naim et al, 2006). Pertinent to the logistics triad is the concept that the carrier is an integral member of the supply chain (Stank and Goldsby, 2000). By considering the logistics triad it is then possible to consider the value adding nature of freight transport that contributes to the overall performance of the supply chain and in delivering customer value (Mason and Lalwani, 2006).

It is often seen that freight transport operations have to be flexible in responding to uncertainties so as to ensure effectively delivery of goods (Narus and Anderson, 1996, Boughton, 2003) while at the same time minimising the impact of transport on economic and environmental costs (Duclos et al., 2003). The offering of flexibility has often been as a result of the commoditisation of freight transport with carriers adopting a reactive "one size fits all" strategy to logistic provision (Bask, 2001,). The result is a potential dichotomy in attempting to achieve flexibility and cost reduction.

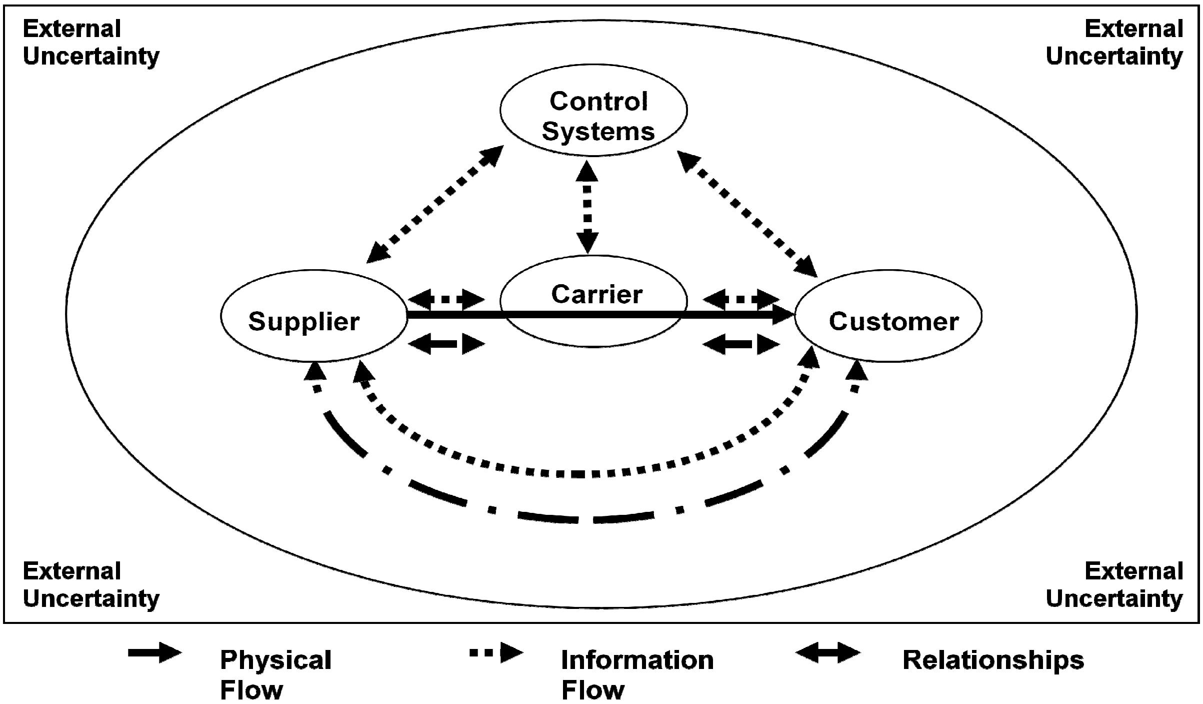

Figure 1: The logistics triad uncertainty model (Sanchez Rodrigues et al, 2008)

Naim et al (2006) suggest that a proactive strategy, where different flexibility types are considered, is a more effective way for carriers to deliver value in the supply chain. Based on a synthesis of the existing literature they highlight a number of generic flexibility capabilities that carriers should consider when offering their services;

• Mode flexibility	Ability to provide different modes of transport
• Fleet flexibility	Ability to provide different vehicle types to carry different goods
• Vehicle flexibility	Ability to configure vehicles to carry products of different types or to cater for different loading facilities
• Node flexibility	Ability to plan, approve and implement new nodes in the network
• Link flexibility	Ability to establish new links between nodes
• Temporal flexibility	Ability to sequence infrastructure investment and the degree to which the use of such infrastructure requires coordination between users
• Capacity flexibility	Ability of a transport system to accommodate variations or changes in traffic demand
• Routing flexibility	Ability to accommodate different routes
• Communication flexibility	Ability to manage a range of different information types

Method:

The research underpinning this paper follows the overall process as given in Figure 2. The conceptual model is as given in Figure 1 (Sanchez Rodrigues et al, 2008) which has been tested through opinion based methods such as focus groups and surveys (Sanchez Rodrigues et al, 2010a, Sanchez Rodrigues et al, 2010b). A number of empirical case studies have been undertaken which have been analysed in terms of the impact of uncertainty on freight transport costs and CO_2 equivalent emissions (e.g. Sanchez Rodrigues et al, 2010c).

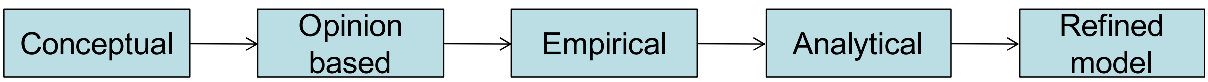

Figure 2: Development of the logistics triad uncertainty model

This paper focuses on the last stage of the research process wherein we take the results of the preceding stages and close the loop back to the body of literature in order to extend the logistics triad uncertainty model. In particular we interrogate the freight transport flexibility types developed by Naim et al (2006) to show which are most relevant to a 'surge' and 'base' response to uncertainty. We also explore the literature on supply chain resilience with the view to the establishment of a final refined model in the form of a management feedback system.

Analysis and Findings:

Opinion based research (Sanchez Rodrigues et al, 2010a, Sanchez Rodrigues et al, 2010b) identifies the expectations of stakeholders to the likely causes of uncertainty in the logistics triad. The biggest expected uncertainly is a delay with the most dominant being due to road congestion. Road congestion is an external uncertainty source that in the main is mostly predictable based on the time of day that road journeys are undertaken. With routeing algorithms, carriers can accommodate the expected delays into their planned schedules. When unexpected events, such as road traffic accidents, do occur their occurrence can be mitigated by the application of satellite navigation systems that enable alternative routes to be sought.

The second biggest issue emerging from the opinion based research was the uncertainty due to changing demand from customers. Demand tends to be highly volatile with unexpected short-notice additional transport requirements or cancellations of previously agreed loads. This volume volatility can be exacerbated by poor information visibility can which reduces demand accuracy, increases safety stock levels at the shipper and increases the number of unnecessary transport movements. The lack of demand accuracy can have a knock-on effect on the volatility of transport volume requirements.

In empirical case based research Sanchez Rodriguez et al (2010c) evaluate the impact of uncertainty in the logistics triad on economic and environmental costs. They found that uncertainty led to two phenomena, which they term as 'extra distance' and 'extra time'. 'Extra distance / extra time' may be defined as any non value-added or unnecessary distance / time within a distribution network due to supply chain uncertainty, and defined as the difference between the distance/time vehicles actually ran, and the distance/time they would have needed to have run if:

- the transport operation had received accurate and timely information on the volumes to be moved, and/or
- there had been no unexpected delays at loading or unloading points and/or
- there had been no operational failures within the distribution network and/or
- there had been no congestion on the journey that could not have been foreseen

'Extra distance' has the potential to increase fuel usage leading to increased costs and engine emissions while 'extra time' leads to unnecessary additional slack time built in the schedules hence not fully utilising the vehicle resources available.

Observations were undertaken of a FMCG secondary distribution operation based in the UK (Sanchez Rodrigues et al, 2010c). Observations included interrogating the vehicle routing and scheduling (VRS) system used to optimise, track and trace, and re-optimise transport movements. In addition, discussions with planners and managers were undertaken to corroborate and elaborate on the interpretation of data from the VRS system. The data of interest for our paper is shown in the first two columns of Table 1; the 'extra distance / time' types and the causes of uncertainty. In the other columns we include some description of each 'extra distance / time' type as well as the mitigations approaches used by the planners.

The mitigation approaches we have classified as 'a priori' and 'a posteriori', and we have related them to 'base' and 'surge' strategies respectively. In the 'a priori' category, there is potentially sufficient information available before the event that causes the uncertainty. We note what was actually done (for the case of route diversion) and, in italics, what the planners believed could be done if the information was made available, enabled via communication flexibility (for the cases of load more than advised and products not loaded). In the 'a posteriori' case action can only be taken after the event and we note in Table 1 what was actually actioned by the planners and relate such actions to capacity, communication, fleet and routing flexibilities.

The observations of Table 1 are synonymous the training guidelines developed for the United States of America military logisticians (Brecke and Garcia, 1995, 1998). Logistics decision making, as that undertaken by logistics planners, is a temporal activity and is dependent on a critical path timeline. We redraw their generic timeline as Figure 3 which is modified to encapsulate the type of uncertainties and mitigations we have defined in Table 1.

The Start Point, SP, equates to any event, or uncertainty cause, that disrupts the logistics operation. The Recognition Phase is that time during which the planner is aware of the event occurring. The planner can be said to have 'sensed' the occurrence of the event by the Recognition Point, RP. The planner then has a Decision Window, DW, by which to seek alternative courses of action during the Uncertainty Reduction Phase before he makes a decision at the Decision Point, DECP and starts the Implementation Phase at the Default Point, DEFP.

Extra distance/time types	**Uncertainty causes**	**Description**	**A posteriori 'surge' mitigation**	**A priori 'base' mitigation**
Extra distance/time due to route diversion	Road restrictions Unplanned Road Congestion	Extra distance needs to be run in an attempt to minimise the delay to the trip. But this may not always be possible and hence extra time generated.	Routing flexibility to accommodate re-routeing. Communication flexibility to utilise GPS and re-routing software.	'Extra time' built into the plan when it is known that at certain times of the day there is likely to be delays e.g. rush hour or evening curfews
Extra distance/time due to delays	Store Suppliers Unplanned stops Unplanned Road Congestion	Delays may occur, e.g. due to slow (un)loading at stores/ suppliers. This could incur an additional vehicle due to the vehicle originally assigned to the trip may not arrive at destination on time.	Capacity flexibility to accommodate variations or changes in traffic demand. Routing flexibility to get around delays.	
Extra distance/time due to load more than advised	Late notification of extra volume from stores Late notification of extra volume from suppliers	The originally planned vehicle size is not appropriate and hence additional vehicle are need to accommodate a higher volume.	Capacity flexibility to accommodate variations or changes in traffic demand. Link flexibility to allow vehicles to be sourced from other flows.	*Advanced notice of changes in planned volume. Communication flexibility required to accommodate new sources of information.*
Extra distance/time due to inappropriate vehicle size	Technical vehicle failure	Original vehicle not available for departure and may be substituted by a number of smaller sized vehicles.	Capacity flexibility and Fleet flexibility to provide different vehicle types.	
Other	Product not loaded at distribution centres Product not loaded at suppliers	Volume accumulates for the next day and this product ultimately needs to be moved which may lead to late notification of extra volume.	Capacity flexibility to accommodate variations or changes in traffic demand. Routing flexibility to ensure full vehicle loads.	*Advanced notice of missed additional products. Communication flexibility required to accommodate new sources of information.*

Table 1: Empirical data analysis

It may be concluded that DW defines the time which it takes for the logistics operation respond to the Event and by DEFP the logistics operations have recovered. We may postulate that how well and quickly that recovery is achieved is dependent on the inherent flexibilities of the logistics triad, or how ready is the logistics triad in responding to uncertainty. There is also a feedback phase where the lessons learnt from the actions undertaken are utilised by planners in preparing for the next possible event.

Approaches that detect and manage, or sense and respond, to unplanned or abnormal occurrences is well known in the literature (Haeckel and Nolan, 1993) with examples of its implementation again coming from military logistics (Tripp et al., 2006).

In addition, we find analogue between our research findings and supply chain resilience (for example, Christopher and Peck, 2004, Sheffi and Rice Jr, 2005). Ponomarov and Holcomb (2009) define supply chain resilience as "the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations".

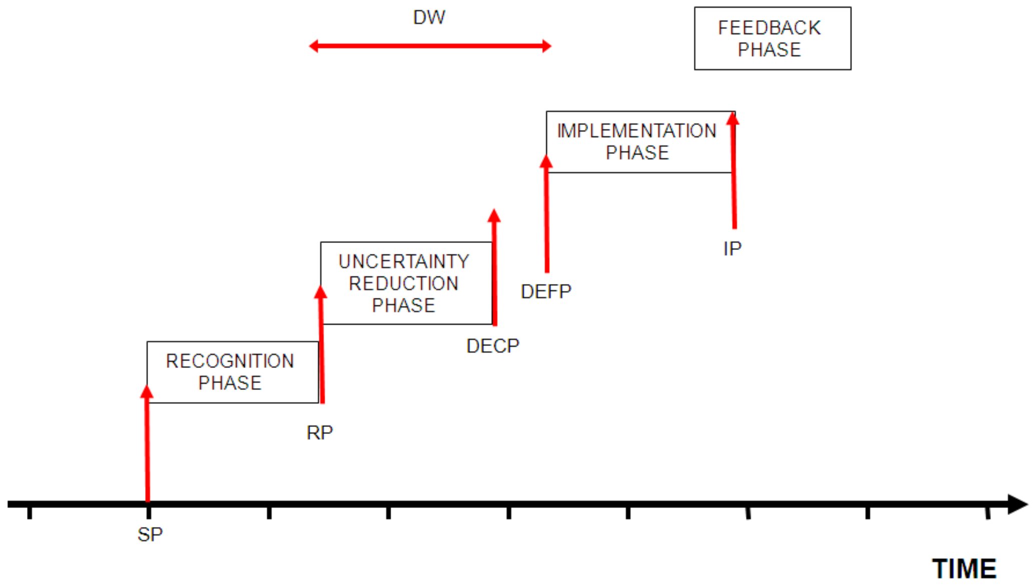

Figure 3: The logistics planner's decision timeline

The supply chain resilience literature encapsulates the concepts of readiness, response, and recovery. With consideration of Figure 3 and with the inclusion of the concept of sensing we may define logistics resilience as;

a) Readiness: before SP, the logistics triad is prepared for uncertainty or a disruptive event through the development of freight transport flexibility capabilities at a reasonable cost.
b) Sensing: minimising the lag between the event occurring and the logistics triad's recognition of the event, RP, ensures the number of options available to planners is maximised.
c) Response: reaction to a specific event is given by DW. A quick and flexible response implies minimising the time to react to the disruptions and begin the recovery phase.
d) Recovery: a return to normal stable or steady state conditions, by the implementation point, IP

The implications of developing adequate flexibility types on resilience are as given in Figure 4, which is a development of Bodendorf and Zimmerman (2005) who used similar curves to highlight the benefits of an electronic disturbance detection system. Hence, the sooner an event occurs, the more options that are available to a planner for corrective action, and hence the possibility of finding a better course of action in the time available increases. Thus costs may be minimised.

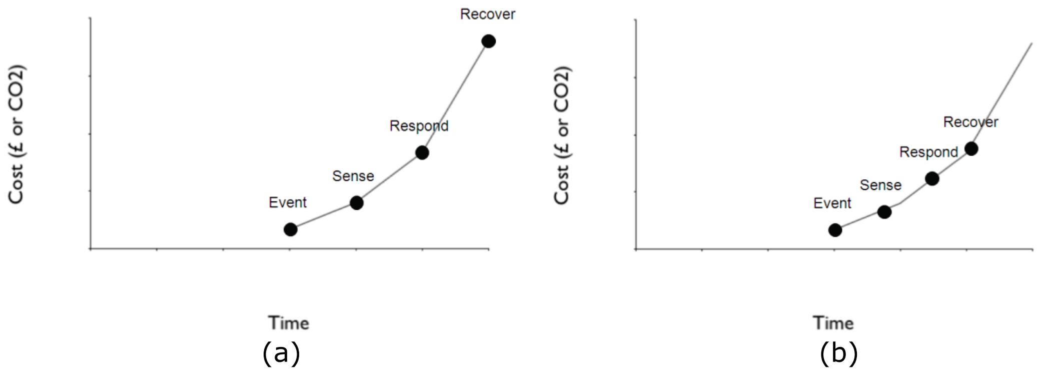

Figure 4: The benefits of resilience – (a) without resilience, (b) with resilience

Much of the above discussion concerns the 'a posteriori' actions after an event has occurred. But as we noted in Table 1, with the two cases where 'a posteriori' actions are the norm, facilitating communication flexibility would enable 'a priori' actions to be taken. In such a situation we would then find that the cost curves shown in Figure 4 will become as shown in Figure 5.

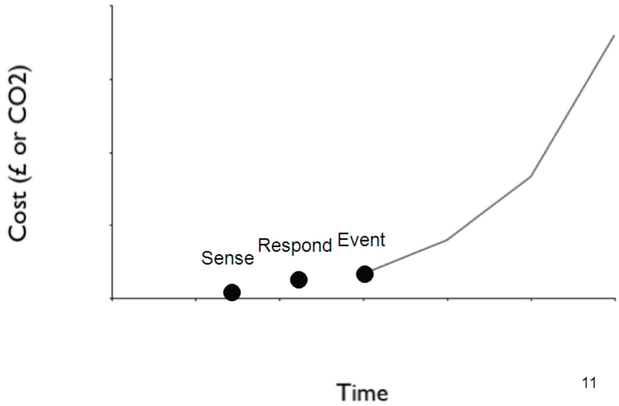

Figure 5: Benefits of enhanced communication flexibility leading to 'a priori' knowledge

Achieving the cost curve in Figure 5 will require information visibility in the logistics triad. Empirical observations have noted that while additional loads, and in many cases volume changes, are known well in advance by suppliers, stores or distribution centres, these are often not communicated in time for the logistics planner's 'a priori' schedule. Hence, a simple action, observed in another case (Naim et al, 2009) would be to ensure that such information is transferred immediately and directly to the logistics planner, thereby increasing communication flexibility.

Bringing all the elements of the findings together, we may then develop a management feedback control system as shown in Figure 6. Sensing events, through real-time data collection, is a critical element of the system, whether it be for 'a priori' or 'a posteriori' decision making.

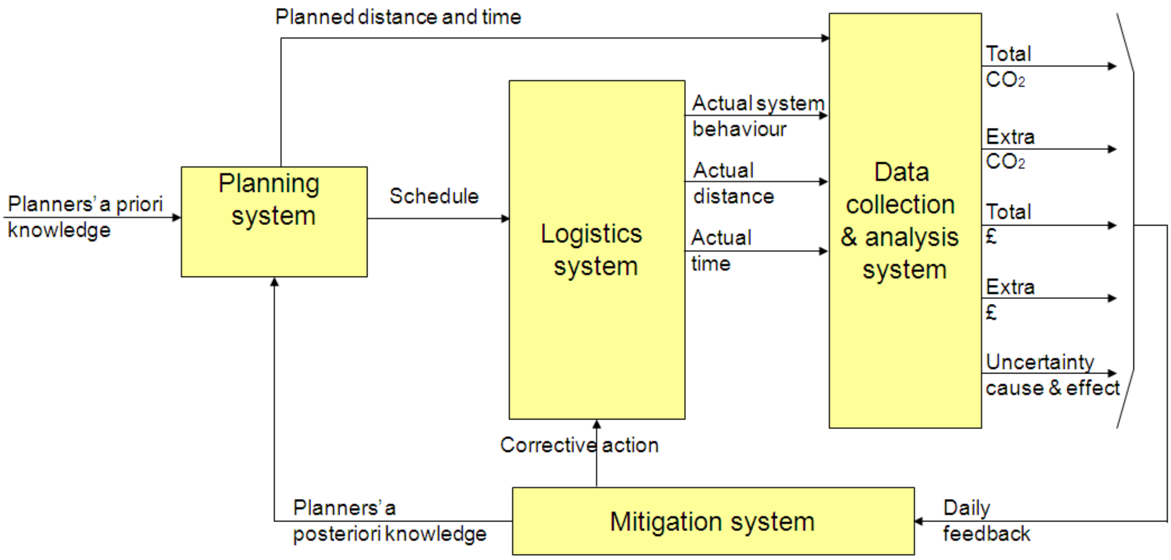

Figure 6: Management feedback control system to minimise extra distance / time

Notable in the case research (Sanchez Rodrigues et al, 2010c) is the lack of appreciation of the impact of extra distance / time which may yield increased additional economic and environmental costs. Over a year, in a large logistics network, that may equate to £1 million and 500 tonnes of CO_2.

Conclusion:

We find that logistics planners either build contingents into their schedules (a priori) or they respond with contingencies (a posteriori). The former is associated with a 'base' approach while the latter is equivalent to a 'surge' approach. The logistics triad may achieve enhanced resilience through the development of freight transport flexibilities. In particular, within the context of a management feedback control system, communication flexibility will enhance the ability to sense and respond 'a priori' to an event.

REFERENCES:

Bask, A., 2001, Relationships among TPL providers and members of supply chains: a strategic perspective, Journal of Business and Industrial Marketing, 16(6) 470–486.

Beier, F., 1989, Transportation contracts and the experience effect: a framework for future research, Journal of Business Logistics, 10(2) 73-89.

Bodendorf, F. and Zimmerman, R., 2005, Proactive supply chain event management with agent technology, International Journal of Electronic Commerce, 9(4) 57-89.

Boughton, R.F., 2003, Addressing the escalating cost of road transport, Logistics and Transport Focus, 5(3) 36-43.

Brecke, F.H. and Garcia, S.K, 1995, "Training methodology for logistics decision making", Report AL/HR-TR-1995-0098, Air Force Materiel Command, Brooks Air Force Base, Texas.

Brecke, F.H. and Garcia, S.K, 1998, "Desktop training for decision makers", Report AL/HR-TR-1997-0045, United States Air Force Research Laboratory.

Christopher, M. and Towill, D.R., 2001, An integrated model for the design of agile supply chain, International Journal of Physical Distribution and Logistics Management, 31(4) 235-246.

Christopher, M. and Towill, D.R., 2002, Developing market specific supply chain strategies, International Journal of Logistics Management, 13(1) 1-14.

Davis, T., 1993, Effective Supply Chain Management, Sloan Management Review, Summer, pp. 35-46.

Duclos, L.K., Vokurka, R.J. and Lummus, R.R., 2003, A conceptual model of supply chain flexibility, Industrial Management & Data Systems, 103(6) 446-56.

Haeckel, S. H., & Nolan, R. L. 1993. Managing by wire. Harvard Business Review, 71(5), 122-132.

Mason, R. and Lalwani, C., 2006, Transport integration tools for supply chain management, International Journal of Logistics: Research and Applications, 9(1) 57–74

Mason-Jones, R. and Towill, D.R., 1998, Shrinking the supply chain Uncertainty Circle, Control, September, pp. 17-22.

Naim, M. M., Aryee, G. and Potter, A., 2010, Determining a logistics provider's flexibility capability, International Journal of Production Economics, 127(1) 39-45

Naim, M.M., Potter, A.T., Mason, R.J. and Bateman, N., 2006, The role of transportation flexibility in logistics provision, The International Journal of Logistics Management, 17(3) 297-311.

Narus, J.A. and Anderson, J.C., 1996, Rethinking distribution: adaptive channels, Harvard Business Review, 74(4) 112-20.

Peck, H., Abley, J., Christopher, M., Haywood, M., Saw, R., Rutherford, C. and Strathen, M., 2003, Creating Resilient Supply Chains: A Practical Guide. Cranfield University, Cranfield, Bedford).

Ponomarov, S.Y. and Holcomb, M.C., 2009, Understanding the concept of supply chain resilience, International Journal of Logistics Management, 20(1) 124–143.

Sanchez Rodrigues, R. V., Potter, A. T. and Naim, M. M., 2010a, Evaluating the causes of uncertainty in logistics operations, International Journal of Logistics Management, 21(1) 45-64.

Sanchez Rodrigues, R. V., Potter, A. T. and Naim, M. M., 2010b, The Impact of Logistics Uncertainty on Sustainable Transport Operations, International Journal of Physical Distribution and Logistics Management, 40(1/2) 61-83.

Sanchez Rodrigues, V., Potter, A., Naim, M., McKinnon, A. and Darby, J., 2010c, Measuring the time and distance impact of transport uncertainty: a FMCG case study, Logistics Research Network Conference, Harrogate, 8th-10th September, 606-615.

Sanchez Rodrigues, V., Stantchev, D. S., Potter, A. T., Naim, M. M. and Whiteing, A. E., 2008, Establishing a transport operation focussed uncertainty model for the supply chain, International Journal of Physical Distribution and Logistics Management, 38(5) 388-411.

Sheffi, Y. and Rice, J.B., 2005, A supply chain view of the resilient enterprise, MIT Sloan Management Review, 47(1) 41–48.

Stank, T.P. and Goldsby, T.J., 2000, A framework for transportation decision making in an integrated supply chain, Supply Chain Management: An International Journal, 5(2) 71-77.

Tripp, R. S., Amouzegar, M. A., McGarvey, R. G., Bereit, R., George, D., & Cornuet, J. 2006. Sense and Respond Logistics Integrating Prediction, Responsiveness, and Control Capabilities: Rand.

Van der Vorst, J. and Beulens, A., 2002, Identifying sources of uncertainty to generate supply chain redesign strategies, International Journal of Physical Distribution & Logistics Management, 32(6) 409-430.